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ENVIRONMENT AGENCY AUSTRIA

Austria's National Inventory Report 2023

Submission under the United Nations Framework Convention on Climate Change

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REPORT
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VIENNA 2023

Since 23 December 2005 the Umweltbundesamt has been accredited as Inspection Body for emission inventories, Type A (ID No. 241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG), by decree of Accreditation Austria (first decree, No. BMWA-92.715/0036-I/12/2005, issued by Accreditation Austria / Federal Ministry of Economics and Labour on 19 January 2006).

The information covered refers to the following accreditation scope of the IBE: 2006 IPCC GL for National Greenhouse Gas Inventories, 2006 GL Revised Supplementary KP and 2006 GL Supplement Wetlands (akkreditierung-austria.gv.at/overview)

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The authors of this report want to express their thanks to all experts at the *Umweltbundesamt* as well as experts from other institutions involved in the preparation of the Austrian Greenhouse Gas Inventory for their contribution to the continuous improvement of the inventory.

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This submission is made to meet the reporting requirements for national greenhouse gas inventories under the UNFCCC and under Regulation (EU) 218/1999 ("Governance Regulation"). This report is the official 2023 submission of Austria under the UNFCCC and the EU Governance Regulation in fulfilment of Article 26. It replaces the one designated as DRAFT submitted on March 15th 2023 and has undergone a complete and final quality control and layout/typesetting.

This report is compiled and published as an inspection report in accordance with the Accreditation Law and the international standard ISO/IEC 17020, in fulfilment of and in compliance with the IPCC 2006 Guidelines, the 2006 GL Revised Supplement KP as well as the 2006 GL Supplement Wetlands (scope of accreditation regarding GHG emissions) as well as the UNFCCC Reporting Guidelines.

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PREFACE

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Austria is required to produce and regularly update National Greenhouse Gas Inventories. Methodologies, content and format of the inventory are prescribed by the IPCC (IPCC, 2006) in its reporting guidelines that have been agreed by the Conference of the Parties to the Climate Change Convention. A complete inventory submission requires a National Inventory Report and the common reporting format tables. With Decision 24/CP.19 (FCCC/CP/2013/10/Add.3) the revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention were adopted. According to this decision an annual GHG inventory submission shall consist of an National Inventory Report (NIR) and CRF tables.

This submission is solely done under the UNFCCC, and not under the Kyoto Protocol any more as the 2nd Kyoto period 2013-2020 is over. However, the information on accounting of Kyoto Protocol units (former chapter 12) as well as the changes in the national registry (former chapter 14) are continued to be reported (refer to Annex 6 und Annex 7) until the true-up period is terminated.

The report also presents GHG data relevant under the Effort-sharing Regulation[1] (target period 2021-2030) covering greenhouse gas emissions for sectors not covered by the emissions trading system. It is submitted as final report[2] to the European Commission in fulfilment of Austria's obligations under Article 26 of Regulation (EU) No 218/1999 ("*Governance Regulation*")[3] governing reporting of greenhouse gas inventory data by Member States from 2023 onwards. The purpose of this regulation is to monitor anthropogenic greenhouse gas emissions and to evaluate the progress towards meeting the Union greenhouse gas reduction commitments in accordance with the Paris Agreement.

The structure of the report follows the outline and general structure of the national inventory report as required under Decision 24/CP.19 (Appendix). First, there is an Executive Summary giving an overview of Austria's greenhouse gas inventory. Chapters 1 and 2 provide general information on the inventory preparation process and summarize the overall trends in emissions. Comprehensive information on the methodologies used for estimating emissions of Austria's greenhouse gas inventory is presented in the Sector Analysis Chapters 3–8. Chapter 9 reports on indirect emissions. Chapter 10 gives an overview of recalculations, including improvements made and planned in response to the previous reviews (UNFCCC 2020, ESD 2022).

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1 REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

2 First submission 2023 was done on 12th January 2023 providing preliminary inventory data for 2021 and information as stipulated in Art. 26 (3) in the EU Governance Regulation ("Short-NIR 2023"; UMWELTBUNDESAMT 2023b)

3 REGULATION EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

This is the 22nd version of the National Inventory Report (NIR) submitted by Austria and it builds on the NIR submitted in 2022[4]. It is based on AUT CRF tables submitted on 13 April 2023. Aim of this report is to document the methodology in order to facilitate understanding of the calculation of the Austrian GHG emission data. The more interested reader is kindly referred to the background literature cited in this document.

Data differs from last years' reported data as some activity data have been updated or improvements in methodology have been made to enhance accuracy of the greenhouse gas inventory (for further information see Chapter 10 Recalculations and Improvements). Data and information presented in the NIR 2023 replaces the information submitted in previous years.

The CO_2-equivalent emissions presented in this report were calculated by applying the Global Warming Potentials ('GWPs') according to the 5th Assessment Report ('AR5') of the Intergovernmental Panel on Climate Change (IPCC). As a result, the values for CH_4, N_2O and F-gas emissions in metric tons of CO_2e have changed significantly compared to the previous years' report (NIR 2022), which presented the CO_2 equivalents in accordance with the 4th Assessment Report ('AR4'). The effects are shown separately in chapter 10.2.2.

With this change, Austria fulfills the requirements of the EU Governance Regulation 2018/1999[5] on GHG inventories applicable from 2023 onwards, which, by means of its Delegated Regulation 2020/1044[6] Article 2 ('Greenhouse Gas Potentials'), requires the use of the GHG potentials listed in Annex 1 of this Regulation in accordance with AR5.

Note, that the CRF Table 8s4 on Recalculations of f-gases submitted together with this report contains an error: HFC and PFC data on the previous years' submission were incorrectly converted to 'AR 5' by the CRF Reporter. However, recalculation numbers of f-gases presented in this report are correct.

Michael Anderl in his function as head of the Expert Team *National Emission Inventories* of the *Umweltbundesamt* is responsible for the preparation of Austria's National Greenhouse Gas Inventory as well as for the preparation of the NIR.

Michael Anderl in his function as head of the *Inspection Body for Emission Inventories* is responsible for the content of this report and for the quality management system of the Austrian Greenhouse Gas Inventory. Katja Pazdernik acts as deputy head of the *Inspection Body for Emission Inventories.*

Project leader for the preparation of the Austrian GHG inventory is Stephan Poupa.

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4 Austria's National Inventory Report 2022 – Submission under the United Nations Framework Convention of Climate Change and under the Kyoto Protocol. Report REP-0811. Umweltbundesamt, Vienna.

5 REGULATION EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

6 COMMISSION DELEGATED REGULATION (EU) 2020/1044 of 8 May 2020 supplementing Regulation (EU) 2018/1999 of the European Parliament and of the Council with regard to values for global warming potentials and the inventory guidelines and with regard to the Union inventory system and repealing Commission Delegated Regulation (EU) No 666/2014

Specific responsibilities for the preparation of the Austrian GHG inventory are:

- Data management .... Stephan Poupa
- Fuel combustion stationary .... Stephan Poupa ('Sector Coordinator')
- Fuel combustion mobile .... Gudrun Stranner ('Sector Coordinator')
- Fugitive emissions .... Marion Gangl ('Sector Coordinator")
- Industrial processes .... Maria Purzner ('Sector Coordinator')
- Product use .... Maria Purzner ('Sector Coordinator')
- Agriculture .... Simone Mayer ('Sector Coordinator')
- LULUCF .... Peter Weiss ('Sector Coordinator')
- Waste .... Katja Pazdernik ('Sector Coordinator')
- Key Category Analysis .... Andreas Zechmeister
- Uncertainty Analysis .... Andreas Zechmeister

Project leader for the preparation of the NIR is Katja Pazdernik.

Specific responsibilities for the NIR 2023 have been as follows:

- Executive Summary .... Katja Pazdernik
- Chapter 1.1, 1.4 .... Katja Pazdernik
- Chapter 1.2, 1.3 .... Manuela Wieser, Günther Schmidt
- Chapters 1.5, 1.6 .... Andreas Zechmeister
- Chapter 2 .... Katja Pazdernik, Marion Gangl, all sector experts
- Chapters 3.1, 3.2, 3.4 .... Stephan Poupa, Wolfgang Schieder (3.2.14)
- Chapter 3.2 (Road Transport, Aviation).... Gudrun Stranner, Barbara Schodl, Günther Schmidt
- Chapter 3.3 .... Marion Gangl, Katja Pazdernik, Jérôme Colson
- Chapter 4.1–4.8 .... Maria Purzner, Manuela Wieser, Jérôme Colson
- Chapter 5 .... Simone Mayer, Michael Anderl, Lisa Makoschitz
- Chapter 6 .... Peter Weiss, Bradley Matthews, Erwin Moldaschl
  Elisabeth Schwaiger, Bettina Schwarzl, Merlin Mayer
- Chapters 7.1–7.3, 7.5 .... Katja Pazdernik, Michael Roll
- Chapter 7.4 .... Stephan Poupa
- Chapter 8 .... Katja Pazdernik
- Chapter 9 .... Katja Pazdernik
- Chapter 10 .... all sector experts

CONTENTS

EXECUTIVE SUMMARY

ES.1 BACKGROUND INFORMATION ON GREENHOUSE GAS (GHG) INVENTORIES AND CLIMATE CHANGE

ES.1.1 Background information on climate change

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. It undergoes natural variability. Since industrialisation started some 150 years ago, mankind has been influencing the climate via the emission of greenhouse gases. In 1992, by adopting the United Nations Convention on Climate Change, the countries of the world came together to prevent harmful effects of climate change. However, the Convention did not include binding commitments to limit GHG emissions. To go this step further the Kyoto Protocol was adopted in 1997: It sets binding emission limits for 37 industrialized countries for the period 2008–2012. An agreement on a second Kyoto commitment period from 2013 to 2020 was achieved 2012 at the 18th Conference of the Parties in Doha (Qatar) (UNFCCC CMP.8). The agreed reduction for the EU is 20% compared to 1990 emissions, which is in line with the climate and energy package 2020 of the EU.

The decision to negotiate a new global agreement for the period after 2020 was made at the Conference of the Parties in Durban in 2011. In December 2015, this was adopted at the 21st Conference of the Parties in Paris. It entered into force on November 4, 2016, as more than 55 Parties covering at least 55% of global GHG emissions ratified it.

The Paris Agreement established the long-term 2°C target for the first time in an international treaty. It also calls for additional efforts to limit temperature increases to 1.5°C. In contrast to the Kyoto Protocol, this new agreement includes not only industrialized but also newly industrializing and developing countries in order to take account of the change in the global distribution of GHG emissions. Plans for emission reductions (Nationally Determined Contributions, NDCs) of the participating countries have been submitted to the UNFCCC.

ES.1.2 Background information on greenhouse gas inventories

To be able to evaluate the trend of greenhouse gas emissions, especially the progress in achieving the emission reduction goal, it is necessary to regularly compile an inventory of GHG emissions.

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL-RELATED TRENDS

In 2021 Austria's total greenhouse gas (GHG) emissions (without Land Use, Land Use Change and Forestry – LULUCF) amounted to 77.5 Mt CO_2 equivalents (CO_2e). Compared to the 1990 base year[7], 2021 GHG emissions without LULUCF decreased by 1.9%. Compared to 2020 GHG emissions increased by 4.9%.

The most important gas in the Austrian GHG balance remains carbon dioxide (CO_2) with a share of 85 % in total 2021 emissions (without LULUCF). Emissions of CO_2 primarily result from combustion activities. Methane (CH_4), which mainly arises from livestock farming and waste disposal, contributes 8.4 % (2021) to total national GHG emissions. Nitrous oxide (N_2O), with agricultural soils as the main source, contributes another 4.0% (2021). The remaining 2.4% are emissions of fluorinated compounds, which are mostly emitted from the use of these gases as substitutes for ozone depleting substances (ODS) in refrigeration equipment.

Table 1: Austria's greenhouse gas emissions by gas.

GHG emissions	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Total
	CO_2 equivalents (kt)							
1990	62 167	11 319	4 011	2.0	1 063	485	NO,NA	**79 047**
1995	64 044	10 514	3 856	324	75	1 134	6.0	**79 953**
2000	66 172	9 218	3 871	677	80	592	9.8	**80 619**
2005	79 097	8 514	3 188	1 104	150	509	26	**92 589**
2010	72 017	7 836	2 994	1 426	71	346	3.9	**84 693**
2011	69 909	7 604	3 087	1 518	66	317	3.8	**82 506**
2012	67 283	7 470	3 061	1 599	46	321	8.0	**79 788**
2013	67 776	7 349	3 046	1 689	45	315	9.1	**80 229**
2014	64 176	7 191	3 127	1 787	48	324	9.9	**76 663**
2015	66 366	7 103	3 142	1 897	45	319	13	**78 884**
2016	67 227	7 023	3 231	1 884	46	405	5.7	**79 821**
2017	69 609	6 993	3 175	1 892	40	412	11	**82 132**
2018	66 572	6 758	3 136	1 946	29	398	15	**78 854**
2019	67 956	6 609	3 131	1 802	35	450	13	**79 994**
2020	62 121	6 503	3 089	1 705	27	455	11	**73 911**
2021	66 019	6 499	3 123	1 486	23	371	12	**77 532**

Note: Global warming potentials (GWPs) according to the 5th Assessment Report (IPCC 2013) (100 years time horizon): carbon dioxide (CO_2) = 1; methane (CH_4) = 28; nitrous oxide (N_2O) = 265; sulphur hexafluoride (SF_6) = 23 500; nitrogen trifluoride (NF_3) = 16 100; hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances

[7] Austria's base year under the UNFCCC is 1990. Under the EU Effort Sharing, the base year is 2005 (relates only to emissions not included in the EU Emissions Trading Scheme). Unless otherwise specified, references to the base year in this report refer always to 1990.

Over the period 1990–2021 CO_2 emissions increased by 6.2%, mainly due to higher CO_2 emissions from iron and steel production. During the same period CH_4 emissions decreased by 43%, mainly due to lower emissions from solid waste disposal sites and N_2O emissions decreased by 22% due to lower emissions from agricultural soils and the chemical industry. HFC emissions increased remarkably between 1990 and 2021 (from 2.0 to 1 486 kt CO_2e), whereas PFC and SF_6 emissions decreased by 98% and 24% respectively. NF_3 emissions amounted to 12 kt CO_2e in 2021 compared to zero emissions in 1990.

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS

The dominant sector regarding GHG emissions in Austria is *Energy*, causing 67% of total national GHG emissions in 2021 (67% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (22% in 2021) and *Agriculture* (9.3% in 2021).

Table 2: Austria's greenhouse gas emissions by sector.

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO_2 equivalents (kt)					
1990	52 665	13 615	8 400	-12 207	4 367	NO*
1995	54 162	13 606	8 130	-19 771	4 055	NO
2000	55 291	14 408	7 644	-14 284	3 277	NO
2005	66 715	15 652	7 181	-18 418	3 041	NO
2010	59 281	15 935	7 188	-19 759	2 289	NO
2011	56 971	16 126	7 265	-15 360	2 143	NO
2012	54 830	15 730	7 212	-5 767	2 017	NO
2013	55 005	16 139	7 211	-6 242	1 874	NO
2014	51 280	16 289	7 346	-7 612	1 747	NO
2015	53 064	16 800	7 376	-6 563	1 645	NO
2016	54 289	16 498	7 489	-6 993	1 546	NO
2017	56 001	17 231	7 444	-3 249	1 457	NO
2018	54 555	15 596	7 330	4 921	1 373	NO
2019	54 937	16 520	7 221	2 132	1 315	NO
2020	49 930	15 524	7 197	-5 222	1 259	NO
2021	52 142	16 959	7 221	-10 402	1 211	NO

**not occurring*

ES.4 OTHER INFORMATION

Overview of Emission Estimates and Trends of Indirect GHGs and SO_2

Emissions of indirect greenhouse gases decreased in the period from 1990 to 2021: NO_x by 44%, CO by 58%, NMVOC by 67%, and SO_2 by 85%. The most important emission source for NO_x, SO_2 and CO is *Energy* (fuel combustion). The most important emission source for NMVOC is *Agriculture*.

Table 3: Emissions of indirect GHGs and SO_2 1990–2021.

	NO_x	CO	NMVOC	SO_2
	[kt]			
1990	218	1 248	334	74
1995	198	973	248	47
2000	211	728	181	31
2005	246	625	156	26
2010	204	580	137	16
2011	196	563	132	15
2012	191	563	130	15
2013	192	566	124	14
2014	185	531	118	14
2015	182	542	113	14
2016	174	537	112	13
2017	165	527	112	13
2018	153	485	108	11
2019	144	498	108	11
2020	123	473	110	10
2021	121	522	111	11
Trend 1990–2021	**-44%**	**-58%**	**-67%**	**-85%**

1 INTRODUCTION

1.1 Background information on greenhouse gas (GHG) inventories and climate change

1.1.1 Background information on climate change

1.1.1.1 Global Warming

Temperature around the world has been rising since the Industrial Revolution. Scientific evidence makes clear that human activities are mostly responsible for the increase by emitting greenhouse gases like carbon dioxide, methane, nitrous oxide as well as various fluorinated and chlorinated gases (IPCC 2014).

The average global temperature on earth has increased by a little more than 1° Celsius since 1880, while two-thirds of the warming has occurred since 1975 (NASA 2020).

According to the fifth assessment report of the IPCC 2014, temperature will rise by another 0.9–5.4°C in the 21st century, depending on the emission scenario.

The IPCC 2019 states that global warming from the pre-industrial period to the present will persist for centuries and will continue to cause further long-term changes in the climate system.

It will lead to changes in the hydrological cycle as well as to modification of the albedo (total reflectivity of the earth) and to significant changes of the atmospheric circulation. This will increase the risk of extreme weather events such as hurricanes, droughts and floods and others.

1.1.1.2 Climate Change in Austria

Since 1880, an approx. 2°C increase in the average air temperature in Austria has been recorded (APCC 2014), which is significantly higher than the global average. The effects of global warming in Austria are already visible today: rapid melting of glaciers, thawing of permafrost, an increasing number of hot days, longer vegetation periods, etc.

In 2015, regional climate projections for the near (2050) and distant future (2100) were made available for Austria (called ÖKS15), providing comprehensive, high-resolution and error-corrected information on climate change. All models consistently show significant increases in annual and seasonal mean temperatures throughout Austria, about +1.3°C to +1.4°C by 2050. By the end of the 21st century, with +4.0°C throughout Austria, RCP8.5 predicts a much more pronounced increase in temperature than RCP4.5 at +2.3°C.

Being aware of the need for further research to various topics related to climate change, Austria launched StartClim and the Austrian Climate Research Program (ACRP) in the last century and installed in 2011 the Climate Change Center Austria (CCCA). Furthermore a strategy to adapt to climate change in Austria was developed in 2012 and updated in 2017.

1.1.1.3 The Convention, its Protocols and the flexible mechanisms thereunder

In 1992 Austria signed the United Nations Framework Convention on Climate Change (UNFCCC) which sets an ultimate objective of stabilizing atmospheric concentrations of greenhouse gases at levels that would prevent "dangerous" human interference with the climate system. Such levels, which the Convention does not quantify, should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The UNFCCC covers all greenhouse gases not covered by the Montreal protocol[8]: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) as well as hydrogenated fluorocarbons (HFCs), perfluorinated halocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

Five years after adoption of the Climate Change Convention in 1997, governments took a further step forward and adopted the landmark Kyoto Protocol. Building on the Convention, the Kyoto Protocol broke new ground with its legally binding constraints on greenhouse gas emissions and its innovative 'mechanisms' aimed at cutting the cost of curbing emissions. Under the terms of the Protocol, the industrialised world – Parties listed in Annex I of the Convention and known as 'Annex I countries' – pledged to reduce their greenhouse (GHG) emissions by 5% below 1990 levels by the period 2008–2012. The European Union is also a Party to the Convention and the KP and agreed on a reduction target of 8% below 1990 levels during the five-year commitment period from 2008 to 2012. The EU and its Member States decided to achieve this goal jointly, for Austria an emission target of minus 13% was set.

The KP entered into force on 16 February 2005, triggered by Russia's ratification in November 2004 which fulfilled the requirement that at least 55 Parties to the Convention ratified (or approved, accepted, or acceded to) the Protocol, including Annex I Parties accounting for 55% of that group's carbon dioxide emissions in 1990: by April 2011, 190 Parties had ratified the KP, accounting for 63.7% of emissions of Annex I Parties.

The Protocol sets out three 'flexible mechanisms' to help countries meet their obligations to cut emissions.

- *Emission Trading*: Article 17 of the Kyoto Protocol allows Annex I Parties (basically, the industrialised nations) to purchase the rights to emit greenhouse gases (GHG) from other Annex I countries which have reduced their GHG emissions below their assigned amounts. Trading can be carried out by intergovernmental emission trading, or entity-source trading where assigned amounts are allocated to sub-national entities.
- *Joint Implementation*: Article 6 allows an Annex I Party to gain a credit (converted to Assigned Amounts) by investing in another Annex I country in a project which reduces GHG emissions.
- *Clean Development Mechanism*: Article 12 allows an Annex I country (or companies in an Annex I country) which funds projects in developing countries (non-Annex I Party) to get credits for certified emission reductions providing that "benefits" accrue for the host country.

Tradable emission permits tie the emissions to a fixed ceiling, the costs of emission reduction being as low as possible.

[8] The Montreal Protocol sets the elimination of ozone-depleting substances as its final objective and covers chloro and bromo fluorocarbons.

The final assessment on compliance with the goals of the first commitment period of the KP was made 2016 in the true up process after finalization of the last review reports.

The so called Doha Amendment extends GHG mitigation obligations of the Kyoto Protocol until 2020, establishing a second commitment period. As of 28 October 2020, 147 Parties had deposited their instrument of acceptance, exceeding the threshold of 144 instruments of acceptance. The Doha Amendment entered into force on 31 December 2020.[9]

Independently of the setting into force of the Doha Amendment, the European Community has fixed its goal in the so called Effort Sharing Decision (Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020), with the goal of a 20% cut of emissions below the 1990 emission level by 2020. The ESD Directive also sets national emission targets for the member states, the Austrian target is −16% related to 2005 (not considering the sectors/sources regulated by the EU ETS).

Paris Agreement:

After negotiations on a global climate protection agreement failed in Copenhagen in 2009, the decision to negotiate a new global agreement for the period after 2020 was made at the Conference of the Parties in Durban in 2011. In December 2015, this was adopted at the 21st Conference of the Parties in Paris. It entered into force on November 4, 2016, as more than 55 Parties covering at least 55% of global GHG emissions ratified it.

The Paris Agreement established the long-term 2°C target for the first time in an international treaty. It also calls for additional efforts to limit temperature increases to 1.5°C. In contrast to the Kyoto Protocol, this new agreement includes not only industrialized but also newly industrializing and developing countries in order to take account of the change in the global distribution of GHG emissions. Plans for emission reductions (Nationally Determined Contributions, NDCs) of the participating countries have been submitted to the UNFCCC. From 2020, all Parties are required to submit increasingly ambitious climate change mitigation plans on a regular basis and to report transparently on progress to date from 2024. By the second half of the century, global decarbonization efforts are to result in "net zero emissions.

To meet the goal of the Paris Agreement, the emission reduction target of at least 40 % (relative to 1990) of the EU's 2030 climate and energy policy framework adopted in 2014 has been increased to a net emission reduction target of at least 55 % under the new EU Climate Law, adopted under the European Green Deal.

For 2050, the European Commission has set itself the goal to be climate-neutral, a legally binding target that it is also set out in the EU Climate Law. To achieve the ambitious targets of the Climate Law, the EU Commission presented in July 2021 a legislative "Fit for 55" package, which includes proposals and amendments to a number of existing legal rules (such as the Effort Sharing Regulation, Emissions Trading Directive and the Energy Efficiency Directive).

[9] https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment

1.1.2 Background information on greenhouse gas inventories

As a Party to the Convention, Austria is required to produce and regularly update National Greenhouse Gas Inventories. To date, National Greenhouse Gas Inventories have been produced for the years 1990 to 2021. Furthermore Parties shall submit a National Inventory Report (NIR) containing detailed and complete information on their inventories, in order to ensure the transparency of the inventory.

The Environmental Control Act ('Umweltkontrollgesetz'; Federal Law Gazette 152/1998)[10] designated the Umweltbundesamt as the single national entity with overall responsibility for inventory preparation. Within the Umweltbundesamt, the Inspection Body for Emission Inventories (IBE) was established and entrusted with the preparation of and reporting on emission inventories; since 2005 the IBE is accredited according to EN ISO/IEC 17020. In 2011, 2016 and 2020 the re-accreditation was passed successfully. In between these re-accreditation audits several external audits were conducted by quality experts appointed by Accreditation Austria, last in January 2022.

For the purpose of Quality Assurance, resulting from increased requirements of transparency, consistency, comparability, completeness and accuracy of the national greenhouse gas inventory, the inventories have been annually reviewed by international experts managed by the Climate Secretariat in Bonn (expert review team ERT). To date, Austria's Greenhouse Gas Inventory was reviewed by three in-country reviews (2006, 2007[11] and 2013) and various centralized reviews in 2001 (during the trial period of the review process), 2003, 2004, 2005, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2018, 2020 (as a desk review[12]) and 2022. In 2017, 2019 and 2021 no UNFCCC Reviews were conducted[13].

The reports on Austria's inventory reviews can be found on the UNFCCC website[14], the recommendations of the 2020 Review and their implementation are included in Table 331. A final review report on the 2022 UNFCCC centralized review was not available at the time of NIR 2023 finalization. Thus, information on recommendations and implementations from the latest inventory review is not included in in Table 331.

Moreover annual reviews were conducted for all EU MS inventories 2013–2020 according to Article 19 of the MMR (Monitoring Mechanism Regulation No 525/2013). in 2012 a technical review was done by EU experts, with the aim of supporting the determination of Member States' annual emission allocations under Decision No 406/2009/EC (Effort-Sharing Decision). In 2015 this 'ESD-Review' was conducted as a trial review as inventories were submitted delayed due to the technical problems with the CRF Reporter. Annual ESD reviews of the Austrian inventory were successfully passed in 2017, 2018, 2019, 2021 and 2022. 'Comprehensive ESD-Reviews' were carried out in 2016 and 2020 with no technical corrections being necessary.

[10] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011109

[11] In February 2007 the in-country review of the initial report of Austria (the Pre-commitment period review) took place, it included the review of assigned amount, the national inventory system and the national registry.

[12] The review 2020 was originally organized as an in-country review, but had to be converted to a 'remote centralised review' given the of impacts of Covid-19.

[13] only initial checks of the greenhouse gas inventory of Austria were conducted

[14] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/inventory-review-reports-2021

1.2 Description of the national inventory arrangements

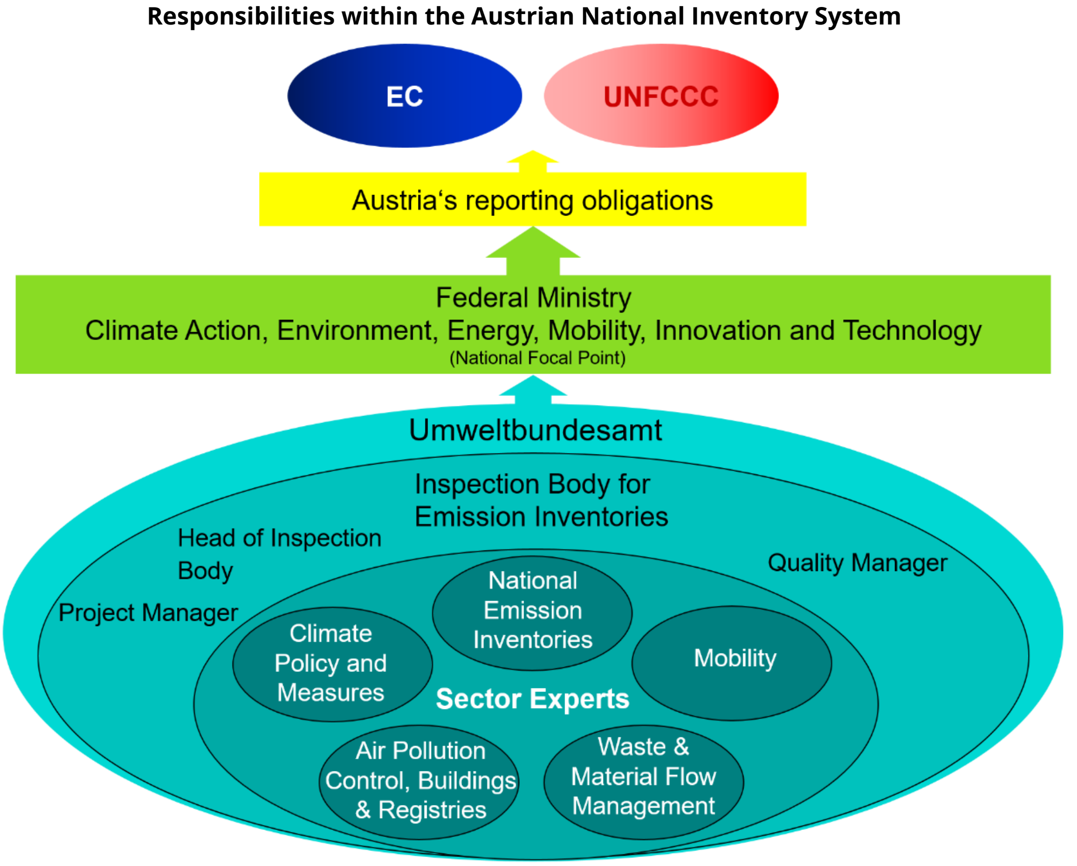
1.2.1 Institutional, legal and procedural arrangements

Austria's reporting obligations to the UNFCCC, UNECE and EC are administered by the Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK) - until 28th of January 2020 known as 'Federal Ministry of Sustainability and Tourism' (BMNT). With the Environmental Control Act (Federal Law Gazette 152/1998), that entered into force on the 1st of January 1999, the Umweltbundesamt has been designated as single national entity with overall responsibility for inventory preparation. This law regulates responsibilities of environmental control in Austria and lists the tasks of the Umweltbundesamt. Furthermore, the Environmental Control Act establishes the Umweltbundesamt as a private limited company owned by the Republic of Austria. To assure that the Umweltbundesamt has the resources to fulfil all listed tasks, the financing is set up as a fixed amount of money annually allocated to the Umweltbundesamt. The Umweltbundesamt is free to manage this so called 'basic funding', provided that the tasks are fulfilled. Projects beyond the scope of the Environmental Control Act are financed on a project basis by the contracting entity, which may be national, EC authorities or private entities.

One task of the Umweltbundesamt is the preparation of technical expertise and the data basis for fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. For the Umweltbundesamt a national air emission inventory that identifies and quantifies the sources of pollutants in a consistent manner is of a high priority. Such an inventory provides a common means for comparing the relative contribution of different emission sources and hence can serve as an important basis for policies to reduce emissions.

Thus the Umweltbundesamt established the 'Inspection Body for Emission Inventories' (IBE, hereinafter also referred to as inspection body) which is entrusted with the preparation of emission inventories as assigned to the Umweltbundesamt. The personnel of the IBE consists of staff from various organisational units of the Umweltbundesamt, who in the course of their inspection activity are assigned to the IBE and are in this context responsible to the head of the inspection body. They are free from any commercial, financial and other pressures that might influence their technical judgement, and technical instructions from outside the IBE may not be given for the preparation of emission inventories (see Figure 1).

Figure 1: Responsibilities within the Austrian National Inventory System (greenhouse gases).



Source: Umweltbundesamt

The quality system is maintained and updated under the responsibility of a quality representative, the inventory work is coordinated by a project manager. For these functions as well as for the head of inspection body deputies are appointed. Regarding the inventory work, specific responsibilities for the different emission source/sink categories ('Sector Experts') are defined. There are 8 sectors defined (Energy, Transport, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF and Waste). At least two experts form a sector team and one of them is nominated as 'Sector Coordinator'. For more information on the QMS please refer to Chapter 1.2.3.

In addition, the Austrian emissions trading registry is managed by the Umweltbundesamt on behalf of the Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology'. This mandate was given to the Umweltbundesamt in the Registry Ordinance (Registerstellenverordnung) Federal Law Gazette II No. 208/2012. The Umweltbundesamt is responsible for the operational management of the registry and serves as a contact point for national and international authorities.

The Austrian emissions trading registry has been operational since 2005 and serves both as registry for the EU Emissions Trading Scheme and as the national registry for Austria.

Besides the Environmental Control Act there are some other legal and institutional arrangements in place as the main basis for the national system:

- The Austrian Emissions Certificate Trading Act[15] that regulates monitoring and reporting in the context of the EU Emissions Trading Scheme (ETS) in Austria. The Umweltbundesamt takes the emission reports of the emissions trading scheme into account for the national greenhouse gas inventory in order to comply with requirements of the EU Monitoring Mechanism and the UNFCCC. This is not only important for emissions from combustion of fuels, for which more detailed information is available in the ETS reports than is provided in the national energy balance, but also for emissions from industrial processes. First data from the EU ETS were available for the year 2005. Since then ETS data have been considered in the submissions.
- The Austrian statistical office (Statistik Austria) is required by contract with the BMK (formerly referred to as BMNT) to annually prepare the national energy balance (the contracts also cover some quality aspects). The energy balance is prepared in line with the methodology of the Organisation for Economic Co-operation and Development (OECD) and is submitted annually to the International Energy Agency (IEA) (IEA/EUROSTAT Joint Questionnaire (JQ) Submission). The national energy balance is the most important data basis for the Austrian Air Emissions Inventory.
- According to national legislation (Bundesstatistikgesetz 2000[16]), the Austrian statistical office has to prepare annual import/export statistics, production statistics and statistics on agricultural issues (livestock counts etc.), providing an important data basis for calculating emissions from the sectors *Industrial Processes, Product Use* and *Agriculture*.
- In order to comply with the reporting obligations, the Umweltbundesamt has the possibility to obtain confidential data from the national statistical institute (of course these data have to be treated confidentially). The legal basis for this data exchange is the Bundesstatistikgesetz 2000[16] (federal statistics law), which allows the national statistical office to provide confidential data to authorities that have a legal obligation for the processing of these data.
- According to paragraph 38 (1) of the EG-K 2013[17] each licensee of an operating boiler with a thermal capacity of more than two megawatts (MW) is obliged to report the emissions to the competent authority. The Umweltbundesamt can request copies of these emission declarations. This data is used to verify the data from the national energy balance for the Energy sector.
- According to the old Landfill Ordinance (Deponieverordnung 1996)[18] the operators of landfill sites had to report type and amount of waste deposited annually. These reports (collected in a central database run by Umweltbundesamt) still provide the main basis for calculating emissions from the sector *Waste* for the inventory years 1998-2007.
- Starting with the deposited waste of the year 2008 landfill operators have been – pursuant to the new Landfill Ordinance (Deponieverordnung 2008)[19] – obliged to submit their data annually and electronically via the portal http://edm.gv.at (Electronic Data Management –

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[15] *„Emissionszertifikate-Gesetz 2011"*; Federal Law Gazette I No 118/2011

[16] *„Bundesstatistikgesetz 2000"*; Federal Law Gazette I No 163/1999

[17] *„Emissionsschutzgesetz für Kesselanlagen 2013"*; Federal Law Gazette I No 127/2013

[18] *„Deponieverordnung";* Federal Law Gazette No 164/1996

[19] *„Deponieverordnung 2008"*; Federal Law Gazette II No 39/2008

'EDM'). Responsible for data collection and analysis is the BMK. The necessary data is requested by the Umweltbundesamt for the purpose of inventory preparation.

- Since 2004 there is a reporting obligation to the BMK under the Austrian Fluorinated Compounds (FC) Ordinance[20] for users of FCs for the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. This data is notified via EDM and used for estimating emissions from the consumption of fluorinated compounds (IPCC sector *2.F*).

More information on the National Inventory System in Austria (NISA) is provided in Annex 5.

1.2.2 Overview of inventory planning, preparation and management

Umweltbundesamt is designated as the single national entity responsible for Austria's GHG inventory by law, and thus is also responsible for coordinating QA/QC and verification activities. Responsibilities of the different functions – quality representative, sector expert, sector coordinator, project manager, head of inspection body, report coordinator, cross-sector analyst, etc. – are defined in the QMS. Within the inventory system specific responsibilities for the different emission source/sink categories ('Sector Experts') are defined. There are 8 sectors defined (Energy, Transport, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF and Waste). At least two experts form a sector team and one of them is acting as 'Sector Coordinator'. Sector experts collect activity data, emission factors and all relevant information needed for finally estimating emissions. The sector experts are also responsible for the choice of methods, data processing and archiving and for contracting studies, if needed. Furthermore sector experts perform Quality Assurance and Quality Control (QA/QC) activities regarding their sector.

For the Austrian greenhouse gas inventory the main planning is performed once a year at the so called Management Review, which is conducted in two parts.

The first part comprises the annual sector talks (sectoral improvement planning), in which the sector team discusses all issues related to the respective sector with the head of the inspection body (HI), rates all issues according to their urgency and resource needs, and finally agrees on measures/activities. Furthermore the HI checks the implementation of the previously integrated improvements.

The second part is the actual management review meeting where the QR presents the 'IBE Management Review Report' on activities within and performance of the IBE in the last year to the HI. Based on this report, the HI reviews the QMS, and sets measures for the improvement of the effectiveness of the management system and its processes and improvements of the Inspection Body related to the fulfilment of EN ISO/IEC 17020. The report also includes the planning regarding internal audits, QA and verification activities as well as the training plan and resource planning.

Finally the report, and particularly planned improvements with high resource needs, are presented to the managing directors of the Umweltbundesamt, to obtain the necessary additional resources. Furthermore issues that need intervention by the managing directors or the ministry are discussed. On the basis of the decisions at the management review, the project manager and sector experts work out a detailed working plan including milestones, timelines and responsibilities.

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[20] *„Industriegas-Verordnung (HFKW-FKW-SF6-VO)";* Federal Law Gazette II No. 447/2002

Table 4 gives an overview on the tasks of inventory preparation together with a typical timeline.

Table 4: Overview Inventory related tasks.

Task	Description	Deadline
Management Review	Preparation of a report including evaluation of the fulfilment of the previous improvement plan and a plan for QMS and inventory improvement based on audit and review findings.	Summer
Kick-Off	Meeting of inventory team (HI, sector experts, project-/quality- and data managers of the inventory, report coordinators, cross-sector analyst and all deputies); definition of a working plan.	End of Summer
Activity data collection	Collection of activity data, including contracting out studies.	November 15
Inventory preparation	Estimation of emissions for all sources, including collection of background data.	December 15
Compilation of national inventory	Updating the data base and conversion to the CRF reporter	December 23
Quality checks	Tier 1 and Tier 2 QA/QC activities	December
Compilation of preliminary data and information[21] (Short-NIR)	Compilation of the inventory report 'Short NIR' and submission to the EC (Governance Regulation No 2018/1999)	January 15
Preparation of NIR	Compilation of the National Inventory Report	January–March
EU Submission NIR	Submission of the National Inventory Report to the EC (MMR)	March 15
UNFCCC Submission NIR	Submission of the National Inventory Report to the UNFCCC	April 15

1.2.3 Quality assurance, quality control and verification

For fulfilment of the reporting obligations the Umweltbundesamt, in particular the *Inspection Body for Emission Inventories*, operates a QMS based on the International Standard EN ISO/IEC 17020 *General Criteria for the operation of various types of bodies performing inspections*.

Since 23 December 2005 the Umweltbundesamt has been accredited[22] as Inspection Body for emission inventories, Type A (ID No. 0241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG)[23], by decree of Accreditation Austria (first decree, No. BMWA-92.715/0036-I/12/2005, issued by Accreditation Austria / Federal Ministry of Economics and Labour on 19 January 2006).

In addition to the elements of a QMS as described in the EN ISO 9000 series, the EN ISO/IEC 17020 focusses on the competence of the personnel, and ensures strict independence, impartiality and integrity. The implementation is audited by the Austrian Accreditation Body ('Akkreditierung Austria') regularly (about every 20 months). Every five years the accreditation has to be renewed in a more comprehensive audit. The accreditation of the IBE was awarded for the first time in 2005 and was renewed in 2011, 2016 and 2020.

[21] Including greenhouse gases and inventory information listed in Annex V to the EU Governance Regulation No 2018/1999

[22] For more information on the accreditation please refer to Annex 5.

[23] Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012)

Major elements of the QMS are the Quality Manual of the IBE and its quality and technical procedures ('Austrian QA/QC Plan').

1.2.3.1 Requirements of the EN ISO/IEC 17020 compared to the IPCC 2006 GL

The IPCC 2006 GL set out the major elements of a QA/QC system to be implemented by emission inventory compilers

- inventory agency responsible for coordinating QA/QC activities and definition of roles and responsibilities
- a QA/QC plan
- general QC procedures (Tier 1) and source category-specific QC procedures (Tier 2)
- QA and review procedures and verification activities
- QA/QC system interaction with uncertainty analysis (see chapter on uncertainties)
- reporting, documentation and archiving

Table 5: Overview of QA/QC aspects in different technical and quality standards.

IPCC 2006 GL	EMEP/EEA GB 2019[24]	EN ISO 9001[25]	EN ISO/IEC 17020[26]
Roles and Responsibilities	Roles and Responsibilities	X	X
QA/QC plan	QA/QC plan	X	X
QC procedures	QC procedures	X	X
QA procedures	QA procedures	X	X
QA/QC system interaction with uncertainty analysis	QA/QC system interaction with uncertainty analysis	-	-
Verification activities	Verification activities	(X)	(X)
Reporting, documenting and archiving procedures	Reporting, documenting and archiving procedures	X	X
-	Inventory management report[27]	Management review (report)	Management review (report)
-	-	Control of documents and records	Control of documents and records
-	-	Internal audits	Internal audits
-	-	-	Competence
-	-	-	independence, impartiality and integrity

The implementation of these elements in the Austrian QMS is described in the following chapters.

[24] Requirements largely based on the 'Quality Assurance/Quality Control and Verification' chapter of the 2006 IPCC Guidelines (IPCC 2006).

[25] Basic international standard for quality management and quality assurance

[26] contains additional requirements compared to ISO 9001

[27] According to the EMEP/EEA Guidebook, it also is good practice to summarize lessons learned from previous inventory preparation cycles in an inventory management report.

1.2.3.2 Quality policy and objectives

As stated in the Quality Manual of the IBE, the overall objective of the work of the IBE is to promote climate change mitigation and air quality control measures via a high quality emission inventory reporting under the relevant national, European and international frameworks and conventions.

To achieve this, the IBE is committed to strict impartiality and quality management. In this context, the term quality means:

- Fulfilment of requirements for emission inventories to provide a solid data basis for the political processes in the context of greenhouse gas and air pollutant emissions.
- Providing emission inventories that facilitate the definition and evaluation of measures, which needs a forward looking maintainance and improvement of the emission inventory. Therefore the IBE keeps its staff updated on the latest technical expertise, scientific findings and the latest developments by encouraging the participation of its staff in international technical and political processes and ensure the transfer of knowledge within the IBE.
- Compliance with the EN ISO/IEC 17020 standard by ensuring the implementation and continuous improvement of a QMS as described in the quality manual by the IBE and its personnel. The QMS procedures are designed to facilitate the preparation of the emission inventories in a professional and timely manner, particularly to enhance the transparency to allow full reproduction, and ensure correctness by applying quality checks and validation activities. One of the key managerial functions is raising the personnel's awareness for quality control.

Aim of the IBE is to provide a best-practise example by setting a high quality standard – even higher than specified in the requirements – so as to improve the quality of air emission reporting in the long term, and to encourage other countries to set up similar systems.

The **quality objectives** for emission inventories are above all the fulfilment of all relevant requirements in terms of content and format: 'TACCC': transparency, accuracy, completeness, comparability, consistency (as defined in the IPCC 2006 GL), and timeliness.

The QMS was primarily developed to meet the requirement of reporting greenhouse gas emissions under the Kyoto Protocol. For this reason the emphasis was originally placed on greenhouse gases, but by now all air pollutants are covered by the QMS.

1.2.3.3 QA/QC Plan

Activities to be conducted by the personnel of the IBE are written down in quality and technical procedures that complement the Quality Manual. Such activities are:

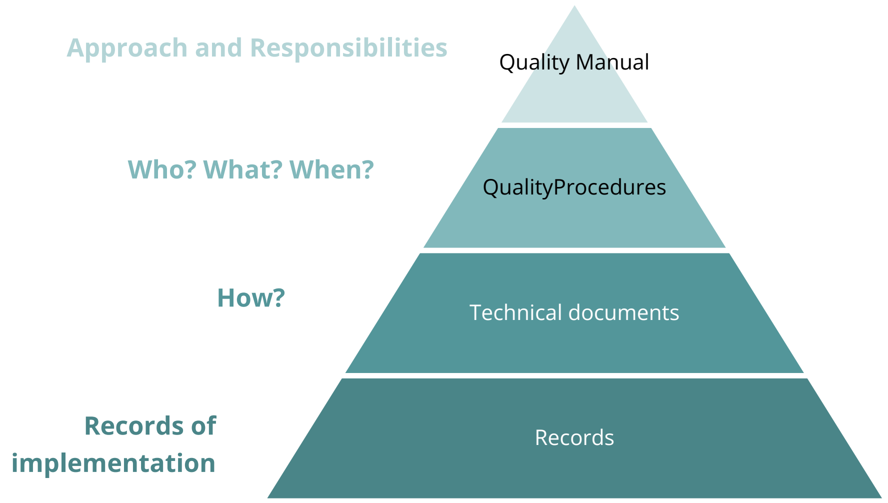
- QC activities
- Procedures for country specific methodologies
- Internal audits (QM specific)
- Procedures for service contracting
- Inventory improvement plan
- Documentation and archiving
- Treatment of confidential data
- Annual Management Review

Quality Manual

The Quality System is divided into three levels:

- Level 1: General (the actual 'Quality Manual' containing general information, description of QMS, general responsibilities etc.): https://www.umweltbundesamt.at/klima/emissionsinventur/emi-akkreditierung
- Level 2: Detailed description of activities to be conducted and checklists and forms to be filled in ('quality procedures' and 'technical documents').
- Level 3: Documentation of QC activities (filled in checklists, ...)

Figure 2: Structure of the Austrian Quality Management System (QMS).



Source: Umweltbundesamt

1.2.3.4 QC Activities

The following four quality-check-steps are performed before finalization of the data submission:

1. Tier 2 (category specific): by the sector expert in the course of the inventory preparation
2. Tier 1 (general) / Step 1: QC by the sector expert after emissions have been estimated
3. Tier 1 (general) / Step 2: QC by the data manager in the course of the preparation of the overall inventory (electronic checks e.g. check for completeness and comparison with last years' inventory)
4. Tier 1 (general) / Step 3: QC of final submission by the sector expert

Where possible the checks (1), (2) and (4) are conducted by the sector expert that has not predominantly prepared the sectoral inventory in the particular year.

QC activities are conducted according to QC checklists, which cover issues like:

- ✓ documentation of assumptions
- ✓ documentation of expert judgements
- ✓ clear explanation of recalculations
- ✓ provision of references
- ✓ plausibility of data
- ✓ consistency of data
- ✓ completeness
- ✓ correct transformation/transcription into CRF
- ✓ information on background tables
- ✓ consistency of data and information with information in inspection reports
- ✓ treatment of confidential data

Additionally, in the course of the NIR preparation, the following four QC steps are performed:

1. Tier 2 (category specific) / Step 1: check of methodologies, assumptions and explanations by sector expert in the course of report preparation
2. Tier 2 (category specific) / Step 2: check of methodologies, assumptions and explanations by the head of inspection body
3. Tier 1 (general) / Step 1: final check of each sector chapter by the corresponding sector experts (in particular regarding consistency of values in the NIR and the latest CRF tables)
4. Tier 1 (general) / Step 2: final check of consistency of figures in reporting format and report by a member of the IBE team (usually done by the report coordinator who checks at least 5 values per sector)

If CRF tables are updated during the preparation of the inventory, the data manager informs the whole team immediately to make sure that comparisons between CRF and NIR data are done by sector experts with the latest data set.

1.2.3.5 QA Activities

The following QA activities are performed:

Validation of methodologies and calculation

New and improved methodologies are documented as a SOP (standard operating procedure) together with a template for calculating emissions, where needed. The SOP is checked for applicability and transparency and finally approved by the head of the inspection body. New and changed calculation files are validated before use.

Annual second party audits for every sector

Once a year the documentation of one emission source per sector is checked throughout the whole emission estimation and reporting process (i.e. archiving of underlying information, emission calculation, input into the data management system, documentation, information in the NIR etc.) for transparency, reproducibility, clearness and completeness. This tool has proved to be very helpful in order to further improve the documentation and the implementation of QA/QC routines.

Second party audits for work performed by service contractors

The sector experts at the Umweltbundesamt are responsible for incorporation of results in the inventory database and additional QA/QC procudures (carried out as second party audit).

Accreditation audits (third party audits)

In the course of the accreditation process, conformity of the QMS with EN ISO/IEC 17020 is regularly monitored. Audits are performed every 20 months on average by the accreditation body (one day audit). Every fifth year the accreditation has to be renewed in a more comprehensive audit. The audits aim to assess the QM system with regard to compliance with the underlying standard EN ISO/IEC 17020, to check its implementation in practice and to assure that measures and recommendations as set out in previous audits have been implemented accordingly.

Input data examination

Input data examinations refer to examinations of complex input data (i.e. collected and aggregated data, particularly statistics, or generally data provided by data collectors as the opposite to input data provided by one single facility). These examinations go beyond the scope of Tier 2 QC procedures performed during inventory preparation and are as far as possible conducted in close cooperation with the data suppliers.

The aim of the examinations is to assess:

- whether the requirements regarding independence and integrity are fulfilled
- the long term availability of the data
- the data collection and data management process
- QC of the data processing

Resulting areas of improvement are discussed with the data suppliers.

Since 2007 input data examinations have been conducted together with all main data suppliers :

- Statistik Austria regarding
  - energy balance in 2007
  - agricultural statistical data in 2009
  - import/export and production statistics in 2016
- the administrator of the landfill database in 2009
- the administrator of the electronic data management for landfills (EDM) in 2014
- the national forest inventory at the Austrian Federal Office and Research Centre for Forests (BFW) in 2016

It is planned to conduct follow-up examinations with these institutions only when substantial changes become apparent.

These input data examinations have proven a good basis for the cooperation with the data suppliers.

1.2.3.6 Error correction and continuous improvement

All issues regarding transparency, accuracy, completeness, consistency or comparability identified by experts from different backgrounds are incorporated in the inventory improvement plan. The sources of these findings are:

- UNFCCC Reviews
- ESD Reviews

- external experts (e.g. experts from federal provinces who prepare a partly independent emission inventory for their federal province compare their results with the disaggregated national inventory)
- stakeholders (e.g. industrial facilities or association of industries: the NIR is communicated to every data supplier and Austrian experts involved in emission inventorying after submission)
- personnel of the IBE (head of inspection body, sector experts etc.).

These findings are documented including a plan to improve the inventory, a timeline and responsibilities. The improvement plan and fulfilment of planned improvements is monitored by the head of inspection body. Improvements that are relevant in terms of resources are presented in the annual Management Review to the managing directors, and if additional resources are needed, these are notified to the Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK).

1.2.3.7 Treatment of confidentiality issues

The IBE ensures confidential treatment of sensitive information obtained in the course of its inspection activities.

According to the Austrian Envirionmental Information Act[28] §4 (2) emissions data are generally publicly accessible and are explicitely not seen as confidential data, with the possibility to request confidentiality in justified exceptional cases. This is the case for emissions of fluorinated substances for semiconductors, where detailed emissions data could give clues regarding the setting up of industrial processes and therefore emissions are reported at a higher aggregated level

Generally, for transparency reasons, activity data is reported together with emissions data. Activity data, particularly that relates to less than three plant operators, in some cases has to be treated confidentially and is therefore not reported because this data is sensitive according to a plant operator.

Compliance with confidentiality provisions is organized and documented in the QM manual which contains specific quality system procedures. Staff of the inspection body is obliged to issue a written commitment stating their full compliance with all provisions.

- **Confidentiality of statistics**
  The strict confidentiality provisions concerning handling of sensitive data relating to individuals and organisations are regulated by the Austrian Federal Statistics Act 2000[29]. The Environmental Control Act[30] allows the Umweltbundesamt to request confidential statistical data, this data is then incorporated in the emission inventory. To protect the confidential data, only aggregated results are reported.
- **Security of data**
  Confidentiality of sensitive data used to calculate emission is a legal obligation: Ensuring confidentiality through technical and organisational measures (e.g. final QC whether confidential information is not visible in CRF tables) is obligatory for Umweltbundesamt and consequently also for the Inspection Body.

[28] *„UIG Umweltinformationsgesetz"* Federal Law Gazette No 495/1993

[29] Federal Act on Federal Statistics (Federal Statistics Act 2000) No 163/1999

[30] *„UKG Umweltkontrollgesetz*" Federal Law Gazette I No 152/1998

- **Trust of respondents**
  Individuals, associations and organizations providing information to the Inspection Body can be sure that the provided data are used exclusively for purposes of inspection activities. Data – either of official, private or of another nature – are treated confidentially and will not be passed on to third parties. In the course of inventory reviews, such data and information is exchanged with the review team only if needed for judging the conformity of emission calculation following the strict rules for confidentiality set up by the review process.

Also in case of voluntary reviews an absolute confidential treatment of data exchanged is ensured by strictly adhering to the rules of the QM System of the Inspection Body.

1.2.3.8 QMS activities and improvements 2022

In 2022 several improvements concerning the personnel of the inventory team have been made: The number of sector experts of the IP, PU and fugitive emissions teams was raised to three. Additionally a second deputy was nominated for the coordination of the report "Austria's annual greenhouse gas inventory" and the "National Inventory Report". Currently, the IBE team consists of 24 persons and each position is at least double staffed. Four of our experts participated in the international inventory reviews in 2022. An audit by the accreditation body was successfully passed in February 2022.

1.2.4 Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory

QA/QC procedures are performed as defined in the QA/QC plan (see Chapter 1.2.3.3).

As Austria is a small country, many of the experts regarding greenhouse gas inventories have been involved by some means or other e.g. in inventory preparation, in preparation of the uncertainty study, in national or regional task groups etc. The NIR is circulated after publication to all experts that are involved in the estimation of the greenhouse gas emissions in Austria as identified by the Inspection Body. These are in particular:

- experts from federal provinces (some prepare a partly independent emission inventory for their federal province and compare their results with the disaggregated national inventory),
- data supplier, e.g. industrial facilities or association of industries

Any comment received from any expert is considered for the inventory improvement plan.

1.2.5 Archiving and documentation

For each sector the documentation includes:

Documentation of the methodology:

- Description (source/sink category, emissions, key source, completeness, uncertainty)
- Methodology
- Template for emission estimation
- Documentation of validation

Documentation of actual emission calculation:

- Methodology
- 'Logbook' (who did what and when)
- Calculation file
- References for activity data, emission factors and/or emissions, respectively
- Documentation of assumptions, sources of data and information, expert judgements etc. to allow full reproduction and understanding of choices made
- Recalculations
- Planned improvements
- QC activities

Documentation of expert judgements in line with the IPCC 2006 GL:

- Name of the expert and institution/department
- Date
- Basis of judgement (references to relevant studies etc.)
- Underlying assumptions

Relevant literature has to be archived and references to be stated in the internal documentation as well as in the NIR.

1.3 Inventory preparation, and data collection, processing and storage

The Austrian greenhouse gas inventory for the period 1990 to 2021 was compiled according to the recommendations for inventories as specified in the UNFCCC reporting guidelines according to Decision 24/CP.19, the Common Reporting Format (CRF), and the IPCC 2006 Guidelines.

In Austria, emissions of greenhouse gases are estimated together with emissions of air pollutants in a single database based on the CORINAIR (CORe INventory AIR)/SNAP (Selected Nomenclature for sources of Air Pollution) nomenclature. This nomenclature was designed by the ETC/AE (European Topic Centre on Air Emissions) to estimate not only emissions of greenhouse gases but all kind of air pollutants.

During the inventory preparation process, sector experts collect activity data, emission factors and all relevant information needed for finally estimating emissions. The sector experts are also responsible for the choice of methods, data processing and archiving and for service contracting of e.g. studies, if needed. As part of the quality management system the head of the 'Inspection Body for Emission Inventories' approves the methodological choices and the sectoral improvement plans. Sector experts also perform Quality Control (QC) and Quality Assurance (QA) activities regarding their sector. All data collected together with emission estimates are fed into a database (see below), where data sources are well documented for full reproducability of the inventory.

As mentioned above, the Austrian Inventory is based on the SNAP nomenclature, and has to be transformed according to the IPCC Guidelines into the UNFCCC Common Reporting Format to comply with the reporting obligations under the UNFCCC. In addition to the actual emission data, the background tables of the CRF are filled in by the sector experts, and finally QA/QC procedures as defined in the QA/QC plan are carried out before the data are submitted to the UNFCCC.

For the inventory management a reliable data management to fulfil the data collecting and reporting requirements is needed. As mentioned above, data are collected by the different sector experts and the reporting requirements grow rapidly and may change over time. Data management is carried out by using MS Excel™ spreadsheets in combination with Visual Basic™ macros, which is a very flexible system that can easily be adjusted to new requirements. The data are stored in a central network server which is backed up daily for the needs of data security. The inventory management as part of the QMS includes a control system for all documents and data, for records and their archives as well as documentation on QA/QC activities.

This ensures the necessary documentation and archiving for full reproducability of the inventory and for the timely response to requests during the review process.

1.4 Brief general description of methodologies (including tiers used) and data sources used

- The main data supplier for the Austrian Emission Inventories is Statistik Austria, providing the underlying energy source data. The Austrian energy balances are based on several databases mainly prepared by the Federal Ministry of Economy, Family and Youth, „Bundeslastverteiler" and Statistik Austria. Their methodology follows the IEA and Eurostat conventions. The aggregated balances, for example transformation input and output or final energy use, are harmonised with the IEA tables as well as their sectoral breakdown which follows the NACE classification.
- Information about activity data and emissions of the industry sector is mostly obtained directly from individual plants, or in other cases from Associations of the Austrian Industries. Activity data for some sources are obtained from Statistik Austria which provides statistics on production data[31].
- Operators of steam boilers with more than 50 MW report their emissions and their activity data directly to the Umweltbundesamt. Data from national and sometimes international studies are also used.
- Until 2008, operators of landfill sites reported their activity data directly to the Austrian Ministry of Environment or the Umweltbundesamt, where they were – after a check – in turn incorporated into a database on landfills. Emissions for the years 1998–2007 are calculated on basis of these data. Since 2009 landfill operators have to register and report their waste input directly at the portal of the Electronic Data Management. These data are evaluated by the responsible body at federal level (BMK) and are made available for emission calculation.
- Activity data needed for the calculation of non-energetic emissions are based on several statistics collected by Statistik Austria and national and international studies.

[31] „Industrie und Gewerbestatistik" published by STATISTIK AUSTRIA for the years until 1995; „Konjunkturstatistik im produzierenden Bereich" published by STATISTIK AUSTRIA for the years since 1997.

The following table presents the main data sources used for activity data:

Table 6: Main data sources for activity data.

Sector	Data Sources for Activity Data
Energy	• Energy Balance from Statistik Austria • EU-ETS • Steam boiler database • Small scale combustion market data • Direct information from industry or associations of industry
Transport	• Energy Balance from Statistik Austria • Yearly new vehicle registrations from Statistik Austria • Yearly growth rates of transport performance on Austrian roads from Federal Ministry of Climate Action, Environment, Energy, Mobility, In-novation and Technology (BMK) • ZBD: Zentrale Beguchtachtungsdatenbank (periodically updated specific mileage) • Yearly flight movements from Austro Control • Yearly FC of airport ground activities at Vienna International Airport
IPPU	• National production statistics • Import/export statistics • EU-ETS • Direct information from industry or associations of industry • Short term statistics for trade and services • Austrian foreign trade statistics • Structural business statistics • Surveys at companies and associations
Agriculture	• National studies • National agricultural statistics obtained from Statistik Austria • National fertilizer statistics obtained from Agrarmarkt Austria (AMA) • Distributing company (sales data)
LULUCF	• National forest inventory obtained from the Austrian Research Centre for Forests • National agricultural statistics and land use statistics obtained from Statistik Austria and from the IACS system • Wetland and settlement areas from the Real Estate Database
Waste	• Federal Waste Management Plan (Data sources: Database on landfills (1998–2007), Electronic Data Management (EDM) in environment and waste management) • EMREG-OW (Electronic Emission Register of Surface Water Bodies) • National Studies

Emission calculation and related inventory work (reporting, QA/QC, documentation and archiving etc.) is carried out by the sector experts of the Inspection Body for Emission Inventories (IBE).

In cases which exceed the IBE's resources, the IBE concludes service contracts with qualified institutions (particularly universities or research institutes).

The IBE is responsible for:

- choice of the contractor i.e. judging his/her expertise with regard to the technical and QMS requirements

- specifying the technical and QMS requirements in the service contract
- performing and documenting a detailed QC check of the results i.e. checking if the specified requirements were fulfilled
- implementation of the results into the emission inventory in line with the technical and QMS requirements particularly the requirement of full reproducibility of the emission inventory

Service contracts have e.g. entered into with:

- Technical University Graz (road and off-road transport)
- University of Natural Resources and Applied Life Sciences (agriculture)

However, the final assessment of fulfilment of the requirements is made by the IBE.

Detailed information on data sources for activity and emission data or emission factors used by sector can be found in the Chapters 3–8.

For large point sources the Umweltbundesamt preferably uses – after careful assessment of plausibility of this data – emission data that are reported by the 'operator' of the source because these data usually reflect the actual emissions better than data calculated using general emission factors, as the operator has the best information about the actual circumstances.If such data is not available, and for area sources, national emission factors are used or, if there are no national emission factors, international emission factors are used to estimate emissions. Where no applicable data is found, standard emission factors e.g. from the EMEP/EEA Guidebook are applied.

The main sources for emission factors are:

- National studies for country specific emission factors
- Plant-specific data reported by plant operators
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories[32]
- 2019 Refinement to the 2006 IPCC Guidelines[33]
- EMEP/EEA air pollutant emission inventory guidebooks[34]
- Handbook emission factors for road transport (HBEFA), Version 4.2 (INFRAS, 2022)
- National forest inventory obtained from the Austrian Research Centre for Forests
- Soil inventories by the Federal States and by the Austrian Federal Office and Research Centre for Forests
- Modelling of the forest soil C stock changes Austrian Research Centre for Forests

[32] https://www.ipcc-nggip.iges.or.jp/public/2006gl/?msclkid=f48edfa2badf11ec90525bf3c93873fc

[33] The 2019 Refinement does not revise the 2006 IPCC Guidelines, but updates, supplements and/or elaborates the 2006 IPCC Guidelines where gaps or out-of-date science have been identified. It does not replace the 2006 IPCC Guidelines, but should be used in conjunction with the 2006 IPCC Guidelines and, where indicated, with the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement).

[34] Prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (TFEIP) and published by the European Environment Agency (EEA). Latest update: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

For key categories (see Chapter 1.5) the most accurate methods for the preparation of the greenhouse gas inventory should be used. Required methodological changes and planned improvements are described in the corresponding sector analysis chapters (Chapters 3–8).

1.4.1 EU Emissions Trading System (EU ETS)

The European Union Emissions Trading Scheme has been established by Directive 2003/87/EC of the European Parliament and of the Council[35] and amended by several legal acts[36]. From 2013 onwards, it is known as the European Union Emissions Trading System (EU ETS). It includes heavy energy-consuming installations in power generation and manufacturing. The activities covered are energy activities, the production and processing of ferrous metals, the mineral industry and some other production activities. From 2012 onwards, CO_2 emissions from aviation have also been included. For the trading period 2013–2020 the scope of the EU ETS has been further extended to include additional installations from the metal and chemical industry and compressor stations. For more detailed information on the included activities please refer to Annex I of the above mentioned directive.

Greenhouse gases covered under the EU ETS are CO_2 (since 2005), N_2O (since 2010) and PFC (since 2013).[37] About one third of total Austrian GHG emissions currently result from installations under the EU-ETS (~29 Mt CO_2 in 2021).

Plant operators have to report their activity data and emissions annually for the GHG as mentioned above; for the first time they reported their emissions of 2005 in March 2006. The first trading period of the EU ETS ran from 2005–2007. The second trading period, which coincided with the 1st Kyoto commitment period, ran from 2008–2012. The third trading period, which coincides with the 2nd Kyoto commitment period, ran from 2013 to 2020. The fourth trading period started in 2021 and will run until 2030. Since 2012 aircraft operators have also been included into the scheme. They have to report their emissions concerning internal flights in the European Economic Area.

General rules for reporting and verification of emissions in the EU ETS are defined in EU Directive 2003/87/EC and specific rules can be found in Commission Regulation (EU) No 2018/2066[38]. In Austria, Member State specific regulations are defined in the Austrian Emissions Allowance Trading Act[39]. This ordinance also specifies that the Umweltbundesamt has to incorporate, as far as necessary, the verified emissions of the emissions trading scheme into the national greenhouse gas inventory. For a detailed description of the sectors covered and the incorporation of these emissions

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35 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, OJ L 275/32

36 Directive 2004/101/EC, Directive 2008/101/EC, Regulatin (EC) No 219/2009, Directive 2009/29/EC, Decision No 1359/2013/EU, Regulation (EU) No 421/2014, Decision (EU) 2015/1814, Regulation (EU) 2017/2392, Directive (EU) 2018/410, Commission Delegated Decision (EU) 2020/1071, Commission Delegated Regulation (EU) 2021/1416 and Decision (EU) 2023/136

37 Austria unilaterally opted-in N_2O as of 2010. Since 2013 N_2O and PFCs have been included in the EU ETS at EU level.

38 Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012, amended by Commission Implementing Regulation (EU) 2020/2085, Commission Implementing Regulation (EU) 2022/388 and Commission Implementing Regulation (EU) 2022/1371

39 Emissionszertifikategesetz 2011, Federal Law Gazette I No. 118/2011, as amended

into the national inventory please refer to the chapters 3 Energy (CRF Sector 1) and 4 Industrial Processes and Product Use (CRF Sector 2).

An important feature of the emissions reported under the EU-ETS is that these emissions have to pass independent verification by an accredited verifier. The Austrian Federal Ministry for Sustainability and Tourism has to fulfil a quality control function, which is implemented by spot checks of emissions and verification reports that the Umweltbundesamt performs on behalf of the Ministry.

1.4.2 Electronic Data Management (EDM)

The electronic data management of the Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' is an electronic recording and notification system (information network), implemented as an integrated e-government application. It allows enterprises and authorities to handle registration and notification obligations online in the areas of waste and environment (e.g. on Austrian Emissions Allowances, HFC or EMREG – Emission Register Surface Water). Data from this source are used for reporting in the sector *Wast*e (e.g. landfilled and biologically treated amounts).

There are around 40 000 users registered, covering national and international waste owners (collectors, operators of treatment plants, waste producers) doing their reporting obligations according to national legislation, e.g. on landfilled amounts.

1.4.3 Other data (E-PRTR)

The European Pollutant Release and Transfer Register (E-PRTR) is the EU-wide register containing key environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland. It was established through the E-PRTR Regulation (EC) No 166/2006.

E-PRTR was preceded by the European Pollutant Emission Register (EPER), with reporting years 2001 or 2002 and 2004. It covers 91 pollutants from nine activity groups, including all pollutants reported already under EPER. However, emissions only have to be reported if they exceed certain thresholds. In contrast to EPER, E-PRTR also includes data on releases to land, accidental releases, waste transfers and diffuse emissions[40].

Umweltbundesamt implemented E-PRTR in Austria using an electronic system enabling the facilities and the authorities to fulfil the requirements of the E-PRTR Regulation online. In 2008, installations reported for the first time releases and transfers of pollutants and waste from 2007 under the E-PRTR, which is an annual reporting obligation. The plausibility of the reports is checked by the competent authorities and Umweltbundesamt. Umweltbundesamt also checks the data for consistency with other reporting obligations, across the years and across facilities with the same activity.

[40] Data can be downloaded from**:** https://www.umweltbundesamt.at/umweltthemen/industrie/daten-industrie/prtr

Since submission 2018 data from E-PRTR or its predecessor have been used in one source category (*NFR 2.B.10* for NMVOC). The main reason for not using EPRTR data on a broader scale in the national inventory is that the E-PRTR reports contain only very little information other than emission data, whereby these emissions can either be reported as estimated, measured or calculated emissions. Activity data are often reported in units not useful for the inventory, and also the type of activity data may be different between producers of the same product. In addition, E-PRTR data is not complete for IPCC sectors and it is difficult to include this point source information because no background information (such as fuel consumption data) is available. Furthermore the reporting thresholds are relatively high, so that many of the relevant installations do not have to report.

Thus greenhouse gas emission data from the EU Emissions Trading System (see chapter 1.4.1), combined with the top-down approach of the national inventory has been considered to be more reliable and data of EPER/E-PRTR has not been used as a source for point source data for the national inventory, but for verification purposes – where possible.

1.5 Brief description of key categories

The identification of key categories is described in the IPCC 2006 GL (Volume 1, Chapter 4). It stipulates that a key category is one that is prioritised within the National System because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both.

All notations, descriptions of identification and results for key categories included in this chapter are based on the IPCC 2006 GL. The identification includes all reported greenhouse gases CO_2, CH_4, N_2O, HFC, PFC, SF_6 and NF_3, and all IPCC categories.

The presented key category analysis was performed by the Umweltbundesamt with data for greenhouse gas emissions of the submission 2021 and comprises a level assessment for the years 1990 and 2020 and a trend assessment for the trend of the year 2021 with respect to the 1990 emissions. As also descripted in the IPCC 2006 GL categories were first identified for the inventory excluding LULUCF and then the key category analysis was repeated for the full inventory including LULUCF categories.

The key category analysis presented here follows approach 1 and 2 of the guidelines and is carried out at a more detailed level in comparison to the KCA of the CRF Reporter. Therefore the key categories described in the Austrian NIR differ slightly from the ones in the corresponding CRF table 7.

The detailed methodology for identifying the key categories is described in detail in Annex 1.

The key categories without LULUCF (determined by Approach1 and Approach 2) comprise 75 399 kt CO_2e in the year 2021, which corresponds to 97.2% of Austria's total greenhouse gas emissions (without LULUCF). The key categories including LULUCF amounted to 64 846 kt CO_2e (96.6%) in 2021.The following tables present the results of the KCA approach 1 and approach 2 including LULUCF and excluding LULUCF by indicating the ranking of the different subcategories as well as emissions/removal data.

Table 7: Key categories including LULUCF.

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2021	TA 1990–2021	LA 1990	LA 2021	TA 1990–2021	1990	2021	Share 2021
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	9	3	26				3 294	4 467	4.9%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	18		7				1 229	120	0.1%
1 A 1 a other	Public Electricity and Heat Production	CO_2	51	16			12		286	1 049	1.1%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	4						6 247	0	0.0%
1 A 1 b gaseous	Petroleum refining	CO_2	41	27					437	533	0.6%
1 A 1 b liquid	Petroleum refining	CO_2	14	8					1 958	2 217	2.4%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO_2	34	34					506	354	0.4%
1 A 2 a gaseous	Iron and Steel	CO_2	27	17					650	994	1.1%
1 A 2 a solid	Iron and Steel	CO_2	20	21					1 107	760	0.8%
1 A 2 b gaseous	Non-ferrous Metals	CO_2		40					75	275	0.3%
1 A 2 c gaseous	Chemicals	CO_2	31	15					519	1 220	1.3%
1 A 2 c other	Chemicals	CO_2		37					125	294	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	23	10			8		943	1 580	1.7%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	24		2			13	853	20	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO_2	42						398	210	0.2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	33	22					507	743	0.8%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	46		15				345	38	0.0%
1 A 2 f gaseous	Other	CO_2	29	23					559	665	0.7%
1 A 2 f liquid	Other	CO_2	32		22				508	147	0.2%
1 A 2 f other	Other	CO_2		26			14		67	616	0.7%
1 A 2 f solid	Other	CO_2	30	41					535	253	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	53	13					256	1 345	1.5%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	22	14					1 014	1 323	1.4%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2			10				91	1	0.0%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	28		18				610	149	0.2%
1 A 3 b diesel oil	Road Transportation	CO_2	6	1	12	3	1		5 360	16 839	18.4%
1 A 3 b gasoline	Road Transportation	CO_2	2	4	9	2	4	15	7 896	4 213	4.6%
1 A 3 b gasoline	Road Transportation	N_2O			25			11	83	7	0.0%
1 A 3 e gaseous	Other	CO_2		32					224	374	0.4%
1 A 4 a gaseous	Commercial/Institutional	CO_2	26	18					698	923	1.0%
1 A 4 a liquid	Commercial/Institutional	CO_2	17	25	19				1 420	631	0.7%
1 A 4 a other	Commercial/Institutional	CO_2			3			4	83	0	0.0%
1 A 4 b biomass	Residential	CH_4	52	43		21	22		264	236	0.3%
1 A 4 b gaseous	Residential	CO_2	15	6	24	9	6		1 856	3 791	4.1%
1 A 4 b liquid	Residential	CO_2	5	7	11				5 633	3 332	3.6%
1 A 4 b solid	Residential	CO_2	12		1			6	2 511	61	0.1%
1 A 4 b solid	Residential	CH_4			8	22		1	224	5	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO_2	19	20					1 180	808	0.9%
1 A 4 c solid	Agriculture/Forestry/Fisheries	CO_2			20				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH_4	44			16			373	NA	0.0%
1 B 2 b	Natural Gas	CH_4	50	42					290	238	0.3%
2 A 1	Cement Production	CO_2	13	9		8			2 033	1 889	2.1%
2 A 2	Lime Production	CO_2	40	24					439	663	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO_2	36	33					481	357	0.4%
2 B 1	Ammonia Production	CO_2	38	30					467	500	0.5%

IPCC Category Code	IPCC Category	GHG	Approach 1 LA 1990	Approach 1 LA 2021	Approach 1 TA 1990–2021	Approach 2 LA 1990	Approach 2 LA 2021	Approach 2 TA 1990–2021	1990	2021	Share 2021
2 B 2	Nitric Acid Production	N_2O	25		5			10	780	41	0.0%
2 C 1	Iron and Steel Production	CO_2	3	2	16		2		6 840	11 002	12.0%
2 C 3	Aluminium Production	PFC	21			11			1 032	0	0.0%
2 C 3	Aluminium Production	CO_2			13				150	6	0.0%
2 C 4	SF6 used in Mg Foundries	SF_6	54		6			8	235	5	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	45			17			349	165	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		12	21		11	9	0	1 431	1.6%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		35			18		124	304	0.3%
3 A 1	Cattle	CH_4	7	5	23	4	5	17	4 854	3 938	4.3%
3 B 1 1	Cattle	CH_4	37	29		13	16		467	508	0.6%
3 B 1 1	Cattle	N_2O	49	39		20	21		294	280	0.3%
3 B 1 3	Swine	N_2O				26			99	57	0.1%
3 B 2 5	Indirect N2O Emissions	N_2O				25	27		103	111	0.1%
3 D 1	Direct N2O Emissions from Managed Soils	N_2O	16	11		10	9	12	1 776	1 500	1.6%
3 D 2	Indirect N2O emissions from Managed Soils	N_2O	47	38		18	20		341	286	0.3%
4	Total land use categories	N_2O				24	26		113	112	0.1%
4 A 1	Forest land remaining forest land	CO_2	1	46		1	3	16	-8 122	-8 938	9.8%
4 A 2	Land converted to forest land	CO_2	11	44	14	7	10	3	-2 957	-1 437	1.6%
4 B 2	Land converted to cropland	CO_2				23	23		190	211	0.2%
4 C 1	Grassland remaining grassland	CO_2	48	36		19	19		294	296	0.3%
4 C 2	Land converted to grassland	CO_2	43			15	25	5	391	138	0.2%
4 E 2	Land converted to Settlements	CO_2	39	31		14	17		448	441	0.5%
4 F 2	Land converted to Other land	CO_2	35	28		12	15		502	514	0.6%
4 G	HWP	CO_2	10	45	17	6	7	7	-3 122	-1 889	2.1%
5 A	Solid Waste Disposal	CH_4	8	19	4	5	13	2	4 081	878	1.0%
5 D	Waste Water Treatment and Discharge	N_2O					24		86	152	0.2%
5 D	Waste Water Treatment and Discharge	CH_4						14	137	25	0.0%
									64 168	**64 376**	**95.9%**

Table 8: Key categories excluding LULUCF.

IPCC Category Code	IPCC Category	GHG	Approach 1 LA 1990	Approach 1 LA 2021	Approach 1 TA 1990–2021	Approach 2 LA 1990	Approach 2 LA 2021	Approach 2 TA 1990–2021	1990	2021	Share 2021
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	8	3		7	3		3 294	4 467	5.8%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	15		7				1 229	120	0.2%
1 A 1 a other	Public Electricity and Heat Production	CO_2	44	16		20	13		286	1 049	1.4%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	3						6 247	0	0.0%
1 A 1 b gaseous	Petroleum refining	CO_2	36	27					437	533	0.7%
1 A 1 b liquid	Petroleum refining	CO_2	11	8					1 958	2 217	2.9%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO_2	31	32					506	354	0.5%
1 A 2 a gaseous	Iron and Steel	CO_2	24	17			14		650	994	1.3%

			Approach 1			Approach 2					
IPCC Category Code	**IPCC Category**	**GHG**	**LA 1990**	**LA 2021**	**TA 1990–2021**	**LA 1990**	**LA 2021**	**TA 1990–2021**	**1990**	**2021**	**Share 2021**
1 A 2 a solid	Iron and Steel	CO_2	17	21					1 107	760	1.0%
1 A 2 b gaseous	Non-ferrous Metals	CO_2		37					75	275	0.4%
1 A 2 c gaseous	Chemicals	CO_2	28	15			12		519	1 220	1.6%
1 A 2 c other	Chemicals	CO_2		34			20		125	294	0.4%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	20	10		13	8		943	1 580	2.0%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	21		2			10	853	20	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO_2	37	41					398	210	0.3%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	30	22					507	743	1.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	40		14				345	38	0.0%
1 A 2 f gaseous	Other	CO_2	26	23					559	665	0.9%
1 A 2 f liquid	Other	CO_2	29		20				508	147	0.2%
1 A 2 f other	Other	CO_2		26			17		67	616	0.8%
1 A 2 f solid	Other	CO_2	27	38					535	253	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	46	13					256	1 345	1.7%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	19	14		12	11		1 014	1 323	1.7%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	25		16				610	149	0.2%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2			10				91	1	0.0%
1 A 3 b diesel oil	Road Transportation	CO_2	5	1	12	4	1		5 360	16 839	21.7%
1 A 3 b diesel oil	Road Transportation	N_2O					24		11	199	0.3%
1 A 3 b gasoline	Road Transportation	CO2	1	4	9	1	4	12	7 896	4 213	5.4%
1 A 3 b gasoline	Road Transportation	CH_4						14	77	7	0.0%
1 A 3 b gasoline	Road Transportation	N_2O			22	28		8	83	7	0.0%
1 A 3 e gaseous	Other	CO_2	48	30					224	374	0.5%
1 A 4 a gaseous	Commercial/Institutional	CO_2	23	18			15		698	923	1.2%
1 A 4 a liquid	Commercial/Institutional	CO_2	14	25	17				1 420	631	0.8%
1 A 4 a other	Commercial/Institutional	CO_2			3			3	83	0	0.0%
1 A 4 b biomass	Residential	CH_4	45	40		21	23		264	236	0.3%
1 A 4 b biomass	Residential	N_2O					29		62	85	0.1%
1 A 4 b gaseous	Residential	CO_2	12	6	23	9	6		1 856	3 791	4.9%
1 A 4 b liquid	Residential	CO_2	4	7	11	3			5 633	3 332	4.3%
1 A 4 b solid	Residential	CO_2	9		1			4	2 511	61	0.1%
1 A 4 b solid	Residential	CH_4	49		8	22		1	224	5	0.0%
1 A 4 b solid	Residential	N_2O						15	11	0	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO_2	16	20					1 180	808	1.0%
1 A 4 c solid	Agriculture/Forestry/Fisheries	CO_2			18				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH_4	38			16			373	NA	-
1 B 2 b	Natural Gas	CH_4	43	39					290	238	0.3%
2 A 1	Cement Production	CO_2	10	9		8	7		2 033	1 889	2.4%
2 A 2	Lime Production	CO_2	35	24		15			439	663	0.9%
2 A 4 c	Non-metallurgical Magnesium	CO_2	32	31					481	357	0.5%
2 B 1	Ammonia Production	CO_2	34	29					467	500	0.6%
2 B 2	Nitric Acid Production	N_2O	22		5			7	780	41	0.1%
2 C 1	Iron and Steel Production	CO_2	2	2	15	2	2		6 840	11 002	14.2%
2 C 3	Aluminium Production	PFC	18			11			1 032	0	0.0%
2 C 3	Aluminium Production	CO2			13				150	6	0.0%
2 C 4	SF6 used in Mg Foundries	SF6	47		6			5	235	5	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	39			17	25		349	165	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		12	19		10	6	0	1 431	1.8%

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2021	TA 1990–2021	LA 1990	LA 2021	TA 1990–2021	1990	2021	Share 2021
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		33		24	19		124	304	0.4%
3 A 1	Cattle	CH_4	6	5	21	5	5	13	4 854	3 938	5.1%
3 B 1 1	Cattle	CH_4	33	28		14	18		467	508	0.7%
3 B 1 1	Cattle	N_2O	42	36		19	22		294	280	0.4%
3 B 1 3	Swine	N_2O				26	30		99	57	0.1%
3 B 2 5	Indirect N2O Emissions	N_2O				25	27		103	111	0.1%
3 D 1	Direct N2O Emissions from Managed Soils	N_2O	13	11		10	9	9	1 776	1 500	1.9%
3 D 2	Indirect N2O emissions from Managed Soils	N_2O	41	35		18	21		341	286	0.4%
3 G	Liming	CO_2					28		46	99	0.1%
5 A	Solid Waste Disposal	CH_4	7	19	4	6	16	2	4 081	878	1.1%
5 D	Waste Water Treatment and Discharge	N_2O				27	26		86	152	0.2%
5 D	Waste Water Treatment and Discharge	CH_4				23		11	137	25	0.0%
									76 638	**75 319**	**97.1%**

The key category with the highest contribution to the national total emissions excl. LULUCF in 2020 is *1.A.3.b Road Transportation – diesel oil (CO_2)* 21.7% in 2021 (share of 6.8% in 1990). This strong increase is mainly due to the increase of road performance. This category is also the most important category in terms of emission trends: Since 1990 emissions increased by 214%. The second most important source of greenhouse gas emissions in Austria is *2.C.1 Iron and Steel Production*, with a contribution to national total emissions of 14.2% in 2021. The key category with the highest contribution to national removals is *4.A.1 Forest land remaining forest land (CO_2)*.

Comparison Approach 1 – Approach 2 KCA

The following categories have been identified as key additionally to the Approach 1 analysis:

Table 9: comparison results Approach 1 – Approach 2 KCA.

IPCC Category Code	IPCC Category	Greenhouse Gas
1 A 3 b diesel oil	Road Transportation	N_2O
1 A 3 b gasoline	Road Transportation	CH_4
1 A 4 b biomass	Residential	N_2O
1 A 4 b solid	Residential	N_2O
3 B 1 3	Swine	N_2O
3 B 2 5	Indirect N_2O Emissions	N_2O
3 G	Liming	CO_2
4	Total land use categories	N_2O
4 B 2	Land converted to cropland	CO_2
5 D	Waste Water Treatment and Discharge	CH_4
5 D	Waste Water Treatment and Discharge	N_2O

1.6 General assessment of completeness

CRF Table 9 (Completeness) gives information on the aspect of completeness. This chapter includes additional information. An assessment of completeness for each sector is given in the Sector Overview part of the corresponding subchapters.

Sources and sinks

All sources and sinks included in the IPCC 2006 Guidelines are adressed. No additional sources and sinks specific to Austria have been identified.

Gases

Both direct GHGs as well as precursor gases are covered by the Austrian inventory.

Geographic coverage

The geographic coverage is complete. There is no part of the Austrian territory not covered by the inventory.

Notation keys

The sources and sinks not considered in the inventory but included in the IPCC 2006 Guidelines are clearly indicated, the reasons for such exclusion are explained. In addition, the notation keys presented below are used to fill in the blanks in all the tables in the CRF. Notation keys used in the NIR are consistent with those reported in the CRF. Notation keys are used according to the UNFCCC reporting guidelines (FCCC/CP/2013/10).

Allocations to categories may differ from Party to Party. The main reasons for different category allocations are different allocations in national statistics, insufficient information on the national statistics, national methods, and the impossibility to disaggregate emission declarations.

IE *(included elsewhere)*:

'IE' is used for emissions by sources and removals by sinks of greenhouse gases that have been estimated but included elsewhere in the inventory instead of the expected source/sink category. Where 'IE' is used in the inventory, the CRF completeness table (Table 9) indicates where (in the inventory) these emissions or removals have been included. Such deviation from the expected category is explained.

NE *(not estimated)*:

'NE' is used for existing emissions by sources and removals by sinks of greenhouse gases which have not been estimated. Where 'NE' is used in an inventory for emissions or removals, both the NIR and the CRF completeness table indicate why emissions or removals have not been estimated. For emissions by sources and removals by sinks of greenhouse gases marked by 'NE' check-ups are in progress to establish if they actually are 'NO' (not occurring). As part of the improvement programme of the inventory, it is planned that these source or sink categories are either estimated or reported as 'NO'.

NA *(not applicable)*:

'NA' is used for activities in a given source/sink category that do not produce emissions or lead to removals of a specific gas.

C *(confidential)*:

'C' is used for emissions which could lead to the disclosure of confidential information if reported at the most disaggregated level. In this case a minimum of aggregation is required to protect business information.

In the Austrian QMS a transparency and completeness index is used to quantify the quality of the inventory, calculated as follows:

*Transparency [%] = [1 – (number of IE/number of estimates)]*100*

*Completeness [%] = [1 – (number of NE/number of estimates)]*100*

The total number of data records (emission/removal data) are counted as well as the numbers reported as 'not estimated' and 'included elsewhere'. Then the share of 'NE' and 'IE' to total data records are determined. The following table shows the results of this years' evaluation of transparency and completeness. The notation key 'IE' is applied for some sub-categories, in particular in the sectors Energy, IPPU and LULUCF. Explanations are provided in the respective sectoral chapters on 'Completeness' as well as in CRF Table 10.

"NE" is meanwhile only reported in the LULUCF sector, for categories *4.D.1.2* (flooded land remaining flooded land) and *4.D.1.3* (other wetlands remaining other wetlands). However, the number of "NE" in this sector decreased clearly compared to the previous submission (from 15 to 10) due to improved reporting for *4.A.1* Forest land remaining forest land – forest not in yield beginning with submission 2023.

Table 10: Transparency and completeness in UNFCCC submission 2023.

Sector	**Submission 2023**			
	IE	**NE**	**Transparency**	**Completeness**
1 Energy	47	0	*93%*	*100%*
2 IPPU	8	0	*98%*	*100%*
3 Agriculture	0	0	*100%*	*100%*
4 LULUCF	9	10	*98%*	*97%*
5 Waste	1	0	*98%*	*100%*
Total	**65**	**10**	***96%***	***99%***
Total number of estimates*	**1 581**			

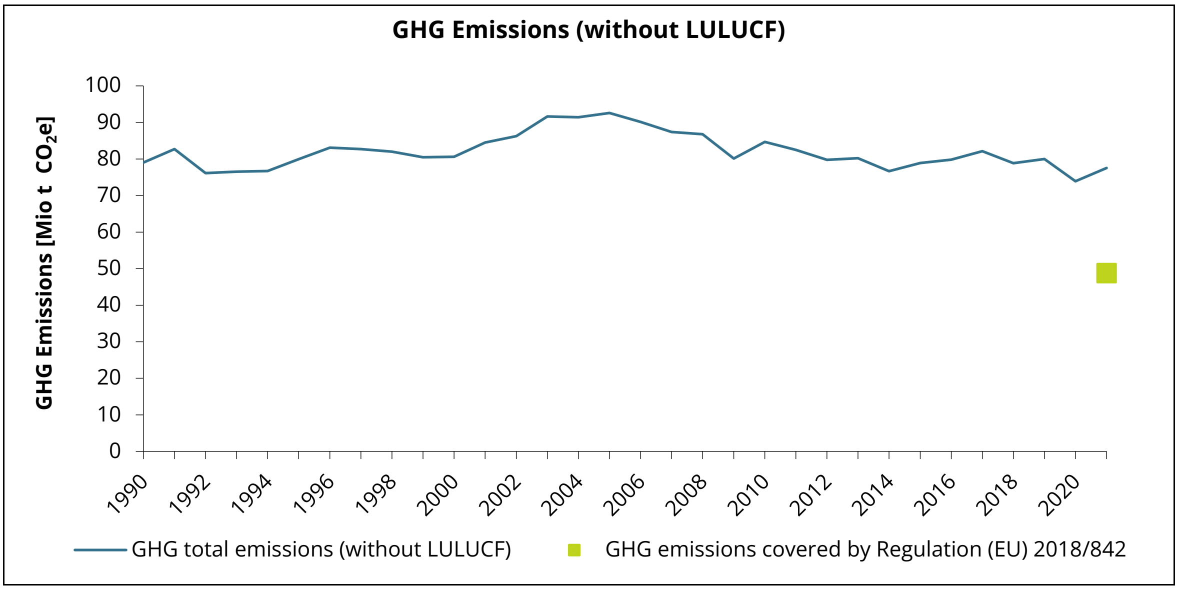
* *including IE and NE, but also NO and NA*

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

In 2021 Austria's total greenhouse gas (GHG) emissions (without Land Use, Land Use Change and Forestry – LULUCF) amounted to 77.5 Mt CO_2 equivalents (CO_2e). Compared to the 1990 base year[41], 2021 GHG emissions without LULUCF decreased by 1.9%. Compared to 2020 GHG emissions increased by 4.9%.

Figure 3: Trend in GHG emissions 1990–2021 without LULUCF.



The CO_2-equivalent emissions presented in this report were calculated on the basis of the Global Warming Potentials ('GWPs') according to the 5th Assessment Report ('AR5') of the Intergovernmental Panel on Climate Change (IPCC 2013) for the first time. The change of GWPs has led to an increase in national total GHG emissions in metric tons of CO_2e over the entire time series (see chapter 10.2.2).

Greenhouse gas emissions covered by Regulation (EU) No. 2018/842 ('Effort Sharing Regulation') amounted to 48 805 082 t CO_2 equivalents in 2021, and were thus slightly above the level of the annual emission allocation (AEA) for this year.

[41] Austria's base year under the UNFCCC is 1990. Under the EU Effort Sharing, the base year is 2005 (relates only to emissions not included in the EU Emissions Trading Scheme). Unless otherwise specified, references to the base year in this report refer always to 1990.

Table 11: GHG Emissions (covered by the ESR) and status of ESR-target achievement 2021

t CO_2-Äquivalent (AR5)	**2021**
Total GHG emissions without LULUCF	77 532 351
Total verified emissions from stationary installations under Directive 2003/87/EC2	28 703 349
GHG emissions covered by Regulation (EU) 2018/842[13]	48 805 082*
Annual Emission Allocations (AEA) pursuant to Article 4(3) of Regulation (EU) 2018/842[42]	48 768 448
Deviation from AEA	-36 634

**Defined as: Total greenhouse gas emissions without LULUCF minus total verified emissions from stationary installations under Directive 2003/87/EC ("ETS emissions") minus CO_2 emissions from 1.A.3.a civil aviation.*

Trend 2020–2021

The largest increases in emissions between 2020 and 2021 took place in the sectors *Energy (CRF 1)* (+2 212 kt CO_2e; +4.4 %) and *Industrial Processes and Other Product Use (CRF 2)* (+1 435 kt CO_2e; +9.2%).

The main reasons for the emissions increase in sector *Energy (CRF 1)* were the higher natural gas and gasoil consumption in category *1.A.4 Other Sectors* as well as the higher diesel oil and motor gasoline sales in category *1.A.3 Transport.*

Emissions from *Industrial Processes and Other Product Use (CRF 2)* increased due to a strong increase in iron and steel production (+7.2 %) after lower production levels during the pandemic year 2020. The increase was partly counterbalanced by a strong decrease of emissions of F-gases (-14 %), where on the one hand the effects of measures related to the EU F-gas regulation (No. 517/2014) are now visible, and on the other hand lower emissions due to decommissioning of equipment were reported.

Net removals from *LULUCF* (*CRF 4*) show an increase of 99% (5 180 kt CO_2e) from 2020 to 2021, mainly caused by increased sinks in the Forest land soil and harvested wood products. However, it should be noted that the annual variations of the LULUCF category (both positive and negative) are very high over the entire 1990-2021.

Emissions from *Agriculture (CRF 3)* increased slightly by 0.3 % (+24 kt CO_2e) from 2020 to 2021, mainly due to rising emissions from mineral fertilizer application. In addition, slightly increased cattle numbers (dairy cows and non-dairy cattle) resulted in higher emissions from *enteric fermentation* in 2021 compared to the previous year.

The declining emission trend of recent decades continues for the sector *Waste (CRF 5)* with a further decline by 3.9 % (−49 kt CO_2e) 2020 to 2021 mainly due to the decreasing carbon content of waste deposited in preceding years.

The most important gas in the Austrian GHG balance remains carbon dioxide (CO_2) with a share of 85 % in total 2021 emissions (without LULUCF). Emissions of CO_2 primarily result from combustion

[42] as included in Annex II of COMMISSION IMPLEMENTING DECISION (EU) 2020/2126 of 16 December 2020 on setting out the annual emission allocations of the Member States for the period from 2021 to 2030 pursuant to Regulation (EU) 2018/842 of the European Parliament and of the Council

activities. Methane (CH_4), which mainly arises from livestock farming and waste disposal, contributes 8.4 % (2021) to total national GHG emissions. Nitrous oxide (N_2O), with agricultural soils as the main source, contributes another 4.0% (2021). The remaining 2.4% are emissions of fluorinated compounds, which are mostly emitted from the use of these gases as substitutes for ozone depleting substances (ODS) in refrigeration equipment.

Table 12: Austria's anthropogenic greenhouse gas emissions (without LULUCF) by gas

GHG emissions	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Total
	CO_2 equivalents (kt)							
1990	62 167	11 319	4 011	2.0	1 063	485	NO,NA	**79 047**
1995	64 044	10 514	3 856	324	75	1 134	6.0	**79 953**
2000	66 172	9 218	3 871	677	80	592	9.8	**80 619**
2005	79 097	8 514	3 188	1 104	150	509	26	**92 589**
2010	72 017	7 836	2 994	1 426	71	346	3.9	**84 693**
2011	69 909	7 604	3 087	1 518	66	317	3.8	**82 506**
2012	67 283	7 470	3 061	1 599	46	321	8.0	**79 788**
2013	67 776	7 349	3 046	1 689	45	315	9.1	**80 229**
2014	64 176	7 191	3 127	1 787	48	324	9.9	**76 663**
2015	66 366	7 103	3 142	1 897	45	319	13	**78 884**
2016	67 227	7 023	3 231	1 884	46	405	5.7	**79 821**
2017	69 609	6 993	3 175	1 892	40	412	11	**82 132**
2018	66 572	6 758	3 136	1 946	29	398	15	**78 854**
2019	67 956	6 609	3 131	1 802	35	450	13	**79 994**
2020	62 121	6 503	3 089	1 705	27	455	11	**73 911**
2021	66 019	6 499	3 123	1 486	23	371	12	**77 532**

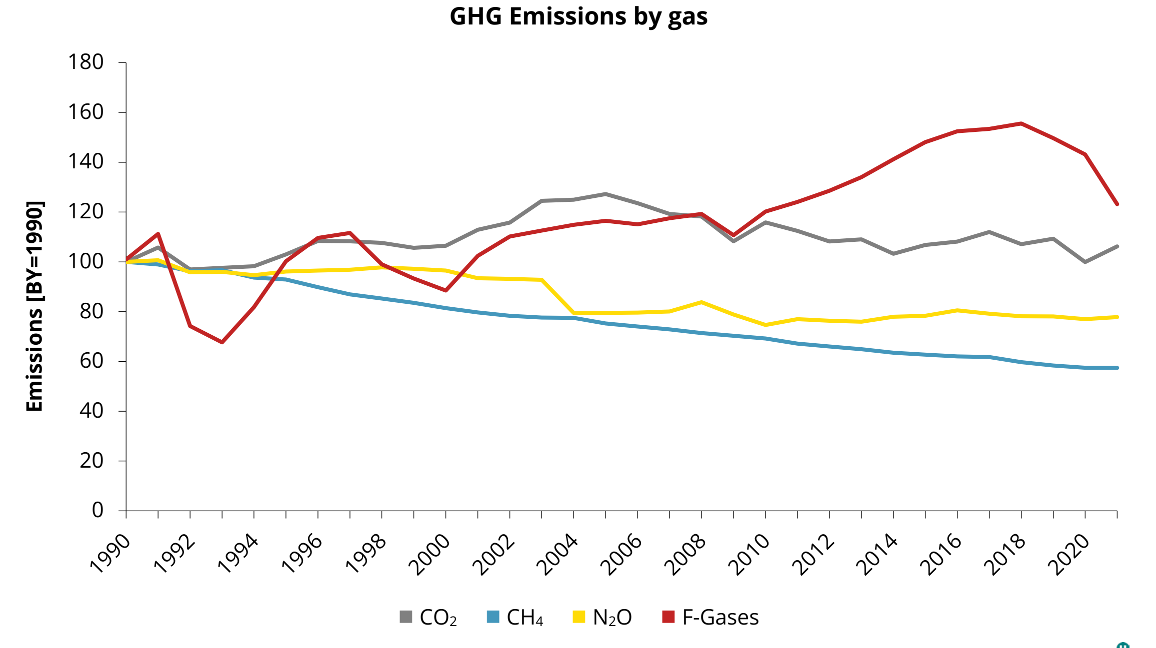
Note: Global warming potentials (GWPs) according to the 5th Assessment Report (IPCC 2013) (100 years time horizon): carbon dioxide (CO_2) = 1; methane (CH_4) = 28; nitrous oxide (N_2O) = 265; sulphur hexafluoride (SF_6) = 23 500; nitrogen trifluoride (NF_3) = 16 100; hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances

Table 13: Austria's greenhouse gas emissions by gas 1990 and 2021

GHG	1990	2021	Trend 1990–2021	1990	2021
	CO_2 equivalent [kt]			Share in national total [%]	
Total	**79 047**	**77 532**	**-1.9%**	**100%**	**100%**
CO_2	62 167	66 019	6.2%	79%	85%
CH_4	11 319	6 499	-43%	14%	8.4%
N_2O	4 011	3 123	-22%	5.1%	4.0%
F-gases	1 550	1 892	22%	2.0%	2.4%

Emissions without LULUCF

Figure 4: Trend in greenhouse gas emissions 1990–2021 by gas in index form (1990 = 100).



Source: Umweltbundesamt

CO_2

The main source of CO_2 emissions in Austria is fossil fuel combustion; within the fuel combustion sector transport is the most important sub-source.

CO_2 emissions in 2021 were 6.2% above the level 1990. In absolute figures, CO_2 emissions increased from 62 167 to 66 019 kt during the period from 1990 to 2021 mainly due to higher CO_2 emissions from iron and steel production.

CH_4

The main sources of CH_4 emissions in Austria are agriculture (enteric fermentation) and solid waste disposal on land (landfills).

CH_4 emissions decreased steadily during the period from 1990 to 2021 from 11 319 to 6 499 kt CO_2 equivalents. In 2021, CH_4 emissions were 43% below the level of 1990, mainly due to lower emissions from solid waste disposal sites.

N_2O

The main source of N_2O emissions is sector Agriculture with a share of 72% (2021) in national total N_2O emissions. Agricultural soils contribute most to national N_2O Emissions (57% in 2021). Other important sources of N_2O emissions are fuel combustion (18%) and manure management (15%).

N_2O emissions show a decreasing trend, resulting in 3 123 kt CO_2 equivalents in 2021 compared to 4 011 kt CO_2 equivalents in 1990 (−22%). The general decrease is mainly due to lower N_2O emissions from agricultural soils and chemical industry; the strong decrease 2003–2004 was also due to emission reduction measures in the chemical industry.

HFCs

HFC emissions increased remarkably during the period from 1990 to 2021 from 2.0 to 1 486 kt CO_2 equivalents. HFCs are used as substitutes for HCFCs (Hydro Chloro Fluoro Carbons; these are ozone depleting substances), the use of which has been banned for most applications.

PFCs

PFC emissions show an inverse trend of HFC emissions. PFC emissions decreased remarkably during the period from 1990 to 2021, from 1 063 to 23 kt CO_2 equivalents (−98%). In 1990 PFCs were mainly emitted as by-products of primary aluminium production, which closed down in Austria in 1992; Semiconductor manufacture is the main source of PFC emissions.

SF_6

SF_6 emissions in 1990 amounted to 485 kt CO_2 equivalents. Until 1996 emissions increased steadily as a result of increasing emissions from metal production and semiconductor manufacture reaching 1 213 kt CO_2 equivalents. In 2021 SF_6 emissions amounted to 371 kt CO_2 equivalents, which was 24% below the level of 1990. Current emissions mainly result from disposal of noise insulating windows.

NF_3

In 1990 no NF_3 was emitted in Austria. NF_3 emissions solely arise from semiconductor manufacture; NF_3 has been in use in Austria since 1994. In 2021, NF_3 emissions amounted to 12 kt CO_2 equivalents.

2.2 Description and interpretation of emission trends by sector

Table 14 presents a summary of Austria's anthropogenic greenhouse gas emissions by sector.

Table 14: Summary of Austria's anthropogenic greenhouse gas emissions by sector.

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO_2 equivalents (kt)					
1990	52 665	13 615	8 400	-12 207	4 367	NO*
1995	54 162	13 606	8 130	-19 771	4 055	NO
2000	55 291	14 408	7 644	-14 284	3 277	NO
2005	66 715	15 652	7 181	-18 418	3 041	NO
2010	59 281	15 935	7 188	-19 759	2 289	NO
2011	56 971	16 126	7 265	-15 360	2 143	NO
2012	54 830	15 730	7 212	-5 767	2 017	NO
2013	55 005	16 139	7 211	-6 242	1 874	NO
2014	51 280	16 289	7 346	-7 612	1 747	NO
2015	53 064	16 800	7 376	-6 563	1 645	NO
2016	54 289	16 498	7 489	-6 993	1 546	NO
2017	56 001	17 231	7 444	-3 249	1 457	NO

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO_2 equivalents (kt)					
2018	54 555	15 596	7 330	4 921	1 373	NO
2019	54 937	16 520	7 221	2 132	1 315	NO
2020	49 930	15 524	7 197	-5 222	1 259	NO
2021	52 142	16 959	7 221	-10 402	1 211	NO

**not occurring*

The dominant sector regarding GHG emissions in Austria is *Energy*, causing 67 % of the total national GHG emissions in 2021 (67 % in 1990), followed by the sectors *Industrial Processes and Other Product Use* (22 % in 2021) and *Agriculture* (9.3 % in 2021).

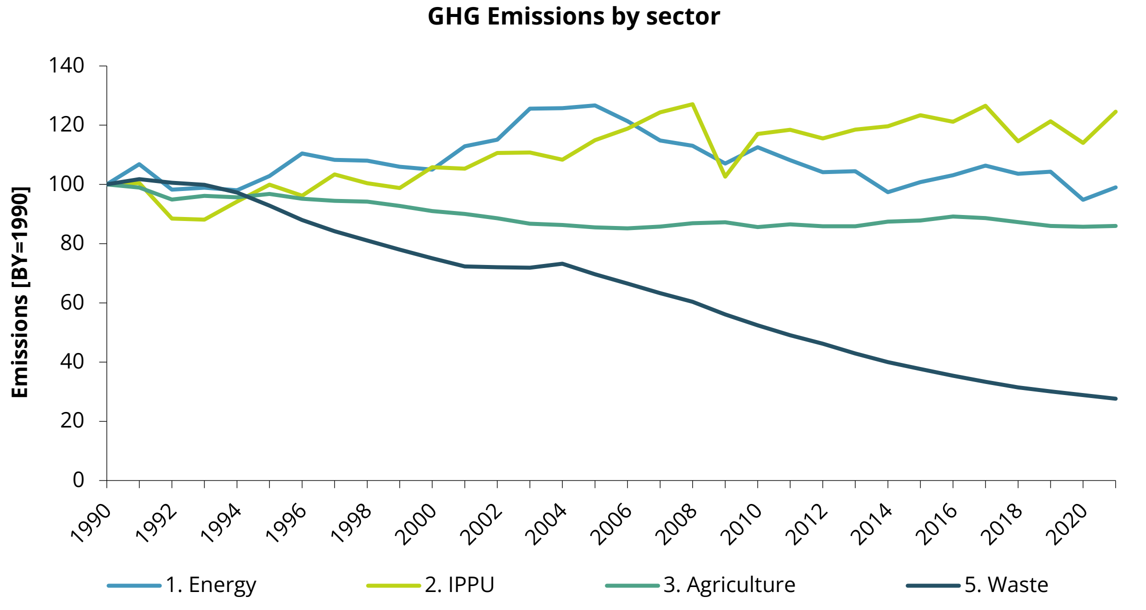
Table 15: Austria's greenhouse gas emissions (without LULUCF) for 1990 and 2021 expressed as aggregate levels and trends, as well as respective sector contributions.

GHG	1990	2021	Trend 1990–2021	1990	2021
	Emissions [kt CO_2e]			Share [%]	
Total	**79 047**	**77 532**	**-1.9%**	**100%**	**100%**
Energy	52 665	52 142	-1.0%	67%	67%
IPPU	13 615	16 959	+25%	17%	22%
Agriculture	8 400	7 221	-14%	11%	9.3%
Waste	4 367	1 211	-72%	5.5%	1.6%

Total emissions without emissions from sector LULUCF

The only sector with 2021 GHG emissions above the level in 1990 is *Industrial Processes and Other Product Use* (+25 %; +3 343 kt CO_2e). All other sectors show decreasing trends, with the most significant decreases in GHG emissions in the sectors *Waste* (-72 %; -3 157 kt CO_2e) and *Agriculture* (-14 %; -1 179 kt CO_2e).

Figure 5: Trend in greenhouse gas emissions 1990–2021 by sector in index form (1990 = 100).



Source: Umweltbundesamt

A more detailed description and interpretation of emissions trends per sector is given in the following sub-chapters.

2.2.1 Energy

In 2021, greenhouse gas emissions from sector *1 Energy* amounted to 52 142 kt CO_2 equivalents which corresponds to 67% of total national emissions. Emissions from fuel combustion (*1.A*) contribute 99% of total Energy emissions, while fugitive emissions from fuels (*1.B*) are of minor importance.

The most important **sub-category** is *transport* with a share of 42% in 2021, followed by *manufacturing industries and construction* (21%), the sub-category *other sectors* (19%) and *energy industries* (17%). The most important **greenhouse gas** is CO_2, contributing 98% to total sectoral GHG emissions, followed by CH_4 (1.2%) and N_2O (1.1%).

From 2020 to 2021, emissions from the energy sector increased by 4.4%, mainly due to increasing emissions from *1.A.4 Other Sectors*, *1.A.3 Transport* and *1.A.2 Manufacturing Industries*.

Emissions from O*ther Sectors* increased by 1 006 kt CO_2e due to higher natural gas and gasoil consumption which is mainly because heating degree days increased by 12.5%.

Emissions from transport increased by 777 kt CO_2e, in particular emissions from *1.A.3.b Road transport* (+860 kt CO_2e), mainly due to higher diesel and gasoline fuel sales (+597 kt CO_2 from diesel oil and +251 kt CO_2 from gasoline in the road transport sector).

Increased emissions (+401 kt CO_2e) were also reported for *Manufacturing Industries*, mainly due to higher natural gas, fuel waste, diesel oil and petrol coke cunsumption.

Emissions from *energy industries* increased by 55 kt CO_2e, where the closure of a coal-fired power plant was almost offset by the increased electricity generation from natural gas.

From 1990 to 2021, the **overall trend** in GHG emissions from the sector *Energy* shows a decrease by 523 kt CO_2e.

The dips and jumps from year to year are mainly due to:

- the weather circumstances in the corresponding years (in particular cold or mild winters, and/or dry or wet summers) which affect the heating demand, and the availability of electricity from hydro and wind power plants
- the economic situation as reflected in the gross domestic product (GDP)
- change in power generation (switch from coal to gas and wind power plants)
- national "lockdowns" due to the COVID pandemic (2020-2021)

Trend 1990–2021 by sub-category

In 2021, the emissions from sub-category ***1.A.1 Energy Industries*** were 37% below the 1990 level. GHG emissions from thermal power plants have generally been decreasing since 2005, mainly because of the growing contribution of renewable energy sources, the substitution of solid and liquid fuels by natural gas and biomass as well as improvements in efficiency. In 2020, the last Austrian coal-fired power plant was shut down.

The share of biomass used as a fuel in this sector increased from 0.9% (1990) to 28% (2021). The contribution of hydro, wind and photovoltaic power plants to total public electricity production increased from 69% (1990) to 82% (2021). Electricity consumption increased by 50.8% since 1990 and since 2002 the increase is to a large extent covered by electricity imports (depending on year).

GHG emissions from ***1.A.2 Manufacturing Industries and Construction*** increased by 14% from 1990 to 2021, mainly from Off-road vehicles and other machinery (1.A.2.g.vii) as well as the Chemicals Industry (1.A.2.c). However, emissions from the pulp, paper and printing industry (1.A.2.d) and other manufacturing industry (1.A.2.g.viii) have been decreasing since 1990. Fuel consumption increased by 39% in that period, mainly due to increased use of natural gas and biomass. As natural gas has a lower carbon content, and CO_2 emissions from biomass combustion are not accounted for under the UNFCCC reporting framework, the increase in GHG emissions from this category is significantly smaller compared to the increase in fuel consumption.

The sector ***1.A.3 Transport*** showed an increase in GHG emissions since 1990 (+57%) mainly due to an increase of road performance (mileage) of diesel cars and freight transport. In addition to the increase of road performance **within** Austria, the amount of fuel sold in Austria but **used elsewhere** – an effect called fuel export mainly caused by a lower fuel tax compared to Austria's neighbouring countries – has increased considerably since 1990. Between 2005 and 2012 total GHG emissions decreased due to lower amounts of fuel sold together with an increased use of biofuels for blending and the gradual replacement with newer vehicles with lower specific fuel consumption. Since then GHG emissions from transport have been **gradually increasing** with rising traffic volumes, although a sharp decrease in the pandemic year 2020 was observed. **From 2020 to 2021** GHG emissions increased again by 3.7% due to increased vehicle kilometres. Sales of biofuels – pure and for blending – increased by 2.0 % in this period.

The variation in demand for heating and hot water generation due to climatic circumstances and the shift in the fuel mix are the most important drivers for emissions from sub-category ***1.A.4 Other Sectors***. Emissions in 2021 were 30% lower than in 1990. This reduction is mainly attributable to the declining consumption of heating oil and coal and the increase in the consumption of biomass and natural gas as well as the growing importance of district heating and the modernisation of heating systems. Total fuel consumption of this sub-category has decreased by 3% since 1990.

Emissions from ***1.B Fugitive emissions*** decreased by 57% since 1990 due to the progressive closure of coal mines up until 2006. There have been no coal-mining activities in Austria since 2007. Fugitive Emissions from ***1.B.2 Oil and Natural gas*** are also below 1990 level (-17%) as volumes of crude oil and crude gas produced declined and the material of gas distribution network has changed over time (less cast iron pipes).

2.2.2 Industrial Processes and Other Product Use

In 2021, greenhouse gas emissions from *Industrial Processes and Other Product Use* amounted to 16 959 kt CO_2 equivalent, which correspond to 22% of total national emissions.

The most important **sub-categories** of this sector are *metal industry* and *mineral industry*, generating 65% and 18% of total sectoral emissions, respectively. The most important **greenhouse gas** of this sector is CO_2 with a contribution of 88.1% to total sectoral emissions, followed by HFCs with 8.8%, SF_6 with 2.2%, N_2O with 0.4%, CH_4 with 0.3% and PFCs with 0.1%. NF_3 contributes 0.07% to total emissions from this sector in 2021.

From 2020 to 2021, overall emissions from this sector increased by 9.2%. This is mainly due to a strong increase in iron and steel production, resulting in 16% higher GHG emissions from this source compared to 2020. The increase was partly counterbalanced by a strong decrease in F-gas emissions (-13.9 %), where on the one hand the effects of measures related to the EU F-gas regulation (No. 517/2014) are now visible, and on the other hand lower emissions from decommissioning were reported.

The **overall trend** in GHG emissions from *Industrial Processes and Other Product Use* is an increase of 25% from 1990 to 2021. Within this period, emissions were at minimum in 1993 then increased until peaking in 2008. Since then, emission fluctuated just below this maximum. **Main drivers** for the trend in emissions from this sector were (i) the termination of primary aluminium production in 1993, (ii) the introduction of N_2O abatement technologies in the chemical industry in 2004 and in 2009 (which became fully operational in 2010), (iii) increasing iron and steel production resulting in 61% higher GHG emissions in 2021 compared to 1990 and (iv) a strong increase of HFC emissions over the 1990-2021 period from 2.0 to 1 486 kt CO_2 equivalent.

Sub-category trends between 1990 and 2021

The largest increase in GHG emissions between 1990 and 2021 can be observed in the *metal industry* due to an increase in GHG emissions from iron and steel production (+61%). In sub-categories *mineral industry* and *chemical industry*, GHG emissions declined over the same period by 2.0% and 46.4%, respectively. Emissions from *non-energy products from fuels and solvent use* dropped by 52.6%, due to legal measures controlling the solvent content of products and their use.

Emissions of *fluorinated gases* increased by 22% since 1990, driven by increasing emissions of HFCs (+359% since 1995) due to HFCs replacing Ozone Depleting Substances (ODSs) as cooling agents.

2.2.3 Agriculture

In 2021, greenhouse gas emissions from *Agriculture* amounted to 7 221 kt CO_2 equivalent, which correspond to 9.3% of total national emissions.

The **most important sub-categories** of this sector are *enteric fermentation* (58%) and *agricultural soils* (25%). *Agriculture* is the largest source of national N_2O and CH_4 emissions: in 2021, 72% (8.5 kt N_2O) of total N_2O emissions and 74% (172 kt CH_4) of total CH_4 emissions originated from this sector. Total GHG emissions from the sector *Agriculture* are dominated by CH_4 with a share of 67% and N_2O with a share of 31%. CO_2 emissions account for 2.1% of the emissions from this sector.

From 2020 to 2021 GHG emissions increased slightly by 0.3%, mainly due to rising emissions from mineral fertilizer application. In addition, slightly increased cattle numbers (dairy cows and non-dairy cattle) resulted in higher emissions from *enteric fermentation* in 2021 compared to the previous year.

The **overall trend** in GHG emissions from *Agriculture* shows a decrease of 14% from 1990 to 2021. The **main drivers** for this trend are decreasing livestock numbers of cattle and swine as well as lower amounts of N-fertilizers applied on agricultural soils.

2.2.4 LULUCF

In 2021, net removals from sector *LULUCF* amounted to −10 402 kt CO_2 equivalent, which correspond to 13% of national total GHG emissions (without LULUCF) in the same year.

With regard to the **overall trend**, the net removals from *LULUCF* are 15% lower in 2021 compared to those in the base year 1990 with substantial annual variations in the observed period (regarding the regression trend line the decrease of net removals is about 75 % for the observed period from 1990 to 2021). The **main driver** for this trend is the biomass and soil carbon stock change in *Forest land*. Fluctuations are due to weather conditions which influence growth rates (e.g. very low increment in 2003) as well as decay in forest soils, natural disturbances (windthrows and bark beetle infestations, e.g. very high harvest rates in 2007 and 2008), timber demand and prices.

The **most important sub-category** is *Forest land (4.A)* with net removals of −10 375 kt CO_2 equivalent in 2021 (including indirect emissions).

Compared to the previous submission, the *Forest land* category has been subject to major revisions in the time series due to the availability of data from the latest cycle of the national forest inventory (2016/2021) which changed the time series since 2009, new soil carbon modelling results and, for the first time, emissions/removals estimates for the forests not-in-yield (see chapter 10.1.4). Due to these recalculations, the *LULUCF* category and the *Forest land* subcategory became, for the first time since reporting began, net GHG sources in single years, namely in 2018 and 2019. The net source values in these years are explained by high harvest rates due to natural disturbances and low increments due to weather conditions.

2.2.5 Waste

In 2021, greenhouse gas emissions from the sector *Waste* amounted to 1 211 kt CO_2 equivalent, which correspond to 1.6% of total national emissions.

The most important sub-category of *Waste* is *solid waste disposal*, which caused 73% of the emissions from this sector in 2021, followed by *waste water treatment and discharge* (15%) and *biological treatment of solid waste* (13%). The most important greenhouse gas is CH_4 with a share of 81% in emissions, mainly arising from *solid waste disposal*, followed by N_2O with 19% and CO_2 with 0.2%.

From 2020 to 2021 GHG emissions continued to decrease (−3.9%) mainly due to the decreasing carbon content of waste deposited in preceding years.

The **overall trend** in GHG emissions from *Waste* is decreasing, with a decrease of 72% from 1990 to 2021. The **main driver** for this trend is the implementation of waste management policies: Waste separation, reuse and recycling activities have increased since 1990 and the amount of disposed waste has decreased correspondingly especially since 2004 when pre-treatment of waste became obligatory (although some exceptions were granted to some Austrian provinces until end of 2008). The legal basis for the reduced disposal of waste as well as the landfill gas recovery is the Landfill Ordinance. Since 2009 all waste with high organic content has to be pre-treated before deposition (without exceptions). Furthermore, methane recovery from landfills was implemented in the 1990s.

2.3 Emission Trends for Indirect Greenhouse Gases and SO_2

Emission estimates for NO_x, CO, NMVOC and SO_2 are also reported in the CRF. This chapter summarizes the trends for these gases.

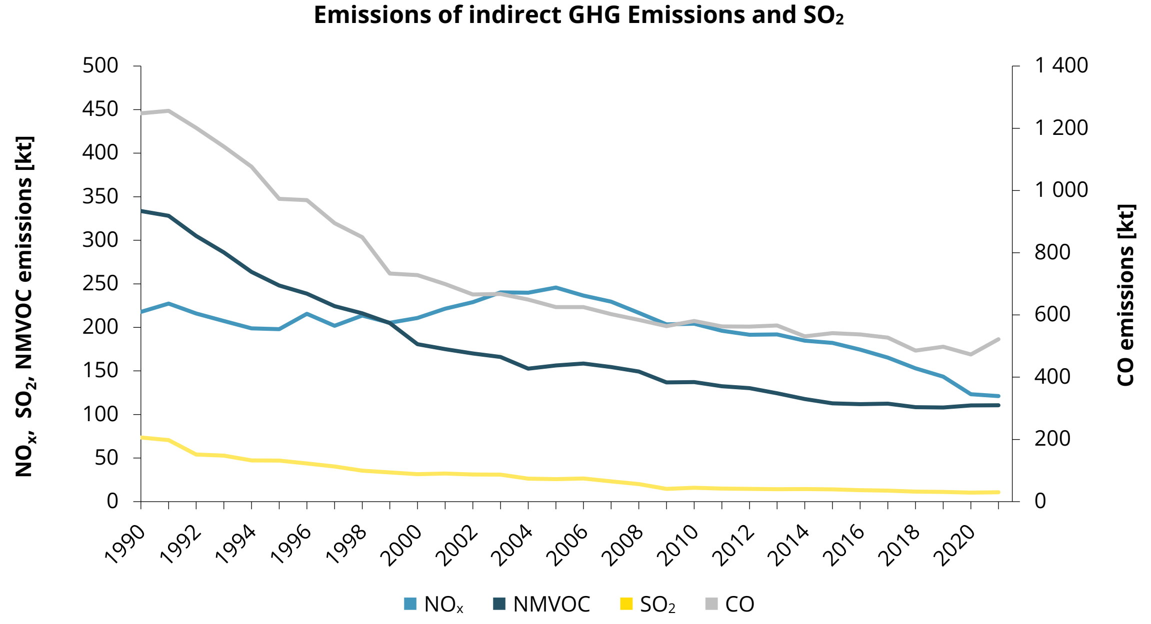
A detailed description of the methodology used to estimate these emissions is provided in *Austria's Informative Inventory Report (IIR) 2023, Submission under the UNECE/CLRTAP Convention*, published in spring 2023 (UMWELTBUNDESAMT 2023b). Total emissions shown below are different from totals reported under UNECE/CLRTAP due to differences in the accounting of emissions from aviation and shipping.

Table 16: Total emissions and trends 1990–2021 of indirect GHGs and SO_2.

	NO_x	**CO**	**NMVOC**	**SO_2**
	[kt]			
1990	218	1 248	334	74
1995	198	973	248	47
2000	211	728	181	31
2005	246	625	156	26
2010	204	580	137	16
2011	196	563	132	15
2012	191	563	130	15
2013	192	566	124	14
2014	185	531	118	14

	NO_x	CO	NMVOC	SO_2
		[kt]		
2015	182	542	113	14
2016	174	537	112	13
2017	165	527	112	13
2018	153	485	108	11
2019	144	498	108	11
2020	123	473	110	10
2021	121	522	111	11
Trend 1990–2021	**-44%**	**-58%**	**-67%**	**-85%**

Figure 6: Emissions of indirect GHGs and SO_2 1990–2021.



Source: Umweltbundesamt

The most important emission source for NO_x, SO_2 and CO is fuel combustion. The most important emission source for NMVOC is *Industrial Processes*.

NO_x

NO_x emissions decreased from 218 to 121 kt during the period from 1990 to 2021. In 2021 NO_x emissions were 44% below the level of 1990. In 2021 about 91% of NO_x emissions in Austria originated from fossil fuel combustion, with the major part originating from *1.A.3.b Road transportation* (45% in national total NO_x emissions in 2021).

CO

CO emissions decreased from 1 248 to 522 kt during the period from 1990 to 2021. In 2021 CO emissions were 58% below the level of 1990. In the year 2021, 97% of total CO emissions in Austria originated from fuel combustion activities. The most important sub-source regarding CO emissions is *1.A.4 Other sectors* (51% in national total CO emissions) followed by *1.A.2 Manufacturing industries* *and construction* with 35% and *1.A.3.b Road Transport* with 9,1% share in national total CO emissions in 2021.

NMVOC

NMVOC emissions decreased from 334 to 111 kt during the period from 1990 to 2021. In 2021 NMVOC emissions were 67% below the level of 1990. The most important source of NMVOC emissions is *2 Industrial Processes*, contributing 35% to national total NMVOC emissions in 2021 (contribution of *2.D.3.1 Solvent Use* 31%), followed by *1.A. Fuel Combustion Activities* (31%).

SO_2

SO_2 emissions decreased from 74 to 11 kt during the period 1990 to 2021. In 2021 SO_2 emissions were 85% below the level of 1990. Fuel combustion activities (*1.A*) contribute 94% to total emissions (2021).

2.4 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

The uncertainty calculation was performed applying approach 1 of the IPCC 2006 GL, for all sectors including and excluding LULUCF. As a result of the uncertainty analysis, the following tables show a total uncertainty of 5.1% for the base year 1990 and 4.4% for 2021 (excluding LULUCF), as well as a total uncertainty of 9.1% for the base year 1990 and of 7.9% for the year 2021 (including LULUCF). Further details can be found in the Annex 2.

Table 17: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 1990 – excluding LULUCF.

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	5.0	50.0	50.2	0.04	0.00
1.A Stationary Combustion – Biomass	CO_2	5.0	1.0	5.1	0.00	0.00
1.A Stationary Combustion – Biomass	N_2O	5.0	50.0	50.2	0.00	0.01
1.A Stationary Combustion – Gaseous Fuels	CH_4	2.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	2.0	0.2	2.0	0.08	0.37
1.A Stationary Combustion – Gaseous Fuels	N_2O	2.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH_4	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO_2	0.5	0.5	0.7	0.02	0.01
1.A Stationary Combustion – Liquid Fuels	N_2O	0.5	50.0	50.0	0.01	0.00
1.A Stationary Combustion – Other fuels	CH_4	10.0	50.0	51.0	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	10.0	15.0	18.0	0.02	0.20
1.A Stationary Combustion – Other fuels	N_2O	10.0	50.0	51.0	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH_4	0.5	50.0	50.0	0.02	0.02
1.A Stationary Combustion – Solid Fuels	CO_2	0.5	0.5	0.7	0.01	0.00
1.A Stationary Combustion – Solid Fuels	N_2O	0.5	50.0	50.0	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH_4	3.0	30.0	30.1	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.A.3.a Transport – Civil Aviation	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.a Transport – Civil Aviation	N_2O	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO_2	3.0	3.0	4.2	0.08	1.01
1.A.3.b Transport – Road Transportation – Diesel	N_2O	3.0	30.0	30.1	0.00	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	3.0	3.0	4.2	0.18	0.07
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	3.0	70.0	70.1	0.01	0.00
1.A.3.b Transport – Road Transportation – LPG	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH_4	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N_2O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH_4	5.0	50.0	50.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO_2	5.0	30.0	30.4	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N_2O	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	5.0	70.0	70.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	5.0	50.0	50.2	0.00	0.00
1.A.3.c Transport – Railways	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.c Transport – Railways	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.c Transport – Railways	N_2O	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.d Transport – Navigation	N_2O	3.0	70.0	70.1	0.00	0.00
1.A.3.e Transport – Other Transportation	CH_4	2.0	50.0	50.0	0.00	0.00
1.A.3.e Transport – Other Transportation	CO_2	2.0	0.2	2.0	0.00	0.00
1.A.3.e Transport – Other Transportation	N_2O	2.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CH_4	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CO_2	1.0	0.5	1.1	0.00	0.00
1.A.5.b Mobile	N_2O	1.0	50.0	50.0	0.00	0.00
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	5.0	50.0	50.2	0.06	0.05
1.B.2.a Fugitive Emission – Oil	CH_4	0.5	50.0	50.0	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO_2	0.5	0.5	0.7	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH_4	5.0	10.0	11.2	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO_2	5.0	0.2	5.0	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO_2	5.0	2.0	5.4	0.02	0.03
2.A.2 Mineral Industry – Lime Production	CO_2	20.0	5.0	20.6	0.01	0.06
2.A.3 Mineral Industry – Glass Production	CO_2	10.0	1.0	10.0	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	2.0	5.0	5.4	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	10.0	5.0	11.2	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	2.0	5.0	5.4	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO_2	20.0	2.0	20.1	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH_4	2.0	5.0	5.4	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO_2	2.0	5.0	5.4	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	2.0	5.0	5.4	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	2.0	5.0	5.4	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
2.B.5 Chemical Industry – Carbide Production	CO_2	5.0	10.0	11.2	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	10.0	10.0	14.1	0.00	0.00
2.B.10 Chemical Industry – Other	CH_4	2.0	5.0	5.4	0.00	0.00
2.B.10 Chemical Industry – Other	CO_2	2.0	5.0	5.4	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO_2	0.5	0.5	0.7	0.00	0.01
2.C.1 Metal Industry – Iron and Steel Production	CH_4	0.5	0.0	0.5	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO_2	5.0	25.0	25.5	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO_2	2.0	0.5	2.1	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	2.0	50.0	50.0	0.43	0.41
2.C.3 Metal Industry – Aluminium Production	SF_6	2.0	50.0	50.0	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF_6	5.0	5.0	7.1	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO_2	10.0	50.0	51.0	0.00	0.00
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	20.0	30.0	36.1	0.03	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	SF_6	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	NF_3	5.0	10.0	11.2	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	51.0	0.00	0.88
2.F.2 Foam Blowing	HFC	10.0	0.0	10.0	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.5	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.4	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.0	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.1	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	25.0	50.0	55.9	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	25.0	50.0	55.9	0.01	0.03
2.G. Other Product Manufacture and Use	N_2O	20.0	0.0	20.0	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH_4	10.0	20.0	22.4	1.89	0.54
3.A.2 Enteric Fermentation – Sheep	CH_4	10.0	40.0	41.2	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH_4	10.0	20.0	22.4	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH_4	10.0	40.0	41.2	0.00	0.00
3.B.1.1 Manure Management – Cattle	CH_4	10.0	20.0	22.4	0.02	0.01
3.B.1.1 Manure Management – Cattle	N_2O	10.0	100.0	100.5	0.14	0.00
3.B.1.2 Manure Management – Sheep	CH_4	10.0	30.0	31.6	0.00	0.00
3.B.1.2 Manure Management – Sheep	N_2O	10.0	100.0	100.5	0.00	0.00
3.B.1.3 Manure Management – Swine	CH_4	10.0	20.0	22.4	0.00	0.00
3.B.1.3 Manure Management – Swine	N_2O	10.0	100.0	100.5	0.02	0.00
3.B.1.4. Manure Management – Other	CH_4	10.0	30.0	31.6	0.00	0.00
3.B.1.4. Manure Management – Other	N_2O	10.0	100.0	100.5	0.00	0.00
3.B.2.5 Indirect N_2O Emissions	N_2O	5.0	200.0	200.1	0.07	0.00
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	5.0	200.0	200.1	20.21	0.39
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	5.0	200.0	200.1	0.74	0.02
3.F Field Burning of Agricultural Residues	CH_4	100.0	40.0	107.7	0.00	0.00
3.F Field Burning of Agricultural Residues	N_2O	100.0	50.0	111.8	0.00	0.00
3.G Liming	CO_2	5.0	50.0	50.2	0.00	0.00
3.H Urea application	CO_2	5.0	50.0	50.2	0.00	0.00
3.I Other	CO_2	5.0	50.0	50.2	0.00	0.00
5.A Solid Waste Disposal	CH_4	12.0	25.0	27.7	2.05	1.01
5.B Biological Treatment of Solid Waste	CH_4	20.0	50.0	53.9	0.00	0.00
5.B Biological Treatment of Solid Waste	N_2O	20.0	50.0	53.9	0.00	0.00
5.C Incineration and Open Burning of Waste	CH_4	7.0	0.0	7.0	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
5.C Incineration and Open Burning of Waste	CO_2	7.0	20.0	21.2	0.00	0.00
5.C Incineration and Open Burning of Waste	N_2O	7.0	0.0	7.0	0.00	0.00
5.D Waste Water Treatment and Discharge	CH_4	20.0	50.0	53.9	0.01	0.00
5.D Waste Water Treatment and Discharge	N_2O	20.0	100.0	102.0	0.01	0.01
Total					**26.18**	**5.19**
Total Uncertainties				**Uncertainty in total inventory %:**	**5.12**	**2.28**

Table 18: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 2021 – excluding LULUCF.

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	5.0	50.0	50.2	0.05	0.00
1.A Stationary Combustion – Biomass	CO_2	5.0	1.0	5.1	0.00	0.00
1.A Stationary Combustion – Biomass	N_2O	5.0	50.0	50.2	0.02	0.01
1.A Stationary Combustion – Gaseous Fuels	CH_4	1.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	1.0	0.2	1.0	0.05	0.09
1.A Stationary Combustion – Gaseous Fuels	N_2O	1.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH_4	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO_2	0.5	0.5	0.7	0.01	0.01
1.A Stationary Combustion – Liquid Fuels	N_2O	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Other fuels	CH_4	5.0	50.0	50.2	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	5.0	15.0	15.8	0.17	0.11
1.A Stationary Combustion – Other fuels	N_2O	5.0	50.0	50.2	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH_4	0.5	50.0	50.0	0.00	0.02
1.A Stationary Combustion – Solid Fuels	CO_2	0.5	0.5	0.7	0.00	0.00
1.A Stationary Combustion – Solid Fuels	N_2O	0.5	50.0	50.0	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.a Transport – Civil Aviation	N_2O	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO_2	3.0	3.0	4.2	0.85	1.01
1.A.3.b Transport – Road Transportation – Diesel	N_2O	3.0	30.0	30.1	0.01	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	3.0	3.0	4.2	0.05	0.07
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	3.0	70.0	70.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH_4	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N_2O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH_4	5.0	50.0	50.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO_2	5.0	30.0	30.4	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.A.3.b Transport – Road Transportation – Biomass	N_2O	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	5.0	70.0	70.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	5.0	50.0	50.2	0.00	0.00
1.A.3.c Transport – Railways	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.c Transport – Railways	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.c Transport – Railways	N_2O	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CH_4	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CO_2	3.0	3.0	4.2	0.00	0.00
1.A.3.d Transport – Navigation	N_2O	3.0	70.0	70.1	0.00	0.00
1.A.3.e Transport – Other Transportation	CH_4	1.0	50.0	50.0	0.00	0.00
1.A.3.e Transport – Other Transportation	CO_2	1.0	0.2	1.0	0.00	0.00
1.A.3.e Transport – Other Transportation	N_2O	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CH_4	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CO_2	1.0	0.5	1.1	0.00	0.00
1.A.5.b Mobile	N_2O	1.0	50.0	50.0	0.00	0.00
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	5.0	50.0	50.2	0.00	0.05
1.B.2.a Fugitive Emission – Oil	CH_4	0.5	50.0	50.0	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO_2	0.5	0.5	0.7	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH_4	5.0	10.0	11.2	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO_2	5.0	0.2	5.0	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO_2	1.1	2.0	2.3	0.00	0.00
2.A.2 Mineral Industry – Lime Production	CO_2	1.6	5.0	5.2	0.00	0.00
2.A.3 Mineral Industry – Glass Production	CO_2	10.0	1.0	10.0	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	2.0	5.0	5.4	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	10.0	5.0	11.2	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	2.0	5.0	5.4	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO_2	20.0	2.0	20.1	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH_4	2.0	5.0	5.4	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO_2	2.0	5.0	5.4	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	2.0	5.0	5.4	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	2.0	5.0	5.4	0.00	0.00
2.B.5 Chemical Industry – Carbide Production	CO_2	5.0	10.0	11.2	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	10.0	10.0	14.1	0.00	0.00
2.B.10 Chemical Industry – Other	CH_4	2.0	5.0	5.4	0.00	0.00
2.B.10 Chemical Industry – Other	CO_2	2.0	5.0	5.4	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO_2	0.5	0.5	0.7	0.01	0.01
2.C.1 Metal Industry – Iron and Steel Production	CH_4	0.5	0.0	0.5	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO_2	5.0	25.0	25.5	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO_2	2.0	0.5	2.1	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	2.0	50.0	50.0	0.00	0.41
2.C.3 Metal Industry – Aluminium Production	SF_6	2.0	50.0	50.0	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF_6	5.0	5.0	7.1	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO_2	10.0	50.0	51.0	0.00	0.00
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	20.0	30.0	36.1	0.01	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.2	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
2.E Electronics Industry	PFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	SF_6	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	NF_3	5.0	10.0	11.2	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	51.0	0.89	0.88
2.F.2 Foam Blowing	HFC	10.0	0.0	10.0	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.5	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.4	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.0	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.1	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	25.0	50.0	55.9	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	25.0	50.0	55.9	0.05	0.03
2.G. Other Product Manufacture and Use	N_2O	20.0	0.0	20.0	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH_4	1.0	20.0	20.0	1.03	0.05
3.A.2 Enteric Fermentation – Sheep	CH_4	10.0	40.0	41.2	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH_4	4.0	20.0	20.4	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH_4	10.0	40.0	41.2	0.00	0.00
3.B.1.1 Manure Management – Cattle	CH_4	1.0	20.0	20.0	0.02	0.00
3.B.1.1 Manure Management – Cattle	N_2O	1.0	100.0	100.0	0.13	0.00
3.B.1.2 Manure Management – Sheep	CH_4	10.0	30.0	31.6	0.00	0.00
3.B.1.2 Manure Management – Sheep	N_2O	10.0	100.0	100.5	0.00	0.00
3.B.1.3 Manure Management – Swine	CH_4	4.0	20.0	20.4	0.00	0.00
3.B.1.3 Manure Management – Swine	N_2O	4.0	100.0	100.1	0.01	0.00
3.B.1.4. Manure Management – Other	CH_4	10.0	30.0	31.6	0.00	0.00
3.B.1.4. Manure Management – Other	N_2O	10.0	100.0	100.5	0.00	0.00
3.B.2.5 Indirect N_2O Emissions	N_2O	5.0	200.0	200.1	0.08	0.00
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	5.0	200.0	200.1	14.97	0.39
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	5.0	200.0	200.1	0.55	0.02
3.F Field Burning of Agricultural Residues	CH_4	100.0	40.0	107.7	0.00	0.00
3.F Field Burning of Agricultural Residues	N_2O	100.0	50.0	111.8	0.00	0.00
3.G Liming	CO_2	5.0	50.0	50.2	0.00	0.00
3.H Urea application	CO_2	5.0	50.0	50.2	0.00	0.00
3.I Other	CO_2	5.0	50.0	50.2	0.00	0.00
5.A Solid Waste Disposal	CH_4	12.0	25.0	27.7	0.10	1.01
5.B Biological Treatment of Solid Waste	CH_4	20.0	50.0	53.9	0.00	0.00
5.B Biological Treatment of Solid Waste	N_2O	20.0	50.0	53.9	0.00	0.00
5.C Incineration and Open Burning of Waste	CH_4	7.0	0.0	7.0	0.00	0.00
5.C Incineration and Open Burning of Waste	CO_2	7.0	20.0	21.2	0.00	0.00
5.C Incineration and Open Burning of Waste	N_2O	7.0	0.0	7.0	0.00	0.00
5.D Waste Water Treatment and Discharge	CH_4	20.0	50.0	53.9	0.00	0.00
5.D Waste Water Treatment and Discharge	N_2O	20.0	100.0	102.0	0.04	0.01
Total					**19.10**	**4.23**
Total Uncertainties				**Uncertainty in total inventory %:**	**4.37**	**2.06**

Table 19: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 1990 – including LULUCF.

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	5.0	50.0	50.25	0.05	0.00
1.A Stationary Combustion – Biomass	CO_2	5.0	1.0	5.10	0.00	0.00
1.A Stationary Combustion – Biomass	N_2O	5.0	50.0	50.25	0.00	0.01
1.A Stationary Combustion – Gaseous Fuels	CH_4	2.0	50.0	50.04	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	2.0	0.2	2.01	0.11	0.51
1.A Stationary Combustion – Gaseous Fuels	N_2O	2.0	50.0	50.04	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH_4	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO_2	0.5	0.5	0.71	0.02	0.01
1.A Stationary Combustion – Liquid Fuels	N_2O	0.5	50.0	50.00	0.01	0.00
1.A Stationary Combustion – Other fuels	CH_4	10.0	50.0	50.99	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	10.0	15.0	18.03	0.02	0.28
1.A Stationary Combustion – Other fuels	N_2O	10.0	50.0	50.99	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH_4	0.5	50.0	50.00	0.03	0.03
1.A Stationary Combustion – Solid Fuels	CO_2	0.5	0.5	0.71	0.01	0.01
1.A Stationary Combustion – Solid Fuels	N_2O	0.5	50.0	50.00	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.a Transport – Civil Aviation	N_2O	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO_2	3.0	3.0	4.24	0.12	1.41
1.A.3.b Transport – Road Transportation – Diesel	N_2O	3.0	30.0	30.15	0.00	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	3.0	3.0	4.24	0.25	0.10
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	3.0	70.0	70.06	0.01	0.01
1.A.3.b Transport – Road Transportation – LPG	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH_4	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N_2O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH_4	5.0	50.0	50.25	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO_2	5.0	30.0	30.41	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N_2O	5.0	3.0	5.83	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	5.0	70.0	70.18	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	5.0	3.0	5.83	0.00	1.30
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	5.0	50.0	50.25	0.00	0.00
1.A.3.c Transport – Railways	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.c Transport – Railways	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.c Transport – Railways	N_2O	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport – Navigation	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport – Navigation	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.d Transport – Navigation	N_2O	3.0	70.0	70.06	0.00	0.00
1.A.3.e Transport – Other Transportation	CH_4	2.0	50.0	50.04	0.00	0.00
1.A.3.e Transport – Other Transportation	CO_2	2.0	0.2	2.01	0.00	0.00
1.A.3.e Transport – Other Transportation	N_2O	2.0	50.0	50.04	0.00	0.00
1.A.5.b Mobile	CH_4	1.0	50.0	50.01	0.00	0.00
1.A.5.b Mobile	CO_2	1.0	0.5	1.12	0.00	0.00
1.A.5.b Mobile	N_2O	1.0	50.0	50.01	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	5.0	50.0	50.25	0.08	0.08
1.B.2.a Fugitive Emission – Oil	CH_4	0.5	50.0	50.00	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO_2	0.5	0.5	0.71	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH_4	5.0	10.0	11.18	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO_2	5.0	0.2	5.00	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO_2	5.0	2.0	5.39	0.03	0.04
2.A.2 Mineral Industry – Lime Production	CO_2	20.0	5.0	20.62	0.02	0.08
2.A.3 Mineral Industry – Glass Production	CO_2	10.0	1.0	10.05	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	2.0	5.0	5.39	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	10.0	5.0	11.18	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	2.0	5.0	5.39	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO_2	20.0	2.0	20.10	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH_4	2.0	5.0	5.39	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO_2	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	2.0	5.0	5.39	0.00	0.00
2.B.5 Chemical Industry – Carbide Production	CO_2	5.0	10.0	11.18	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	10.0	10.0	14.14	0.00	0.00
2.B.10 Chemical Industry – Other	CH_4	2.0	5.0	5.39	0.00	0.00
2.B.10 Chemical Industry – Other	CO_2	2.0	5.0	5.39	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO_2	0.5	0.5	0.71	0.01	0.01
2.C.1 Metal Industry – Iron and Steel Production	CH_4	0.5	0.0	0.50	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO_2	5.0	25.0	25.50	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO_2	2.0	0.5	2.06	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	2.0	50.0	50.04	0.60	0.60
2.C.3 Metal Industry – Aluminium Production	SF_6	2.0	50.0	50.04	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF_6	5.0	5.0	7.07	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO_2	10.0	50.0	50.99	0.00	0.00
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	20.0	30.0	36.06	0.04	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	SF_6	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	NF_3	5.0	10.0	11.18	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	50.99	0.00	1.24
2.F.2 Foam Blowing	HFC	10.0	0.0	10.00	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.50	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.36	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.00	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.12	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	25.0	50.0	55.90	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	25.0	50.0	55.90	0.01	0.04
2.G. Other Product Manufacture and Use	N_2O	20.0	0.0	20.00	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH_4	10.0	20.0	22.36	2.64	0.77
3.A.2 Enteric Fermentation – Sheep	CH_4	10.0	40.0	41.23	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH_4	10.0	20.0	22.36	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH_4	10.0	40.0	41.23	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
3.B.1.1 Manure Management – Cattle	CH_4	10.0	20.0	22.36	0.02	0.01
3.B.1.1 Manure Management – Cattle	N_2O	10.0	100.0	100.50	0.20	0.00
3.B.1.2 Manure Management – Sheep	CH_4	10.0	30.0	31.62	0.00	0.00
3.B.1.2 Manure Management – Sheep	N_2O	10.0	100.0	100.50	0.00	0.00
3.B.1.3 Manure Management – Swine	CH_4	10.0	20.0	22.36	0.00	0.00
3.B.1.3 Manure Management – Swine	N_2O	10.0	100.0	100.50	0.02	0.00
3.B.1.4. Manure Management – Other	CH_4	10.0	30.0	31.62	0.00	0.00
3.B.1.4. Manure Management – Other	N_2O	10.0	100.0	100.50	0.00	0.00
3.B.2.5 Indirect N_2O Emissions	N_2O	5.0	200.0	200.06	0.09	0.00
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	5.0	200.0	200.06	28.27	0.75
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	5.0	200.0	200.06	1.04	0.03
3.F Field Burning of Agricultural Residues	CH_4	100.0	40.0	107.70	0.00	0.00
3.F Field Burning of Agricultural Residues	N_2O	100.0	50.0	111.80	0.00	0.00
3.G Liming	CO_2	5.0	50.0	50.25	0.00	0.00
3.H Urea application	CO_2	5.0	50.0	50.25	0.00	0.00
3.I Other	CO_2	5.0	50.0	50.25	0.00	0.00
5.A Solid Waste Disposal	CH_4			220.45	0.01	0.00
4 Total land use categories	CH_4			109.46	0.03	0.00
4 Total land use categories	N_2O			50.42	37.54	0.00
4.A.1 Forest land remaining forest land	CO_2			35.74	2.50	0.00
4.A.2 Land converted to forest land	CO_2			229.02	0.00	0.00
4.B.1 Cropland remaining cropland	CO_2			59.21	0.03	0.00
4.B.2 Land converted to cropland	CO_2			230.53	1.03	0.00
4.C.1 Grassland remaining grassland	CO_2			52.65	0.09	0.00
4.C.2 Land converted to grassland	CO_2			42.65	0.00	0.00
4.D.1 Wetlands remaining Wetlands	CO_2			42.65	0.00	0.00
4.D.2 Land converted to Wetlands	CO_2			34.01	0.05	0.00
4.E.2 Land converted to Settlements	CO_2			76.88	0.33	0.00
4.F.2 Land converted to Other land	CO_2			49.00	5.24	0.00
4.G HWP	CO_2	12.0	25.0	27.73	2.87	1.50
5.B Biological Treatment of Solid Waste	CH_4	20.0	50.0	53.85	0.00	0.00
5.B Biological Treatment of Solid Waste	N_2O	20.0	50.0	53.85	0.00	0.00
5.C Incineration and Open Burning of Waste	CH_4	7.0	0.0	7.00	0.00	0.00
5.C Incineration and Open Burning of Waste	CO_2	7.0	20.0	21.19	0.00	0.00
5.C Incineration and Open Burning of Waste	N_2O	7.0	0.0	7.00	0.00	0.00
5.D Waste Water Treatment and Discharge	CH_4	20.0	50.0	53.85	0.01	0.01
5.D Waste Water Treatment and Discharge	N_2O	20.0	100.0	101.98	0.02	0.01
Total					**83.48**	**8.89**
Total Uncertainties				**Uncertainty in total inventory %:**	**9.14**	**2.98**

Table 20: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 2021 – including LULUCF.

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	5.0	50.0	50.25	0.06	0.00
1.A Stationary Combustion – Biomass	CO_2	5.0	1.0	5.10	0.00	0.00
1.A Stationary Combustion – Biomass	N_2O	5.0	50.0	50.25	0.02	0.01
1.A Stationary Combustion – Gaseous Fuels	CH_4	1.0	50.0	50.01	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	1.0	0.2	1.02	0.07	0.13
1.A Stationary Combustion – Gaseous Fuels	N_2O	1.0	50.0	50.01	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH_4	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO_2	0.5	0.5	0.71	0.01	0.01
1.A Stationary Combustion – Liquid Fuels	N_2O	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion – Other fuels	CH_4	5.0	50.0	50.25	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	5.0	15.0	15.81	0.22	0.15
1.A Stationary Combustion – Other fuels	N_2O	5.0	50.0	50.25	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH_4	0.5	50.0	50.00	0.00	0.03
1.A Stationary Combustion – Solid Fuels	CO_2	0.5	0.5	0.71	0.00	0.01
1.A Stationary Combustion – Solid Fuels	N_2O	0.5	50.0	50.00	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.a Transport – Civil Aviation	N_2O	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO_2	3.0	3.0	4.24	1.13	1.41
1.A.3.b Transport – Road Transportation – Diesel	N_2O	3.0	30.0	30.15	0.01	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	3.0	3.0	4.24	0.07	0.10
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	3.0	70.0	70.06	0.00	0.01
1.A.3.b Transport – Road Transportation – LPG	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH_4	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N_2O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH_4	5.0	50.0	50.25	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO_2	5.0	30.0	30.41	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N_2O	5.0	3.0	5.83	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	5.0	70.0	70.18	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	5.0	3.0	5.83	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	5.0	50.0	50.25	0.00	0.00
1.A.3.c Transport – Railways	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.c Transport – Railways	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.c Transport – Railways	N_2O	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport – Navigation	CH_4	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport – Navigation	CO_2	3.0	3.0	4.24	0.00	0.00
1.A.3.d Transport – Navigation	N_2O	3.0	70.0	70.06	0.00	0.00
1.A.3.e Transport – Other Transportation	CH_4	1.0	50.0	50.01	0.00	0.00
1.A.3.e Transport – Other Transportation	CO_2	1.0	0.2	1.02	0.00	0.00
1.A.3.e Transport – Other Transportation	N_2O	1.0	50.0	50.01	0.00	0.00
1.A.5.b Mobile	CH_4	1.0	50.0	50.01	0.00	0.00
1.A.5.b Mobile	CO_2	1.0	0.5	1.12	0.00	0.00
1.A.5.b Mobile	N_2O	1.0	50.0	50.01	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	5.0	50.0	50.25	0.00	0.08
1.B.2.a Fugitive Emission – Oil	CH_4	0.5	50.0	50.00	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO_2	0.5	0.5	0.71	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH_4	5.0	10.0	11.18	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO_2	5.0	0.2	5.00	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO_2	1.1	2.0	2.28	0.00	0.00
2.A.2 Mineral Industry – Lime Production	CO_2	1.6	5.0	5.25	0.00	0.00
2.A.3 Mineral Industry – Glass Production	CO_2	10.0	1.0	10.05	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	2.0	5.0	5.39	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	10.0	5.0	11.18	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	2.0	5.0	5.39	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO_2	20.0	2.0	20.10	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH_4	2.0	5.0	5.39	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO_2	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	2.0	5.0	5.39	0.00	0.00
2.B.5 Chemical Industry – Carbide Production	CO_2	5.0	10.0	11.18	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	10.0	10.0	14.14	0.00	0.00
2.B.10 Chemical Industry – Other	CH_4	2.0	5.0	5.39	0.00	0.00
2.B.10 Chemical Industry – Other	CO_2	2.0	5.0	5.39	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO_2	0.5	0.5	0.71	0.01	0.01
2.C.1 Metal Industry – Iron and Steel Production	CH_4	0.5	0.0	0.50	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO_2	5.0	25.0	25.50	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO_2	2.0	0.5	2.06	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	2.0	50.0	50.04	0.00	0.60
2.C.3 Metal Industry – Aluminium Production	SF_6	2.0	50.0	50.04	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF_6	5.0	5.0	7.07	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO_2	10.0	50.0	50.99	0.00	0.00
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	20.0	30.0	36.06	0.01	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	SF_6	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	NF_3	5.0	10.0	11.18	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	50.99	1.18	1.24
2.F.2 Foam Blowing	HFC	10.0	0.0	10.00	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.50	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.36	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.00	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.12	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	25.0	50.0	55.90	0.00	0.00
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	25.0	50.0	55.90	0.06	0.04
2.G. Other Product Manufacture and Use	N_2O	20.0	0.0	20.00	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH_4	1.0	20.0	20.02	1.38	0.09
3.A.2 Enteric Fermentation – Sheep	CH_4	10.0	40.0	41.23	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH_4	4.0	20.0	20.40	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH_4	10.0	40.0	41.23	0.00	0.00

IPCC category/Group	GHG	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		%	%	%		%
		input data Note A	input data Note A			K^2 + L^2
3.B.1.1 Manure Management – Cattle	CH_4	1.0	20.0	20.02	0.02	0.00
3.B.1.1 Manure Management – Cattle	N_2O	1.0	100.0	100.00	0.17	0.00
3.B.1.2 Manure Management – Sheep	CH_4	10.0	30.0	31.62	0.00	0.00
3.B.1.2 Manure Management – Sheep	N_2O	10.0	100.0	100.50	0.00	0.00
3.B.1.3 Manure Management – Swine	CH_4	4.0	20.0	20.40	0.00	0.00
3.B.1.3 Manure Management – Swine	N_2O	4.0	100.0	100.08	0.01	0.00
3.B.1.4. Manure Management – Other	CH_4	10.0	30.0	31.62	0.00	0.00
3.B.1.4. Manure Management – Other	N_2O	10.0	100.0	100.50	0.00	0.00
3.B.2.5 Indirect N_2O Emissions	N_2O	5.0	200.0	200.06	0.11	0.00
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	5.0	200.0	200.06	19.97	0.75
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	5.0	200.0	200.06	0.73	0.03
3.F Field Burning of Agricultural Residues	CH_4	100.0	40.0	107.70	0.00	0.00
3.F Field Burning of Agricultural Residues	N_2O	100.0	50.0	111.80	0.00	0.00
3.G Liming	CO_2	5.0	50.0	50.25	0.01	0.00
3.H Urea application	CO_2	5.0	50.0	50.25	0.00	0.00
3.I Other	CO_2	5.0	50.0	50.25	0.00	0.00
5.A Solid Waste Disposal	CH_4			218.82	0.01	0.00
4 Total land use categories	CH_4			121.48	0.04	0.00
4 Total land use categories	N_2O			38.77	26.64	0.00
4.A.1 Forest land remaining forest land	CO_2			113.34	5.89	0.00
4.A.2 Land converted to forest land	CO_2			55.88	0.00	0.00
4.B.1 Cropland remaining cropland	CO_2			50.80	0.03	0.00
4.B.2 Land converted to cropland	CO_2			228.90	1.02	0.00
4.C.1 Grassland remaining grassland	CO_2			166.99	0.12	0.00
4.C.2 Land converted to grassland	CO_2			63.59	0.00	0.00
4.D.1 Wetlands remaining Wetlands	CO_2			63.59	0.01	0.00
4.D.2 Land converted to Wetlands	CO_2			30.14	0.04	0.00
4.E.2 Land converted to Settlements	CO_2			123.14	0.89	0.00
4.F.2 Land converted to Other land	CO_2			48.99	1.90	0.00
4.G HWP	CO_2	12.0	25.0	27.73	0.13	1.50
5.B Biological Treatment of Solid Waste	CH_4	20.0	50.0	53.85	0.00	0.00
5.B Biological Treatment of Solid Waste	N_2O	20.0	50.0	53.85	0.00	0.00
5.C Incineration and Open Burning of Waste	CH_4	7.0	0.0	7.00	0.00	0.00
5.C Incineration and Open Burning of Waste	CO_2	7.0	20.0	21.19	0.00	0.00
5.C Incineration and Open Burning of Waste	N_2O	7.0	0.0	7.00	0.00	0.00
5.D Waste Water Treatment and Discharge	CH_4	20.0	50.0	53.85	0.00	0.01
5.D Waste Water Treatment and Discharge	N_2O	20.0	100.0	101.98	0.05	0.01
Total					**62.06**	**6.25**
Total Uncertainties				**Uncertainty in total inventory %:**	**7.88**	**2.50**

3 ENERGY (CRF SECTOR 1)

3.1 Sector Overview

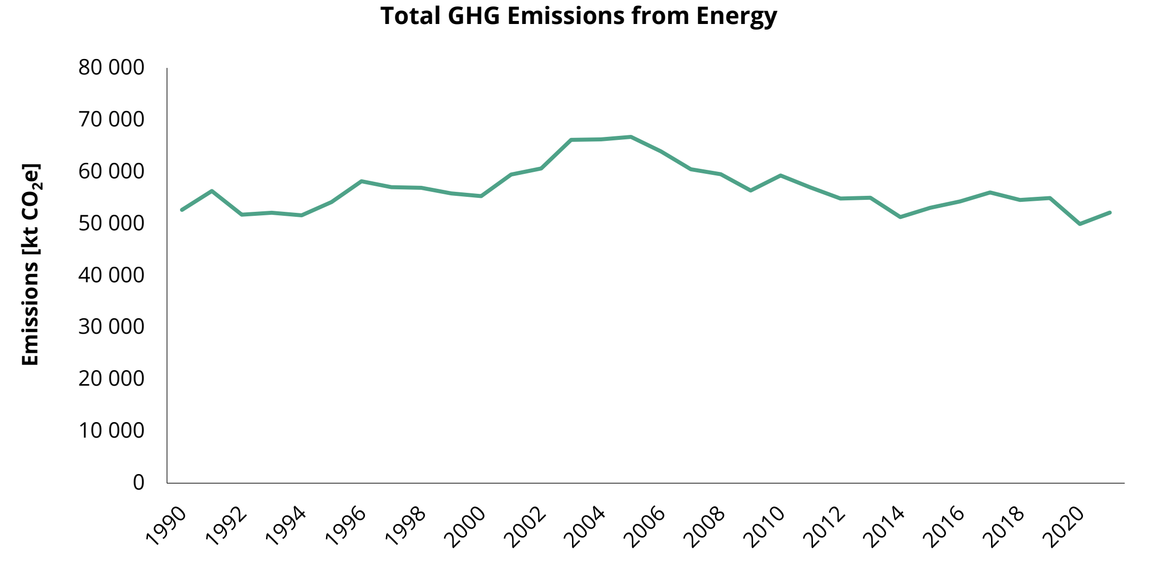
In the energy sector emissions originating from fuel combustion activities in road traffic, in the energy and manufacturing industry and in the commercial, agricultural and residential sector (Category *1.A*) as well as fugitive emissions from fuels (Category *1.B*) are considered. However, fugitive emissions make up only about 0.6% of total emissions from this sector.

Emissions from the energy sector are the main source of GHGs in Austria. In the year 2021, about 67.3% of national total GHGs emissions and 77.1% of national total CO_2 emissions from Austria arose from the energy sector.

Emission trends

Emissions from the energy sector decreased by 1% from 52.7 Mt CO_2 equivalents in 1990 to 52.1 Mt CO_2 equivalents in 2021, which is mainly caused by decreasing emissions from energy industries and the residential sector while emissions from the transport sector increased.

Figure 7: Trend of GHG emissions from 1990–2021 for energy.



Source: Umweltbundesamt

Total emissions from energy mainly consist of CO_2 whereas N_2O and CH_4 emissions only make up about 1.1% and 1.2%, respectively. The increase in N_2O emissions is primarily due the increasing activity of transport. The decrease of CH_4 emissions mainly occurs in the residential sector due to a shift to more efficient biomass heating and in category *1.B.1.a Coal Mining and Handling* due to the closure of coalmines. The strong increase in CO_2 emissions from 2002 to 2003 is primarily due to increased coal consumption of power plants. Between 2005 and 2021, CO_2 emissions decreased by 22.2%. Between 2020 and 2021, emissions from public electricity generation fell slightly and higher electricity generation from gas turbine power plants offset the closure of the last coal-fired power plant in operation. Emissions from road transport increased due to higher diesel and gasoline fuel sales. In the year 2021, emissions from households (*1.A.4.b.i*) increased by 11.2% due to higher heating demand (heating degree days were about 12.5% higher than in 2020).

Table 21: Emissions of greenhouse gases and their trend from 1990–2021 from category 1 Energy.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	kt CO_2 equivalent
1990	50 930	48.29	1.44	52 665
1991	54 637	43.62	1.57	56 275
1992	50 139	42.75	1.53	51 740
1993	50 549	40.38	1.54	52 087
1994	50 270	33.49	1.53	51 614
1995	52 777	34.46	1.59	54 162
1996	56 793	33.51	1.69	58 180
1997	55 724	31.02	1.67	57 035
1998	55 593	30.28	1.69	56 888
1999	54 506	30.35	1.72	55 811
2000	53 997	29.88	1.72	55 291
2001	58 126	30.42	1.81	59 457
2002	59 331	29.08	1.80	60 622
2003	64 831	28.76	1.87	66 130
2004	64 972	27.14	1.88	66 229
2005	65 475	25.79	1.95	66 715
2006	62 652	26.33	2.01	63 921
2007	59 225	25.96	2.02	60 488
2008	58 280	25.42	2.04	59 531
2009	55 155	25.35	1.99	56 392
2010	57 971	27.03	2.09	59 281
2011	55 701	25.69	2.08	56 971
2012	53 532	26.55	2.09	54 830
2013	53 708	26.29	2.12	55 005
2014	50 058	24.18	2.06	51 280
2015	51 827	24.28	2.10	53 064
2016	53 041	24.44	2.13	54 289
2017	54 706	25.79	2.16	56 001
2018	53 347	22.87	2.14	54 555
2019	53 746	22.20	2.15	54 937
2020	48 784	21.65	2.04	49 930
2021	50 933	22.96	2.14	52 142
1990–2021	**0.0%**	**-52.4%**	**48.0%**	**-1.0%**

The most important sub categories regarding total emissions in 1990 were Energy Industries (*1.A.1*), *Transport* (*1.A.3*) and *Other Sectors* (*1.A.4*), mainly residential space heating. GHG emissions from the residential sector decreased since 1990 because of a change in the fuel mix. A significant increase took place for the transport sector, which had a national total share of 28.6% in 2020 and 28.3% in 2021. The decrease in GHG emissions from *1.B fugitive emissions* from fuels is primarily due to the decrease in CH_4 emissions from coal mining.

Figure 8: GHG emissions [kt CO_2e] from 1990–2021 from Energy by sub categories.

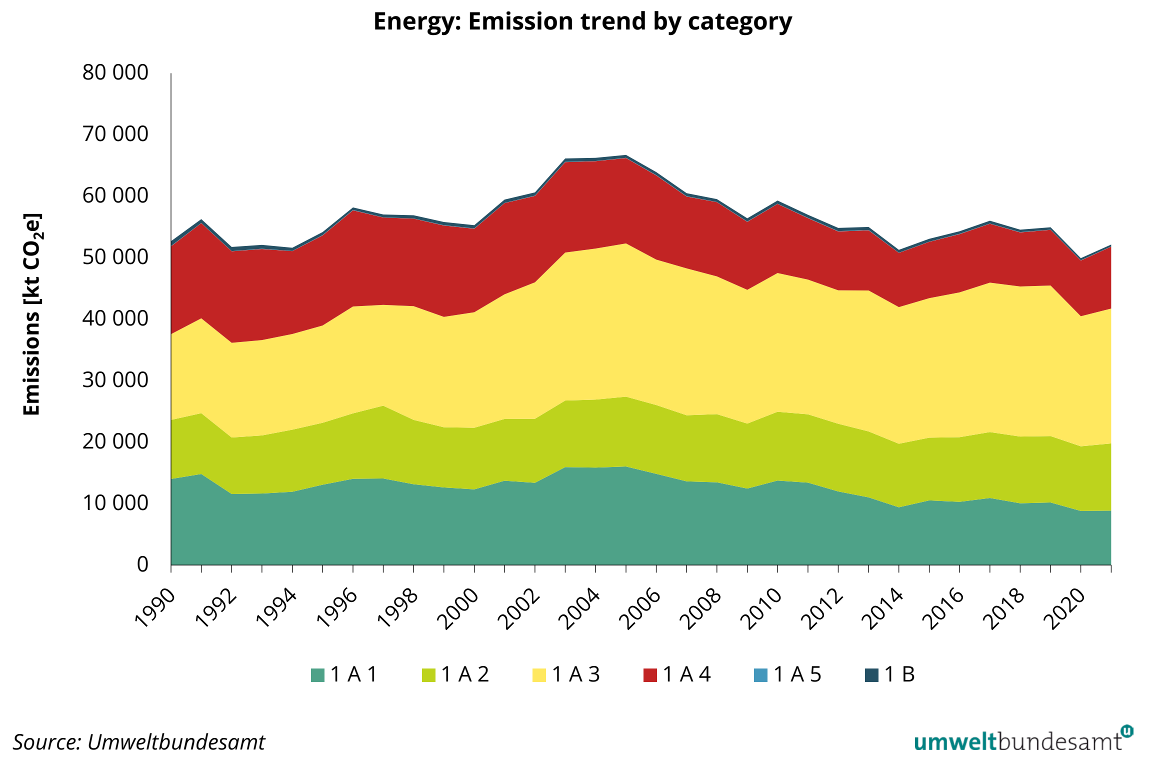


Table 22: GHG emissions [kt CO_2e] from 1990–2021 from Energy by sub categories.

	1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	1.B.1	1.B.2
1990	52 665	51 891	14 008	9 609	13 952	14 286	36	774	373	401
1991	56 275	55 650	14 796	9 914	15 429	15 473	38	624	203	421
1992	51 740	51 069	11 552	9 203	15 396	14 884	34	671	215	456
1993	52 087	51 450	11 626	9 456	15 523	14 805	40	637	184	453
1994	51 614	51 103	11 915	10 105	15 567	13 474	42	512	63	449
1995	54 162	53 657	13 059	10 065	15 847	14 653	33	505	41	463
1996	58 180	57 749	14 034	10 635	17 400	15 641	40	430	27	403
1997	57 035	56 560	14 080	11 829	16 411	14 203	38	474	28	447
1998	56 888	56 386	13 137	10 465	18 516	14 224	43	502	28	475
1999	55 811	55 276	12 634	9 765	17 980	14 853	42	536	28	508
2000	55 291	54 755	12 315	10 023	18 792	13 583	42	537	30	506
2001	59 457	58 902	13 705	10 050	20 286	14 819	42	555	29	525
2002	60 622	60 083	13 369	10 430	22 199	14 042	43	539	34	504
2003	66 130	65 575	15 916	10 848	24 055	14 712	43	555	28	527
2004	66 229	65 727	15 853	11 066	24 574	14 190	44	502	6	496
2005	66 715	66 244	16 026	11 361	24 928	13 884	44	471	0	470
2006	63 921	63 421	14 821	11 192	23 663	13 701	45	500	0	500
2007	60 488	59 982	13 622	10 748	23 887	11 680	46	506	0	506
2008	59 531	59 066	13 447	11 096	22 416	12 062	46	465	0	465
2009	56 392	55 878	12 437	10 568	21 759	11 069	45	513	0	513
2010	59 281	58 779	13 747	11 188	22 567	11 232	44	502	0	502
2011	56 971	56 476	13 409	11 098	21 916	10 010	43	495	0	495
2012	54 830	54 320	11 975	10 993	21 732	9 578	42	510	0	510
2013	55 005	54 500	11 006	10 733	22 911	9 809	41	505	0	505
2014	51 280	50 810	9 387	10 339	22 226	8 818	40	471	0	471
2015	53 064	52 608	10 502	10 204	22 702	9 161	39	456	0	456

	1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	1.B.1	1.B.2
2016	54 289	53 866	10 287	10 515	23 555	9 471	38	423	0	423
2017	56 001	55 539	10 903	10 722	24 305	9 572	37	462	0	462
2018	54 555	54 155	10 054	10 833	24 422	8 810	36	400	0	400
2019	54 937	54 563	10 170	10 818	24 472	9 069	35	374	0	374
2020	49 930	49 575	8 800	10 522	21 156	9 064	34	355	0	355
2021	52 142	51 811	8 855	10 923	21 932	10 070	30	331	0	331
1990–2021	**-1.0%**	**-0.2%**	**-36.8%**	**13.7%**	**57.2%**	**-29.5%**	**-15.3%**	**-57.2%**	**-100.0%**	**-17.3%**

3.2 Fuel Combustion Activities (Category 1.A)

This chapter gives an overview of emissions and key sources of fuel combustion activities. It includes information on completeness, QA/QC, uncertainty, recalculations and planned improvements as well as on emissions, emission trends and methodologies applied (including emission factors). In addition, this chapter provides information on the sectoral/referential approach comparison and the feedstock/non-energy use of fuels.

3.2.1 Comparison of the Sectoral Approach with the Reference Approach

3.2.1.1 Comparison of CO_2 emissions

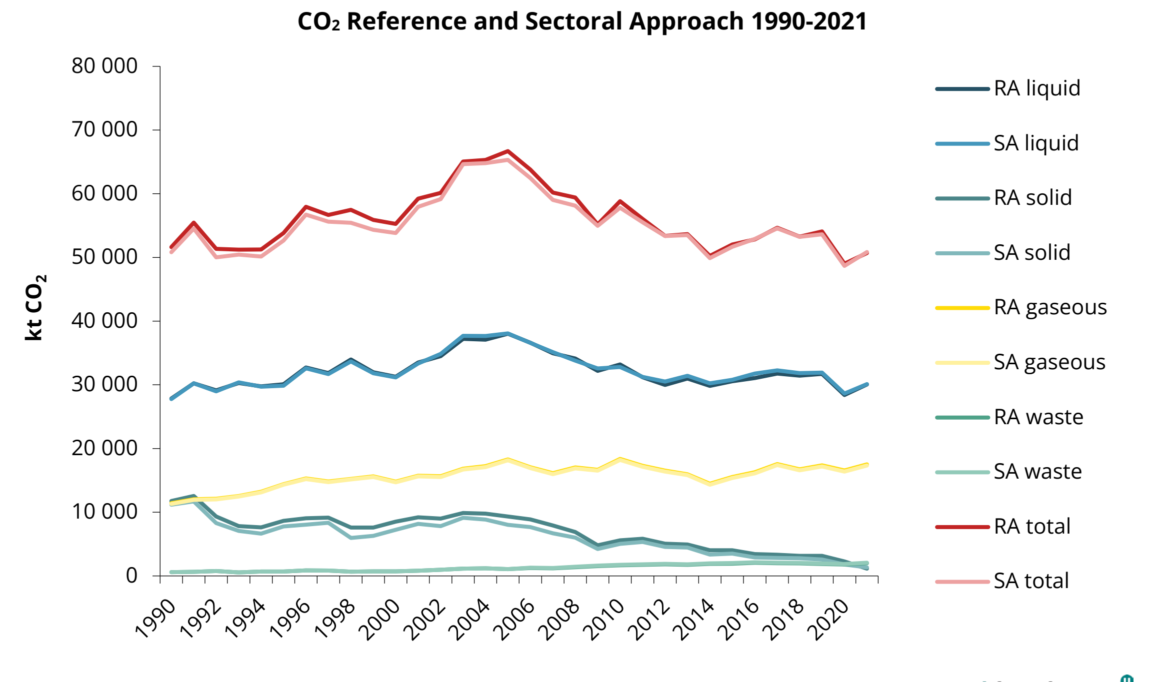
In the following, CO_2 emissions from the sectoral and reference approach are compared and explanations for the differences are provided.

The reference approach shows -0.3% lower CO_2 emissions in 2021 and a maximum of 3.64% higher emissions in 1998 (mainly due to solid fuels). The weighted average of differences for all years 1990 to 2021 shows that the reference approach is 1.4% higher than the sectoral approach. The weighted average for the more recent years 2010 to 2021 shows 0.5% higher CO_2 emissions from the reference approach (with a range of -0.31% to 1.79%).

Since submission 2021, the reference approach considers energy balance data of pure fossil diesel and gasoline while in previous submissions blended biofuels were included in those fuel data. Furthermore, double counting of coal tar in the reference approach is removed and some double counting of liquid fuels is removed in the sectoral approach. In addition, the carbon content of waste non-biomass fraction in the reference approach is harmonized with the sectoral approach.

The following figure shows the results for the two approaches for the period 1990–2021. Solid fuels show the most significant deviation (with a maximum in 1998).

Figure 9: CO_2 emissions of the Reference and Sectoral Approach 1990 to 2021.



Source: Umweltbundesamt

Table 23 presents CO_2 emissions of the sectoral and reference approach in tabular form.

Table 23: CO_2 emissions [kt] of sectoral and reference approach.

	Reference Approach					Sectoral Approach 1 A Fuel Combustion				
	Liquid	**Solid**	**Gaseous**	**Waste**	**Total**	**Liquid**	**Solid**	**Gaseous**	**Waste**	**Total**
1990	27 849	11 766	11 417	580	51 612	27 764	11 183	11 301	580	50 828
1991	30 224	12 550	12 044	643	55 462	30 238	11 703	11 940	643	54 525
1992	29 144	9 327	12 101	763	51 336	28 971	8 284	12 000	763	50 019
1993	30 286	7 828	12 545	551	51 210	30 377	7 056	12 453	551	50 437
1994	29 753	7 618	13 205	679	51 256	29 719	6 628	13 115	679	50 142
1995	30 081	8 653	14 404	690	53 829	29 862	7 779	14 317	690	52 649
1996	32 716	9 054	15 307	867	57 944	32 604	8 041	15 210	867	56 722
1997	31 849	9 155	14 815	838	56 657	31 704	8 341	14 720	838	55 604
1998	33 965	7 598	15 233	674	57 471	33 680	5 952	15 144	674	55 451
1999	31 978	7 584	15 615	708	55 886	31 824	6 280	15 522	708	54 335
2000	31 254	8 512	14 791	714	55 270	31 176	7 248	14 695	714	53 833
2001	33 492	9 194	15 738	806	59 230	33 337	8 168	15 632	806	57 943
2002	34 509	9 000	15 655	962	60 126	34 843	7 823	15 536	962	59 164
2003	37 213	9 866	16 832	1 133	65 044	37 695	9 124	16 694	1 133	64 647
2004	37 092	9 772	17 237	1 201	65 303	37 673	8 843	17 089	1 201	64 807
2005	38 023	9 318	18 293	1 059	66 693	38 072	8 013	18 156	1 073	65 315
2006	36 604	8 878	17 068	1 243	63 794	36 582	7 673	16 923	1 294	62 472
2007	34 955	7 925	16 123	1 184	60 187	35 123	6 690	15 986	1 240	59 040
2008	34 119	6 893	17 026	1 374	59 412	33 791	6 012	16 878	1 435	58 117
2009	32 194	4 800	16 667	1 539	55 200	32 572	4 236	16 523	1 618	54 950
2010	33 193	5 583	18 366	1 678	58 820	32 804	5 021	18 209	1 754	57 787
2011	31 185	5 828	17 288	1 738	56 039	31 231	5 331	17 144	1 815	55 521
2012	29 980	5 051	16 523	1 819	53 374	30 518	4 553	16 382	1 895	53 348
2013	30 998	4 938	15 954	1 757	53 647	31 414	4 450	15 821	1 832	53 517
2014	29 840	4 038	14 476	1 886	50 240	30 236	3 355	14 325	1 973	49 890
2015	30 564	4 018	15 523	1 919	52 024	30 786	3 497	15 369	2 011	51 665

	Reference Approach					Sectoral Approach 1 A Fuel Combustion				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
2016	31 068	3 428	16 278	2 066	52 840	31 762	2 893	16 112	2 143	52 910
2017	31 775	3 322	17 570	1 995	54 663	32 269	2 826	17 407	2 066	54 568
2018	31 432	3 140	16 720	1 964	53 255	31 832	2 779	16 569	2 041	53 220
2019	31 727	3 139	17 350	1 879	54 095	31 917	2 577	17 180	1 953	53 627
2020	28 402	2 260	16 547	1 806	49 015	28 624	1 799	16 382	1 869	48 674
2021	30 059	1 140	17 498	1 994	50 692	30 113	1 340	17 336	2 059	50 849

Table 24 presents the difference of CO_2 emissions in percent between reference and sectoral approach.

Table 24: Difference of CO_2 emissions by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	0.31%	5.21%	1.03%	0.00%	1.54%
1991	-0.05%	7.23%	0.87%	0.00%	1.72%
1992	0.60%	12.59%	0.84%	0.00%	2.63%
1993	-0.30%	10.94%	0.74%	0.00%	1.53%
1994	0.11%	14.93%	0.69%	0.00%	2.22%
1995	0.73%	11.23%	0.61%	0.00%	2.24%
1996	0.34%	12.59%	0.64%	0.00%	2.15%
1997	0.46%	9.75%	0.65%	0.00%	1.90%
1998	0.85%	27.66%	0.59%	0.00%	3.64%
1999	0.49%	20.76%	0.60%	0.00%	2.85%
2000	0.25%	17.44%	0.65%	0.00%	2.67%
2001	0.46%	12.57%	0.67%	0.00%	2.22%
2002	-0.96%	15.04%	0.77%	0.00%	1.63%
2003	-1.28%	8.13%	0.83%	0.00%	0.61%
2004	-1.54%	10.50%	0.87%	0.00%	0.77%
2005	-0.13%	16.28%	0.75%	-1.30%	2.11%
2006	0.06%	15.71%	0.86%	-3.87%	2.12%
2007	-0.48%	18.46%	0.86%	-4.52%	1.94%
2008	0.97%	14.65%	0.88%	-4.29%	2.23%
2009	-1.16%	13.30%	0.87%	-4.88%	0.45%
2010	1.19%	11.20%	0.86%	-4.33%	1.79%
2011	-0.15%	9.32%	0.84%	-4.23%	0.93%
2012	-1.76%	10.95%	0.86%	-3.99%	0.05%
2013	-1.32%	10.98%	0.84%	-4.09%	0.24%
2014	-1.31%	20.34%	1.05%	-4.43%	0.70%
2015	-0.72%	14.88%	1.00%	-4.58%	0.70%
2016	-2.18%	18.49%	1.03%	-3.60%	-0.13%
2017	-1.53%	17.57%	0.93%	-3.42%	0.17%
2018	-1.26%	12.99%	0.91%	-3.77%	0.07%
2019	-0.60%	21.79%	0.99%	-3.76%	0.87%
2020	-0.77%	25.59%	1.01%	-3.36%	0.70%
2021	-0.18%	-14.94%	0.93%	-3.17%	-0.31%

Positive numbers indicate that CO_2 emissions from the reference approach are higher than emissions from the sectoral approach.

Explanation of differences

- *Solid fuels:* In the sectoral approach plant specific CO_2 emission factors are used for large coal boilers since 2005
  According to the IPCC 2006 Guidelines, the total coal consumption from **integrated steel plants** except the use for coke production must be reported in category *2.C.1*. The methodology of calculating *2.C.1* emissions includes higher uncertainty, because year specific carbon

contents of the different fuel types are not available at the level of final use, and because total reported CO_2 emissions from integrated steel plants are calculated by means of an **input/output mass balance**. Thus, the emissions reported under *1.A.2.a* covers the uncertainty of the approach for *2.C.1*. E.g. in 2021 about 11 Mt of solid fuels CO_2 from integrated iron plants are considered in *2.C.1* and 1.5 Mt CO_2 are considered in *1.A.2.a*.

- *Liquid Fuels:* The energy balance is mass-balanced but not carbon balanced. Fuel category *Other Oil* is an aggregation of several fuel types and therefore it is difficult to quantify a reliable carbon emission factor for the reference approach. The reference approach takes a share of feedstocks used for plastics and solvent production as non-carbon stored. In the sectoral approach, emissions from plastics waste incineration are reported as "other fuels", but in the reference approach, it is included in "liquid fuels". Emissions from solvent use are included in category *2.D.3* under subcategory *Solvent Use*.
- *Gaseous fuels*: The small difference is due to the methodological uncertainty of subtracting emissions from Non-Energy Use used for chemical processes.
- *Other fuels:* The sectoral approach considers industrial waste with sector/plant specific carbon contents since the year 2005 while the methodology for the reference approach uses a single emission factor of 75 t CO_2/TJ. Furthermore, the activity data for the MSW non-biomass-fraction has been taken from the national energy balance while for the sectoral approach a different fraction has been chosen.

At current, it is not possible to quantify the amount of solvents and plastic products, which are imported or exported by products, bulk or waste.

- In the sectoral approach, sector- or even plant-specific net calorific values are taken to calculate the energy consumption, whereas in the reference approach, average (country specific) calorific values are applied.

3.2.1.2 Comparison of energy consumption

Table 25 shows the energy consumption of the two approaches. For the reference approach, non-energy consumption according to the energy balance is subtracted. The comparison shown in Table 25 is equal to CRF table 1.A(c). Please note that positive numbers indicate that the RA shows higher energy consumption than the SA.

Table 25: Energy consumption of sectoral and reference approach in [PJ].

Year	Reference Approach excluding non energy use and reductants					Sectoral Approach				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
1990	394.3	118.0	204.0	8.1	724.3	368.4	113.5	204.0	9.0	694.8
1991	429.4	126.2	215.5	9.0	780.1	400.8	118.9	215.5	10.1	745.3
1992	423.6	93.4	216.6	10.7	744.3	384.3	85.2	216.6	12.0	698.2
1993	434.6	78.1	224.8	8.3	745.8	400.8	72.7	224.8	9.8	708.1
1994	428.2	76.3	236.7	9.1	750.2	392.0	68.3	236.7	10.5	707.6
1995	430.2	87.3	258.8	9.4	785.8	393.9	79.9	258.4	10.9	743.1
1996	468.6	91.9	275.9	12.2	848.7	435.1	82.9	274.5	14.0	806.6
1997	463.1	93.6	265.7	11.3	833.7	422.8	86.3	265.7	13.1	787.9
1998	487.9	77.2	273.4	10.5	848.9	448.5	61.8	273.4	12.3	796.0
1999	460.7	75.6	280.2	9.8	826.3	424.1	64.1	280.2	11.6	780.0
2000	449.5	85.9	262.5	10.5	808.4	417.2	74.7	265.3	12.3	769.5
2001	481.8	93.5	282.2	12.6	870.1	447.1	84.0	282.2	14.5	827.7
2002	496.5	91.0	280.4	14.8	882.8	465.2	80.5	280.4	16.8	842.9

Year	Reference Approach excluding non energy use and reductants					Sectoral Approach				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
2003	532.5	99.8	301.1	17.1	950.6	502.9	94.1	301.3	19.4	917.8
2004	535.0	99.1	307.5	21.7	963.2	502.4	91.9	308.5	24.6	927.4
2005	538.2	92.9	325.2	16.7	972.9	508.7	84.9	327.7	19.5	940.8
2006	529.8	89.3	303.4	20.0	942.5	489.3	81.9	305.5	24.2	900.9
2007	509.5	80.4	286.5	19.4	895.9	470.5	71.8	288.6	23.3	854.2
2008	494.3	76.9	302.2	20.6	894.0	452.7	64.7	304.7	24.1	846.2
2009	468.1	55.5	294.3	22.1	839.9	436.2	45.4	298.3	27.5	807.4
2010	482.1	64.4	324.2	25.0	895.7	439.6	53.8	328.7	30.1	852.1
2011	452.3	67.0	307.0	27.5	853.9	418.6	57.2	309.5	32.4	817.6
2012	443.2	58.7	293.5	26.7	822.1	408.3	49.0	295.7	32.2	785.2
2013	456.7	58.1	283.1	26.0	823.8	420.4	48.2	285.6	32.1	786.3
2014	440.5	46.5	256.3	26.2	769.5	404.5	36.1	258.6	33.9	733.1
2015	448.7	48.0	275.2	27.3	799.2	411.6	37.4	277.4	34.8	761.2
2016	455.6	42.3	288.9	29.3	816.1	423.4	31.1	290.8	37.3	782.7
2017	458.7	41.0	311.6	28.1	839.4	431.1	30.5	314.2	35.7	811.4
2018	461.6	39.5	296.6	26.9	824.7	426.1	29.9	299.1	35.2	790.2
2019	472.9	35.1	306.4	26.0	840.4	427.5	27.6	309.0	34.1	798.2
2020	430.3	26.0	292.1	27.3	775.7	383.2	19.2	294.6	35.1	732.1
2021	454.2	28.4	309.4	27.8	819.9	403.1	14.2	311.8	36.1	765.2

Table 26: Difference of energy consumption by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	7.0%	4.0%	0.0%	-10.2%	4.2%
1991	7.1%	6.1%	0.0%	-10.9%	4.7%
1992	10.2%	9.6%	0.0%	-11.0%	6.6%
1993	8.4%	7.5%	0.0%	-14.6%	5.3%
1994	9.2%	11.6%	0.0%	-13.8%	6.0%
1995	9.2%	9.3%	0.2%	-13.6%	5.7%
1996	7.7%	10.8%	0.5%	-12.9%	5.2%
1997	9.5%	8.5%	0.0%	-14.2%	5.8%
1998	8.8%	24.9%	0.0%	-14.8%	6.7%
1999	8.6%	18.0%	0.0%	-15.5%	5.9%
2000	7.7%	15.0%	-1.0%	-14.4%	5.1%
2001	7.8%	11.3%	0.0%	-12.8%	5.1%
2002	6.7%	13.0%	0.0%	-11.7%	4.7%
2003	5.9%	6.1%	-0.1%	-11.7%	3.6%
2004	6.5%	7.8%	-0.3%	-11.7%	3.9%
2005	5.8%	9.4%	-0.8%	-14.5%	3.4%
2006	8.3%	9.1%	-0.7%	-17.3%	4.6%
2007	8.3%	12.0%	-0.7%	-16.6%	4.9%
2008	9.2%	18.9%	-0.8%	-14.5%	5.7%
2009	7.3%	22.1%	-1.3%	-19.5%	4.0%
2010	9.7%	19.7%	-1.4%	-17.0%	5.1%
2011	8.1%	17.2%	-0.8%	-15.1%	4.4%
2012	8.5%	19.9%	-0.8%	-17.2%	4.7%
2013	8.6%	20.5%	-0.9%	-19.0%	4.8%
2014	8.9%	28.8%	-0.9%	-22.7%	5.0%

Year	Liquid	Solid	Gaseous	Waste	Total
2015	9.0%	28.3%	-0.8%	-21.4%	5.0%
2016	7.6%	35.9%	-0.7%	-21.5%	4.3%
2017	6.4%	34.5%	-0.8%	-21.2%	3.5%
2018	8.3%	32.4%	-0.8%	-23.5%	4.4%
2019	10.6%	27.1%	-0.8%	-23.9%	5.3%
2020	12.3%	35.4%	-0.8%	-22.0%	6.0%
2021	12.7%	100.3%	-0.8%	-23.0%	7.1%

Energy consumption is different between the two approaches because

- Transformation and distribution losses are not considered in the sectoral approach.
- The sectoral approach uses sector-specific NCVs.
- The methodology of the approaches is not comparable at fuel type level.

Recalculations

Recalculations follow the revisions of the energy balance.

Since submission 2021, the reference approach considers energy balance data of pure fossil diesel and gasoline while in previous submissions blended biofuels were included in those fuel data. Furthermore, double counting of coal tar in the reference approach has been removed and some double counting of liquid fuels is removed in the sectoral approach. In addition, the carbon content of waste non-biomass fraction in the reference approach has been harmonized with the sectoral approach.

3.2.2 International bunker fuels

3.2.2.1 International aviation

In 2021, the share of international aviation in the total fuel consumption in the aviation sector in Austria represents 98% (defined on energy content) which is the same share as reported in previous years. Greenhouse gas emissions and activity data from aviation assigned to international bunkers include the transport modes international airport traffic (LTO-cycles) and international cruise traffic for IFR-flights (International Flight Rules) as shown in the following Table 27.

Table 27: Greenhouse gas emissions and activity from international bunkers-aviation 1990–2021.

	CO_2 [kt]		CH_4 [kt]		N_2O [kt]		Activity [TJ]
	int. LTO	int. cruise	int. LTO	Int. cruise	int. LTO	int. cruise	int. LTO + int. cruise
Year	Kerosene						
1990	116	764	0.01	NA	0.005	0.02	12 097
1991	131	859	0.02	NA	0.006	0.03	13 601
1992	142	934	0.02	NA	0.007	0.03	14 782
1993	151	991	0.02	NA	0.007	0.03	15 683
1994	157	1 033	0.02	NA	0.007	0.03	16 360
1995	176	1 157	0.02	NA	0.008	0.04	18 315
1996	195	1 279	0.02	NA	0.009	0.04	20 244

	CO_2 [kt]		CH_4 [kt]		N_2O [kt]		Activity [TJ]
	int. LTO	int. cruise	int. LTO	Int. cruise	int. LTO	int. cruise	int. LTO + int. cruise
Year				**Kerosene**			
1997	203	1 334	0.03	NA	0.009	0.04	21 112
1998	211	1 383	0.03	NA	0.010	0.04	21 894
1999	206	1 355	0.03	NA	0.009	0.04	21 452
2000	210	1 485	0.03	NA	0.010	0.05	23 296
2001	200	1 452	0.03	NA	0.010	0.05	22 687
2002	233	1 307	0.03	NA	0.010	0.04	21 170
2003	243	1 210	0.04	NA	0.010	0.04	19 963
2004	290	1 435	0.04	NA	0.011	0.05	23 699
2005	270	1 689	0.04	NA	0.012	0.05	26 927
2006	268	1 781	0.04	NA	0.012	0.06	28 150
2007	290	1 886	0.04	NA	0.013	0.06	29 894
2008	294	1 888	0.04	NA	0.013	0.06	29 979
2009	269	1 624	0.04	NA	0.012	0.05	26 014
2010	276	1 773	0.04	NA	0.012	0.06	28 159
2011	314	1 854	0.05	NA	0.014	0.06	29 793
2012	302	1 771	0.04	NA	0.014	0.06	28 477
2013	294	1 682	0.04	NA	0.013	0.05	27 141
2014	297	1 680	0.04	NA	0.013	0.05	27 177
2015	313	1 814	0.05	NA	0.013	0.06	29 243
2016	321	2 004	0.02	NA	0.009	0.06	31 957
2017	310	1 936	0.01	NA	0.009	0.05	30 873
2018	338	2 192	0.02	NA	0.009	0.06	34 777
2019	381	2 525	0.02	NA	0.010	0.07	40 032
2020	148	896	0.01	NA	0.004	0.02	14 381
2021	173	1 055	0.01	NA	0.005	0.03	16 913
1990–2021	**49%**	**38**	**-35%**		**-10%**	**17%**	**40%**

Methodological Issues

Emissions have been calculated using the methodology and emission factors as described in *1.A.3.a Civil Aviation*.

Recalculations

No category specific recalculations have been carried out.

Planned Improvements

According to the EEA the emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA, 2019) should have been updated in 2022, but so far no new spreadsheet has been transmitted. Austria will update its aviation calculation tool as soon as the new emission factors are published. At the moment the EEA emission factor spreadsheet still contains the same values as provided in the 'EMEP/EEA air pollutant emission inventory guidebook 2016' (EEA, 2016). This is relevant, because the CO_2 emission factor is taken from the Guidebook.

3.2.2.2 International navigation

In 2021, the share of international navigation in the total fuel consumption in the navigation sector in Austria represented 69% (defined on energy content). Greenhouse gas emissions from navigation assigned to international bunkers are presented in the following table.

Table 28: Greenhouse gas emissions from international bunkers-marine 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	45.9	0.0029	0.021	52.1
1991	39.9	0.0026	0.018	45.4
1992	38.8	0.0025	0.017	44.1
1993	39.9	0.0026	0.018	45.3
1994	50.7	0.0032	0.023	57.6
1995	57.1	0.0036	0.026	64.9
1996	58.5	0.0037	0.026	66.5
1997	57.1	0.0035	0.026	64.9
1998	62.3	0.0038	0.028	70.9
1999	61.6	0.0038	0.028	70.1
2000	67.2	0.0041	0.031	76.4
2001	71.0	0.0042	0.033	80.8
2002	79.8	0.0046	0.036	90.8
2003	63.6	0.0036	0.029	72.4
2004	76.0	0.0041	0.034	86.4
2005	74.5	0.0035	0.033	84.4
2006	65.2	0.0021	0.027	73.4
2007	70.0	0.0022	0.028	78.4
2008	64.6	0.0022	0.025	72.1
2009	55.2	0.0014	0.020	61.2
2010	65.4	0.0018	0.023	72.3
2011	57.7	0.0015	0.019	63.5
2012	58.9	0.0015	0.019	64.7
2013	62.9	0.0015	0.020	69.0
2014	58.3	0.0013	0.018	63.8
2015	48.0	0.0008	0.014	52.3
2016	52.3	0.0010	0.016	57.0
2017	54.2	0.0011	0.016	58.9
2018	39.4	0.0007	0.011	42.9
2019	45.4	0.0009	0.013	49.3
2020	42.5	0.0009	0.012	46.2
2021	61.3	0.0013	0.017	66.4
1990–2021	**33%**	**-56%**	**-17%**	**27%**

Methodological Issues

Since 2010, greenhouse gas emissions from water-borne navigation (inland navigation on the River Danube) have been reported separately for the national and the international share of navigation from 1990 onwards.

For this purpose Austria uses a bottom-up method to calculate the international fuel consumption in navigation which is based on freight transport activities on the River Danube. As domestic navigation on the River Danube is navigation between Danube harbours located within Austria, international navigation is navigation across national boundaries and transit navigation, expressed in:

tons x kilometers → (GWh/tkm*tkm; CO_2/tkm*tkm etc.)

As inland tkm on the Danube are used to calculate bottom-up domestic navigation, tkm from import, export and transit-activities on the Danube are used to calculate the international share of navigation on the Danube.

Statistical data (tkm) for freight activities (split up into inland, import, export and transit tkm) on the River Danube were obtained from (Via Donau 2022). For detailed methodological issues concerning factors like kg diesel/tkm and emissions factors see the results of the model GEORG as described in *1.A.2 g.vii.*

Activity Data & Emission Factors

Activity data and implied emission factors from navigation assigned to international bunkers are presented in the following table.

Table 29: Emission factors and activity data for international bunkers-marine 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	619	74.2	4.8	33.3
1991	539	74.2	4.8	33.3
1992	524	74.2	4.8	33.3
1993	538	74.2	4.7	33.3
1994	684	74.2	4.7	33.4
1995	770	74.2	4.7	33.5
1996	789	74.2	4.6	33.6
1997	770	74.2	4.6	33.7
1998	840	74.2	4.6	33.7
1999	831	74.2	4.5	33.8
2000	905	74.2	4.5	33.9
2001	957	74.2	4.4	34.0
2002	1 076	74.2	4.3	33.9
2003	858	74.2	4.2	33.8
2004	1 025	74.2	4.0	33.6
2005	1 005	74.2	3.5	32.7
2006	880	74.2	2.4	31.1
2007	944	74.2	2.4	29.9
2008	871	74.2	2.6	28.6
2009	745	74.2	1.9	26.9
2010	882	74.2	2.1	25.9
2011	779	74.2	1.9	24.8
2012	794	74.2	1.8	24.2
2013	849	74.2	1.8	23.7
2014	785	74.4	1.6	23.1

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2015	645	74.4	1.3	22.5
2016	704	74.4	1.4	22.2
2017	728	74.4	1.5	21.8
2018	530	74.4	1.4	21.6
2019	610	74.4	1.5	21.4
2020	572	74.4	1.6	21.2
2021	823	74.4	1.6	20.9

Recalculations

No category specific recalculations have been carried out.

Planned Improvements

No category-specific improvements are planned.

3.2.3 Feedstocks and non-energy use of fuels

Non-energy use of fuels is considered in the national energy balance. This chapter presents explanations for the reported non-energy use together with information on where CO_2 emissions due to the manufacture, use and disposal of carbon containing products are considered.

Lubricants

manufacture: emissions are assumed to be included in total emissions from category *1.A.1.b* petroleum refinery.

use: VOC emissions from lubricants used in rolling mills are considered in category *2.C.1*. It is assumed that other uses of lubricants do not result in VOC or CO_2 emissions due to the low vapour pressure of lubricants.

CO_2 from lubricants which are used in engines are considered in category *2.D.1.*

disposal: In case that waste oil is used as fuel, emissions from incineration of lubricants (waste oil) are included in categories *1.A.1.a* and *1.A.2*. In case that energy is not recovered, incineration of waste oil is reported under category *5.C.*

Bitumen

manufacture: emissions from the production of bitumen are assumed to be included in total emissions of category *1.A.1.b* petroleum refinery.

use: GHG emissions from the use of bitumen for road paving and roofing are considered as not applicable/negligible.

disposal: CO_2 emissions from the disposal from bitumen are assumed to be negligible. Recycling is not considered.

Naphtha

manufacture: Naphta is produced in the oil refinery and transferred to a petrochemical plant. Residues from the petrochemical plants are transferred back to the oil refinery steam cracker.

use: Naphta is used for plastics production (e.g. ethylene).

Petroleum coke

In IEA JQ (2021), non energy use is reported for the manufacture of electrodes.

manufacture: No information about emissions from manufacture of electrodes is currently available.

use: Emissions from the use of electrodes are considered in category *2.B.4* carbide production and *2.C* metal production.

Residual fuel oil

use: Considerable amounts of residual fuel are used in blast furnaces until the year 2015. Emissions are considered in *2.C.1*.

Coking coal, Bituminous coal, Coke oven coke, Coal Tar

manufacture: emissions from the production of coke are considered in category *1.A.2.a*.

use: CO_2 emissions from coal, coke and coal tar used in iron and steel industry are reported under *2.C*. The use of coal tar as a reductant in blast furnaces is considered under category *2.C.1* and is relevant for the years 2010-2014 only.

Natural Gas

use: emissions from the use of natural gas as a feedstock in ammonia production are accounted for in the industrial processes sector (category *2.B.1*).

Plastics waste

manufacture: Emissions from manufacture of plastics are considered in category *2.B.*

use: plastics waste is used as a reductant in blast furnaces since the year 2006. Emissions are considered in *2.C.1*.

disposal: Any emissions from waste disposal are considered in category 5.A. Waste incineration with energy use is considered in *1.A – other fossil fuels* and – to a minor degree – waste incineration without energy recovery is considered in category *5.C*.

Solvents

manufacture: emissions from the production of solvents are considered in sector *2.D.3*

use: Indirect CO_2 emissions from solvent use are considered in sector *2.D.3*. Incineration of waste solvents is considered under category *1.A – other fossil fuels.*

disposal: emissions from the disposal of solvents are considered in 5.A.

Paraffin wax

use: CO_2 emissions from paraffin wax use are considered in sector *2.D.2*.

Lubricants

use: CO_2 emissions from lubricants use are considered in sector *2.D.1*.

3.2.4 CO_2 capture from flue gases and subsequent CO_2 storage, if applicable

CO_2 capture from flue gases and CO_2 storage is not occurring in Austria.

3.2.5 Country-specific issues

With regard to country-specific issues, it can be referred to Chapter 3.2.9, where point source emissions as well as the CO_2 emission trading system (ETS) are considered.

3.2.6 Source Category Description

Transport (1.A.3)

In 2021, the most important source of GHGs was the *transport* category with a share of 28.3% in national total GHG emissions. 15.2% of national GHG emissions were released by passenger cars, 2.2% by light duty vehicles, 10% by heavy-duty vehicles and 0.2% by mopeds and motorcycles. Austria's railway system is mainly driven by electricity, only 0.1% of overall GHGs originate from this category. Fuels used by ships on inland waterways have a share of 0.05% in total GHG emissions. Because Austria is a landlocked country, there is no occurrence of maritime activities. However, emissions from international transport at inland waterways are excluded from the national total and reported as marine bunkers. About 0.03% of national GHG arise from domestic aviation. Gas pipeline compressors contribute 0.5% to national GHG emissions.

Manufacturing Industries (1.A.2)

Combustion in *manufacturing industries and construction* was the second largest sub-category with a share of 14.1% in 2021 national total GHG emissions. This category also includes mobile machinery mainly used in the construction sector. Considerably large amounts of CO_2-emissions from non-energy fuel use, such as reducing agents used in iron and steel industries and natural gas used for ammonia production, are reported as emissions from industrial processes (CRF Category 2).

Other Sectors (1.A.4)

Fossil fuels, mainly used for space and water heating in the commercial, agricultural and household sector (sub-category *1.A.4 Other Sectors* or "small combustion" sector), formed the third largest sub-category with a share of 13% in 2021 total national GHG emissions. Emissions of this category are very dependent on the climatic circumstances and on the economic trend. E.g. a "cold winter" in combination with an economic uptrend may increase emissions from space heating significantly. In Austria a large share of solid biomass consumption is used for space and water heating. Category *1.A.4* also includes emissions from mobile machinery mainly used in agriculture and forestry.

Energy Industries (1.A.1)

The fourth largest GHG source of the energy sector in 2021 with a share of 11.4% total GHG emissions was *energy industries*, where fossil fuels are used for electrical power and district heating production. In the year 2020, overall gross public electricity production was 62 664 GWh[43], of which 42 133 GWh (67%) were generated by hydro plants, 11 009 GWh (18%) by thermal power plants and 0 523 GWh (15%) by wind, solar and geothermal power plants. Industrial auto producers generated 8 077 GWh of electricity in the year 2020. There are no operating nuclear plants in Austria. Due to the importance of hydropower, the seasonal water situation in Austria has a high influence on the need for electric power generation by fossil fuels. In energy industries, biomass is mainly used by smaller district heating plants. The oil refining industry, which consists of only one plant in Austria, is also included in this category (sub-category *1.A.1.b Petroleum refining*). Crude oil input of the oil refinery was 8.3 Mt in 2021. Furthermore, this category includes emissions from other energy industries, which is mainly natural gas consumption of the oil/gas exploration sector and of gas refining industries (sub-category *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries*).

Military (1.A.5)

Category *1.A.5 Other* includes emissions from military air and road transport as well as from other mobile machinery. It contributes 0.04% to total GHG emissions in 2021.

3.2.7 Key Categories

The methodology and results of the key category analysis is presented in Chapter 1.5. Table 30 presents the Tier 1 key source categories of *1.A Fuel Combustion Activities*.

Table 30: Key sources of sector Energy (Tier 1, excl. LULUCF).

IPCC Category	Category Name	GHG	Key source
1.A.1.a gaseous	Public Electricity and Heat Production	CO_2	LA
1.A.1.a liquid	Public Electricity and Heat Production	CO_2	LA 1990; TA
1.A.1.a other	Public Electricity and Heat Production	CO_2	LA
1.A.1.a solid	Public Electricity and Heat Production	CO_2	LA 1990
1.A.1.b gaseous	Petroleum refining	CO_2	LA
1.A.1.b liquid	Petroleum refining	CO_2	LA
1.A.1.c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO_2	LA
1.A.2.a gaseous	Iron and Steel	CO_2	LA
1.A.2.a solid	Iron and Steel	CO_2	LA
1.A.2.b gaseous	Non-ferrous Metals	CO_2	LA 2021
1.A.2.c gaseous	Chemicals	CO_2	LA
1.A.2.c other	Chemicals	CO_2	LA 2021
1.A.2.d gaseous	Pulp, Paper and Print	CO_2	LA
1.A.2.d liquid	Pulp, Paper and Print	CO_2	LA 1990; TA
1.A.2.d solid	Pulp, Paper and Print	CO_2	LA
1.A.2.e gaseous	Food Processing, Beverages and Tobacco	CO_2	LA
1.A.2.e liquid	Food Processing, Beverages and Tobacco	CO_2	LA 1990; TA
1.A.2.f gaseous	Other	CO_2	LA
1.A.2.f liquid	Other	CO_2	LA 1990

[43] Source: IEA Questionnaire December/2021 by STATISTIK AUSTRIA.

IPCC Category	Category Name	GHG	Key source
1.A.2.f other	Other	CO_2	LA 2021
1.A.2.f solid	Other	CO_2	LA
1.A.2.g.7 liquid	Off-road vehicles and other machinery	CO_2	LA
1.A.2.g.8 gaseous	Other Manufacturing Industries	CO_2	LA
1.A.2.g.8 liquid	Other Manufacturing Industries	CO_2	LA 1990; TA
1.A.2.g.8 solid	Other Manufacturing Industries	CO_2	TA
1.A.3.b diesel oil	Road Transportation	CO_2	LA, TA
1.A 3 b diesel oil	Road Transportation	N_2O	-
1.A.3.b gasoline	Road Transportation	CO_2	LA; TA
1.A.3.b gasoline	Road Transportation	N_2O	TA
1.A.3.c liquid	Railways	CO_2	-
1.A.3.e gaseous	Other	CO_2	LA
1.A.4.a gaseous	Commercial/Institutional	CO_2	LA
1.A.4.a liquid	Commercial/Institutional	CO_2	LA; TA
1.A.4.a solid	Commercial/Institutional	CO_2	-
1.A.4.a other	Commercial/Institutional	CO_2	TA
1.A.4.b biomass	Residential	CH_4	LA
1.A.4.b gaseous	Residential	CO_2	LA; TA
1.A.4.b liquid	Residential	CO_2	LA; TA
1.A.4.b solid	Residential	CO_2	LA 1990; TA
1.A.4.b solid	Residential	CH_4	LA 1990; TA
1.A.4.c liquid	Agriculture/Forestry/Fisheries	CO_2	LA
1.A.4.c solid	Agriculture/Forestry/Fisheries	CO_2	TA

LA = Level Assessment (if not further specified – for the years 1990 and 2021)

TA = Trend Assessment 1990–2021

3.2.8 Completeness

Table 31 provides an overview of the IPCC categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated. "NO" indicates that the Austrian energy balance does not quote any energy consumption for the relevant sector and fuel category.

Emissions of all sources of category *1.A Fuel Combustion* have been estimated; the status of emission estimates of this category is complete.

Table 31: Overview of subcategories of Category 1.A Fuel Combustion: transformation into SNAP Codes and status of estimation for the year 2021.

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
1.A.1.a Public Electricity and Heat Production	**0101 Public power 0102 District heating plants**			
1.A.1.a Liquid Fuels		✓	✓	✓
1.A.1.a Solid Fuels		✓	✓	✓
1.A.1.a Gaseous Fuels		✓	✓	✓
1.A.1.a Biomass		✓	✓	✓
1.A.1.a Other Fuels		✓	✓	✓

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
1.A.1.b Petroleum refining	**0103 Petroleum refining plants**			
1.A.1.b Liquid Fuels		✓	✓	✓
1.A.1.b Solid Fuels		NO	NO	NO
1.A.1.b Gaseous Fuels		✓	✓	✓
1.A.1.b Biomass		NO	NO	NO
1.A.1.b Other Fuels		NO	NO	NO
1.A.1.c Manufacture of Solid fuels and Other Energy Industries	**010503 Oil/Gas Extraction plants**			
1.A.1.c Liquid Fuels		✓	✓	✓
1.A.1.c Solid Fuels		IE(1)	IE(1)	IE(1)
1.A.1.c Gaseous Fuels		✓	✓	✓
1.A.1.c Biomass		NO	NO	NO
1.A.1.c Other Fuels		NO	NO	NO
1.A.2.a Iron and Steel	**0301 Comb. In boilers, gas turbines and stationary engines (Iron and Steel Industry)** **030326 Processes with Contact-Other(Iron and Steel Industry)**			
1.A.2.a Liquid Fuels		✓	✓	✓
1.A.2.a Solid Fuels		✓	✓	✓
1.A.2.a Gaseous Fuels		✓	✓	✓
1.A.2.a Biomass		✓	✓	✓
1.A.2.a Other Fuels		NO	NO	NO
1.A.2.b Non-ferrous Metals	**0301 Comb. In boilers, gas turbines and stationary engines(Non-ferrous Metals Industry)**			
1.A.2.b Liquid Fuels		✓	✓	✓
1.A.2.b Solid Fuels		✓	✓	✓
1.A.2.b Gaseous Fuels		✓	✓	✓
1.A.2.b Biomass		✓	✓	✓
1.A.2.b Other Fuels		✓	✓	✓
1.A.2.c Chemicals	**0301 Comb. in boilers, gas turbines and stationary engines (Chemical Industry)**			
1.A.2.c Liquid Fuels		✓	✓	✓
1.A.2.c Solid Fuels		✓	✓	✓
1.A.2.c Gaseous Fuels		✓	✓	✓
1.A.2.c Biomass		✓	✓	✓
1.A.2.c Other Fuels		✓	✓	✓
1.A.2.d Pulp, Paper and Print	**0301 Comb. in boilers, gas turbines and stationary engines (Pulp, Paper and Print Industry)**			
1.A.2.d Liquid Fuels		✓	✓	✓
1.A.2.d Solid Fuels		✓	✓	✓
1.A.2.d Gaseous Fuels		✓	✓	✓
1.A.2.d Biomass		✓	✓	✓
1.A.2.d Other Fuels		✓	✓	✓
1.A.2.e Food Processing, Beverages and Tobacco	**0301 Comb. in boilers, gas turbines and stationary engines (Food Processing, Beverages and Tobacco Industry)**			
1.A.2.e Liquid Fuels		✓	✓	✓
1.A.2.e Solid Fuels		✓	✓	✓
1.A.2.e Gaseous Fuels		✓	✓	✓

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
1.A.2.e Biomass		✓	✓	✓
1.A.2.e Other Fuels		✓	✓	✓
1.A.2.f Non-Metallic Minerals	**030311 Cement** **030317 Glass** **030312 Lime** **030319 Bricks and Tiles** **030323 Magnesia production (dolomite treatment)**			
1.A.2.f Liquid Fuels		✓	✓	✓
1.A.2.f Solid Fuels		✓	✓	✓
1.A.2.f Gaseous Fuels		✓	✓	✓
1.A.2.f Biomass		✓	✓	✓
1.A.2.f Other Fuels		✓	✓	✓
1.A.2.g Other	**0301 Comb. in boilers, gas turbines and stationary engines** **0808 Other Mobile Sources and Machinery-Industry**			
1.A.2.g Liquid Fuels		✓	✓	✓
1.A.2.g Solid Fuels		✓	✓	✓
1.A.2.g Gaseous Fuels		✓	✓	✓
1.A.2.g Biomass		✓	✓	✓
1.A.2.g Other Fuels		✓	✓	✓
1.A.3.a Civil Aviation	**080501 Domestic airport traffic (LTO cycles – < 1 000 m)** **080503 Domestic cruise traffic (> 1 000 m)**			
1.A.3.a Aviation Gasoline		✓	✓	✓
1.A.3.a Jet Kerosene		✓	✓	✓
1.A.3.b Road Transportation	**0701 Passenger cars** **0702 Light duty vehicles < 3.5 t** **0703 Heavy duty vehicles > 3.5 t and buses** **0704 Mopeds and Motorcycles < 50 cm^3** **0705 Motorcycles > 50 cm^3** **0706 Gasoline evaporation from vehicles**			
1.A.3.b Gasoline		✓	✓	✓
1.A.3.b Diesel Oil		✓	✓	✓
1.A.3.b LPG		✓	✓	✓
1.A.3.b Gaseous Fuels		✓	✓	✓
1.A.3.b Biomass		✓	✓	✓
1.A.3.b Other Fuels		✓	IE(2)	IE(2)
1.A.3.c Railways	**0802 Other Mobile Sources and Machinery-Railways**			
1.A.3.c Liquid Fuels		✓	✓	✓
1.A.3.c Solid Fuels		✓	✓	✓
1.A.3.c Gaseous		NO	NO	NO
1.A.3.c Biomass		✓	✓	✓
1.A.3.c Other Fuels		✓	IE(2)	IE(2)
1.A.3.d Navigation	**0803 Other Mobile Sources and Machinery-Inland waterways**			
1.A.3.d Residual Oil		NO	NO	NO
1.A.3.d Gas/Diesel oil		✓	✓	✓
1.A.3.d Gasoline		✓	✓	✓
1.A.3.d Gaseous		NO	NO	NO
1.A.3.d Biomass		✓	✓	✓
1.A.3.d Other Fuels		✓	IE(2)	IE(2)

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
1.A.3.e.i Pipeline Transport	**010506 Pipeline Compressors**			
1.A.3.e.i Gaseous Fuels		✓	✓	✓
1.A.3.e.ii Other - Airport Ground activities	**0810 Other off-road (Airport Ground Activities)**			
1.A.3.e.ii Liquid Fuels		✓	✓	✓
1.A.3.e.ii Gaseous Fuels		✓	✓	✓
1.A.3.e.ii Other Fuels		✓	IE(2)	IE(2)
1.A.3.e.ii Biomass		✓	✓	✓
1.A.4.a Commercial/Institutional	**0201 Commercial and institutional plants**			
1.A.4.a Liquid Fuels		✓	✓	✓
1.A.4.a Solid Fuels		✓	✓	✓
1.A.4.a Gaseous Fuels		✓	✓	✓
1.A.4.a Biomass		✓	✓	✓
1.A.4.a Other Fuels		✓	✓	✓
1.A.4.b Residential	**0202 Residential plants** **0809 Other Mobile Sources and Machinery-Household and gardening**			
1.A.4.b Liquid Fuels		✓	✓	✓
1.A.4.b Solid Fuels		✓	✓	✓
1.A.4.b Gaseous Fuels		✓	✓	✓
1.A.4.b Biomass		✓	✓	✓
1.A.4.b Other Fuels		✓	IE(2)	IE(2)
1.A.4.b Peat		✓	✓	✓
1.A.4.c Agriculture/Forestry/Fisheries	**0203 Plants in agriculture, forestry and aquaculture** **0806 Other Mobile Sources and Machinery-Agriculture** **0807 Other Mobile Sources and Machinery-Forestry**			
1.A.4.c Liquid Fuels		✓	✓	✓
1.A.4.c Solid Fuels		✓	✓	✓
1.A.4.c Gaseous Fuels		✓	✓	✓
1.A.4.c Biomass		✓	✓	✓
1.A.4.c Other Fuels		✓	IE(2)	IE(2)
1.A.5 Other	**0801 Other Mobile Sources and Machinery-Military**			
1.A.5 Liquid Fuels		✓	✓	✓
1.A.5 Solid Fuels		NO	NO	NO
1.A.5 Gaseous Fuels		NO	NO	NO
1.A.5 Biomass		✓	✓	✓
1.A.5 Other Fuels		✓	IE(2)	IE(2)
Marine Bunkers	**080404 International sea traffic (international bunkers)**			
Gasoline		NO	NO	NO
Gas/Diesel oil		✓	✓	✓
Residual Fuel Oil		NO	NO	NO
Lubricants		NO	NO	NO
Coal		NO	NO	NO
Other Fuels		NO	NO	NO
Aviation Bunkers	**080502 International airport traffic (LTO cycles – < 1 000 m)** **080504 International cruise traffic (> 1 000 m)**			
Jet Kerosene		✓	✓	✓

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
Gasoline		NO	NO	NO
Multilateral Operations		NO	NO	NO

[(1)] *Emissions from coke ovens are included in 1.A.2.a iron and steel industries*

[(2)] *Other fuels include the share of fossil methanol in FAME (biodiesel). CH_4 and N_2O emissions of this share are reported under biomass.*

3.2.9 Methodology Overview

Stationary combustion

For stationary combustion the IPCC Tier 1 and Tier 2 methodologies have been applied. Activity data are taken either from national statistics or from the IEA/EUROSTAT joint questionnaires. Calorific values used for conversion of fuel activity data from [tonnes] and [cubic metres] into [Terajoule] are country specific. Country specific emission factors are fuel and technology dependent.

Mobile sources

For mobile sources either Tier 3 or country specific methods (Tier 2) have been applied, where technology dependent activity data are calculated by means of a bottom up model and adjusted to top down activity data. Bottom up activity data are calculated by means of vehicle-kilometres, vehicle stock statistics and operating condition dependant fuel consumption per vehicle kilometre. Bottom up fuel consumption of civil aviation is calculated by aircraft specific LTO-cycle and cruise-kilometre consumption. Top down activity data are based on fuel sales taken from the national energy balance.

Table 32: Overview of applied 1.A Methodologies by source and gas.

	Method			Emission factor		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1 A 1 a liquid	T2	T1	T1	CS	D	D
1 A 1 a solid	T2	T1	T1	CS	D	D
1 A 1 a gaseous	T2	T1	T1	CS	D	D
1 A 1 a other	T2	T2	T1	CS	CS	D
1 A 1 a biomass	T1	T1,T2	T1	D	CS,D	D
1 A 1 b liquid	T2	T1	T1	CS	D	D
1 A 1 b gaseous	T2	T1	T1	CS	D	D
1 A 1 c 2 gaseous	T2	T1	T1	CS	D	D
1 A 1 c 3 gaseous	T2	T1	T1	CS	D	D
1 A 1 c 3 biomass	NA	T1	NA	NA	D	NA
1 A 2 a liquid	T2	T1	T1	CS	D	D
1 A 2 a solid	T2	T1	T1	CS	D	D
1 A 2 a gaseous	T2	T1	T1	CS	D	D
1 A 2 a biomass	T1	T2	T1	D	CS	D
1 A 2 b liquid	T2	T1	T1	CS	D	D
1 A 2 b solid	T2	T1	T1	CS	D	D
1 A 2 b gaseous	T2	T1	T1	CS	D	D
1 A 2 b other	T2	T2	T1	CS	CS	D
1 A 2 b biomass	T1	T2	T1	D	CS	D

	Method			Emission factor		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1 A 2 c liquid	T2	T1	T1	CS	D	D
1 A 2 c solid	T2	T1	T1	CS	D	D
1 A 2 c gaseous	T2	T1	T1	CS	D	D
1 A 2 c other	T2	T2	T1	CS	CS	D
1 A 2 c biomass	T1	T1,T2	T1	D	CS,D	D
1 A 2 d liquid	T2	T1	T1	CS	D	D
1 A 2 d solid	T2	T1	T1	CS	D	D
1 A 2 d gaseous	T2	T1	T1	CS	D	D
1 A 2 d other	T2	T2	T1	CS	CS	D
1 A 2 d biomass	T1	T1,T2	T1	D	CS,D	D
1 A 2 e liquid	T2	T1	T1	CS	D	D
1 A 2 e solid	T2	T1	T1	CS	D	D
1 A 2 e gaseous	T2	T1	T1	CS	D	D
1 A 2 e other	T2	T2	T1	CS	CS	D
1 A 2 e biomass	T1	T1,T2	T1	D	CS,D	D
1 A 2 f liquid	T2	T1	T1	CS	D	D
1 A 2 f solid	T2	T1	T1	CS	D	D
1 A 2 f gaseous	T2	T1	T1	CS	D	D
1 A 2 f other	T2	T2	T1	CS	CS	D
1 A 2 f biomass	T1	T2	T1	D	CS	D
1 A 2 g 7 liquid	T3	T3	T3	CS	CS	CS
1 A 2 g 7 biomass	T1	T3	T3	D	CS	CS
1 A 2 g 8 liquid	T2	T1	T1	CS	D	D
1 A 2 g 8 solid	T2	T1	T1	CS	D	D
1 A 2 g 8 gaseous	T2	T1	T1	CS	D	D
1 A 2 g 8 other	T2	T2	T1	CS	CS	D
1 A 2 g 8 biomass	T1	T1,T2	T1	D	CS,D	D
1 A 3 a aviation gasoline	T2	T2	T2	CS	CS	CS
1 A 3 a jet kerosene	T3	T3	T3	CS	CS	CS
1 A 3 b 1 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 1 diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 b 1 LPG	T2	T3	T3	CS	CS	CS
1 A 3 b 1 gaseous	T2	T3	T3	CS	CS	CS
1 A 3 b 1 biomass	T1	T3	T3	D	CS	CS
1 A 3 b 1 other	T2	-	-	CS	-	-
1 A 3 b 2 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 2 diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 b 2 LPG	T2	T3	T3	CS	CS	CS
1 A 3 b 2 gaseous	T2	T3	T3	CS	CS	CS
1 A 3 b 2 biomass	T1	T3	T3	D	CS	CS
1 A 3 b 2 other	T2	-	-	CS	-	-
1 A 3 b 3 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 3 diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 b 3 LPG	T2	T3	T3	CS	CS	CS
1 A 3 b 3 gaseous	T2	T3	T3	CS	CS	CS
1 A 3 b 3 biomass	T1	T3	T3	D	CS	CS
1 A 3 b 4 gasoline	T2	T3	T3	CS	CS	CS

	Method			Emission factor		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1 A 3 b 4 biomass	T1	T3	T3	D	CS	CS
1 A 3 c liquid	T2	T3	T3	CS	CS	CS
1 A 3 c solid	T2	T3	T3	CS	CS	CS
1 A 3 c biomass	T1	T3	T3	D	CS	CS
1 A 3 c other	T2	-	-	CS	-	-
1 A 3 d gas/diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 d gasoline	T2	T3	T3	CS	CS	CS
1 A 3 d biomass	T1	T3	T3	D	CS	CS
1 A 3 d other	T2	-	-	CS	-	-
1 A 3 e 1 gaseous	T2	T1	T1	CS	D	D
1 A 3 e 2 liquid	T2	T2	T2	CS	CS	CS
1 A 3 e 2 gaseous	T2	T2	T2	CS	CS	CS
1 A 3 e 2 other	T2	-	-	CS	-	-
1 A 4 a 1 liquid	T2	T1,T2	T1	CS	CS,D	D
1 A 4 a 1 solid	T2	T1	T1	CS	D	D
1 A 4 a 1 gaseous	T2	T1	T1	CS	D	D
1 A 4 a 1 other	T2	T2	T1	CS	CS	D
1 A 4 a 1 biomass	T1	T1,T2	T1	D	CS,D	D
1 A 4 b 1 liquid	T2	T1,T2	T1	CS	CS,D	D
1 A 4 b 1 solid	T2	T1	T1	CS	D	D
1 A 4 b 1 gaseous	T2	T1	T1	CS	D	D
1 A 4 b 1 peat	T1	T1	T1	D	D	D
1 A 4 b 1 biomass	T1	T1,T2	T1	D	CS,D	D
1 A 4 b 2 liquid	T2	T3	T3	CS	CS	CS
1 A 4 b 2 biomass	T1	T3	T3	D	CS	CS
1 A 4 b 2 other	T2	-	-	CS	-	-
1 A 4 c 1 liquid	T2	T1,T2	T1	CS	CS,D	D
1 A 4 c 1 solid	T2	T1	T1	CS	D	D
1 A 4 c 1 gaseous	T2	T1	T1	CS	D	D
1 A 4 c 1 biomass	T1	T2	T1	D	CS	D
1 A 4 c 2 gasoline	T3	T3	T3	CS	CS	CS
1 A 4 c 2 diesel oil	T3	T3	T3	CS	CS	CS
1 A 4 c 2 biomass	D	T3	T3	D	CS	CS
1 A 4 c 2 other	T2	-	-	CS	-	-
1 A 5 b liquid	T2	T3	T3	CS	CS	CS
1 A 5 b biomass	T1	T3	T3	D	CS	CS
1 A 5 b other	T2	-	-	CS	-	-

Consideration of point source emissions

For the following categories and pollutants, plant or boiler specific emission declarations are considered each year.

- 1.A.1.a Public Electricity and Heat Production (about 130 boilers): CO, SO_2, NO_x;
- 1.A.1.b Petroleum Refining (1 plant): SO_2, NO_x, CO, VOC ("IE": reported under 1 B);
- 1.A.2.a Iron and Steel (2 integrated iron & steel plants): CO_2, CO, VOC, SO_2, NO_x;
- 1.A.2.f Non-Metallic Minerals – Cement production (10 plants): CO_2, SO_2, NO_x, CO, VOC.

To avoid double counting of point source emissions with area sources (data from the national energy balance), the consistency of reported activity by plant operators with activity data from energy statistics is checked. Reported data must not be greater than data from energy statistics for the respective category (the correspondence of a plant to the specific energy balance sector is determined by identical NACE or ISIC-Codes). Only consistent and complete point source data are used for inventory preparation. If point source data are not consistent, then data from the national energy balance are used.

Activity data and emissions of point source emissions declarations are checked by comparing implied emission factors against IPCC default values or by comparing emissions to those of a simple Tier 1 approach.

3.2.9.1 Consistency with the EU emission trading system (EU-ETS)

Currently the following industrial branches are fully covered by the national ETS:

- 1.A.1.b Oil refineries
- 1.A.2.a+2.C.1 Iron and steel manufacturing industries
- 1.A.2.f Non-metallic mineral industries (cement, glass, lime, bricks and tiles, other ceramic materials)

Combustion plants of other industrial branches (including power plants) are considered, if their thermal plant capacity exceeds 20 MW_{th} (excluding boilers < 3 MW, biomass-boilers and hazardous and municipal waste incineration boilers).

The following branches have a high coverage of ETS installations:

- 1.A.1.a Public electricity and heat production (about 80 %). Coverage of about 95% for fuels (except waste)
- 1.A.2.d Pulp, paper and print (around 75 %)
- 1.A.2.c Chemicals (around 75 %)

Description of received ETS data

ETS data is submitted by means of a standard calculation sheet, which includes numerical data about multiple fuels, processes and material flows. Additionally, a written QA/QC report has to be submitted. National legislation (Emissionszertifikategesetz §7) allows the use of detailed ETS data for reasons of inventory compilation.

For fuel combustion and industrial processes, the following numerical data is reported:

- Activity data: mass or volume of fuel consumption/process input material
- Net calorific value of fuel
- Oxidation factor of fuel/conversion factor of process material
- CO_2 emission factor of fuel or process material
- Share of non-fossil CO_2 (biomass) in case of "non-traded fuels"

For sites with complex material flows (e.g. refineries, iron and steel plants, chemical plants), carbon mass balance data is reported alternatively:

- Activity data: mass or volume of material flow (may have a negative sign)

- Net calorific value of material
- Carbon content of material
- Direct CO_2 measurements

The ETS reports include data about "traded-fuels" (e.g. different types of coal and fuel oils, natural gas) as well as "non-traded fuels" (e.g. industrial wastes, biomass). For each of the "traded fuels", a national default NCV and a national default CO_2 emission factor may be selected for emission calculation. For "non-traded fuels" (industrial waste, mostly used in cement industry), plant operators have to make their own estimate of the carbon content and the NCV. However, carbon contents (t C/t waste) and oxidation factors of common waste fuels (tyres, waste oil, plastics waste) used in the cement industry are widely harmonized between different operators.

Methodology of ETS data consideration

ETS "bottom up" data since 2005 are used for calculation of emission data in categories *1.A.1*, *1.A.2, 1.A.3.e* and *1.A.4.a*. About 200 plants report 800 fuel and material flows yearly, which are considered in the inventory. From the year 2013 onwards, the scope of ETS has been expanded by natural gas compressors used in energy industries (CRF *1.A.1.c* and *1.A.3.e*), smaller steel-works (CRF *1.A.2.a* and *2.C*), magnesite sinter plants (CRF *1.A.2.f* and *2.A*) and chemical industries (CRF *1.A.2.c* and *2.B*).

- In accordance with STATISTIK AUSTRIA, each plant is allocated to a NACE category of the energy balance.
- In accordance with STATISTIK AUSTRIA, each reported fuel is allocated to a fuel type according to the energy statistics system. For "non-traded fuels", systematic errors of allocation have to be avoided as far as possible.
- ETS fuel masses/volumes and NCVs are used for activity data calculation. The remaining activity data is calculated by means of remaining fuel masses/volumes and averaged NCVs from the energy balance:
  $Activity_{category,\ fuel} = (Energy\_Balance\_Activity_{category,\ fuel} - \Sigma i(ETS\_Activity_{plant\ i,\ fuel})) \times Energy\_Balance\_NCV_{fuel} + \Sigma i(ETS\_Activity_{plant\ i,\ fuel} \times ETS\_NCV_{plant\ i,\ fuel})$.
- ETS CO_2 emissions are considered by fuel. The remaining CO_2 emissions are calculated by remaining activity data and "national default" emission factors:
  $CO_{2\,category,\ fuel} = (Energy\_Balance\_Activity_{category,\ fuel} - \Sigma i(ETS\_Activity_{plant\ i,\ fuel})) \times Energy\_Balance\_NCV_{fuel} \times Default\_EF_{fuel} + \Sigma i(ETS\_CO_{2\,plant\ i,\ fuel})$.

3.2.9.2 Choice of emission factors for stationary combustion

Emission factors for combustion plants are expressed as kg/GJ for CO_2 and as g/GJ for CH_4 and g/GJ for N_2O. Please note that emission factors sometimes are different for different sectors because of the different share of fuel combusted. E.g., the CO_2 emission factor for "hard coal" used in the energy industries is different from the factor used for manufacturing industry because different hard coal types with different origin are used; "hard coal" is actually a group of different hard coal types.

Emission factors may vary over time for the following reasons:

- The chemical characteristics of a fuel category varies, e.g. sulphur content in residual oil, carbon content of coal, CH_4 content of natural gas.
- The mix of fuels in the fuel category changes over time. If the different fuels of a fuel category have different calorific values and their share in the fuel category changes, the calorific value of the fuel category might change over time.

- The technical equipment of a combustion plant, which burns a specific fuel, changes over time.
- Changes in technologies (rather relevant for air pollutants such as NO_X, VOC or $PM_{2.5}$)

References for country specific CO_2 and CH_4 default emission factors are included in national studies (BMWA-EB 1990, 1996, 2003, UMWELTBUNDESAMT 2001a, UMWELTBUNDESAMT 2004a). Detailed figures are included in the relevant chapters.

CO_2 emission factors for stationary sources per fuel type

Natural Gas (fossil)

For all sources of natural gas combustion, a CO_2 emission factor of 55.4 t CO_2/TJ (UMWELTBUNDESAMT 2001a) is applied for 1990–2018. For the year 2019 onwards, a factor of 55.6 t CO_2/TJ is applied.

In 2016, national gas supplier companies provided detailed data about natural gas composition and heating values for the years 2013–2015 and a CO_2 emission factor of 55.4 t/TJ and a net calorific value of 36.4 MJ/Nm^3 has been calculated. The emission factor is in line with the emission factor used so far for emission calculations and valid until the inventory year 2018.

The CO_2 emission factor and the calorific value have been used as default values for ETS reporting since 2016 and have been first published by the ministry of environment in January 2017. Updates are planned to be published every three years.

In the year 2020, an updated (slightly higher) natural gas CO_2 emission factor (55.6 t CO_2/TJ) has been published (BMNT 2020), which is applied for the years 2019 to 2021.

Table 33 shows the typical composition of natural gas as reported by the main national natural gas supplier for 2021.

Table 33: Typical natural gas composition of Austrian main supplier 2021 (NCV = 36.68 MJ/Nm^3)

Component	% Volume
CH_4	95.64
C_2H_6	2.86
C_3H_8	0.34
n-C_4H_{10}	0.05
i-C_4H_{10}	0.06
n-C_5H_{12}	0.01
i-C_5H_{12}	0.01
C_6H_{14}+	0.02
CO_2	0.47
N_2	0.52
O_2	0.75

Liquid fuels (fossil)

Fuel oil: Depending on the sulphur content three fuel oil categories are considered in the inventory. CO_2 emission factors are taken from (BMWA-EB 1996).

Gasoil, Diesel Oil: CO_2 emission factors are taken from (BMWA-EB 1996).

Liquid Petroleum Gas, LPG: CO_2 emission factors are taken from (BMWA-EB 1996).

Refinery Gas: The CO_2 emission factor is based on plant specific measurements.

Solid fuels (fossil)

Coal: (BMWA-EB 1996): CO_2 emission factors are based on elemental analysis with the assumption that 100% of carbon is released as CO_2 (values originate from the study (HACKL & MAUSCHITZ 1996), where the EF are based on the elemental analysis for different coal types).

Peat (fossil)

A default emission factor of 106 t/TJ for peat is taken from (IPCC 2006 GUIDELINES).

Municipal Solid Waste, MSW (partly fossil)

The fossil carbon content for MSW is taken from (ABFALLWIRTSCHAFT 2003). A fraction analysis of the typical wet MSW for Vienna[44] was performed by the local waste authority of Vienna (MA 48) in 1997/1998.

The fossil and non fossil carbon content of each fraction is taken from (ÖKOINSTITUT 2002). This leads to a fossil share of 45% of the overall carbon content of 261 kg C/t $MSW_{wet\ matter}$. The CO_2 emission factor was converted into t CO_2/TJ by means of a net calorific heating value of 8.81 GJ/t. The calculated CO_2 emission factor for MSW is 48.88 t/TJ. The emissions factor has been applied for the years 1990 to 2004.

From the year 2005 onwards, an updated MSW CO_2 emission factor of 43.45 t CO_2/TJ is applied. The updated emission factor is based on a new study (UMWELTBUNDESAMT AND TU VIENNA 2019). Emission factors were derived from a methodology worked out by the Technical University of Vienna (TU 2015) and available MSW fraction analyses. The methodology of TU Vienna uses CO_2 stack measurements as well as available input and output process measurement parameters of the plants. These plant specific measurements have been used to validate a methodology based on MSW fraction analysis (manual sorting of fractions such as paper, kitchen and garden waste, packaging plastics, packaging glass, metals) to calculate the total carbon content and the fossil share of carbon. The resulting emission factor was derived from MSW sorting analysis of several years.

Industrial Waste (partly fossil)

The main share of industrial waste is used in cement and chemical industry for the purpose of energy recovery. For cement industry emission factors are based on the studies (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004) which include information about fractions and carbon contents. Details about emissions from cement industry are given in Chapter 3.2.11.2.

The fractions and the specific carbon contents of waste incinerated in hazardous waste incineration plants (rotation kilns), chemical industry, pulp and paper industry and wood products manufacturing industry are not reported within the ETS and therefore are unknown.

Until the submission 2019, a CO_2 emission factor of 104.17 t/TJ had been applied for those unknown waste fractions. Within (UMWELTBUNDESAMT & TU VIENNA 2019) the Technical University of Vienna (TU Vienna) presented an emission factor, which better reflects actual known dependencies of heating value, water content and carbon content of waste fuels. TU Vienna also carried out stack measurements and input analysis of a hazardous waste incineration plant, which shows that the factor represents a "conservative approach" (high certainty that under-estimation does not occur).

[44] Until 1998 incineration of MSW in Vienna took place only at the one plant where the analysis was performed; in 2003 73% of total MSW in Austria was combusted in this plant, the value was applied to total MSW combustion in Austria.

The proposed CO_2 emission factor is 75 t/TJ and has been applied for the whole time series since 1990.

Sewage Sludge (non fossil)

Sewage sludge is incinerated in one waste incineration plant and a couple of public power plants. The default CO_2 emission factor of 112 t/TJ has been selected from the IPCC 2006 Guidelines.

Black Liquor (non fossil)

Black liquor is incinerated in pulp and paper industry and in wood products manufacturing industry. The default CO_2 emission factor of 95.3 t/TJ has been selected from the IPCC 2006 Guidelines.

Biogas, Sewage Sludge Gas, Landfill Gas (non fossil)

Biogas reported by (IEA JQ 2021) is used for energy recovery in all subcategories of Category *1.A.* The default CO_2 emission factor of 54.6 t/TJ has been selected from the IPCC 2006 Guidelines. Biogas is also fed into the public natural gas network or local biogas networks but reported separately in the energy balance. The biogas fed into the public gas network must meet special requirements with regard to purity and calorific value.
(see http://www.biogas-netzeinspeisung.at/rechtliche-planung/index.html).

3.2.9.3 CO_2 emissions reported by the EU-ETS

The following Table 34 shows certificated CO_2 emissions from the ETS (UMWELTBUNDESAMT 2022a) and their allocation to IPCC categories. The allocation does not always follow the category reported by plant operators but is harmonized by means of reported NACE-codes and therefore harmonized with energy statistics. Minor process related emissions which could not be allocated to a specific category (e.g. carburisation material, pyrolisis material) have been allocated to category *1.A.2.g.8*

Table 34: 2005–2021 CO_2 emissions [kt] as reported under the EU-ETS.

	Category	2005	2010	2016	2017	2018	2019	2020	2021
Total ETS[1)]		**33 373**	**30 855**	**28 964**	**30 516**	**28 345**	**29 482**	**26 982**	**28 662**
1.A	FUEL COMBUSTION ACTIVITIES	17 836	15 239	16 073	15 588	15 738	14 104	14 085	14 159
1.A.1.a	Public Electricity and Heat Production	9 335	5 445	6 019	5 420	5 667	4 386	4 379	4 386
1.A.1.b	Petroleum refining	2 724	2 784	2 739	2 824	2 791	2 732	2 750	2 732
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	47	187	194	175	180	159	163	159
1.A.2.a	Iron and Steel	893	1 264	1 374	1 501	1 513	1 493	1 550	1 548
1.A.2.b	Non-ferrous Metals	0	66	62	50	50	51	52	51
1.A.2.c	Chemicals	654	1 163	1 181	1 109	1 188	1 112	1 065	1 111
1.A.2.d	Pulp, Paper and Print	2 044	1 389	1 444	1 474	1 417	1 377	1 378	1 377
1.A.2.e	Food Processing, Beverages and Tobacco	352	308	320	280	257	249	237	249
1.A.2.f	Non-metallic minerals	1 528	1 631	1 637	1 694	1 664	1 654	1 682	1 654
1.A.2.g.8	Other: Stationary	245	391	420	427	415	367	416	367
1.A.3.e	Pipeline compressors	0	561	634	587	547	475	378	475
1.A.4.a	Commercial/Institutional	15	50	49	47	49	48	36	48
2	INDUSTRIAL PROCESSES	13 020	13 758	14 472	12 785	13 777	12 908	14 638	12 857
2.A.1	Cement Production	1 622	1 729	1 710	1 827	1 771	1 821	1 889	1 821
2.A.2	Lime Production	574	581	583	544	584	559	633	559
2.A.3	Glass Production	40	38	38	38	41	39	36	39
2.A.4	Other Process Uses of Carbonates	395	409	439	470	397	388	453	392
2.B.1	Ammonia Production	0	522	467	357	520	491	500	491

	Category	2005	2010	2016	2017	2018	2019	2020	2021
2.B.10	Other Chemical Industry	0	123	120	114	122	124	121	124
2.C.1	Steel	10 388	10 352	11 109	9 431	10 339	9 482	11 002	9 427
2.C.3	Aluminium Production	0	4	4	4	4	4	5	4

1) Source: UMWELTBUNDESAMT (2022a). These data do not include N_2O emissions from nitric acid production.

CO_2 emission factors reported within the ETS

Table 35 and Table 36 show the implied CO_2 emission factors reported within the ETS by fuel and SNAP category for the recent reported year. In some cases, rather small fuel consumption was reported for specific categories. This may lead to significant errors in implied emission factor calculation (e.g. diesel, gasoil) because within the ETS CO_2 emissions are rounded to the nearest ton whereas reported fuel consumption is not rounded.

Table 35: 2021 CO_2 implied emission factors calculated from ETS data. Coal, Petrol Coke, Waste and Natural Gas.

SNAP	102A Hard Coal	105A Brown Coal	107A Coke Oven Coke	110A Petrol Coke	115A Ind. Waste	301A Natural Gas
Weighted average	93.53	97.21	112.28	93.83	79.72	55.59
010101 Public Power plants >= 300 MW_{th}	-	-	-	-	-	55.60
010102 Public Power plants >= 50 MW_{th} < 300 MW_{th}	-	-	-	-	106.25	55.60
010103 Public Power plants <= 50 MW_{th}	-	-	-	-	-	-
010201 Public District Heating plants >= 300 MW_{th}	-	-	-	-	-	55.60
010202 Public District Heating plants >= 50 MW_{th} < 300 MW_{th}	-	-	-	-	-	55.60
010203 Public District Heating plants < 50 MW_{th}	-	-	-	-	-	55.60
010301 Refinery	-	-	-	129.93	-	55.60
010504 Other Energy Industries – Gas Turbines	-	-	-	-	-	55.60
010506 Pipeline Compressors	-	-	-	-	-	55.60
020103 Commercial plants < 50 MW_{th}	-	-	-	-	66.38	55.60
0301 Industry – Steel	-	-	-	-	-	55.60
0301 Industry – Non ferrous metals	-	-	104.00	-	76.55	55.60
0301 Industry – Chemicals	94.70	-	-	-	99.34	55.60
0301 Industry – Pulp and Paper	90.17	-	-	-	124.93	55.60
0301 Industry – Food and Beverages	-	-	107.72	-	68.65	55.60
03010 Industry – Other	-	-	-	-	97.29	55.60
030311 Cement kilns	95.08	96.11	-	93.39	77.42	55.60
030312 Lime kilns	-	98.15	-	-	-	55.60
030317 Glass	128.42	-	104.00	-	-	55.60
030319 Bricks and Tiles	95.08	106.91	-	97.21	50.40	55.60
030323 Dolomite Treatment	-	-	104.00	94.04	64.19	55.60
030326 Integrated Iron & Steel works	93.61	-	112.38	-	84.50	55.52

Table 36: 2021 CO_2 implied emission factors calculated from ETS data. Oil products.

SNAP	203B light fuel oil	203D Heavy fuel oil	204A Gasoil	2050 Diesel	224A other liquid	303A LPG
Weighted average	77.06	80.97	75.00	73.71	69.22	67.85
010101 Public Power plants >= 300 MW_{th}	-	-	75.00	73.70	-	-
010102 Public Power plants >= 50 MW_{th} < 300 MW_{th}	-	-	75.00	74.10	-	-
010103 Public Power plants <= 50 MW_{th}	-	-	-	-	-	-
010201 Public District Heating plants >= 300 MW_{th}	-	-	75.00	73.70	-	-
010202 Public District Heating plants >= 50 MW_{th} < 300 MW_{th}	77.00	-	75.00	73.70	-	-
010203 Public District Heating plants < 50 MW_{th}	77.00	-	75.00	73.70	-	-
010301 Refinery	-	81.05	-	74.10	-	67.86
010504 Other Energy Industries – Gas Turbines	-	-	-	73.70	-	-
010506 Pipeline Compressors	-	-	-	73.70	-	-
020103 Commercial plants < 50 MW_{th}	-	-	-	-	70.87	-
0301 Industry – Steel	-	-	-	73.74	-	-
0301 Industry – Non ferrous metals	-	-	-	73.70	-	-
0301 Industry – Chemicals	-	81.62	75.00	73.70	67.27	-
0301 Industry – Pulp and Paper	78.00	78.00	75.00	73.70	-	-
0301 Industry – Food and Beverages	-	-	-	73.70	-	-
03010 Industry – Other	-	-	75.00	73.70	-	64.00
030311 Cement kilns	78.00	78.00	74.91	-	-	-
030312 Lime kilns	-	-	75.00	-	-	-
030317 Glass	78.00	-	75.00	73.70	-	-
030319 Bricks and Tiles	77.97	78.00	75.00	73.70	-	-
030323 Dolomite Treatment	78.00	78.00	75.00	73.70	-	64.00
030326 Integrated Iron & Steel works	77.00	-	75.00	-	-	-

3.2.9.4 Choice of activity data for stationary sources

Activity data used for estimating emissions in the sectoral approach is taken from the energy balance as well as information on the last revision of the national energy balance.

The national energy balance is provided by Statistik Austria (IEA JQ 2022). The net calorific values (NCV) used for converting mass or volume units of the fuel quantities into energy units [TJ] are provided by Statistik Austria.

In the sectoral approach of Category *1.A*, only the fuel quantities that are combusted are relevant and thus considered for emission calculation. Quantities not considered are: non-energy and feedstock use, international bunker fuels, transformation and distribution losses, transformations of fuels to other fuels like hard coal to coke oven coke and internal refinery processes which have been added to the transformation sector of the energy balance.

Potential emissions from non-energy and feedstock fuel use are considered in the corresponding IPCC categories as described in chapter 3.2.3.

3.2.10 1.A.1 Energy Industries

3.2.10.1 1.A.1.a Public Electricity and Heat Production

Key Sources: CO_2 from 1.A.1.a gaseous, liquid, solid and other fossil fuels

Category *1.A.1.a Public Electricity and Heat Production* covers emissions from fuel combustion in public power and heat plants. The share in total GHG emissions from sector *1.A* is 21.4% for the year 1990 and 11.1% for the year 2021. The increased CH_4 and N_2O emissions are mainly due to increased biomass combustion in plants smaller than 50 MW_{th}.

Methodology

For the years 1990 to 2004, the IPCC Tier 2 methodology is applied by using activity data from energy balance and national CO_2 default emission factors.

For the years 2005–2021, CO_2 emissions from plants having a total boiler capacity of >= 20 MW_{th} are taken from ETS reports and CO_2 emissions from plants < 20 MW_{th} are calculated by means of national default emission factors and the remaining fuel consumption of the energy balance. Coal consumption is fully covered by the ETS. The general methodology is described in chapter 3.2.1.2.

Emission factors

National CO_2 emission factors are taken from (BMWA-EB, 1990, 1996), (UMWELTBUNDESAMT 2001a) and (UMWELTBUNDESAMT 2002). The selected emissions factors for 2021 as well as the national default emission factors are listed in the following table. The CO_2 emission factor for municipal solid waste for the years 1990 to 2004 is taken from (ABFALLWIRTSCHAFT 2003), for the years 2005 onwards it is taken from (UMWELTBUNDESAMT and TU VIENNA 2019). The CO_2 emission factor for industrial waste is also taken from (UMWELTBUNDESAMT and TU VIENNA 2019).

Table 37: Default emission factors of Category 1.A.1.a for the year 2021.

Fuel	Default CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil in plants ≥ 50 MW_{th}	77.00	3.00	0.60
Heavy Fuel Oil in plants ≥ 50 MW_{th}	80.00	3.00	0.60
Fuel Oil in plants ≤ 50 MW_{th}	78.00	3.00	0.60
Gasoil	75.00	3.00	0.60
Diesel oil	75.00	3.00	0.60
Liquified Petroleum Gas	64.00	1.00	0.10
Hard coal in power and CHP plants	95.00	1.00	1.50
Hard coal in district heating plants.	93.00	1.00	1.50
Lignite and brown coal in power and CHP plants ≥ 50 MW_{th}	110.00	1.00	1.50
Lignite and brown coal in district heating plants ≥ 50 MW_{th}	108.00	1.00	1.50
Lignite, brown coal and brown coal briquettes in plants < 50 MW_{th}	97.00	1.00	1.50
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00[1)]	3.00	4.00
Wood Waste	112.00[1)]	10.00	4.00
Sewage Sludge	112.00[1)]	12.00	4.00
Biogas, Sewage Sludge Gas, Landfill Gas	54.60[1)]	1.50	0.10
Municipal Solid Waste 1990–2004	48.88	12.00	4.00
Municipal Solid Waste 2005 onwards	43.45	12.00	4.00
Industrial Waste	75.00	12.00	4.00

[1)] *Reported as CO_2 emissions from biomass.*

Activity data

Total fuel consumption of Category *1.A.1.a* is taken from (IEA JQ 2022) prepared by Statistik Austria.

Fuel consumption in the public electricity sector varies strongly over time. The most important reason for this variation is the fact that in Austria up to 78% of yearly electricity production comes from hydropower. If production of electricity from hydropower is low, production from thermal power plants is high and vice versa.

The following Table 38 presents the gross electricity and heat production of public power and district heating plants. Increasing district heat production is mainly generated by new biomass (local) heat plants and by waste incineration. The share of combined heat and power plants (CHP generation) is increasing and leads to higher efficiency of energy generation. The year 2010 shows a historic maximum of about 19 TWh electricity production from fuel combustion. In the year 2012 electricity production from hydro plants reached a historic maximum of 47.2 TWh and contributed to 74% of total production. District heat production in 2021 was 8% higher than in 2020 because of a 8% higher heating demand during the heating period.

Table 38: Public gross electricity and heat production.

Year	Public gross electricity production [GWh]						Public Heat Production [TJ] by Combustible Fuels
	Total	Hydro[1)]	Combustible Fuels	Geothermal	Solar	Wind	
1990	43 403	30 111	13 292	0.0	0	0	24 427
1991	43 497	30 268	13 229	0.0	0	0	29 038
1992	42 848	33 530	9 318	0.0	0	0	27 601
1993	44 809	35 070	9 738	0.0	1	0	30 428
1994	44 804	34 078	10 725	0.0	1	0	30 729
1995	47 580	35 431	12 147	0.0	1	1	34 426
1996	45 953	32 892	13 055	0.0	1	5	44 483
1997	47 527	34 532	12 973	0.0	2	20	40 597
1998	47 789	35 596	12 146	0.0	2	45	43 415
1999	52 192	39 593	12 546	0.0	2	51	42 465
2000	52 810	41 131	11 609	0.0	3	67	42 197
2001	53 763	39 681	13 972	0.0	5	105	44 575
2002	54 385	40 597	13 636	3.0	9	140	45 056
2003	52 508	34 230	17 888	3.0	15	372	48 896
2004	56 051	37 700	17 397	2.0	18	934	51 786
2005	58 518	38 205	18 958	2.3	21	1 331	54 424
2006	56 225	36 907	17 539	3.1	22	1 753	54 730
2007	56 153	38 018	16 071	2.4	24	2 037	54 066
2008	57 842	39 458	16 341	1.6	30	2 011	60 794
2009	60 515	42 414	16 097	1.5	49	1 954	63 328
2010	61 571	40 500	18 916	1.4	89	2 064	70 415
2011	56 270	36 815	17 344	1.1	174	1 936	70 399
2012	64 030	47 204	14 025	0.7	337	2 463	74 061
2013	60 239	45 226	11 234	0.3	626	3 152	75 274
2014	57 742	44 270	8 840	0.4	785	3 846	69 707
2015	57 455	40 102	11 575	0.1	937	4 840	72 314
2016	60 429	42 482	11 617	0.0	1 096	5 235	74 159
2017	63 114	41 697	13 576	0.1	1 269	6 572	76 620

Year	Public gross electricity production [GWh]						Public Heat Production [TJ] by Combustible Fuels
	Total	Hydro[1)]	Combustible Fuels	Geothermal	Solar	Wind	
2018	60 631	40 745	12 400	0.2	1 455	6 030	74 087
2019	66 268	43 669	13 446	0.2	1 702	7 450	73 573
2020	64 719	44 888	10 997	0.1	2 043	6 792	73 971
2021	62 664	42 133	11 009	0.0	2 783	6 740	80 243

[1)] including pumped storage; Source: IEA JQ 2022

As shown in Table 39 electricity supply increased by 11 TWh since 2000 of which approx. 80% has been supplied by additional imports until 2008. The year 2009 shows falling electricity consumption (supply) but an increase of production, mainly by hydropower. The year 2015 shows an historical maximum of net imports which contributed to 15% of total electricity supply.

Table 39: Electricity supply, gross production, imports, exports and net imports [GWh].

Year	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
1990	46 489	50 294	6 839	7 298	-459
1991	48 793	51 483	8 503	7 738	765
1992	48 197	51 190	9 175	8 621	554
1993	49 073	52 421	8 072	8 804	-732
1994	49 596	53 132	8 219	9 043	-824
1995	50 979	56 225	7 287	9 757	-2 470
1996	52 515	54 880	9 428	8 476	952
1997	53 069	56 704	9 008	9 775	-767
1998	54 039	57 001	10 304	10 467	-163
1999	55 167	60 944	11 608	13 507	-1 899
2000	55 750	61 257	13 824	15 192	-1 368
2001	58 338	62 449	14 467	14 252	215
2002	58 074	62 499	15 375	14 676	699
2003	60 058	60 174	19 003	13 389	5 614
2004	61 320	64 152	16 629	13 548	3 081
2005	62 948	66 833	20 355	17 732	2 623
2006	64 144	64 702	20 925	14 580	6 344
2007	64 762	65 085	21 783	15 767	6 016
2008	65 112	66 852	19 795	14 934	4 862
2009	62 783	69 088	19 542	18 762	780
2010	65 523	71 128	19 909	17 472	2 437
2011	65 702	65 813	24 977	16 777	8 199
2012	66 690	72 603	23 430	20 627	2 803
2013	67 048	68 357	24 960	17 689	7 270
2014	65 977	65 439	26 712	17 437	9 275
2015	67 021	65 299	29 389	19 328	10 062
2016	67 866	68 308	26 366	19 207	7 159
2017	69 029	71 324	29 362	22 817	6 546
2018	69 192	68 618	28 076	19 129	8 947
2019	69 332	74 234	26 047	22 918	3 129
2020	66 936	72 556	24 522	22 327	2 196

Year	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
2021	70 098	70 752	26 436	18 893	7 543

Source: IEQ JQ 2022

[1)] *Excluding own use and heat pumps, boilers and pumped storage use. Including losses*

[2)] *Public and autoproducer gross production*

Recalculations

Recalculations of activity data are following the revisions of the energy balance as described in Annex 4.

Sector specific QA/QC procedures

Large point source data are used for validation of energy consumption. Until the year 2007 the Umweltbundesamt operates a database to store boiler specific data, which is called *„Dampfkesseldatenbank"* (DKDB, UMWELTBUNDESAMT 2007b) which includes fuel consumption, CO, NO_x, SO_x and dust emissions from boilers with a thermal capacity greater than 20 MW which data is used for the years 1990 to 2007. These data are used to generate a sectoral split of the categories *Public Power* and *District Heating* each into the two categories ≥ *300 MW* and ≥ *10 MW to 300 MW* of thermal capacity. Currently about 65 boilers between 10 and 950 MW_{th} are considered in this approach. Large point source activity data from 2005 onwards is considered from ETS reporting.

The remaining fuel consumption (= total consumption minus consumption of large point sources) is the activity data for boilers smaller than 10 MW_{th}.

3.2.10.2 1.A.1.b Petroleum Refining

Key Sources: CO_2 from 1.A.1.b gaseous and liquid fuels

Category *1.A.1.b Petroleum Refining* enfolds emissions from fuel combustion, flaring and thermal cracking of the only petroleum refining plant in Austria. Fugitive CH_4 emissions are included in category *1.B.2.a Fugitive Emissions from Fuels – Oil – Refining/storage*. Since 2003 the plant has been upgraded which increases CO_2 emissions from bitumen blowing and hydrogen production.

The share in total GHG emissions from sector *1.A* is 4.6% for the year 1990 and 5.3% for the year 2021. Crude oil input was 8 megatons in 1990 and 8.2 megatons in 2021.

Methodology

The IPCC Tier 2 methodology is used. For calculation of CO_2 emissions, plant specific emission factors are used. For calculation of N_2O and CH_4 emissions, the default emission factors from the IPCC 2006 Guidelines have been selected.

The carbon contents of *gaseous*, *liquid* and *solid* fuel types are reported by the plant operator. The fuel groups do not correspond with IPCC definitions, e.g. gaseous fuels include refinery gas which is, according to IPCC definition, a liquid fuel.

Table 40: Carbon content per fuel group for petroleum refining.

Fuel-type	Carbon Content [t CO_2/t fuel]	Associated IEA-Fuels
Gaseous	2.683	Natural Gas, Refinery Gas
Liquid	3.047	Residual Fuel Oil, Gas Oil, Diesel, Petroleum, Jet Gasoline, Other Oil Products, LPG
Solid	3.430	Petrol coke (FCC-coke)

For 1990 to 2001, CO_2 emissions are calculated by multiplying activity data from the energy balance by the emission factors in Table 40. CO_2 emissions 2002 to 2005 are reported by the Austrian Association of Mineral Oil Industries and are consistent with ETS 2005 data. From the year 2006 onwards, reported ETS data is used.

To be consistent with IPCC fuel group definition, total CO_2 emissions are disaggregated to the IEA fuel types (see column "Associated IEA-fuels") by using default emission factors for industrial boilers, subtracting the calculated CO_2 emissions from total CO_2 emissions, and associating remaining CO_2 emissions to refinery gas. The resulting IEF for refinery gas is presented in Table 41. The IEF fluctuations reflect changes in refinery gas composition.

Table 41: Implied emission factors for refinery gas.

Year(s)	t CO_2/TJ
1990	65.8
1991	66.4
1992	66.6
1993	75.8
1994	78.8
1995	82.3
1996	62.0
1997	60.0
1998	63.5
1999	62.2
2000	60.5
2001	54.0
2002–2021	64.0

For corresponding crude oil input data which may be used as an indicator over time series refer to description of category *1.B.2.a Oil*.

Table 42: Emission factors of Category 1.A.1.b.

Fuel	CO_2 [t/TJ]	N_2O [kg/TJ]	CH_4 [kg/TJ]
Residual Fuel Oil	80.00	0.60	3.00
Gas oil	75.00	0.60	3.00
Diesel	78.00	0.60	3.00
Other Oil Products	78.00	0.60	3.00
Petrol Coke	100.88	0.60	3.00
Refinery gas	64.00	0.10	1.00
LPG	64.00	0.10	1.00

Fuel	CO_2 [t/TJ]	N_2O [kg/TJ]	CH_4 [kg/TJ]
Natural Gas	55.60	0.10	1.00

Activity data

Fuel consumption is taken from (IEA JQ 2022) except for the years 1999 to 2005, where petrol coke is additionally counted in *other oil products* (1999: +63 kt, 2004: +59 kt) to obtain consistency with plant specific activity data reported in (DKDB, UMWELTBUNDESAMT 2007b).

Sector specific QA/QC procedures

A simple mass balanced input/output validation of energy balance data has been performed which shows a plausible and time series consistent correlation of the input and output material flows as shown in the following table. The last line shows the difference between input and output. Natural gas consumption is not considered in this approach.

Table 43: Refinery input/output mass balance.

Material flow [kt]	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Total Input	**9 062**	**9 259**	**8 887**	**9 233**	**8 457**	**9 607**	**9 030**	**8 948**	**9 576**	**9 952**	**8 871**	**8 870**
Crude oil	7 952	8 619	8 240	8 743	7 719	8 853	8 184	8 064	8 970	9 124	8 168	8 243
NGL	41	43	107	78	134	53	6	37	18	16	14	11
Feedstocks	1 069	597	540	362	325	371	531	552	293	501	421	268
Biofuel (blending)	0	0	0	50	279	332	309	294	294	311	267	348
Total Output	**8 864**	**9 013**	**8 620**	**9 086**	**8 335**	**9 469**	**8 861**	**8 791**	**9 460**	**9 842**	**8 706**	**8 676**
Fuel oil	1 913	1 596	1 075	1 360	934	1 154	898	839	710	735	737	645
Gas oil	1 239	1 454	1 062	997	795	642	635	662	581	476	592	387
Diesel	1 531	1 920	2 662	2 931	2 741	3 453	3 166	3 319	3 472	3 703	3 202	3 329
Other Kerosene	31	8	1	1	3	28	21	15	26	15	13	9
Aviation kerosene	291	420	544	592	476	648	651	613	760	893	362	344
Aviation gasoline	0	0	0	0	0	1	1	1	1	1	1	1
Motor gasoline	2 631	2 276	1 815	1 798	1 589	1 812	1 759	1 782	2 030	2 075	1 805	1 870
White spirit	0	5	0	0	70	0	0	0	0	0	0	0
Bitumen	269	254	343	366	292	290	333	306	369	395	424	440
Other petroleum products	7	29	15	87	172	19	26	27	21	23	45	46
Naphtha	475	621	710	472	720	941	961	804	1 028	1 006	1 051	1 087
LPG	47	60	34	107	87	139	122	102	111	137	117	150
Refinery gas	373	305	312	309	392	282	218	262	281	316	284	296
Petroleum Coke (FCC)	57	66	48	66	62	60	71	59	71	67	73	74
Input-Output	**198**	**246**	**267**	**147**	**123**	**138**	**169**	**157**	**115**	**111**	**165**	**194**

Recalculations

No recalculations have been made in this year's submission.

Planned improvements

No improvements are planned.

3.2.10.3 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries

Key Source: CO_2 from 1.A.1.c gaseous fuels

Category *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries* enfolds emissions from fuel combustion in the oil and gas extraction sector (reported by companies as 'own use'), compressors used for natural gas storage tanks and fuel use of gas processing facilities ('gas refineries'). For 1990 to 1995 transformation losses/own use in gas works are included too. The share in sector *1.A* overall GHG emissions is 1% for the year 1990 and 0.7% for the year 2021.

Methodology

Calculation of CO_2 emissions are following a Tier 2 methodology and calculation of CH_4 and N_2O emissions are following a Tier 1 methodology.

For 2005 to 2021, CO_2 emissions and activity data of natural gas storage compressors are taken from ETS data.

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996).

For calculation of N_2O and CH_4 emissions the default emission factors from the IPCC 2006 Guidelines have been selected.

Table 44: Emission factors of Category 1.A.1.c.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Natural Gas	55.60	1.00	0.10
Heavy Fuel Oil	78.00	3.00	0.60

Activity data

Fuel consumption is taken from (IEA JQ 2022).

Transformation losses in gas works are calculated by subtracting final energy use from transformation input. Since the energy balance (IEA JQ 2022) does not report gas works gas, activity data is taken from the "Austrian Energy Balance" provided by STATISTIK AUSTRIA which is structured differently but consistent with (IEA JQ 2022).

Recalculations

No recalculations have been made in this year's submission.

3.2.10.4 1.A.1.c.iii Other energy industries – charcoal production

CH_4 emissions from Charcoal production are included in *1.A.1.c.iii Other energy industries – biomass.*

Methodology

Calculation of CH_4 emissions from charcoal production is following a Tier 2 methodology.

For the most recent years (2005 to latest inventory year) Austria uses the data from the National Energy Balance to calculate emissions from charcoal production

For the years 1990–2004 an average production amount of 1 000 t was assumed, as the National Energy Balance only provides data for this fuel category starting from 2005. Although the IEA Joint Questionnaire figures also do not show indigenous production for the years prior to 2001, it is unlikely that there was no traditional charcoal production based on wood as feedstock at all as charcoal is produced within small communities for many decades mainly to keep this old tradition in rural areas as a cultural heritage. Hence, it is reasonable to assume a constant charcoal production for the years before 2001. In Table 45 the activity data of charcoal production is presented.

Table 45: Activity data (charcoal produced) and CH_4 emissions for Fugitive Emissions from Solid Fuel Transformation 1990–2021.

Year	Charcoal production (in t)	Charcoal [TJ]	CH_4 emissions [kt]
1990	1 000	31	0.031
1991	1 000	31	0.031
1992	1 000	31	0.031
1993	1 000	31	0.031
1994	1 000	31	0.031
1995	1 000	31	0.031
1996	1 000	31	0.031
1997	1 000	31	0.031
1998	1 000	31	0.031
1999	1 000	31	0.031
2000	1 000	31	0.031
2001	1 000	31	0.031
2002	1 000	31	0.031
2003	1 000	31	0.031
2004	1 000	31	0.031
2005	1 101	34	0.034
2006	1 220	38	0.038
2007	1 149	36	0.036
2008	1 253	39	0.039
2009	1 365	42	0.042
2010	1 181	37	0.037
2011	1 130	35	0.035
2012	1 377	43	0.043
2013	1 269	38	0.038
2014	1 263	36	0.036
2015	1 447	41	0.041
2016	1 382	41	0.041
2017	1 222	35	0.035
2018	1 379	39	0.039
2019	1 425	40	0.041
2020	1 442	41	0.041
2021	1 463	42	0.042

For calculating the emissions, Austria is using a constant country specific NCV of 30 MJ/kg from its National Energy Balance. Due to the absence of measurements which are needed to derive a country specific emission factor, the default emission factor of the revised IPCC 1996 Guidelines (Table 1-14) has been applied for CH_4 (1 000 kg/TJ).

3.2.11 1.A.2 Manufacturing Industries and Construction

3.2.11.1 1.A.2.a Iron and Steel

Key Sources: CO_2 from 1.A.2.a gaseous and solid fuels

Category *1.A.2.a Iron and Steel* enfolds emissions from fuel combustion in iron and steel industry. CO_2 emissions from ore reduction in blast furnaces are included in category *2.C.1.b Pig Iron*. The share in total GHG emissions from Sector *1.A* is 3.5% for the year 1990 and 3.4% for the year 2021.

Methodology

Two iron and steel production sites (the only operating blast furnaces in Austria) are considered as point sources. For 1990 to 2002, CO_2 emissions and fuel consumption from these two plants were reported by the plant operator. The reported fuel consumption of the two plants is subtracted from total fuel consumption for iron and steel production in Austria and the resulting fuel consumption is considered as area source. For the area sources an IPCC Tier 2 methodology was applied for all GHGs.

CO_2, NMVOC, CO, NO_x and SO_2 emissions are reported by the two Austrian iron and steel plants, together with their coal, fuel oil and natural gas fuel consumption. The emissions declaration includes emissions from natural gas consumption not included in the ETS.

The methodology of separating process CO_2 emissions from total integrated steel plants' CO_2 emissions is also explained in the methodology chapter of category *2.C.1*. 100% of natural gas consumption and a share of coke oven gas consumption are considered within category *1.A.2.a* while 100% of solid, liquid and other fuels and a share of coke oven gas are considered as reducing agents in blast furnaces and therefore CO_2 emissions are reported under category *2.C.1*. Activity data of natural gas is taken from plant operator emission reports and includes fuel consumption which is not considered under the ETS. CO_2 emissions from coke oven gas are calculated by subtracting emissions from reducing agents and emissions from natural gas from total CO_2 emissions. The methodology of calculating CO_2 emissions from reducing agents is partly a tier 1 method using default emission factors and reported consumption data as well as data from the energy balance while EU-ETS reporting is based on a detailed mass balance. The resulting methodological uncertainty between the two approaches is therefore fully reflected in the CO_2 emissions from coke oven gas which is the main reason of the fluctuating trend of *1.A.2.a solid fuels.*

The CO_2 emission factor for natural gas is taken from (BMWA-EB 1996). For coke oven coke, a default emission factor of 25.8 t C/TJ (94.6 t CO_2/TJ) has been selected.

CO_2 emissions of integrated steel plants 1990 to 2002 and 2005 to 2021 are reported by plant operators.

N_2O and CH_4 emissions are calculated by means of a Tier 1 methodology.

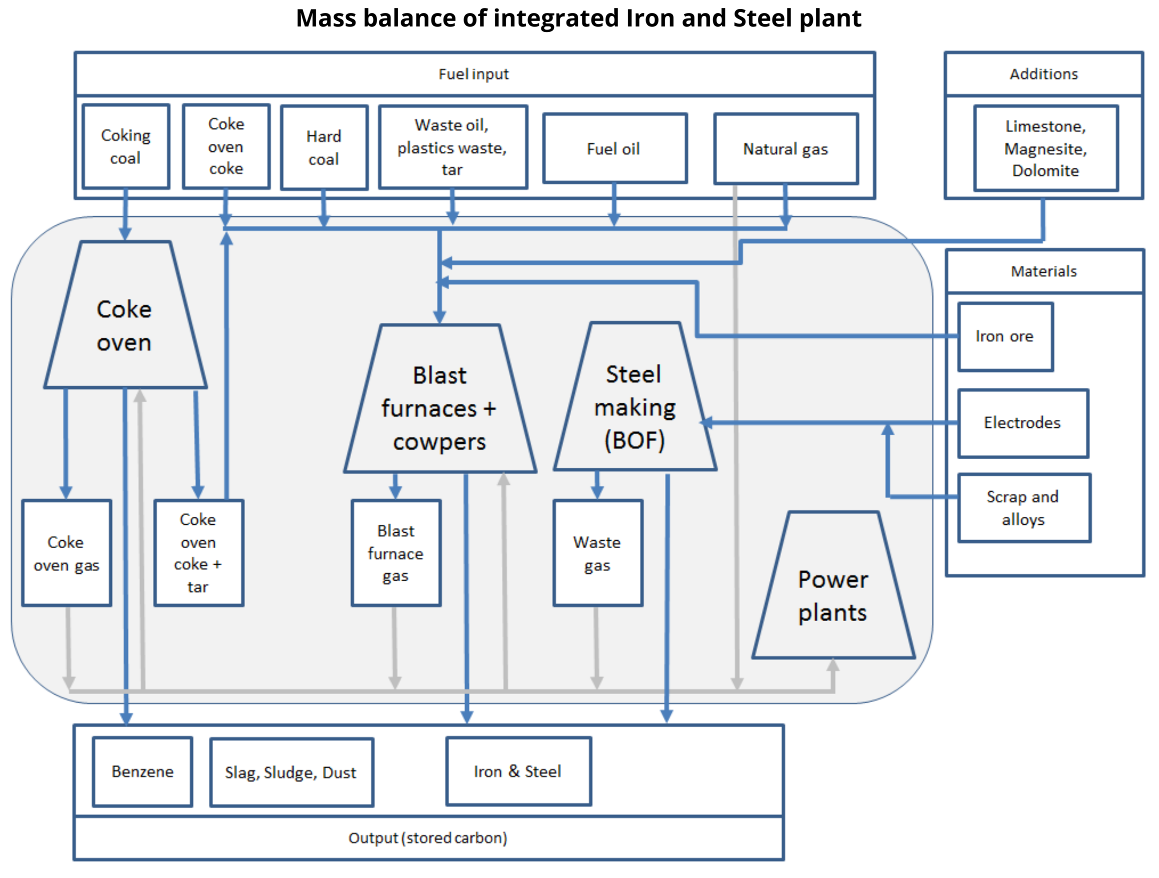
Point source CO_2 emissions 2003 and 2004

Since for the years 2003 and 2004 no point source CO_2 emissions have been reported by plant operators, the Umweltbundesamt performed calculations on the basis of 2000 to 2002 data by means of a simple approach: Activity data reported by plant operators are multiplied by national default emission factors. The resulting emissions are those from blast furnaces and autoproducer power plants. CO_2 emissions from coke ovens (2004: 285 kt) are estimated by means of coke oven output and an emission factor of 0.2 t CO_2/t coke which is equal to 5% transformation losses.

Mass balance of integrated iron and steel plant

The following Figure 10 shows a flow chart of a integrated iron and steel plant representing the mass balance which is used for reporting under the ETS. The grey shaded area illustrates the most important facilities and the interior fluxes between them, although the real conditions are even more complex. The outside parts of the figure shows the carbon containing inputs and outputs of fuels and materials as reported under the ETS. The fuel Input and the internal transformation processes between fuels (e.g. coke oven coke, blast furnace gas, coke oven gas, blast furnace gas, waste gas from basic oxygen furnaces) are reported in the energy balance. CO_2 emissions from reducing agents (coke oven coke, hard coal, fuel oil, waste oil, plastics waste, tar) which are used in the blast furnace as well as the net CO_2 emissions from carbon containing material input such as iron ore, scrap and electrodes as well as output material such as steel and pig iron are reported under CRF category *2.C.1.* CO_2 Emissions from natural gas and coke oven gas are reported under CRF category *1.A.2.a*.

Figure 10: Mass balance of integrated Iron and Steel plant.



Source: Umweltbundesamt

Emissions

The following table lists the results of the two approaches. Please note that process related CO_2 emissions from blast furnaces are reported under category *2.C.1*.

Table 46: Greenhouse gas emissions from Category 1.A.2.a by sub sources.

Year	other sources			integrated steel plants		
	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 [kt]	CH_4 [kt]	N_2O [kt]
1990	193	0.005	0.001	1 640	0.021	0.002
1991	267	0.007	0.001	1 174	0.016	0.002
1992	219	0.006	0.001	966	0.014	0.001
1993	223	0.008	0.001	1 143	0.016	0.002
1994	235	0.008	0.001	1 045	0.015	0.002
1995	293	0.009	0.001	1 045	0.015	0.002
1996	445	0.012	0.002	1 157	0.017	0.002
1997	465	0.011	0.001	1 397	0.020	0.002
1998	424	0.010	0.001	737	0.013	0.001
1999	363	0.008	0.001	967	0.016	0.002
2000	457	0.010	0.001	819	0.013	0.001
2001	477	0.010	0.001	961	0.016	0.002
2002	545	0.011	0.001	1 140	0.017	0.002
2003	544	0.011	0.001	1 190	0.018	0.002
2004	486	0.010	0.001	1 418	0.021	0.002
2005	366	0.010	0.001	1 478	0.022	0.002
2006	380	0.010	0.001	1 172	0.018	0.002
2007	322	0.007	0.001	894	0.015	0.002
2008	374	0.009	0.001	928	0.015	0.002
2009	290	0.006	0.001	730	0.013	0.001
2010	345	0.008	0.001	931	0.016	0.002
2011	345	0.007	0.001	1 101	0.019	0.002
2012	353	0.007	0.001	1 130	0.019	0.002
2013	332	0.007	0.001	1 274	0.021	0.002
2014	307	0.006	0.001	1 189	0.020	0.002
2015	358	0.007	0.001	1 047	0.017	0.002
2016	396	0.008	0.001	1 181	0.018	0.002
2017	374	0.008	0.001	1 284	0.019	0.002
2018	366	0.008	0.001	1 406	0.021	0.002
2019	389	0.008	0.001	1 415	0.021	0.002
2020	395	0.008	0.001	1 408	0.020	0.002
2021	322	0.007	0.001	1 452	0.021	0.002

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002).

The selected and calculated emission factors for 2021 are presented in Table 47 and Table 48.

Activity data

Total fuel consumption is taken from (IEA JQ 2022).

Point source activity data are reported by plant operators which are widely consistent with (IEA JQ 2022).

Table 47: Emission factors of Category 1.A.2.a for area sources.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil	78.00	3.00	0.60
Heavy Fuel Oil	78.00	3.00	0.60
Gas oil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Hard Coal	94.00	10.00	1.50
Lignite and brown coal	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Wood Waste	112.00 [1)]	10.00	4.00

[1)] *Reported as CO_2 emissions from biomass.*

Table 48: Emission factors of Category 1.A.2.a for point sources.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Coke Oven Coke	94.60	1.00	0.10
Natural Gas	55.60	0.10	0.10

Fugitive emissions and losses

An analysis of ETS data shows that the amount of carbon stored in slag, dust, sludge and steel was 78 kt CO_2 equivalents in 2021 (2020: 65 kt; 2019: 71 kt; 2018: 70 kt, 2017: 73 kt, 2016: 83 kt, 2015: 87 kt, 2014: 91 kt, 2013: 83 kt, 2012: 76 kt, 2011: 71 kt, 2010: 66 kt, 2009: 55 kt, 2008: 91 kt). This amount should be considered in the quantification of the difference between the sectoral and the reference approach.

Recalculations

For the years 1990 to 2020, CO_2 emissions have been shifted from *1.A.2.a solid fuels* to category *2.C.1* due to a revised emission estimate of blast furnaces, e.g. 230 kt CO_2 for 1990 and 55 kt CO_2 for 2020. Minor revisions of CH_4 and N_2O follow the changes in activity data for solid fuels.

Other recalculations for the year 2020 follow the revisions of the energy balance.

3.2.11.2 1.A.2.b Non-Ferrous Metals

Key Source: CO_2 from 1.A.2.b gaseous fuels

Category *1.A.2.b Non-Ferrous Metals* enfolds emissions from fuel combustion in non ferrous metal industry. The share in total GHG emissions from sector *1.A* is 0.3% for the year 1990 and 0.6% for the year 2021.

Methodology

CO_2 emissions are calculated by means of a Tier 2 method while N_2O and CH_4 emissions are calculate by means of a Tier 1 method. From the year 2013 onwards, CO_2 ETS data are considered.

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002).

Emission factors for 2021 are presented in the following table.

Table 49: Emission factors of Category 1.A.2.b

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Residual Fuel Oil	78.00	3.00	0.60
Gas oil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Hard Coal	94.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Industrial waste	76.55[1)]	12.00	4.00

[1)] *Implied emission factor*

Activity data

Fuel consumption is taken from (IEA JQ 2022) and ETS.

Recalculations

Changes of activity data 2020 follow the revision of the energy balance.

3.2.11.3 1.A.2.c Chemicals

Key Sources: CO_2 from 1.A.2.c gaseous and other fuels

Category *1.A.2.c Chemicals* enfolds emissions from fuel combustion in chemical industry. The share in total GHG emissions from sector *1.A* is 1.6% for the year 1990 and 3.1% for the year 2021.

Methodology

CO_2 emissions are calculated by means of a Tier 2 method while N_2O and CH_4 emissions are calculated by means of a Tier 1 method. From the year 2013 onwards, CO_2 ETS data are considered.

CO_2 emissions from industrial waste: Table 50 shows the composition of the implied emissions factor for industrial waste. One plant with a capacity of 250 kt solid waste/year is considered with a NCV of 10 TJ/kt waste and a CO_2 emission factor of 75 t/TJ. From 2005 on ETS data is considered with plant specific emissions and energy consumption. The remaining energy use (other waste) is considered with a CO_2 emission factor of 37.50 t/TJ. 'Other waste' is considered as 50% waste gas (with a high share of hydrogen) and chemical reaction heat (which is not relevant for GHG emissions). Therefore, an emission factor of 50% of the default emission factor is selected.

Table 50: Composition of 1.A.2.c Chemical industries – industrial waste – CO_2 IEF for the years 2000 to 2021.

Year	Total energy use	Solid waste		ETS		Other waste		CO_2 IEF
	[TJ]	[TJ]	CO_2 EF	[TJ]	CO_2 IEF	[TJ]	CO_2 EF	[t/TJ]
2000	2 258	1 500	75.00	378[1)]	70.62	380	37.50	67.96
2001	2 815	1 500	75.00	378[1)]	70.62	937	37.50	61.93
2002	4 128	1 500	75.00	378[1)]	70.62	2 250	37.50	54.16
2003	5 821	1 500	75.00	378[1)]	70.62	3 943	37.50	49.31

Year	Total energy use	Solid waste		ETS		Other waste		CO_2 IEF
	[TJ]	[TJ]	CO_2 EF	[TJ]	CO_2 IEF	[TJ]	CO_2 EF	[t/TJ]
2004	7 256	1 500	75.00	378[1)]	70.62	5 378	37.50	29.37
2005	1 431	1 052	75.00	378	70.62	0	37.50	73.84
2006	2 144	1 584	75.00	560	74.59	0	37.50	74.89
2007	1 355	827	75.00	528	75.01	0	37.50	75.00
2008	3 589	3 290	75.00	299	84.88	0	37.50	75.82
2009	3 209	2 938	75.00	271	76.38	0	37.50	75.12
2010	4 190	3 914	75.00	276	77.47	0	37.50	75.16
2011	3 690	3 479	75.00	210	75.10	0	37.50	75.01
2012	3 776	3 517	75.00	259	82.92	0	37.50	75.54
2013	2 858	2 441	75.00	417	83.31	0	37.50	76.21
2014	3 249	2 661	75.00	588	58.28	0	37.50	71.98
2015	3 057	2 466	75.00	591	61.86	0	37.50	72.46
2016	3 363	2 906	75.00	457	77.87	0	37.50	75.39
2017	3 023	2 638	75.00	385	71.98	0	37.50	74.62
2018	2 776	2 327	75.00	448	68.78	0	37.50	74.00
2019	2 479	1 920	75.00	559	65.50	0	37.50	72.86
2020	2 398	1 868	75.00	530	77.92	0	37.50	75.65
2021	3 856	3 439	75.00	418	86.18	0	37.50	76.21

[1)] For 2000 to 2004 the value of 2005 has been selected.

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002).

Table 51: Emission factors of Category 1.A.2.c for 2021.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Residual Fuel Oil	78.00	3.00	0.60
Gas oil	75.00	3.00	0.60
LPG	64.00	1.00	0.10
Other liquid fuels (flaring)	67.27[3)]	3.00	0.60
Hard Coal	94.00	10.00	1.50
Lignite, Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00[1)]	30.00	4.00
Wood Waste	112.00[1)]	10.00	4.00
Black Liquor	95.30[1)]	3.00	2.00
Biogas	54.60[1)]	1.00	0.10
Industrial Waste	76.21[2)]	12.00	4.00

[1)] Reported as CO_2 emissions from biomass; [2)]For the years 1990 to 1999: 75 t/TJ; [3)]IEF derived from ETS data

Activity data

Fuel consumption is taken from (IEA JQ 2022) and from ETS.

Recalculations

Changes of activity data 2020 follow the revision of the energy balance.

3.2.11.4 1.A.2.d Pulp, Paper and Print

Key Source: CO_2 from 1.A.2.d gaseous, solid and liquid fuels

Category *1.A.2.d Pulp, Paper and Print* includes emissions from fuel combustion in pulp, paper and print industry. The share in total GHG emissions from sector *1.A* is 4.3% for the year 1990 and 3.6% for the year 2021.

Methodology

CO_2 emissions are calculated by means of a Tier 2 method while N_2O and CH_4 emissions are calculated by means of a Tier 1 method. For the years 2005 onwards, CO_2 emissions from ETS reports are considered.

CO_2 emissions from industrial waste: The following Table 52 shows the composition of the implied emissions factor 2000–2021 for industrial waste. From 2005 onwards, ETS data is considered with plant specific emissions and energy consumption. From 1990 to 2004, energy consumption of the energy balance is taken and considered with a CO_2 emission factor of 75 t/TJ. Table 52 shows fuel waste consumption as provided by energy statistics together with fuel waste consumption, CO_2 emissions and the calculated IEF from ETS.

Table 52: Composition of 1.A.2.d Pulp, Paper and Print – industrial waste – CO_2 IEF for the years 2000 to 2021.

Year	Total energy use (energy balance)	ETS		CO_2 IEF	CO_2
	[TJ]	[TJ]	CO_2 IEF	[t/TJ]	[kt]
2000	0	-	-	-	-
2001	113	-	-	75.00	8.48
2002	122	-	-	75.00	9.12
2003	201	-	-	75.00	15.11
2004	246	-	-	75.00	18.45
2005	90	111	64.29	64.29	7.15
2006	99	149	43.85	43.85	6.53
2007	150	170	65.52	65.52	11.14
2008	122	101	88.78	88.78	8.92
2009	138	96	91.72	91.72	8.79
2010	166	79	100.85	100.85	7.93
2011	164	91	87.79	87.79	7.99
2012	81	60	116.27	116.27	6.98
2013	153	170	128.46	128.46	21.83
2014	258	180	129.09	129.09	23.20
2015	237	180	140.21	140.21	25.23
2016	268	151	134.22	134.22	20.21
2017	248	178	125.66	125.66	22.36
2018	212	289	73.69	73.69	21.29
2019	231	74	91.13	91.13	6.71
2020	205	94	99.33	99.33	9.38
2021	125	14	124.93	124.93	1.74

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002). Emission factors for 2021 are presented in the following table.

Table 53: Emission factors of Category 1.A.2.d.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Hard Coal	94.00	10.00	1.50
Lignite, Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Residual Fuel Oil	78.00	3.00	0.60
Diesel and Gasoil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Natural Gas	55.60	1.00	0.10
Fuel Wood and Sewage Sludge	112.00[1)]	30.00	4.00
Wood Waste	112.00[1)]	12.00	4.00
Black Liquor	95.30[1)]	3.00	2.00
Biogas and Landfill Gas	54.60[1)]	1.00	0.10
Industrial Waste	124.93	12.00	4.00

[1)] *Reported as CO_2 emissions from biomass*

Activity data

Fuel consumption is taken from (IEA JQ 2022) as presented in Annex 4, and from ETS.

Recalculations

Recalculations of activity data 2020 are following the revision of the energy balance as described in Annex 4.

3.2.11.5 1.A.2.e Food Processing, Beverages and Tobacco

Key Source: CO_2 from 1.A.2.e gaseous and liquid fuels

Category *1.A.2.e Food Processing, Beverages and Tobacco* enfold emissions from fuel combustion in food processing, beverages and tobacco industry. The share in total GHG emissions from sector *1.A* is 1.7% for the year 1990 and 1.5% for the year 2021.

Methodology

CO_2 emissions are calculated by means of a Tier 2 method while N_2O and CH_4 emissions are calculated by means of a Tier 1 method. For the years 2005 onwards, ETS data are considered.

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002).

Emission factors for 2021 are presented in the following table.

Table 54: Emission factors of Category 1.A.2.e.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Residual Fuel Oil	78.00	3.00	0.60
Diesel and Gas oil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Hard Coal	94.00	10.00	1.50
Lignite, Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00[1)]	30.00	4.00
Wood Waste	112.00[1)]	10.00	4.00
Biogas	54.60[1)]	1.00	0.10
Industrial Waste	75.00	12.00	4.00

[1)] *Reported as CO_2 emissions from biomass*

Activity data

Fuel consumption is taken from (IEA JQ 2022) as presented in Annex 4.

Recalculations

Changes in activity data 2020 are based on a revision of the energy balance as described in Annex 4.

3.2.11.6 1.A.2.f Non-Metallic Minerals

Key Source: CO_2 from 1.A.2.f gaseous, solid, liquid and other fuels

Category *1.A.2.f Non-Metallic Minerals* enfolds emissions from fuel combustion in cement, lime, magnesia, glass and bricks & tiles industries. Fuel use of limekilns, which are operated by sugar industries, is reported under category *1.A.2.e food processing, Beverages and Tobacco*. The share in total GHG emissions from Sector *1.A* is 3.2% for the year 1990 and 3.3% for the year 2021.

Cement Clinker Production (NACE 26.51)

This category enfolds emissions from fuel combustion in cement clinker kilns. The yearly production capacity of the 9 Austrian plants is about 4.3 Mt cement clinker. Yearly clinker production is 80% to 90% of total capacity. Further information about yearly clinker production is provided in the methodology chapter of category *2.A.1 Cement production*. Between 2008 and 2014, clinker production was falling by 21% from 4 Mt to 3.1 Mt and has increased to 3.6 Mt in 2021.

Methodology

Information about CO_2 emissions due to fuel combustion for cement production is taken from four studies of the Austrian cement industry (HACKL & MAUSCHITZ, 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004, 2009, 2010-2022). The data presented in these studies include fuel consumption and emission data for emissions from combustion processes and from calcination processes (process specific emissions, see category *2.A.1*) separately. The studies cover the years 1988 to 2021.

For the studies mentioned above, CO_2 emissions from all cement production plants in Austria were investigated. The determination of the emission data took place by inspection of every single plant, recording and evaluation of plant specific records, and plant specific measurements and analysis carried out by independent scientific institutes. Using this data (single measurement data or half-hourly mean values from continuous measurements), yearly mean values for concentration of CO_2 in the waste gas flow were calculated. With the average flow of dry waste gas, the plant specific CO_2 emission mass stream and consequently the plant specific emission factors (normalized to ton clinker and/or ton cement) were calculated.

CO_2 emissions

CO_2 emissions for the years 1990 to 2003 are taken from industry (HACKL & MAUSCHITZ, 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004).

For solid, liquid and gaseous fuels, CO_2 emissions are calculated by multiplying activity data by national default emission factors (for sources of emission factors see relating chapter). The remaining CO_2 emissions are allocated to industrial waste.

CO_2 emissions from 2004 onwards are taken from the ETS allocation plan survey and from ETS reports.

CH_4 and N_2O emissions are calculated by means of the IPCC Tier 1 methodology.

Activity data

Calculated thermal energy intake of cement kilns is between 3.45 GJ/t clinker in 1990 and 4.04 GJ/t clinker in 2021.

Hard Coal, Brown Coal, Petrol Coke and Industrial Waste

In (IEA JQ 2022) the category *Non-metallic Mineral Products* enfolds fuel consumption of NACE Division 26. As within this NACE division, industrial branches other than cement industry do not use coal and industrial waste for fuel combustion but 100% of those fuels are allocated to the cement industry. The same is for petrol coke until 2001, but from 2002 onwards, a share of petrol coke is allocated to magnesia production from dolomite by using ETS data. The following Table 55 shows the amount, NVCs and CO_2 IEFs of industrial waste, which is used as a fuel in cement kilns. After 2005, the share of non-fossil waste has been taken from ETS data. The overall IEF is between 79.2 to 88.5 t CO_2/TJ, which is reasonable because most of the waste origins from oil products. From 1990 to 2004, the mass of fractions with 100% biomass is not explicitly known. The biogenic C-content of the diverse waste fractions is e.g.: 0% for waste oil and solvents, 3–24% for plastics, 27–30% for scrap tyres, 36–42% for high heat value fraction of MSW and 56% for paper reject. Examples of non-fossil waste fractions: glycerine, carcass meal, animal fat, sewage sludge, paper fibre residue and sawdust.

Table 55: Industrial waste used as fuel in cement kilns 1990–2021.

Year	solid waste [kt]					
	100% biomass	Fractions with fossil C-content	NCV[1)] [MJ/kg]	fossil[1)] CO_2 IEF [t/TJ]	biomass[1)] CO_2 IEF [t/TJ]	Fossil +[1)] biomass CO_2 IEF [t/TJ]
1990	–	59	22.07	55.42	–	–
1991	–	67	25.02	47.96	–	–
1992	–	79	23.80	57.66	–	–

Year	solid waste [kt]		NCV[1)] [MJ/kg]	fossil[1)] CO_2 IEF [t/TJ]	biomass[1)] CO_2 IEF [t/TJ]	Fossil +[1)] biomass CO_2 IEF [t/TJ]
	100% biomass	Fractions with fossil C-content				
1993	–	79	23.16	70.55	–	–
1994	–	83	23.41	57.92	–	–
1995	–	87	22.71	68.92	–	–
1996	–	100	21.64	63.02	–	–
1997	–	101	20.78	64.41	–	–
1998	–	122	21.97	81.67	–	–
1999	–	135	21.43	81.29	–	–
2000	–	170	20.94	83.20	–	–
2001	–	218	20.85	85.13	–	–
2002	–	239	20.78	87.32	–	–
2003	–	254	21.91	83.71	–	–
2004	–	257	22.07	83.26	–	–
2005	58	204	23.28	68.92	10.32	79.25
2006	40	261	22.25	63.02	16.60	79.61
2007	34	301	20.21	64.41	17.73	82.14
2008	147	226	22.57	63.36	19.01	82.37
2009	146	219	23.19	61.41	21.42	82.83
2010	129	227	22.19	65.23	18.59	83.82
2011	136	240	21.53	64.06	21.81	85.86
2012	152	263	20.92	63.23	25.30	88.52
2013	146	280	19.90	64.26	20.04	84.30
2014	143	302	21.01	63.50	20.32	83.82
2015	164	307	19.93	59.87	24.06	83.93
2016	158	333	20.73	60.28	20.41	80.70
2017	158	341	21.15	61.03	20.01	81.04
2018	182	366	20.59	60.54	21.42	81.96
2019	169	359	19.82	59.40	20.62	80.02
2020	177	319	19.61	58.79	21.83	80.63
2021	212	348	19.61	55.55	23.48	79.03

[1)] *Of solid waste with fossil and non-fossil C-content.*

Natural Gas and Fuel Oil

For the period 1990 to 2004 natural gas and fuel oil consumption is taken from (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004) and converted into the unit TJ by applying the calorific values reported in (IEA JQ 2022).

Activity data 2005–2021

For the years 2005 onwards, ETS data are taken which covers 100% of cement plants.

Emission factors

CO_2 default emission factors are taken from studies (BMWA-EB 1990, 1996).

Recalculations

No recalculations have been made in this year's submission.

3.2.11.7 1.A.2.g Other Manufacturing Industries and Construction

Key Source: CO_2 from 1.A.2.g.vii liquid fuels
CO_2 from 1.A.2.g.viii gaseous, liquid and solid fuels

This category enfolds emissions due to fuel combustion of the industrial branches as specified in Table 56. The share in total GHG emissions from Sector *1.A* is 3.9% for the year 1990 and 5.6% for the year 2021.

Table 56: ISIC divisions considered in category 1.A.2.g.viii.

ISIC Division(s)	Name
13 and 14	Mining and Quarrying (Non fuel)
17, 18 and 19	Textile and Leather
20	Wood and Wood Products
25	Rubber and Plastic Products
28, 29, 30, 32 and 33	Machinery and Instruments
34 and 35	Transport Equipment
36	Furniture
37	Recycling
45	Construction

Methodology

CO_2 emissions are calculated by means of a Tier 2 method while N_2O and CH_4 emissions are calculated by means of a Tier 1 method. For the years 2005 onwards, CO_2 ETS data are considered.

Activity data

Fuel consumption is taken from (IEA JQ 2022) as presented in Annex 4.

Since the energy balance (IEA JQ 2022) does not report gas works gas the activity data is taken from the "Austrian Energy Balance" provided by STATISTIK AUSTRIA which is in a different structure but consistent with (IEA JQ 2022).

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002).

The emission factors for 2021 are presented in the following table.

Table 57: Emission factors 2021 of category 1.A.2.g.viii Other Manufacturing Industries and Construction.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Hard Coal	94.00	10.00	1.50
Lignite and Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Residual Fuel Oil	78.00	3.00	0.60
Diesel and Gasoil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG and Gas Works gas	64.00	1.00	0.10
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00[1)]	30.00	4.00

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Wood Waste	112.00[1)]	10.00	4.00
Biogas, Sewage Sludge Gas, Landfill gas	54.60[1)]	1.00	0.10
Industrial Waste – fossil (1990–2004)	75.00	12.00	4.00
Industrial Waste – IEF	97.29[2)]	12.00	4.00

[1)] Reported as CO_2 emissions from biomass; [2)] Implied emission factor

Recalculations

Changes of activity data 2020 are based on a revision of the energy balance as described in Annex 4.

1.A.2.g.vii Off-road vehicles and other machinery (industry)

Key Source: yes (liquid, CO_2)

In this chapter the methodology of estimating emissions from mobile sources of CRF *1.A.2.g.vii* is described. The share in total GHG emissions from CRF *1.A* is 0.5% for the year 1990 and 2.7% for the year 2021.

Table 58: Greenhouse gas emissions from category 1.A.2.g.vii mobile sources 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	256	0.01	0.09	283
1991	289	0.01	0.10	320
1992	306	0.02	0.11	339
1993	322	0.02	0.11	356
1994	338	0.02	0.12	374
1995	358	0.02	0.13	397
1996	446	0.02	0.17	496
1997	420	0.02	0.16	469
1998	494	0.02	0.19	553
1999	471	0.02	0.19	528
2000	551	0.02	0.22	618
2001	518	0.02	0.21	581
2002	504	0.02	0.20	565
2003	537	0.02	0.21	599
2004	591	0.02	0.20	652
2005	810	0.02	0.23	880
2006	979	0.02	0.24	1 052
2007	1 060	0.02	0.23	1 130
2008	1 166	0.01	0.23	1 235
2009	1 124	0.01	0.21	1 186
2010	1 077	0.01	0.19	1 135
2011	1 082	0.01	0.19	1 138
2012	1 119	0.01	0.18	1 173
2013	1 128	0.01	0.17	1 180
2014	1 102	0.01	0.16	1 151
2015	1 068	0.01	0.15	1 114
2016	1 083	0.01	0.15	1 127
2017	1 142	0.01	0.15	1 187

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
2018	1 222	0.01	0.15	1 267
2019	1 289	0.01	0.15	1 334
2020	1 238	0.005	0.14	1 280
2021	1 349	0.00	0.15	1 394
1990–2021	**427%**	**-63%**	**67%**	**393%**

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3 methodology.

Energy consumption and emissions of off-road traffic in Austria are calculated with the model GEORG (**G**razer **E**missionsmodell für **O**ff-**R**oad **G**eräte). This model was developed within a study about off-road emissions in Austria (HAUSBERGER 2000). The study was prepared to improve the poor data quality in this sector. The following CRFs were taken into account:

- *1.A.2.g.vii Industry*
- *1.A.3.c Railways*
- *1.A.3.d Navigation*
- *1.A.4.b Household and Gardening*
- *1.A.4.c Agriculture and Forestry*
- *1.A.5 Military (ground activities)*

Activities of mobile machinery in CRF *1.A.2.g.vii Industry* also contain commercially/institutionally used machinery. Austria does not report emissions from these machines separately under CRF *1.A.4.a.2* as the split into commercial/institutional and non-commercial/non-institutional use is not possible due to a lack of data.

Input data to the model are:

- Machinery stock data (obtained from data on licences, through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

With this method national fuel consumption and national emissions are calculated (bottom-up). Calculated fuel consumption of off-road traffic is then summed up with total fuel consumption of inland road transport and is compared with total fuel sold in Austria according to the national energy balance. The difference is allocated to fuel export (for details concerning fuel export see CRF *1.A.3.b*). The emissions reported for Austria also include the emissions from the fuel exports assuming that the fuel export fleet (mainly travelling on highways) is similar to the Austrian fleet on highways.

Activity Data

Activity data, vehicle stock and specific fuel consumption for vehicles and machinery (e.g. leaders, diggers etc.) were taken from:

- Statistik Austria (national energy balance),
- Questionnaire to vehicle and machinery users (HAUSBERGER 2000),
- Interviews with experts and expert judgment validating the questionnaire results (HAUSBERGER 2000) and
- Information from vehicle and machinery manufacturers (HAUSBERGER 2000).

An allocation of pure biofuels in the off-road sector has not been performed due to lack of data.

Activities used for estimating emissions of CRF *1.A.2.g.vii* as well as the implied emission factors are presented below. Combustion of liquid fossil fuels is the only mobile source of CO_2 emissions from category CRF *1.A.2.g.vii.*

The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 59: Implied emission factors and activities from industrial mobile off-road sources 1990–2021.

Year	Activity	Implied Emission Factors		
	TJ	CO_2 t/TJ	CH_4 kg/TJ	N_2O kg/TJ
1990	3 448	74.19	3.69	26.12
1991	3 897	74.19	3.67	26.15
1992	4 127	74.19	3.66	26.17
1993	4 340	74.19	3.66	26.19
1994	4 554	74.19	3.60	26.52
1995	4 821	74.19	3.50	27.11
1996	6 008	74.19	3.35	28.00
1997	5 663	74.19	3.26	28.65
1998	6 660	74.19	3.17	29.17
1999	6 352	74.19	3.12	29.54
2000	7 426	74.19	3.08	29.82
2001	6 980	74.19	3.05	29.98
2002	6 793	74.19	3.00	29.80
2003	7 241	74.19	2.71	28.46
2004	7 965	74.19	2.26	25.56
2005	11 016	73.52	1.69	21.33
2006	13 677	71.57	1.27	17.83
2007	14 819	71.53	1.03	15.67
2008	16 343	71.36	0.86	14.11
2009	15 977	70.33	0.77	13.09
2010	15 324	70.30	0.73	12.59
2011	15 401	70.25	0.69	12.09
2012	15 960	70.09	0.63	11.37
2013	16 051	70.29	0.56	10.74
2014	15 722	70.12	0.52	10.43
2015	15 318	69.71	0.48	10.10
2016	15 424	70.18	0.43	9.64
2017	16 193	70.55	0.38	9.11
2018	17 343	70.46	0.32	8.63

Year	Activity	Implied Emission Factors		
	TJ	CO_2 t/TJ	CH_4 kg/TJ	N_2O kg/TJ
2019	18 264	70.56	0.29	8.26
2020	17 535	70.58	0.27	8.06
2021	19 149	70.46	0.25	7.88

Emission Factors

Based on a new study (SCHWINGSHACKL/REXEIS/WELLER 2020) emission factors for a set of recently measured NRMM were updated as well as the implementation periods of the corresponding emission standards (so called "stages") were taken into account.

The following emission factors for different engine types (average motor capacity) depending on the year of construction and emission standards are used in the GEORG model. They represent emissions according to the engine power output and fuel consumption.

Table 60: Emission factors for diesel engines < 80 kW.

Emission Standard		Fuel	CO_2	CH_4	N_2O
	Years	[g/kwh]			
AG1	1990-1993	285.005	898.622	0.045	0.316
AG2	1994-2001	268.445	846.406	0.035	0.350
Stage 1	2002-2003	274.294	864.848	0.005	0.224
Stage 2	2004-2006	274.294	864.848	0.004	0.120
Stage 3a	2007-2011	274.294	864.848	0.002	0.084
Stage 3b	2012-2017	274.294	864.848	0.001	0.084
Stage 4 SCR	2014-2020	274.294	864.848	0.001	0.084
Stage 5	2020-2021	274.294	864.848	0.00002	0.084

Table 61: Emission factors for diesel engines > 80 kW.

Emission Standard		Fuel	CO_2	CH_4	N_2O
	Years	[g/kwh]			
AG1	1990-1993	277.543	875.092	0.038	0.316
AG2	1994-2001	263.231	829.968	0.029	0.350
Stage 1	2002-2003	258.120	813.852	0.005	0.224
Stage 2	2004-2006	268.550	846.740	0.003	0.120
Stage 3a	2007-2011	268.550	846.740	0.002	0.084
Stage 3b	2012-2017	268.550	846.740	0.001	0.084
Stage 4 SCR	2014-2020	268.550	846.740	0.001	0.084
Stage 5	2020-2021	268.550	846.740	0.00002	0.084

Table 62: Emission factors for 2-stroke-petrol engines.

Emission Standard		Fuel	CO_2	CH_4	N_2O
	Years	[g/kwh]			
AG1	1990-1993	739.000	2 330.067	2.503	0.015
AG2	1994-2001	671.650	2 117.712	1.761	0.015
Stage 1	2002-2003	653.150	2 059.382	1.663	0.015
Stage 2	2004-2006	500.000	1 576.500	0.510	0.014

Emission Standard		Fuel	CO_2	CH_4	N_2O
	Years	[g/kwh]			
Stage 3a	2007-2011	482.143	1 520.196	0.510	0.012
Stage 3b	2012-2021	482.143	1 520.196	0.510	0.012

Table 63: Emission factors for 4-stroke-petrol engines.

Emission Standard		Fuel	CO_2	CH_4	N_2O
	Years	[g/kwh]			
AG1	1990-1993	561.100	1 769.148	0.554	0.038
AG2	1994-2001	540.000	1 702.620	0.440	0.041
Stage 1	2002-2003	469.400	1 480.018	0.420	0.041
Stage 2	2004-2006	469.400	1 480.018	0.407	0.041
Stage 3a	2007-2011	456.361	1 438.907	0.375	0.030
Stage 3b	2012-2021	456.361	1 438.907	0.375	0.030

Recalculations

No recalculations have been carried out.

Planned Improvements

No category-specific improvements are planned.

3.2.12 QA/QC of 1.A.1 and 1.A.2 stationary sources

For general QA/QC see Chapter 1.2.3.

In 2016 STATISTIK AUSTRIA provided an updated documentation for the national energy balance and a document which covers a more actual quantification of uncertainties.

Concerning activity data for sectors *1.A.1* and *1.A.2* there are specific regulations in the Austrian legislation:

- BGBl II No. 1997/331 Feuerungsanlagen-Verordnung,
- BGBl 1989/19 Luftreinhalteverordnung für Kesselanlagen,
- BGBl 1988/380 Luftreinhaltegesetz für Kesselanlagen,
- BGBl 150/2004 Emissionsschutzgesetz für Kesselanlagen – EG K,
- BGBl 84/2006 Emissionsschutzgesetz für Kesselanlagen – EG K,
- BGBl II No. 2007/292 Emissionserklärungsverordnung – EEV.

Additionally the following sector specific QA/QC procedures have been carried out:

- activity data check
  - Survey for the "National Emission Trading Allocation Plan" 1 (NAP1) 1990 to 2002 with almost complete data for 1998 to 2002,
  - 1.A.1.a: public report: fuel consumption and energy production by plant (1990),
  - discussion of activity data with Refinery (incl. methodology of CO_2 emission calculation) and Iron and Steel Industry,

  - check of gas consumption with data from E-Control,
  - check of oil consumption with data from Mineral Oil Association.
- indicators and analysis (activity data and CO_2 emissions)
  - Public "Kyoto Progress" Reports until 2007. Public "Climate Protection" Reports since 2008,
  - energy intensity indicators: Iron and Steel, Cement industry, Refinery, Households.
- external review
  - Federal provinces air emission inventory,
  - Check of methodology and CO_2 emissions by WIFO.
- emission factors check
  - check of IEF (time series),
  - NAP1 survey: Country specific CO_2 emission factors used in the inventory were widely accepted,
  - comparison with IPCC.
- time series consistency
  - plausibility checks of dips and jumps,
  - yearly published emission trends report,
  - repeated values.
- recalculations check of activity data (energy balance), implied emissions factors and emissions.
- Method Documentation with Standard Operation Procedure (SOP);
- "Quick-calculation" of 1.A activity,
- improvement list (external and internal findings);
- link to STATISTIK AUSTRIA, Industrial associations;
- calculation by spreadsheets
  - consistent use of energy balance data (central file),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - use of coding systems (SNAP, SPLIT, NAPFUE),
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

3.2.13 1.A.3 Transport

3.2.13.1 1.A.3.a Civil Aviation

Key Source: No

CRF *1.A.3.a Civil Aviation* covers domestic LTO (landing/take off) and domestic cruise.

For methodological reason it is distinguished between flights according to

- Visual Flight Rules (VFR) which include all flights using aviation gasoline
- Instrumental Flight Rules (IFR) which cover all flights using kerosene

International LTO and international cruise is considered in CRF *1.D.1.a International Bunkers Aviation*. Military Aviation is allocated to CRF *1.A.5 Other.*

Greenhouse gas emissions from domestic aviation are very low related to total emissions from the transport sector *1.A.3* and amounted to 0.3% of total GHG emissions in 1990 and 0.1% in 2021.

Table 64: Greenhouse gas emissions from 1.A.3.a domestic Civil Aviation by subcategories 1990–2021.

Year	CO_2 [kt]			CH_4 [kt]			N_2O [kt]		
	dom. LTO (VFR)	dom. LTO (IFR)	dom. cruise (IFR)	dom. LTO (VFR)	dom. LTO (IFR)	dom. Cruise (IFR)	dom. LTO (VFR)	dom. LTO (IFR)	dom. Cruise (IFR)
	Gasoline	Kerosene	Kerosene	Gasoline	Kerosene	Kerosene	Gasoline	Kerosene	Kerosene
1990	7.8	9.3	21.3	0.0001	0.0020	NA	0.0002	0.001	0.001
1991	8.1	10.4	23.9	0.0001	0.0021	NA	0.0002	0.001	0.001
1992	8.3	11.3	26.0	0.0001	0.0022	NA	0.0002	0.001	0.001
1993	8.6	12.0	27.6	0.0001	0.0023	NA	0.0002	0.002	0.001
1994	8.8	12.5	28.8	0.0001	0.0024	NA	0.0002	0.002	0.001
1995	7.1	14.0	32.2	0.0000	0.0026	NA	0.0002	0.002	0.001
1996	6.8	15.5	35.6	0.0000	0.0031	NA	0.0002	0.002	0.001
1997	7.6	16.2	37.2	0.0001	0.0036	NA	0.0002	0.002	0.001
1998	8.2	16.8	38.5	0.0001	0.0041	NA	0.0002	0.002	0.001
1999	8.7	16.4	37.8	0.0001	0.0041	NA	0.0002	0.002	0.001
2000	6.3	19.3	41.6	0.0000	0.0048	NA	0.0002	0.002	0.001
2001	5.8	15.8	38.4	0.0000	0.0039	NA	0.0002	0.002	0.001
2002	7.4	16.4	38.2	0.0001	0.0041	NA	0.0002	0.002	0.001
2003	8.1	16.1	38.3	0.0001	0.0040	NA	0.0002	0.002	0.001
2004	7.5	17.2	39.5	0.0001	0.0043	NA	0.0002	0.002	0.001
2005	8.6	16.4	41.6	0.0001	0.0041	NA	0.0002	0.002	0.001
2006	8.9	19.6	43.2	0.0001	0.0049	NA	0.0003	0.002	0.001
2007	8.9	20.0	44.7	0.0001	0.0050	NA	0.0003	0.002	0.001
2008	9.1	22.2	39.3	0.0001	0.0055	NA	0.0003	0.002	0.001
2009	10.1	20.4	36.8	0.0001	0.0051	NA	0.0003	0.002	0.001
2010	9.1	19.4	34.9	0.0001	0.0048	NA	0.0003	0.002	0.001
2011	13.6	16.8	31.2	0.0001	0.0042	NA	0.0004	0.002	0.001
2012	7.9	16.9	29.7	0.0001	0.0042	NA	0.0002	0.002	0.001
2013	8.1	16.9	29.5	0.0001	0.0042	NA	0.0002	0.002	0.001
2014	7.4	15.4	27.0	0.0001	0.0038	NA	0.0002	0.001	0.001
2015	8.2	14.9	26.6	0.0001	0.0037	NA	0.0002	0.001	0.001
2016	10.2	14.8	22.5	0.0001	0.0009	NA	0.0003	0.0004	0.001

Year	CO_2 [kt]			CH_4 [kt]			N_2O [kt]		
	dom. LTO (VFR)	dom. LTO (IFR)	dom. cruise (IFR)	dom. LTO (VFR)	dom. LTO (IFR)	dom. Cruise (IFR)	dom. LTO (VFR)	dom. LTO (IFR)	dom. Cruise (IFR)
	Gasoline	Kerosene	Kerosene	Gasoline	Kerosene	Kerosene	Gasoline	Kerosene	Kerosene
2017	7.4	13.8	21.3	0.0001	0.0008	NA	0.0002	0.0004	0.001
2018	7.1	16.1	22.8	0.0001	0.0013	NA	0.0002	0.0004	0.001
2019	6.8	16.4	22.8	0.00005	0.0014	NA	0.0002	0.0005	0.001
2020	5.7	7.7	9.9	0.00004	0.0009	NA	0.0002	0.0002	0.0003
2021	6.3	8.0	9.6	0.00004	0.0010	NA	0.0002	0.0002	0.000
1990–2021	**-20%**	**-14%**	**-55%**	**-17%**	**-50%**		**-17%**	**-81%**	**-62%**

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3A (IFR flights) and Tier 1 (VFR flights) methodology.

IFR – Instrument Flight Rules

Until the submission 2020 Austria has used two different methodologies for calculating emissions of IFR flights:

- Tier 3B: For the years 1990–1999 a country-specific methodology was applied. The calculations were based on a study commissioned by the Umweltbundesamt finished in 2002 (Kalivoda/Kudrna 2002). This methodology was consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on the MEET model (Kalivoda/Kudrna 1997). For emission calculation air traffic movement data[45] (flight distance and destination per aircraft type) and aircraft/engine performances data were used.
- Tier 3A: For the years from 2000 onwards the IPCC 2006 GL Tier 3A methodology has been applied. Tier 3A takes into account average fuel consumption and emission data for LTO phases and various flight lengths, for an array of representative aircraft categories.

Based on a recommendation of the 2020 UNFCCC inventory review, Austria improved time series consistency by using the Tier 3A methodology as described above for the years from 2000 onwards and a trend extrapolation (as described in the IPCC 2006 GL volume 1 chapter 5.3.3) for 1990-1999.

Due to the lack of consistent data Austria was not able to use overlap or surrogate techniques. While the total amount of kerosene used in each year during the period 1990-1999 is out of question (KALIVODA & KUDRNA 2002), for the trend extrapolation it was necessary to determine the yearly ratios of kerosene used for domestic LTO, domestic cruise, international LTO and international cruise based on average shares of kerosene consumption over the three years 2000, 2001 and 2002. As a result four fixed average ratios were used for determing the new kerosene consumption and emissions for the years 1990-1999 for domestic LTO and domestic cruise as well as international LTO and international cruise.

VFR – Visual Flight Rules

The IPCC 2006 GL simple methodology (Tier 1 – fuel-based methodology) is applied.

[45] This data is also used for the split between domestic and international aviation.

Activity Data

Fuel consumption (kerosene and gasoline) for CRF *1.A.3.a.* is presented below. Airport ground handling activities are reported under CRF *1.A.3.e.2 Other (Airport Ground Activities)*.

Table 65: Activity data from 1.A.3.a Civil Aviation by subcategories 1990–2021.

Year	**Activity**		
	dom. LTO (VFR)	**dom. LTO (IFR)**	**dom. Cruise (IFR)**
	Gasoline [TJ]	**Kerosene [TJ]**	**Kerosene [TJ]**
1990	103	127	293
1991	106	143	329
1992	109	156	358
1993	113	165	379
1994	116	172	396
1995	93	193	443
1996	89	213	490
1997	100	222	511
1998	108	231	530
1999	115	226	519
2000	84	265	571
2001	77	217	527
2002	99	226	525
2003	107	221	527
2004	99	237	543
2005	115	225	571
2006	119	269	593
2007	118	274	615
2008	121	305	540
2009	135	280	506
2010	121	267	480
2011	182	231	429
2012	105	232	409
2013	108	232	405
2014	99	211	371
2015	111	205	365
2016	135	203	310
2017	98	189	293
2018	96	221	314
2019	92	226	315
2020	76	106	136
2021	85	110	133
1990–2021	**-17%**	**-14%**	**-55%**

IFR flights

For details of fuel consumption in the years 1990–1999 please refer to **'Methodological Issues'** above.

For the years from 2000 onwards fuel consumption for the different transport modes IFR national LTO, IFR international LTO, IFR national cruise and IFR international cruise was calculated according to the IPCC 2006 GL Tier 3A method, with average consumption data per aircraft types and flight distances. The fuel consumption of IFR international cruise was adjusted as explained below.

IFR flight movements are taken from Austro Control (AUSTRO CONTROL 2022), fuel consumption data from the national energy balance (STATISTIK AUSTRIA 2022).

Bottom up Methodology – fuel consumed

Based on the number of flight movements per aircraft type and airport (national and international) departing Austria, the distances for each airport pair and the specific fuel consumption per aircraft type and distance class, FC (kerosene) and emissions are calculated bottom up.

For the inventory years 2000-2015 flight movements were obtained from special analyses by Statistik Austria (STATISTIK AUSTRIA 2008[46], 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016). In addition, domestic flight movements were compared with a second data source for flight movements, provided by Austro Control (AUSTRO CONTROL 2007[47], 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016) and reconciled to meet these number of flight movements. Distances between airport pairs have been extracted based on IATA codes from single queries on the internet.[48]

Beginning with the inventory year 2016 flight movements have only been taken from Austrocontrol (AUSTRO CONTROL 2016, 2017, 2018, 2019, 2020, 2021, 2022), as they seemed to be more representative compared with international data. Since then distances between departure and arrival aerodromes have been calculated by an automatic distance generator using following formula:

$$D = r * \arccos(\sin(\pi*\varphi(A)/180) * \sin(\pi*\varphi(B)/180) * \cos(\pi*\varphi(A)/180) * \cos(\pi*\varphi(B)/180) * \cos(\pi*(\lambda(A)-\lambda(B))/180))$$

D.. Distance between aerodromes
r… Average radius of the earth (6371 km)
φ(A).. Geographical latitude of departure aerodrome A
φ(B).. Geographical latitude of arrival aerodrome B
λ(A).. Geographical longitude of departure aerodrome A
λ(B).. Geographical longitude of arrival aerodrome B

Therefore, each aerodrome being reported in the flight movements needs to be integrated in the calculation model with its geographical degree of latitude and longitude.

Top down Methodology – fuel sold

The calculated bottom up result for total kerosene consumption is being compared to the total fuel sold reported by the national energy balance:

- For the inventory years 2000-2015 the delta was fully allocated to international cruise, as the data reconciliation of domestic flight movements (see above) had already resulted in increased numbers in line with Austrocontrol.
- Beginning with the inventory year 2016 any delta between the bottom up result and the official amount of kerosene sold has been allocated to domestic LTO, international LTO, national cruise and international cruise depending on their relative shares in total kerosene consumption.

[46] For the years 2000-2007
[47] For the years 2000-2006
[48] www.world-airport-codes.com

The following table shows the fuel consumption for IFR flights and the numbers of national LTO (IFR).

Table 66: Fuel consumption for IFR flights and number of IFR LTO cycles, 1990–2021.

Year	Activity		
	Dom. LTO (IFR) Kerosene [kt]	**Dom. Cruise (IFR) Kerosene [kt]**	**Dom. LTO (IFR) [no. of flights]**
1990	2.94	6.75	-
1991	3.31	7.59	-
1992	3.59	8.25	-
1993	3.81	8.76	-
1994	3.98	9.13	-
1995	4.45	10.23	-
1996	4.92	11.30	-
1997	5.13	11.79	-
1998	5.32	12.22	-
1999	5.21	11.98	-
2000	6.11	13.18	22 611
2001	5.01	12.17	20 325
2002	5.21	12.13	21 422
2003	5.10	12.15	20 243
2004	5.47	12.54	20 175
2005	5.20	13.19	20 179
2006	6.20	13.70	20 727
2007	6.33	14.19	20 740
2008	7.04	12.48	21 457
2009	6.46	11.68	20 530
2010	6.16	11.07	20 532
2011	5.32	9.89	16 185
2012	5.37	9.43	16 405
2013	5.35	9.36	15 741
2014	4.87	8.56	14 776
2015	4.73	8.43	13 282
2016	4.70	7.15	15 515
2017	4.37	6.76	14 781
2018	5.11	7.24	19 735
2019	5.22	7.25	19 679
2020	2.45	3.13	14 196
2021	2.54	3.06	12 917
1990–2021	**-14%**	**-55%**	**-43%**[49]

VFR flights

Fuel consumption for VFR flights were directly obtained from the national energy balance, as total fuel consumption for this flight mode is represented by the total amount of aviation gasoline sold in Austria.

[49] Trend 2000 - onwards

Table 67: Fuel consumption for VFR flights, 1990–2021.

Year	**Activity**
	Dom. LTO (VFR) Gasoline [kt]
1990	2.49
1991	2.56
1992	2.64
1993	2.72
1994	2.81
1995	2.24
1996	2.15
1997	2.42
1998	2.60
1999	2.77
2000	2.04
2001	1.87
2002	2.39
2003	2.60
2004	2.41
2005	2.79
2006	2.87
2007	2.86
2008	2.94
2009	3.27
2010	2.92
2011	4.40
2012	2.54
2013	2.61
2014	2.38
2015	2.65
2016	3.28
2017	2.39
2018	2.30
2019	2.20
2020	1.83
2021	2.03
1990–2021	**-18%**

Emission Factors

The following tables give an overview of the emission factors used for IFR and VFR flights.

Table 68: Comparison of emission factors for 1.A.3.a Civil Aviation – IFR flights

	Inventory years 1990-2015	**Inventory years 2016-2021**
IFR - CO_2	3.15 kg/kg fuel	3.15 kg/kg fuel
IFR - CH_4	9.6% of HC_LTO	10.0% of HC_LTO
IFR - N_2O	0.1 kg/LTO 0.1 kg/t fuel for cruise	2.0 kg/TJ fuel

Table 69: Comparison of emission factors for 1.A.3.a Civil Aviation – VFR flights

	Inventory years 1990-2015	Inventory years 2016-2021
VFR – CO_2	3.15 kg/kg fuel	70.000 kg/TJ fuel
VFR – CH_4	0.5 kg/TJ fuel	0.5 kg/TJ fuel
VFR – N_2O	2.0 kg/TJ fuel	2.0 kg/TJ fuel

CO_2 (Tier 1)

CO_2 emissions for IFR flights are calculated in line with the factor provided by the emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA 2019). The factor used is 3.15 kg/kg fuel.

CH_4 (Tier 1)

CH_4 emission factors are not included in the spreadsheet accompanying the EMEP/EEA 2019 Guidebook (Annex 5). According to the IPCC 2006 Guidelines, the Tier 1 approach assumes that all aircrafts have the same emission factors for CH_4 based on the rate of fuel consumption.

CH_4 emissions for all flights (IFR-LTO) can be estimated with the Tier 1 default value of 0.5 kg/TJ fuel (IPCC 2006) or 10% of total VOC (HC) emissions (IPCC 2006, Chapter Mobile Combustion, Table 3.6.5). For inventory years 1990-2015 a percentage of 9.6% of HC_LTO, for inventory years 2016-2019 10% of total VOC (HC) has been used.

HC emission factors were not included in the old CORINAIR 1996 emission factor spreadsheet for all aircraft types. Therefore, HC emissions for inventory years 1990-2015 were reported based on a calculation with HC IEFs from KALIVODA/KUDRNA (2002). For inventory years 2016 onwards HC emissions are not reported based on the KALIVODA/KUDRNA (2002) study any more, but based on the HC emission factors which are part of the emission factors spreadsheet (EEA 2019) for the different aircraft types.

According to the IPCC 2006 Guidelines, CH_4 emissions are assumed to be negligible in the cruise mode[50]. Therefore CH_4 emissions for domestic and international cruise are reported as "NA".

N_2O (Tier 1)

According to the IPCC Guidelines (IPCC 2006), the Tier 1 approach assumes that all aircrafts have the same emission factors for N_2O based on the rate of fuel consumption.

N_2O emissions for all flights are estimated with the Tier 1 default value of 2.0 kg N_2O/TJ fuel (IPCC 2006, Chapter Mobile Combustion, Table 3.6.5).

Fuel consumption

The specific fuel consumption per distance class is provided in the spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' – Annex 5 (EEA 2019) for a huge number of aircraft types.

As in reality there are always flight movements with aircrafts which are not listed in the spreadsheet, an allocation of unknown aircrafts to listed aircrafts in the spreadsheet has to be undertaken based on research about engine type, number of engines, production series etc. If the unknown

[50] This is assumed to be valid for domestic and international cruise mode.

aircraft cannot be allocated, the aircraft is being labelled as UNKNOWN. The specific fuel consumption and emission factors are separately calculated on the basis of the national and international LTO and cruise averages of each year. This means the calculation distinguishes between:

- Unknown aircraft type for national flights – LTO
- Unknown aircraft type for national flights – cruise
- Unknown aircraft type for international flights – LTO
- Unknown aircraft type for international flights – cruise

For $LTO_{unknown}$ the equation is:

$$FC/LTO = Sum\ FC\_LTO_{unknown} / Sum\ flights\ movements_{unknown}$$

For $Cruise_{unknown}$ the equation is:

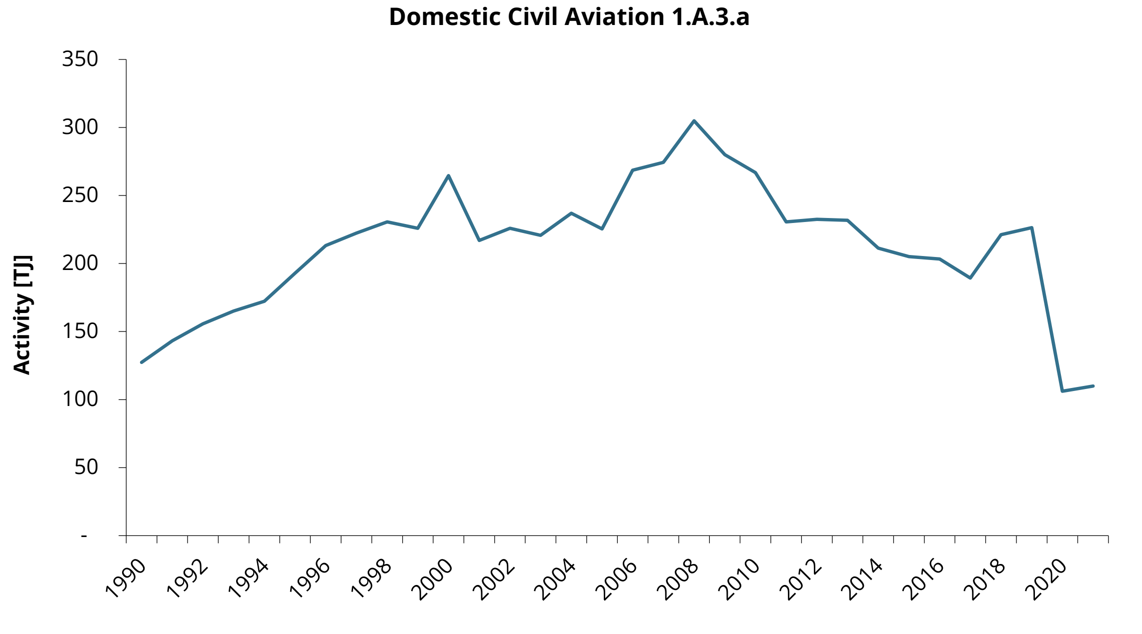
$$FC/km = (Sum\ FC\_cruise_{unknown} / sum\ nm\ cruise_{unknown}) * 125$$

125 nm (nautical miles) is the shortest distance class. For the other distance classes >125 nm the values are being extrapolated.

Quality Assurance and Quality Control (QA/QC)

Time series consistency

Figure 11: Activity data from 1.A.3.a domestic Civil Aviation 1990–2021.



Source: Umweltbundesamt

Tier 3A updated (for inventory years 2016 onwards)

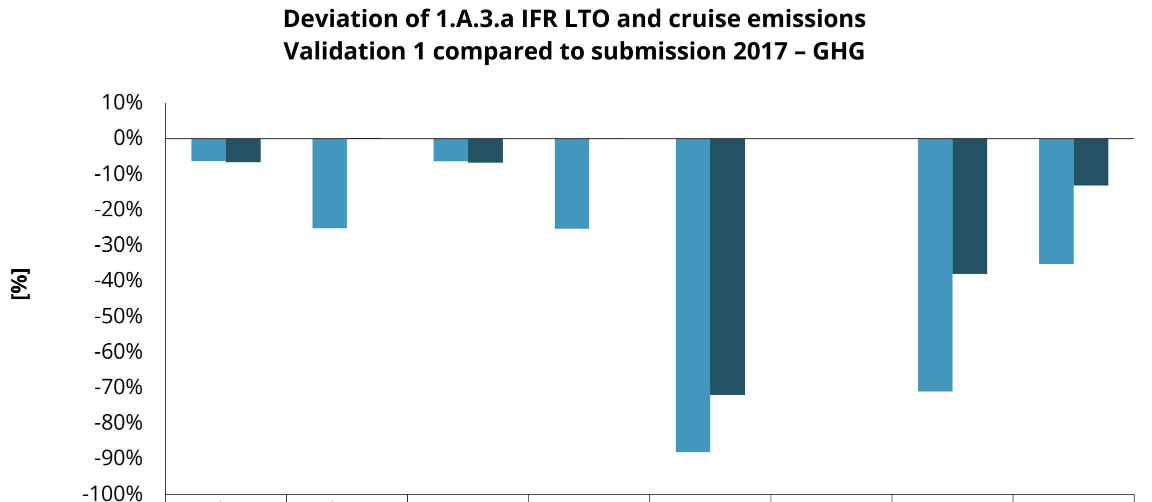
For the inventory years 2000–2015 the Tier 3A methodology is used for IFR flights. Tier 3A is also used for calculating the years from 2016 onwards, however with an improved set of flight movements and updated emission factors.

For the validation of the accuracy of the new data, the inventory year 2015 has been calculated in 2 steps:

Step 1 / Validation 1

The results for the inventory year 2015 (of the submission 2017) with the old aircraft types and emission factors was compared with the results when the same activity data is being calculated with the new set of available aircraft types and emission factors.

Figure 12: Deviation of GHG emissions of 1.A.3.a Civil Aviation – Validation 1.



	Fuel_LTO	Fuel_Cruise	CO_2_LTO	CO_2_Cruise	CH_4_LTO	CH_4_Cruise	N_2O_LTO	N_2O_Cruise
Domestic	-6%	-25%	-6%	-25%	-88%	0%	-71%	-35%
International	-7%	0%	-7%	0%	-72%	0%	-38%	-13%

Source: Umweltbundesamt

The new results for all aircraft types (known and unknown) are lower compared to the submission 2017. It must be noted that many aircrafts which were unknown so far and for which average EFs were calculated can now be allocated to aircraft types listed in the new emission factors spreadsheet. Vice versa some aircraft types which were listed in the old spreadsheets are not listed any more in the new emission factor spreadsheet.

For this reason, a comparison of FC and emissions between known aircraft types of the submission 2018 and the submission 2017 is shown below to demonstrate the separated effect of the changed EFs. Especially HC and CO emissions have drastically changed caused by implementing the new EFs resulting in tiny shares (0.1% – 0.3%) compared to the previous submission.

Table 70: Comparison of FC and emissions of known aircraft types.

	Submission 2018		Submission 2017		comparison	
aircraft types	National _known	International _known	National _known	International _known	National _known	International _known
Sum Fuel_LTO [kg]	4 205 240	91 300 794	4 634 807	96 961 520	91%	94%
Sum Fuel_Cruise [kg]	6 082 564	571 611 993	7 006 418	560 362 063	87%	102%
Sum HC_LTO [g]	4 167	128 451	5 700 251	246 508 917	0.1%	0.1%
Sum HC_Cruise [g]	3 466	200 005	1 360 011	268 778 760	0.3%	0.1%

	Submission 2018		Submission 2017		comparison	
aircraft types	National _known	International _known	National _known	International _known	National _known	International _known
Sum NO_x_LTO [kg]	43 842	1 302 697	47 195	1 277 592	93%	102%
Sumn NO_x_Cruise [kg]	83 786	9 159 335	104 386	7 846 958	80%	117%
Sum CO_LTO [g]	36 334	839 012	64 068 669	1 810 628 962	0.1%	0.05%
Sum CO_Cruise [g]	23 250	1 162 227	22 181 483	731 757 697	0.1%	0.2%
Sum Anzahl Flüge	12 584	126 434	12 584	126 434	100%	100%
Sum Flug-nm	1 685 375	81 632 688	1 685 375	81 632 688	100%	100%

An analysis of domestic flight movements in the inventory year 2015 has shown that the following three aircraft types hold the strongest shares in flown distances holding together a share of 85%:

- Dash 8 Q400 4580 hp (DH8D) with 60%
- Fokker 100 (F100) incl. F70[51] with 25%

This information is useful for the explanation of the changes in domestic emissions.

Table 71: Deviations in EFs of aircraft types DH8D and F100.

DOMESTIC Deviation		Deviation in EFs	
		DH8D	F100
FC_LTO	-6%	-0.03%	-19%
FC_Cruise	-25%	-30% on weighted average for distance classes 250 nm and 500 nm	-1% on weighted average for distance classes 250 nm and 500 nm
CH_4_LTO	-88%	due to changed HC EFs	
N_2O LTO	-71%	due to changed N_2O default EF	
N_2O Cruise	-35%	due to changed default N_2O EF	

An analysis of international flight movements in the year 2015 has shown that the following aircrafts hold the strongest shares in flown distances having together a share of 92% (the first three types holding 52%):

- A320 with 26%
- A319 with 14%
- B777 with 12%
- F100 with 9%
- A321 with 8%
- B767 with 8%
- B737 with 7%
- DH8D with 5%
- B737_100 with 1%

It should be noted that in the old spreadsheet the A320 was the equivalent aircraft type also for the A319. Thus, no comparison is possible. The B777 was the equivalent aircraft type for B778, B77W,

[51] It should be noted that the Fokker 70 (F70) was labelled as a F100 due to the fact that the old CORINAIR spreadsheet did not include the F70 aircraft.

B77L, B773, B772. In the new emission factor spreadsheet for some of these aircrafts specific emission factors are now provided: B772, B773, B77W. The B777 does not exist any more in the new spreadsheet, thus only the A320 and the A319 (which used to be an A320) will be compared in detail for explaining the following differences in international emissions.

Table 72: Deviations in EFs of aircraft type A320.

INTERNATIONAL Deviation		Deviation in emission factors
		A320
FC_LTO	-7%	-7%
CH_4_LTO	-72%	due to changed HC EFs
N_2O LTO	-38%	due to changed default N_2O EF
N_2O Cruise	-13%	due to changed default N_2O EF

The reduction of CH_4 emissions is due to the fact that the CH_4 EF is given as a percentage of HC emissions. Up to the submission 2017 for HC the IEFs from a national flight study (KALIVODA/KUDRNA 2002) were taken as shown below. The new HC EFs result in lower absolute HC and CH_4 emissions. HC IEF for domestic LTO is 88% lower; for international LTO 71% lower which is in line with the CH_4 reduction.

Table 73: Implied emission factors of HC for IFR kerosene for 2015.

t/t fuel	DOMESTIC		INTERNATIONAL	
	KALIVODA/KUDRNA 2002 IEFs	Tier 3A updated IEFs	KALIVODA/KUDRNA 2002 IEFs	Tier 3A updated IEFs
HC_LTO	0.008	0.001	0.005	0.0014

The N_2O emissions are lower due to the lower N_2O EF per unit of fuel as can be shown by comparing the IEFs. The N_2O IEF for domestic LTO is 70% lower; for domestic cruise 10% lower as it is for international LTO and international cruise.

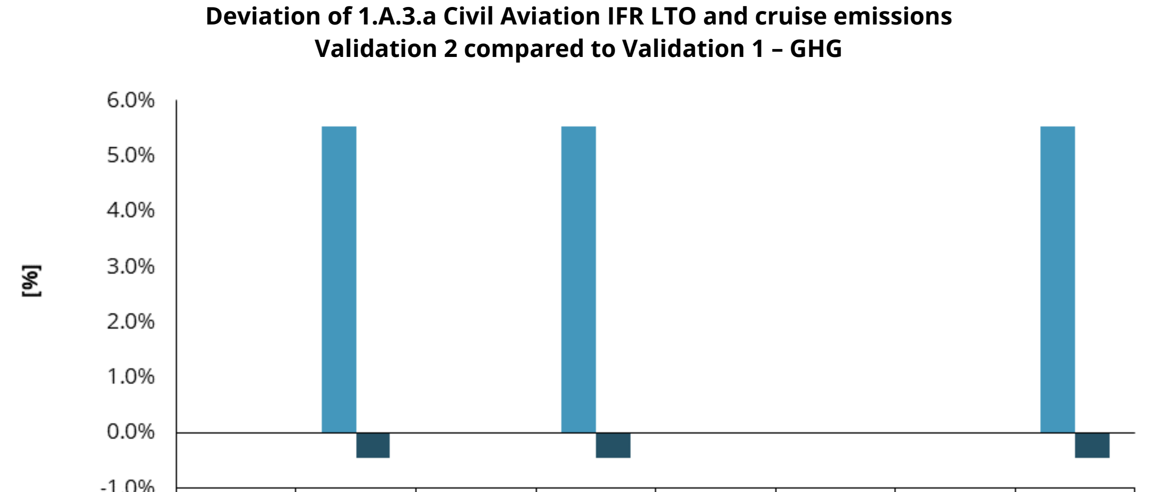
Table 74: Implied emission factors of N_2O for IFR kerosene for inventory year 2015.

t/t fuel	DOMESTIC		INTERNATIONAL	
	Tier 3A IEFs	Tier 3A updated IEFs	Tier 3A IEFs	Tier 3A updated IEFs
N_2O_LTO	0.0003	0.00009	0.0001	0.00009
N_2O_Cruise	0.0001	0.00009	0.0001	0.00009

Step 2 / Validation 2

In the second step the results for the inventory year 2015 of the submission 2017 with the old aircraft types and emission factors were compared with the results when the same activity data is being calculated with the new set of available aircraft types and emission factors and the new distance calculation formula.

Figure 13: Deviation of GHG emissions of 1.A.3.a Civil Aviation - Validation 2.



	Fuel_LTO	Fuel_Cruise	CO_2_LTO	CO_2_Cruise	CH_4_LTO	CH_4_Cruise	N_2O_LTO	N_2O_Cruise
Domestic	0.0%	5.5%	0.0%	5.5%	0.0%	0.0%	0.0%	5.5%
International	0.0%	-0.5%	0.0%	-0.5%	0.0%	0.0%	0.0%	-0.5%

Source: Umweltbundesamt

The new distance calculation is based on great circle distances between airport pairs and only leads to changes in FC cruise and emissions for cruise. For domestic flights the accuracy of distances flown is increased by 5.5% on average leading to an increase of FC and emissions for cruise. For international flights the accuracy is improved by 0.5% on average resulting in slightly lower FC and emissions for cruise.

Harmonization of CRF and IEA data

In 2013 the ERT detected inconsistencies of fuel consumption data of domestic aviation and domestic navigation between the CRF tables and the IEA data (ICR 2013). In response to that it was explained that Austria uses a bottom-up approach to estimate fuel consumption whilst IEA relies on top-down approach based on fuel consumption statistics reported by Statistics Austria

After having discussed this issue with Statistics Austria an Explanatory Note (30/09/2013) has been compiled by Statistics Austria declaring that a regular adoption of inventory data for the split between national and international fuel consumption in civil aviation and navigation in the national statistics will be adopted in the future, as far as the data can be submitted in time (early November).

As part of the regular QA/QC, the energy split between national and international aviation is provided to Statistics Austria for the IEA statistics based on the bottom-up model used to calculate the annual emission inventory.

In 2014 the ERT noted a significant difference in jet kerosene consumption (civil aviation) between IEA data and CRF Table 1.C. In response to the draft ARR 2014, Austria explained that the IEA value also includes military jet kerosene data and that this is the reason for the difference.

Comparison IEA (military jet kerosene data)

In 2014, the ERT noted a significant difference in jet kerosene consumption (civil aviation) between IEA data and CRF Table 1.C. In response to the draft ARR 2014, Austria explained that the IEA value also includes military jet kerosene data and that this is the reason for the difference.

Completeness

In response to a question raised by the ERT (ICR 2013) and based on a recommendation of the 2020 UNFCCC Review, fuel consumption and emissions of mobile sources used for aircraft handling at Austrian airports are now reported under CRF *1.A.3.e.ii.*

Uncertainty Assessment

After the allocation of unknown aircrafts for the year 2015 with the new EMEP/EEA 2016 spreadsheet (EEA 2016), the result was:

- Share of unknown aircraft regarding domestic flown distance: 3.3%
- Share of unknown aircraft regarding international flown distance: 0.2%

In total, only 0.2% of all distances flown departing from Austrian airports are being calculated with average EFs for unknown aircrafts.

Recalculations

No category specific recalculations have been carried out.

Planned improvements

According to the EEA the emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA, 2019) should have been updated in 2022, but so far no new spreadsheet has been transmitted. Austria will update its aviation calculation tool as soon as the new emission factors are published. At the moment the EEA emission factor spreadsheet still contains the same values as provided in the 'EMEP/EEA air pollutant emission inventory guidebook 2016' (EEA, 2016). This is relevant, because the CO_2 emission factor is taken from the Guidebook.

3.2.13.2 1.A.3.b Road Transport

Key Source: Yes (diesel oil CO_2/N_2O and gasoline CO_2)

CRF *1.A.3.b* shows a strong increase in GHG emissions since 1990 (+59%) mainly due to an increase of road performance (kilometres driven) in passenger and freight transport. In addition to the increase of road performance **within** Austria, the amount of fuel sold in Austria but **used elsewhere** – an effect mainly caused by higher fuel prices in neighbouring countries compared to Austria – has increased considerably since 1990. GHG emissions reached a peak in 2005. Between 2005 and 2012, total GHG emissions decreased due to lower amounts of fuel sold, increased use of biofuels for blending and gradual replacement with newer vehicles with lower specific fuel consumption. Since then, GHG emissions from transport have been **gradually increasing** with rising traffic volumes. A sharp decrease in the pandemic year 2020 was observed due to the slump in car mileage and fuel sales**. From 2020 to 2021** GHG emissions increased again by 3.7% due to increased vehicle kilometres. Sales of biofuels – pure and for blending – increased by 2.0 % in this period.

Table 75: Greenhouse gas emissions from Category 1.A.3.b Road Transport 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	13 283	2.92	0.35	13 461
1991	14 752	2.97	0.41	14 949
1992	14 727	2.66	0.42	14 918
1993	14 867	2.38	0.42	15 053
1994	14 915	2.16	0.43	15 097
1995	15 186	1.96	0.44	15 366
1996	16 748	1.73	0.44	16 922
1997	15 765	1.52	0.42	15 929
1998	17 741	1.49	0.45	17 914
1999	17 125	1.31	0.43	17 286
2000	18 033	1.21	0.43	18 192
2001	19 371	1.17	0.45	19 534
2002	21 496	1.19	0.49	21 671
2003	23 239	1.18	0.51	23 420
2004	23 748	1.13	0.51	23 927
2005	24 091	1.07	0.50	24 267
2006	22 722	0.95	0.50	22 896
2007	22 921	0.89	0.52	23 099
2008	21 485	0.80	0.51	21 657
2009	20 866	0.75	0.52	21 040
2010	21 649	0.72	0.56	21 833
2011	20 908	0.68	0.57	21 095
2012	20 839	0.65	0.59	21 032
2013	21 868	0.64	0.66	22 080
2014	21 268	0.63	0.68	21 487
2015	21 679	0.66	0.73	21 913
2016	22 517	0.71	0.77	22 762
2017	23 196	0.76	0.82	23 458
2018	23 348	0.79	0.85	23 621
2019	23 428	0.81	0.86	23 706
2020	20 313	0.72	0.79	20 567
2021	21 162	0.74	0.83	21 428
1990–2021	**59%**	**-75%**	**134%**	**59%**

In 2021, 55% of the total greenhouse gas emissions from CRF *1.A.3.b* are caused by passenger cars, 8% by light duty vehicles, 36% by heavy duty vehicles and buses and around 1% by mopeds and motorcycles. Compared to 1990 passenger cars caused 67% of total GHG emissions from *1.A.3 Transport;* light duty vehicles 8%, heavy duty vehicles 25% and less than 1% by mopeds and motor-cycles.

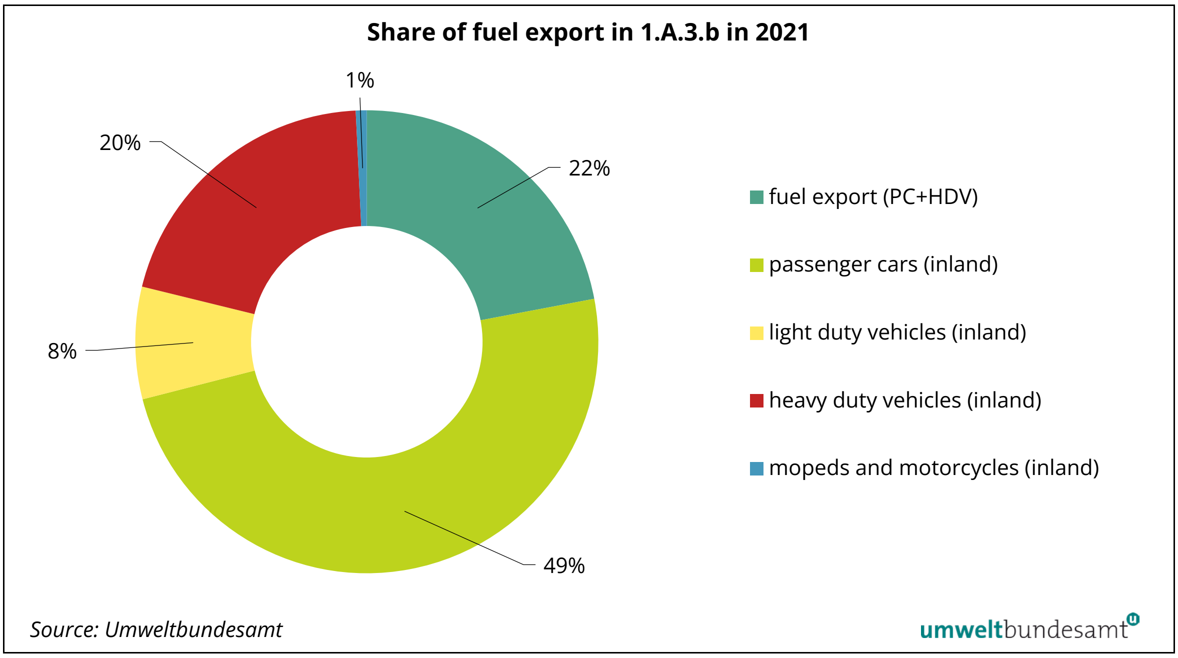
In the following table total greenhouse gas emissions in CO_2e are disaggregated by means of road transportation. Inland emissions and those from fuel export are shown separately in the two relevant vehicle categories passenger cars and heavy duty vehicles and must be added to get the total emissions for each vehicle category. The phenomenon of fuel export is explained in the subchapter Methodological Issues.

Table 76: Greenhouse gas emissions from 1.A.3.b Road Transport differentiated by means of transportation 1990–2021.

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	fuel export	inland	inland	fuel export	inland
	CO_2e [kt]					
1990	8 505	525	1 024	2 462	875	69
1991	9 459	652	1 053	2 685	1 031	69
1992	9 275	586	1 099	2 783	1 104	71
1993	9 137	556	1 116	2 863	1 307	74
1994	9 147	509	1 158	2 985	1 220	78
1995	9 173	493	1 179	3 101	1 337	83
1996	8 984	373	1 216	3 199	3 060	88
1997	8 979	315	1 238	3 305	1 997	94
1998	9 679	462	1 274	3 409	2 989	100
1999	9 580	303	1 313	3 496	2 488	106
2000	9 778	291	1 340	3 624	3 049	110
2001	10 291	465	1 366	3 669	3 630	113
2002	11 323	992	1 405	3 770	4 063	117
2003	11 997	1 449	1 433	3 939	4 482	120
2004	12 207	1 684	1 451	4 023	4 440	122
2005	12 214	1 933	1 436	3 986	4 573	125
2006	11 988	1 904	1 400	3 959	3 515	129
2007	12 109	2 120	1 416	3 980	3 340	133
2008	11 338	1 979	1 369	3 799	3 037	135
2009	11 137	2 073	1 330	3 368	2 992	140
2010	11 177	2 079	1 349	3 561	3 525	143
2011	11 118	1 969	1 367	3 647	2 846	147
2012	10 943	1 924	1 359	3 647	3 007	152
2013	10 982	1 835	1 379	3 650	4 076	158
2014	11 079	1 805	1 400	3 536	3 503	163
2015	11 345	2 007	1 428	3 533	3 433	167
2016	11 721	2 173	1 490	3 934	3 273	173
2017	11 916	2 322	1 536	4 165	3 344	176
2018	11 788	2 437	1 549	4 291	3 381	174
2019	11 500	2 402	1 596	4 340	3 696	173
2020	10 072	1 310	1 611	4 196	3 220	157
2021	10 306	1 462	1 712	4 525	3 274	149
1990–2021	**21%**	**178%**	**67%**	**84%**	**274%**	**114%**

In 2021, the total share of fuel export in CRF *1.A.3.b* amounted to 22% or 4 736 kt CO_2 equivalents of which 31% are attributed to passenger road transport and 69% to road freight transport.

Figure 14: Share of fuel export in 1.A.3.b Road Transport in 2021.



Methodological Issues

The used methodology for estimating CO_2 emissions conforms to the requirements of the IPCC 2006 GL Tier 2 for CO_2 and Tier 3 for CH_4 und N_2O. Below details on EFs are given.

Mobile road combustion is differentiated into the categories Passenger Cars, Light Duty Vehicles, Heavy Duty Vehicles and Buses, Mopeds and Motorcycles. In order to apply the IPCC 2006 GL methodology a split of the fuel consumption of different vehicle categories is needed.

Bottom up Methodology – fuel consumed

Energy consumption and emissions of the different vehicle categories are calculated by multiplying the yearly road performance per vehicle category (km/vehicle and year) by the specific energy use (g/km) and by the emission factors in g/km (Model: NEMO).

NEMO also models the road performance and emissions per vehicle size, age and motor type based on dynamic vehicle specific drop out- and road performance functions.

To determine fuel consumption and emissions of domestic road transport, vehicle stock and total annual road performance (mileage driven per year) of the vehicle categories should be recorded as precisely as possible by national statistics.

Vehicle registrations are being updated yearly. The last update of the specific yearly mileage of passenger cars, light duty vehicles, busses and motorcycles has been done for the years 2019, 2020 and 2021 according to data of the annual inspection of traffic and operational safety (according to §57a of the 1967 Motor Vehicle Act (KFG)) for the submission 2023.

For heavy duty vehicles the current traffic volumes up to and including 2007 are taken from Austrian National Transport Model "VMOe 2025+" Verkehrs-Mengenmodell-Österreich (Federal Transport Model, Ministry of Transport, BMVIT, not published). Mileage data after 2007 is calculated from the growth rates according to the final results of the automatic traffic counting stations and the toll data (ASFINAG 2022; BMK 2022d). For passenger cars, light duty vehicles, buses and motorcycles mileage data from the periodical inspection database was used as described above.

Based on a recommendation made by the UNFCCC during the 2020 Review, Austria collected fuel consumption data of mobile sources used for aircraft handling at Austrian airports. On the basis of specific information from Vienna's International Airport an estimate for all Austrian airports was carried out. Emissions are now reported separately under CRF *1.A.3.e.2 Other*. Fuel and emissions from this source were previously included in CRF *1.A.3.b Road Transport.*

Top down Methodology – fuel sold

Based on the NEMO model fuel consumption and emissions for road transport are calculated with a bottom-up approach. Calculated fuel consumption of road transport is then summed up with calculated fuel consumption of off road traffic and is compared with national total fuel sold.

The difference between the fuel consumption calculated in the bottom-up methodology for road traffic plus off-road transport within Austria and total fuel sales in Austria (obtained from the yearly Austrian energy balance) is allocated to fuel export (fuel sold in Austria but consumed abroad). Emissions reported for Austria also include the emissions from the fuel exports.

According to the bottom-up / top-down methodology for the calculation of domestic fuel consumption and fuel export, an increased use of domestic diesel always results in a reduction of the quantities handled in fuel export, and vice versa

Due to the Austrian methodology for estimating GHG from road transport (please see Methodology 1.A.3.b - fuel export), where the total fuel sold in Austria is subtracted by the inland road transport and the off-road transport to derive fuel exports, there is no underestimation in total fuel consumption of 1.A.3 Transport plus mobile machinery of NRMM (Non-Road Mobile Machinery), because the amount of total fuel sold in Austria taken from the energy balance is the value which determines the GHG emissions of transport. The recalculation therefore did not change the total GHG emissions from transport but only the contributions from the sub-categories.

Fuel export

Since the end of the nineties an increasing discrepancy between the total Austrian fuel sales and the computed domestic fuel consumption became apparent. From 2003 onward this gap accounts for roughly 30% of the total fuel sales. A possible explanation of this discrepancy is the "fuel export in the vehicle tank" – due to the relatively low fuel prices in Austria (in comparison to the neighboring countries). Meaning that to a greater extent fuel is filled up in Austria and consumed abroad. This assumption is underpinned by two national studies (MOLITOR & HAUSBERGER et al. 2004; MOLITOR & SCHÖNFELDER et al. 2009).

It is assumed that the fuel export fleet (mainly travelling on highways) is similar to the Austrian fleet on highways, which means that no different efficiency rates are assumed for the fuel export fleet. It is assumed that fuel export is assigned to three vehicles groups: gasoline PC, diesel PC and diesel trucks.

Gasoline fuel export is calculated from the inland gasoline consumption and the difference to the total sales of gasoline in Austria. The difference is being assigned to the gasoline fuel export in cars. Fuel consumption of diesel fuel export with cars is being calibrated in proportion to the diesel share of the foreign car fleet based on the relation between FC of gasoline cars in fuel export and FC of gasoline cars in inland. After having calculated the diesel export in cars the diesel export of trucks can be estimated by total diesel sales minus diesel FC inland minus diesel export in cars (HAUSBERGER, SCHWINGSHACKL & REXEIS 2015a, p.22).

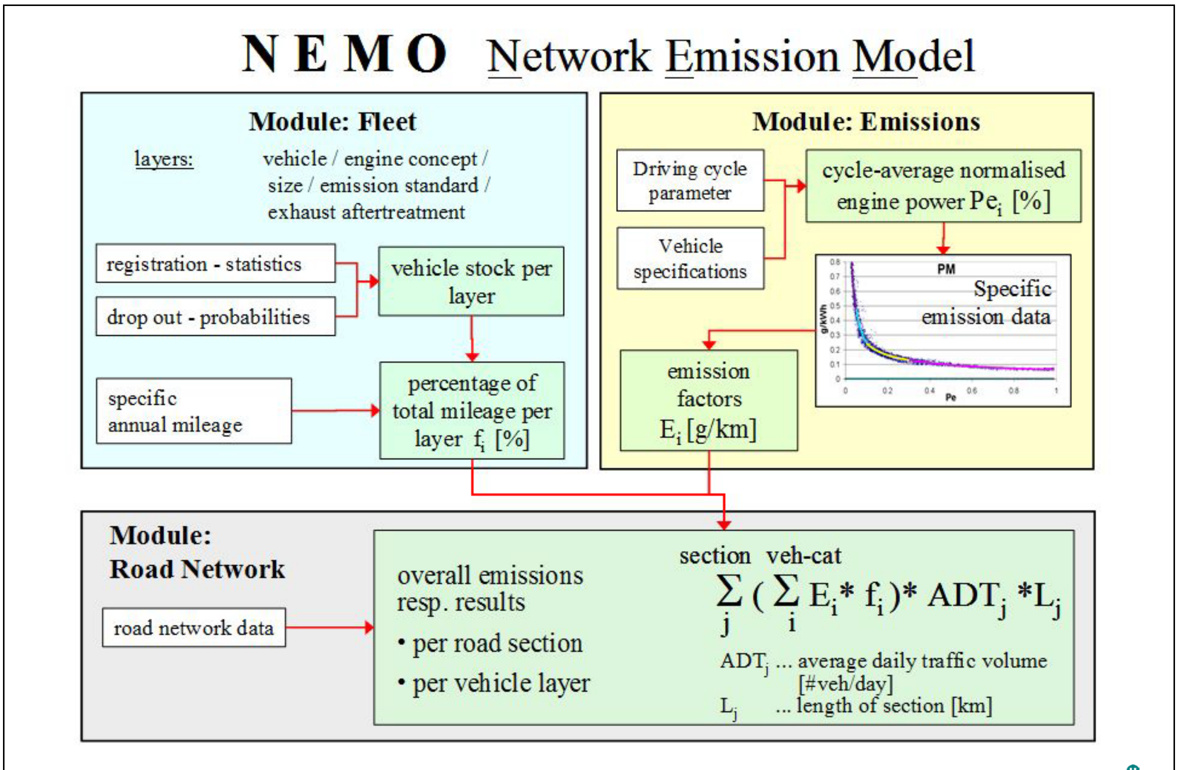
NEMO – Network Emission Model

From the submission in 2015 onwards calculations are based on the model NEMO – Network Emission Model (DIPPOLD, REXEIS & HAUSBERGER 2012; HAUSBERGER, SCHWINGSHACKL & REXEIS 2015a, 2015b; SCHWINGSHACKL & REXEIS 2022). NEMO combines a detailed calculation of the fleet composition with the simulation of energy consumption and emission output on vehicle level. It is fully capable to depict the upcoming variety of possible combinations of propulsion systems (internal combustion engine, hybrid, plug-in-hybrid, electric propulsion, fuel cell …) and alternative fuels (CNG, biogas, FAME, Ethanol, GTL, BTL, H_2 …).

In addition, NEMO has been designed to be also suitable for all main application fields of simulation of energy consumption and emission output on a road-section based model approach. As there does not yet exist a complete road network for Austria on a highly resolved spatial level, the old methodology based on a categorisation of the traffic activity into "urban", "rural" and "motorway" has been currently also applied in NEMO. The model calculates vehicle mileages, passenger-km, ton-km, fuel consumption, all exhaust gas emissions, evaporative emissions and suspended TSP, PM_{10}, $PM_{2.5}$, PM_1 and $PM_{0.1}$ exhaust and non-exhaust emissions of road traffic.

Figure 15 shows a schematic picture of the methodology of NEMO.

Figure 15: Schematic picture of the NEMO model.



Source: Hausberger, Schwingshackl & Rexeis (2015a, 2015b)

Model input

1. Yearly vehicle registrations (STATAT) and an algorithm for drop-out probabilities form the vehicle stock of each vehicle category split into layers according to the propulsion system (SI, CI,..), cylinder capacity classes or vehicle mass;
2. Emission factors of the vehicles according to the year of first registration and the layers from 1);
3. Yearly specific mileages of PCs, LDVs, mopeds and motorcycles (BMK)
4. Yearly growth rates of kilometres driven by PCs and HDVs separated for the federal street network (motorways) and the federal county network (urban, rural) (AUSTRIA TECH)
5. Yearly absolute number of vehicle kilometres (trucks and busses) on Austrian motorways (BMK)
6. Number of passengers per vehicle and tons payload per vehicle;
7. Optional either/or
   a. total gasoline and diesel consumption of the area under consideration,
   b. average km per vehicle and year.

Model output

a. Km driven per vehicle and year,
b. Total fuel consumption of road traffic,
c. Total vehicle mileages,
d. Total passenger-km and ton-km,
e. Specific emission values for the vehicle fleets [g/km], [g/tkm], [g/pkm],
f. Total emissions (evaporative emissions and suspended TSP, PM_{10}, $PM_{2.5}$, PM_1 and $PM_{0.1}$ exhaust and non-exhaust emissions, CO, HC, NO_x, CO_2, SO_2 and several unregulated pollutants among them CH_4 and N_2O) of road traffic.

The calculation is done according to the following method for each year

1. Assessment of the vehicle stock split into layers according to the propulsion system (SI, CI,..), cylinder capacity classes (or vehicle mass for HDV) and year of first registration using the vehicle survival probabilities and the vehicle stock of the year before.

$$stock_{Jg_i,\text{year i}} = stock_{Jg_i,\text{year i}-1} \times \text{survival probability}_{Jg_i}$$

2. Assessment of the km per vehicle for each vehicle layer using age and size dependent functions of the average mileage driven. If option switched on, iterative adaptation of the km per vehicle to meet the total fuel consumption targets.

3. Calculation of the total mileage of each emission category (e.g. passenger car diesel, EURO 3)

$$\text{total mileage}_{E_i} = \sum_{Jg=\text{start.}}^{\text{end}} (\text{stock}_{Jg,\text{year i}} \times \text{km/vehicle}_{Jg_i,\text{year i}})$$

4. Calculation of the total fuel consumption and emissions of each emission category

$$\text{Emission}_{E_i} = \text{total mileage}_{E_i} \times \text{emission factor}_{K_j,E_i}$$

5. Calculation of the total fuel consumption and emissions of each vehicle category

$$\text{Emission}_{\text{veh.category}} = \sum_{E_i=1}^{end} \text{Emission}_{E_i}$$

6. Calculation of the total passenger-km and ton-km

$$\text{transport volumes}_{\text{veh.category}} = \sum_{E_i=1}^{end} (\text{vehicle mileage}_{E_i} \times \text{loading}_{E_i})$$

7. Summation over all vehicle categories with

   Jg_i Index for a vehicle layer (defined size class, propulsion type, year of first registration)

   E_i Index for vehicles within a emission category (defined size class, propulsion type and exhaust certification level)

Module: Fleet

The composition of the vehicle fleet in NEMO is being simulated based on annual Austrian registration statistics per vehicle category and propulsion system as well as age-dependent survival (drop-out) probabilities. Vehicle technologies (exhaust standards or "EURO classes") are assigned to vehicle registrations based on the year of registration.

NEMO combines both detailed calculation of the vehicle fleet composition and simulation of emission factors on a vehicle level. NEMO calculates the percentages of different vehicle layers on the overall traffic volume as a function of year and considered road type based on data on vehicle stock, composition of new registrations and vehicle usage. The simulation of the emissions of the different vehicle layers is based on the correlation of the specific engine emission behaviour (emissions in grams per kilowatt-hour engine work) with the cycle average engine power in a normalised format. The calculation of the required engine power is based on average speed and additional kinematic parameters for the description of the cycle dynamics for a given road section.

Module: Road Network

Starting point for the road network files currently used in the inventory for the three road categories "urban", "rural" and "motorway" are the mileage distributions stored in HBEFA for Austria according to different traffic situations. Within the road categories the average speed is a product of x different driving patterns per vehicle category (dependant on y road types in each of the three road categories with specific inclinations, speed limits, actual traffic flows, average measured speeds, etc.). The resulting average speeds for Austrian "urban", "rural" and "motorway" road category weighted by traffic volume in the attachment can be found in the following table.

Table 77: Resulting average speeds per vehicle category in NEMO (based on traffic situations taken from HBEFA V4.2)

	Speed [km/h] per road category		
Vehicle category	**urban**	**rural**	**motorway**
Passenger Car	32.6	71.2	116.3
Light Duty Vehicle	32.6	71.2	116.2
Heavy Duty Vehicle-Road Truck	29.5	63.5	79.9
Heavy Duty Vehicle-Tow Truck	29.5	63.5	79.9
Coach	29.5	64.3	90.5
Urban Bus	23.7	49.8	-

	Speed [km/h] per road category		
Vehicle category	**urban**	**rural**	**motorway**
Motorcycle-2 cylinders	33.7	68.3	-
Motorcycle-4 cylinders	33.7	68.3	-
Moped	33.7	48.8	-

Activity Data

From 2020 to 2021 fuel consumption of road transport in TJ (gasoline, diesel and alternative fuels including liquid biomass) increased by 4.2%. Specific consumption per average vehicle kilometer and vehicle category did not improve for light duty vehicles; it declined by 0.1% for diesel passenger cars, by 0.6% for gasoline passenger cars, and by 0.6% for heavy duty vehicles. The following table gives an overview of the amount of fuel sold in Austria (including fuel export in the vehicle tank) differentiated by fuel type.

The following table gives an overview of the amount of fuel sold in Austria (including fuel export) differentiated by fuel type.

Table 78: Activity data from category 1.A.3.b Road Transport differentiated by fuel type 1990–2021.

	Fuel consumption (based on fuel sold) [TJ]						
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**other fossil**	**biomass**
1990	176 224	103 530	72 281	413	-	-	-
1991	195 757	113 591	81 739	428	-	-	-
1992	195 563	108 591	86 527	444	-	-	-
1993	197 572	104 156	92 965	451	-	-	-
1994	198 325	100 421	97 442	462	-	-	-
1995	202 087	96 995	104 599	494	-	-	-
1996	223 374	89 706	132 999	670	-	-	-
1997	210 232	85 019	124 682	530	-	-	-
1998	236 781	88 975	147 216	590	-	-	-
1999	228 654	82 683	145 350	622	-	-	-
2000	240 978	79 884	160 422	672	-	-	-
2001	259 017	80 473	177 821	722	-	-	-
2002	287 524	86 678	199 862	984	-	-	-
2003	310 999	88 660	221 206	1 132	-	-	-
2004	317 903	86 254	230 693	947	9	-	-
2005	324 764	83 831	237 650	932	10	170	2 171
2006	312 462	80 461	222 206	948	9	601	8 236
2007	316 184	78 583	226 719	923	69	678	9 211
2008	299 155	70 605	215 379	1 002	131	741	11 296
2009	294 221	70 402	206 937	945	324	949	14 663
2010	305 791	69 285	218 633	889	447	912	15 625
2011	295 561	66 752	211 249	854	479	918	15 309
2012	295 359	65 001	212 068	900	525	899	15 967
2013	309 063	63 750	227 257	841	640	900	15 674
2014	301 637	62 551	220 128	739	692	1 059	16 468
2015	308 880	63 187	225 079	558	715	1 127	18 214
2016	318 313	62 533	236 454	506	708	930	17 182
2017	326 431	61 856	246 395	479	702	848	16 152

Fuel consumption (based on fuel sold) [TJ]							
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**other fossil**	**biomass**
2018	329 483	64 295	246 925	344	681	925	16 312
2019	329 931	64 057	248 214	220	747	881	15 812
2020	286 334	52 494	218 267	128	795	744	13 906
2021	298 261	55 819	226 285	157	765	769	14 465
1990–2021	**69%**	**-46%**	**2 133%**	**-62%**	**8 469%**[52]	**351%**[53]	**566%**[53]

The general equal distribution of pure biofuels to relevant vehicle categories was changed in the calculations of the 2016 submission. The allocation has been done based on expert judgement and was implemented in the model NEMO according to the road performance of each vehicle category:

- *biodiesel B100 is assigned to HDV to 100%*
- *vegetable oil is assigned to HDV to 100%*[54]
- *bioethanol (E85) is assigned to PC to 100%*

The allocation of alternative fuels like liquefied petroleum gas (LPG) and compressed natural gas (CNG) is assumed in the model as follows:

- LPG is assigned to PC, HDV and LDV (only otto-motorised) according to their road performance.
- Natural gas (CNG) is distributed to PC, HDV and LDV (only otto-motorised) according to their road performance.

Biofuels

Since 2005 biogenic fuel (biodiesel, bioethanol, plant oil) has been used in the Austrian road transport sector. Biodiesel and bioethanol are mainly used for blending fossil fuels, whereas plant oil is distributed in pure form. In 2021 the energetic substitution by biofuels amounted to 5.84% in the road transport sector (BMK 2023a).[55] 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (UMWELTBUNDESAMT 2006a).

The following data is used as direct input data in the calculation models based on NEMO and GEORG (see 1.A.2.g.vii).

In 2021 a total of 6 080 917.35 tonnes of fossil diesel were sold based on the calculation of the substitution target according to the Austrian Fuel Ordinance. Based on data from the national biofuel register *elNa* (electronic sustainability certificates), a total of 405 937.20 tonnes of biodiesel and 10 524.13 tonnes of hydrotreated vegetable oil (HVO) were added by blending. In addition, 25 011.73 tonnes of biodiesel and 1 158.86 tonnes of HVO were put on the market in their pure form or as fuel with a higher percentage of biogenic admixture in diesel. In addition, 1 349 112.17 tonnes of fossil gasoline were sold. A total of 76 115.72 tonnes of sustainable bioethanol were added to these fuels, of which 16 564.47 tonnes were biogenic ethyl tertiary butyl ether (ETBE). As

[52] Trend 2004-onwards

[53] Trend 2005-onwards

[54] An allocation to agriculture is not possible at the moment, because of the technical model framework.

[55] The required substitution target amounts to 5.75%, measured by energy content.

in previous years, accounting for 148.91 tonnes, vegetable oil was used. In addition, 291.78 tonnes of bio-methane (biogas) were sold to the transport sector in the year 2021 (BMK, 2023a).

Table 79: Use of biofuels in absolute figures 2005–2021.

Year	Pure [t]		Blended [t]		biofuels total [t]
	biofuel pure	biogas	Biodiesel+HVO	bioethanol	
2005	17 000	-	74 962	-	17 000
2006	52 500	-	287 849	-	52 500
2007	89 209	-	298 665	20 387	89 209
2008	121 276	0.1	304 115	84 894	121 276
2009	133 690	1	405 689	99 407	133 690
2010	92 377	2	426 774	105 872	92 377
2011	101 824	6	421 823	102 744	101 824
2012	74 983	9	440 687	105 366	74 983
2013	80 536	15	443 167	88 833	80 536
2014	159 153	463	474 465	87 676	159 153
2015	174 255	350	528 717	89 541	174 255
2016	80 875	344	495 513	86 893	80 875
2017	46 613	214	458 804	85 208	46 613
2018	63 177	306	462 138	88 186	63 177
2019	58 637	349	448 065	86 290	58 637
2020	34 649	278	390 153	82 019	34 649
2021	26 294	213	416 320	75 511	26 294
2005–2021	**55%**	**279 936%**[56]	**455%**	**270%**[57]	**464%**

Emission Factors

CO_2 emissions are calculated on the basis of tons of fuel. In NEMO a country-specific CO_2 EF is applied assuming a carbon content of 86% for diesel and gasoline resulting in a value of 3.153 kg/kg fossil fuel.

As responded to the ERT's questions during the 2016, 2020 and 2022 UNFCCC Reviews the high CO_2 IEF (75.74 t/TJ) is above the upper IPCC default values (73.00 t/TJ) due to the application of the comparatively low NCV from the national energy balance, which is 41.8 TJ/kt Gasoline for the year 2020. The application of the IPCC default NCV (44.3 TJ/kt) would increase activity data and thus reduce the CO_2-IEF to about 70 t/TJ. Austria therefore does not assume that emissions from Gasoline are overestimated.

As responded to the ERT's question during the UNFCCC Review 2016 on an update on the progress of separate reporting of CH_4 and N_2O emissions associated with biomass (also raised in ARR 2014 para 30) it should be noted that Austria has implemented this improvement in its submission 2018.

CH_4 and N_2O EFs used in NEMO are based on a representative number of vehicles and engines measured in real-world driving situations taken from the "Handbook of Emission Factors" (HBEFA) (HAUSBERGER/KELLER et al. 1998) and on ARTEMIS measurements (basically for passenger cars, light duty vehicles and motorcycles) which are taken into account in HBEFA. As planned in the last NIR

[56] Trend 2008-onwards

[57] Trend 2007-onwards

emission factors have been updated in the 2023 submission according to the HBEFA version V4.2 published in January 2022 (INFRAS 2022) and replacing version V4.1 (MATZER/WELLER et al., 2019).

Summarized innovations in HBEFA version V4.2:

- Update of emission factors for warm-operating conditions and their characteristic motor curves (EURO 6 PCs & EURO VI trucks)

  Passenger cars (PCs): emission factors of EURO 6d-TEMP and EURO 6d from HBEFA V4.2 were used to create the EURO 6 passenger car characteristic motor curves (the year 2020 was used as the HBEFA reference year). For BEVs, the characteristic curves were updated using PHEM modeling with the latest measurement data which results in an average reduction of specific fuel consumption by 8%.

  Trucks: Adaptation of the fleet data to HBEFA V4.2 (HDV EUROVI_ABC_DE) which means a differentiation of the existing emission standard categorisation into EURO VI_A_B_C and EURO VI_D_E in order to be able to better depict the real emission behavior of future emission standards. Measurement data for EURO VI_D are included in HBEFA V4.2 and show significantly lower emission levels than EURO VI_A_B_C.
- Update of aging factors for PCs and trucks

  Within the HBEFA fleet model, all parameters are differentiated according to vehicle age in 1-year increments. Only in the last step the age classes are aggregated into sub-segments (which usually include several years of construction within the same emission concept). In this aggregation step, up to HBEFA V4.1, the cumulative mileage was averaged over the stock (number of vehicles) as weights. This has now been corrected so that annual mileage is used as the weighting parameter. In general, the impact of this change is not large: it leads to a faster increase in cumulative mileage shortly after the introduction of a sub-segment when vehicles are on average new and driven a lot; However, if the average age of the vehicles within a sub-segment increases and the annual mileage decreases, the increase in the cumulative mileage per reference year is smaller.
- Update of emission behavior of diesel PCs with software updates

Software updates

The update in HBEFA V4.2 contains the detailed mapping of the emission development of diesel vehicles with and without a software update in addition to the emission factors for diesel PCs with EA 189 engines, which have already been integrated in HBEFA V4.1. There the effect of the mandatory software update of VW vehicles with the EA189 engine ("Diesel Gate") on the average EURO 5 emission factor has been analysed in several measurement series.

The development of the emission factors and temperature dependencies for the additional software update vehicle layers can be read in a study by TU Graz (Dippold/Hausberger 2021) and is also integrated in HBEFA V4.2.

Ambient temperature influence

Ambient temperature influences on NOx emission factors have been checked, but there have been no changes compared to HBEFA V4.1. Therefore, it is still valid to say that the lower the ambient temperature, the worse NO_x exhaust-aftertreatment systems work.

Moreover, specific yearly CO_2 emission and fuel consumption factors per vehicle kilometre of newly registered passenger cars and light duty vehicles have been implemented according to the national CO_2 monitoring data for the Austrian fleet (BMK 2022b; BMK 2022c).

Cold-start emissions

The cold-start emission module has been checked and there have been no changes compared to HBEFA V4.1.

Cold-start emissions according to IPCC 2006 GL are calculated as separate emissions in addition to the emissions that would be expected if all vehicles were only operated with hot engines and warmed-up catalysts. Cold-start emissions are only allocated for urban and rural driving, as the number of starts in highway conditions seems to be relatively limited. Cold-start emissions are calculated in NEMO for each vehicle category and each pollutant as follows:

Additional impact per start [g / km] =
cold-start surcharge [g / start] / average trip length per cold start [km / start]

The cold start influence is in NEMO included in the calculation of fuel consumption and emissions of CO_2, NO_x, CO, hydrocarbons and PM. For N_2O and NH_3 no cold start emission factors were found in the literature. Thus, the cold-start influence on the greenhouse effects of N_2O emissions could not be taken into account.

The values used for cold-start surcharges come from:

- *PC and LDV*: cold-start model (updated in HBEFA V4.1)
- *HDV*: cold-start study commissioned by Umweltbundesamt (REXEIS et al. 2013)
- *2-wheelers*: derived from cold-start emissions of PC gasoline

Relative factors on top of commercial fuels incl. blending of biofuels (=reference fuels)

All emission factors of alternative and pure biofuels used in NEMO are considered in the model by relative factors compared to commercial fuels. This allows to include any other fuels in the NEMO calculations.

The following table provides the used relative factors compared to the reference fuels. The reference fuels are blended gasoline and blended diesel, because these fuels are commercially launched by fuelling stations on the market. The relative factors are multiplied with the EFs (in g/km) of every EURO-class and vehicle category per year. The relative factors are kept constant for the whole time series, but the final EFs change over time, because the basic EFs per EURO class improve as a consequence of the vehicles' advanced exhaust gas technologies. The relative factors are derived from literature research (e.g. EMEP Guidebook) or exhaust measurements.

Table 80: Relative factors used for bioethanol E85, LPG, CNG and biogas.

Gasoline	blended gasoline	bioethanol E85	LPG	CNG	biogas
FC	1.00	1.00	1.00	0.84	0.84
NOx	1.00	1.51	1.22	0.67	0.67
HC	1.00	1.37	0.85	0.44	0.44
CO	1.00	0.88	1.25	0.70	0.70
PM exhaust	1.00	1.00	1.00	0.71	0.71

Gasoline	blended gasoline	bioethanol E85	LPG	CNG	biogas
Nox_raw	1.00	1.51	1.22	0.67	0.67
N_2O	1.00	0.64	1.00	0.34	0.34
NO_2	1.00	1.51	1.22	1.11	1.11
NH_3	1.00	1.00	1.00	0.68	0.68
CH_4	1.00	1.94	1.00	2.94	2.94
Benzol	1.00	1.00	1.00	1.00	1.00
C22H12	1.00	1.00	0.03	1.00	1.00
C20H12 (k)	1.00	1.00	0.04	1.00	1.00
C20H12 (b)	1.00	1.00	0.00	1.00	1.00
C20H12 (a)	1.00	1.00	0.03	1.00	1.00

Table 81: Relative factors used for biodiesel, plant oil and diesel B20.

diesel	blended diesel	biodiesel (RME[58])	plant oil	diesel B20
FC	1.00	1.00	1.00	1.00
NO_x	1.00	1.20	1.20	1.04
HC	1.00	1.00	1.00	1.00
CO	1.00	0.74	0.74	0.95
PM exhaust	1.00	0.61	0.61	0.92
NO_x_raw	1.00	1.20	1.20	1.04
N_2O	1.00	1.20	1.20	1.04
NO_2	1.00	1.00	1.00	1.00
NH_3	1.00	1.00	1.00	1.00
CH_4	1.00	1.15	1.15	1.03
Benzol	1.00	1.00	1.00	1.00
C22H12	1.00	1.00	1.00	1.00
C20H12 (k)	1.00	1.00	1.00	1.00
C20H12 (b)	1.00	1.00	1.00	1.00
C20H12 (a)	1.00	1.00	1.00	1.00

Implied emission factors for the different means of road transportation are listed in the following tables. In contrast to the CRF tables, Activity data shown in Table 82 to Table 85 include all energy sources (i.e. fossil and bio fuels) used in each vehicle category in order to show the increasing substitution of fossil fuels with biofuels from 2005 onwards. For this reason data provided in these tables do not correspond to the IEFs given in the CRF where they are separately shown for each energy source (e.g. IEF for fossil diesel, fossil gasoline, biomass etc.).

Table 82: Implied emission factors of passenger cars 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	116 967	75.9	21.30	2.65
1991	131 010	75.9	19.45	2.79

[58] rapeseed oil methyl ester

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1992	127 858	75.8	17.64	2.89
1993	125 777	75.8	15.85	2.99
1994	125 415	75.7	14.20	3.05
1995	125 697	75.7	12.67	3.08
1996	121 902	75.6	11.09	3.03
1997	121 262	75.5	9.70	2.96
1998	132 492	75.5	8.58	2.88
1999	129 333	75.4	7.51	2.78
2000	131 969	75.3	6.64	2.69
2001	141 185	75.3	5.98	2.59
2002	161 905	75.2	5.42	2.48
2003	177 042	75.1	4.92	2.38
2004	183 099	75.1	4.50	2.30
2005	187 596	74.7	4.11	2.21
2006	187 198	73.5	3.59	2.17
2007	192 778	73.1	3.27	2.07
2008	182 906	72.1	3.03	1.98
2009	183 558	71.3	2.82	1.90
2010	184 566	71.2	2.64	1.87
2011	182 399	71.1	2.49	1.87
2012	179 779	70.9	2.42	1.88
2013	178 387	71.2	2.38	1.92
2014	180 113	70.9	2.32	1.96
2015	187 341	70.6	2.39	2.05
2016	193 219	71.2	2.58	2.19
2017	197 134	71.5	2.80	2.33
2018	197 730	71.2	2.99	2.39
2019	192 799	71.3	3.09	2.43
2020	157 954	71.2	3.22	2.64
2021	163 083	71.3	3.25	2.63

Table 83: Implied emission factors of light duty vehicles 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	13 637	74.7	7.0	0.9
1991	14 044	74.6	6.1	0.8
1992	14 667	74.5	5.3	0.8
1993	14 912	74.5	4.7	0.7
1994	15 489	74.5	4.2	0.7
1995	15 764	74.4	3.6	0.8
1996	16 276	74.4	3.1	0.9
1997	16 574	74.4	2.8	1.0
1998	17 056	74.3	2.5	1.1

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1999	17 575	74.3	2.1	1.2
2000	17 937	74.3	1.8	1.3
2001	18 284	74.3	1.6	1.4
2002	18 812	74.2	1.4	1.4
2003	19 188	74.2	1.2	1.5
2004	19 423	74.2	1.0	1.5
2005	19 394	73.6	1.0	1.6
2006	19 406	71.7	0.9	1.7
2007	19 643	71.6	0.8	1.7
2008	19 037	71.4	0.7	1.7
2009	18 761	70.4	0.7	1.7
2010	19 032	70.3	0.7	1.8
2011	19 298	70.3	0.7	1.8
2012	19 214	70.1	0.8	1.9
2013	19 428	70.3	0.9	2.1
2014	19 762	70.2	1.1	2.2
2015	20 252	69.8	1.3	2.4
2016	20 966	70.3	1.5	2.5
2017	21 471	70.7	1.8	2.7
2018	21 642	70.6	2.2	2.9
2019	22 228	70.8	2.5	3.1
2020	22 396	70.9	2.8	3.4
2021	23 816	70.8	3.2	3.4

Table 84: Implied emission factors of heavy duty vehicles 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	44 784	74.3	2.7	0.7
1991	49 869	74.2	2.7	0.7
1992	52 170	74.2	2.5	0.7
1993	55 981	74.2	2.3	0.7
1994	56 466	74.2	2.1	0.7
1995	59 602	74.2	2.0	0.7
1996	84 103	74.2	1.6	0.6
1997	71 235	74.2	1.6	0.6
1998	85 990	74.2	1.3	0.6
1999	80 420	74.2	1.2	0.6
2000	89 699	74.2	1.1	0.6
2001	98 134	74.2	1.0	0.6
2002	105 348	74.2	0.9	0.5
2003	113 268	74.2	0.8	0.5
2004	113 852	74.2	0.8	0.5
2005	116 203	73.5	0.7	0.5

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2006	104 237	71.5	0.7	0.6
2007	102 070	71.4	0.6	0.9
2008	95 428	71.3	0.5	1.2
2009	90 046	70.2	0.5	1.5
2010	100 284	70.1	0.4	1.8
2011	91 893	70.0	0.4	2.1
2012	94 317	69.9	0.3	2.3
2013	109 135	70.0	0.3	2.5
2014	99 570	69.8	0.3	2.8
2015	99 030	69.4	0.3	3.0
2016	101 826	69.9	0.2	2.8
2017	105 476	70.3	0.2	2.8
2018	107 752	70.3	0.2	2.9
2019	112 567	70.5	0.2	2.9
2020	103 837	70.6	0.2	2.9
2021	109 345	70.5	0.1	2.9

Table 85: Implied emission factors of mopeds and motorcycles 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	836	76.3	254.0	1.3
1991	834	76.3	242.1	1.3
1992	868	76.3	227.6	1.2
1993	903	76.3	213.4	1.2
1994	955	76.3	199.5	1.2
1995	1 024	76.3	185.7	1.2
1996	1 092	76.3	174.4	1.2
1997	1 160	76.3	165.2	1.2
1998	1 242	76.3	156.9	1.2
1999	1 325	76.3	148.7	1.2
2000	1 372	76.3	142.8	1.2
2001	1 415	76.3	137.6	1.2
2002	1 460	76.3	132.8	1.2
2003	1 501	76.3	128.9	1.2
2004	1 529	76.3	124.7	1.2
2005	1 570	76.3	120.9	1.2
2006	1 620	76.3	115.4	1.2
2007	1 693	75.5	108.6	1.2
2008	1 783	73.0	101.8	1.2
2009	1 856	72.4	96.4	1.2
2010	1 909	72.1	92.1	1.2
2011	1 971	72.1	87.8	1.2
2012	2 049	72.0	83.0	1.2
2013	2 114	72.5	78.4	1.2

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2014	2 192	72.0	73.9	1.2
2015	2 257	72.0	70.3	1.2
2016	2 302	72.9	67.5	1.2
2017	2 350	73.0	64.4	1.2
2018	2 360	72.0	56.8	1.2
2019	2 337	72.0	61.3	1.2
2020	2 147	71.5	59.6	1.2
2021	2 017	72.0	57.7	1.2

Taking into account the carbon part of biofuels (and the associated CO_2 emissions)

According to the 2006 IPCC GLs (volume 2, chapter 3, section 'CO_2 emissions from biofuels' in page 3.17) "*it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks*". In other words, a part of the carbon of biofuels (and the associated CO_2 emissions) may have a fossil origin. In Austria this is the case. Consequently, the CO_2 from fossil methanol in the production of biodiesel (FAME[59]) has been accounted for the time series 2005-2019 resulting in increased emissions for every vehicle sub-category, where blended or pure biodiesel is used.

Calculations were done based on SEMPOS (2018) who published together with a group of experts an accorded point of view among EU MS to agree on a common understanding and define possible ways how to estimate the associated CO_2 emissions to the fossil carbon content in biofuels. The following default values were taken.

Table 86: Values used for the fossil carbon content in biofuels (SEMPOS 2018)

C fossil part – origin from methanol [%]	Carbon content – bio and fossil [% kg/kg]	CO_2-EF for fossil FAME [kt CO_2/kt FAME]
5.4	76.5	0.1515

The fossil part in the production of ETBE[60] has been accounted for the whole time series, as we know that 53% of ETBE are produced from fossil sources (Isobuten) and 47% from bioethanol. The fossil part is being reported as fossil gasoline by the companies.

HVO[61] in contrast is produced through the hydro-treatment of the triglyceride-containing feedstocks (vegetable oil or animal fat). All carbon can be considered of biogenic origin (no fossil part).

Quality Assurance and Quality Control (QA/QC)

Quality management for input data of *1.A.3.b Road Transport* is implemented by carrying out the following checklist after receipt of input data:

- ✓ Are the correct values used (check for transcription errors)?
- ✓ Check of plausibility of input data (time-series order of magnitude)!
- ✓ Is the data set complete for the whole time series?

[59] Fatty Acid Methyl Ester
[60] Ethyl Tert-Butyl Ether
[61] Hydro Vegetable Oil

- ✓ Check of calculation units!
- ✓ Check of plausibility of results (time-series order of magnitude)!
- ✓ Are all references clearly made?
- ✓ Are all assumptions documented?

Uncertainty Assessment

Uncertainty estimates are based on WINIWARTER & RYPDAL (2001) and on HAUSBERGER (2005):

- The uncertainty of activity data (total fuel sold) for road transport is considered to be low (3%), and also the uncertainty of CO_2 emission factors is estimated to be 3%.
- N_2O emission factors are determined in vehicle emission tests, mostly carried out on test benches. Therefore emission factors are prone to uncertainties for the following reasons:
  - test driving cycles cannot fully reflect real driving behaviour,
  - uncertainties of test equipment and emission measurement equipment,
  - emission factor varies over time because of chemical characteristics of the fuels,
  - the influence of aging and maintenance of the vehicle stock.

Due to these reasons the uncertainty for the N_2O emission factor is relatively high; it is estimated to be –70 and +170% (lognorm) for gasoline and ±30% (norm) for diesel.

Recalculations

- **Update of specific vehicle mileage per year**
  A statistical evaluation of the specific annual mileage from the central assessment database (ZBD - annual "sticker check" in accordance with §57a KFG) for the years 2018, 2019 and 2020 was carried out for passenger cars, light duty vehicles, buses and 2-wheelers. The revision of this data resulted in a shift between inland vehicle kilometres and mileage of vehicles in the category fuel export (mainly HDV). In detail, the ZBD data shows that there was an overestimation of inland vehicle kilometres in 2018 and 2019 by the model and an underestimation of inland vehicle kilometres in the pandemic year 2020. This has been corrected accordingly in this year's submission.
- **Update of fuel consumption and emission factors according to HBEFA Version V4.2**
  Update of hot emission factors and characteristic motor curves for EURO 6 passenger cars and EURO VI HDV trucks. Adaptation of the fleet data to HBEFA V4.2 (HDV EUROVI_ABC_DE). Update of aging factors for cars and HDV.

As a result marginal changes of the time series of NFR *1.A.3.b.* occur (-0.55 kt CO_2, -0.02 kt CH_4 and -0.01 kt N_2O).

Planned improvements

Future emission standards (e.g. EURO 7) have not been integrated in NEMO yet. An implementation is planned with the next HBEFA version.

3.2.13.3 1.A.3.c Railways

Key Source: No

In this category emissions from diesel railcars and steam engines are considered.

Table 87: Greenhouse gas emissions from 1.A.3.c Railways 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	178	0.009	0.06	196
1991	163	0.008	0.06	180
1992	162	0.008	0.05	179
1993	158	0.008	0.05	174
1994	159	0.008	0.05	176
1995	149	0.007	0.05	164
1996	134	0.007	0.05	148
1997	133	0.006	0.05	147
1998	131	0.006	0.05	145
1999	135	0.006	0.05	150
2000	135	0.006	0.05	150
2001	134	0.006	0.05	149
2002	130	0.006	0.05	144
2003	141	0.006	0.05	156
2004	141	0.006	0.05	156
2005	161	0.007	0.06	178
2006	154	0.007	0.06	170
2007	153	0.006	0.05	168
2008	152	0.006	0.05	167
2009	147	0.005	0.05	161
2010	143	0.005	0.04	156
2011	120	0.004	0.04	131
2012	124	0.003	0.04	134
2013	106	0.003	0.03	115
2014	115	0.003	0.03	124
2015	87	0.002	0.02	93
2016	112	0.002	0.03	120
2017	97	0.002	0.02	103
2018	92	0.002	0.02	99
2019	93	0.002	0.02	99
2020	81	0.002	0.02	86
2021	81	0.002	0.02	86
1990–2021	**-55%**	**-82%**	**-72%**	**-56%**

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 2 methodology. The applied methodology is described in the subchapter on mobile sources of CRF *1.A.2.g.vii*.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of CRF *1.A.3.c* are presented below. In the following table the activity data includes all energy sources (including hard coal). The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of CRF*1.A.2.g.vii*.

Table 88: Implied emission factors and activity data for 1.A.3.c Railways 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	2 380	74.8	3.8	25.3
1991	2 183	74.8	3.8	25.3
1992	2 165	74.8	3.8	25.3
1993	2 111	74.8	3.7	25.4
1994	2 129	74.7	3.7	25.5
1995	1 987	74.8	3.7	25.6
1996	1 796	74.9	3.7	25.6
1997	1 788	74.6	3.6	26.0
1998	1 761	74.5	3.6	26.2
1999	1 818	74.5	3.6	26.3
2000	1 815	74.5	3.5	26.5
2001	1 807	74.4	3.5	26.7
2002	1 751	74.4	3.4	26.7
2003	1 897	74.4	3.3	26.6
2004	1 892	74.3	3.3	26.5
2005	2 187	73.6	3.2	26.1
2006	2 145	71.6	3.0	25.7
2007	2 132	71.6	2.9	24.8
2008	2 127	71.4	2.7	23.9
2009	2 083	70.4	2.5	23.0
2010	2 026	70.3	2.3	22.0
2011	1 714	70.3	2.1	21.0
2012	1 763	70.1	2.0	20.1
2013	1 510	70.4	1.8	18.9
2014	1 637	70.2	1.6	17.6
2015	1 245	69.8	1.6	16.9
2016	1 590	70.3	1.6	16.6
2017	1 368	70.7	1.5	16.0
2018	1 307	70.7	1.5	15.7
2019	1 310	70.9	1.5	15.3
2020	1 137	70.9	1.5	15.0
2021	1 140	70.8	1.4	14.7

Recalculations

No category specific recalculations have been carried out.

Planned improvements

No category-specific improvements are planned.

3.2.13.4 1.A.3.d Navigation

Key Source: No

This sector includes emissions from gas/diesel oil and gasoline fuelled ships used by vessels and ships of all flags that depart and arrive per trip within Austria. The main sources are the river Danube and some other smaller rivers and lakes.

Table 89: Greenhouse gas emissions from 1.A.3.d Domestic Navigation 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	28.0	0.033	0.008	31.3
1991	29.6	0.033	0.009	33.2
1992	30.9	0.033	0.010	34.7
1993	31.7	0.033	0.010	35.5
1994	32.8	0.033	0.011	36.8
1995	34.3	0.032	0.011	38.5
1996	35.7	0.032	0.012	40.1
1997	38.0	0.031	0.013	42.7
1998	39.6	0.031	0.014	44.5
1999	40.1	0.030	0.014	45.1
2000	42.1	0.030	0.015	47.4
2001	42.8	0.029	0.016	48.2
2002	43.4	0.028	0.016	48.9
2003	44.4	0.028	0.016	50.0
2004	52.4	0.027	0.019	58.8
2005	54.9	0.026	0.020	61.4
2006	56.1	0.025	0.020	62.8
2007	54.8	0.023	0.019	61.1
2008	53.0	0.022	0.019	59.1
2009	53.6	0.021	0.019	59.8
2010	55.0	0.020	0.019	61.2
2011	58.9	0.019	0.020	65.4
2012	53.9	0.017	0.018	59.7
2013	57.3	0.016	0.019	63.4
2014	63.8	0.016	0.021	70.4
2015	65.3	0.015	0.021	71.9
2016	68.5	0.014	0.021	75.1
2017	72.4	0.014	0.022	79.3
2018	74.8	0.013	0.022	81.8
2019	83.6	0.013	0.025	91.3
2020	23.3	0.010	0.005	25.1
2021	35.4	0.010	0.009	38.4
1990–2021	**26%**	**-70%**	**10%**	**23%**

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 2 methodology.

Austria uses the bottom-up model GEORG (HAUSBERGER 2000) to calculate the national fuel consumption of navigation which is made up of freight transport activities on the River Danube and passenger transport on rivers and lakes in Austria. Passenger transport is conducted with passenger ships, private motor boats and sailing boats. The inland navigation fleet (stock) was obtained from registration statistics from provincial governments, the average yearly operating time as well as the average fuel consumption per hour from questionnaires to fleet operators and/or manufacturers' data.

Statistical data (Tkm) for freight activities on the River Danube were obtained from (VIA DONAU 2022). Additionally, fuel consumption for working boats is taken into account in the national fuel consumption of navigation. For detailed methodological issues of the model GEORG see CRF *1.A.2 g.vii.*

Since the **submission 2011**, building on data used in the model GEORG (see CRF *1.A.2.g.vii*), domestic navigation has been calculated following the bottom-up approach – the assumption being that domestic navigation is navigation between harbours located in Austria using the transport, expressed in

tons x kilometer → (GWh/tkm*tkm; CO_2/tkm*tkm etc.)

The applied methodology for estimating emissions of international navigation is described in subchapter 3.2.2.1 International bunker fuels.

Activity Data & Emission Factors

Activity data is updated yearly for freight activities on the River Danube and is obtained from (VIA DONAU 2022). Emission factors were last updated in a study within the submission 2021 (SCHWINGSHACKL/REXEIS & WELLER 2020) which resulted in

- Updated fuel consumption factors (in g/tkm) of Danube freight shipping. According to studies of real fuel consumption (including empty runs, including secondary consumers) current consumption in the upper Danube region amounts to 8.5 g/tkm.
- Updated activities of passenger shipping (Danube, other rivers and lakes), which reflects the trend towards significantly higher activities than assumed before.

Activities used for estimating the emissions and the implied emission factors of CRF *1.A.3.*are presented below. In the following table the activity data includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.vii*.

Table 90: Implied emission factors and activity data for 1.A.3.d Domestic Navigation 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	374	74.9	89.1	22.3
1991	396	74.8	84.1	22.9
1992	414	74.8	80.5	23.4
1993	424	74.8	78.5	23.6
1994	439	74.8	75.0	24.1
1995	459	74.7	70.5	24.7
1996	478	74.7	66.5	25.2

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1997	509	74.7	61.5	25.9
1998	530	74.6	57.9	26.4
1999	538	74.6	56.0	26.6
2000	564	74.6	52.4	27.1
2001	573	74.6	50.5	27.4
2002	582	74.6	48.7	27.3
2003	596	74.6	46.5	27.2
2004	703	74.5	38.5	27.4
2005	741	74.0	34.8	26.7
2006	775	72.4	31.7	26.2
2007	758	72.2	30.6	25.7
2008	742	71.4	29.5	25.3
2009	762	70.4	27.2	24.8
2010	782	70.3	25.1	24.5
2011	838	70.3	22.3	24.3
2012	768	70.2	22.6	23.5
2013	814	70.4	20.2	23.1
2014	909	70.2	17.3	22.7
2015	936	69.8	15.9	22.1
2016	974	70.3	14.5	21.7
2017	1 025	70.6	13.2	21.5
2018	1 061	70.5	12.3	21.1
2019	1 183	70.7	10.8	20.9
2020	331	70.3	30.1	16.0
2021	501	70.6	19.9	18.2

Quality Assurance and Quality Control (QA/QC)

Harmonization CRF and IEA data

In 2013 the ERT detected inconsistencies of fuel consumption data of domestic aviation and domestic navigation between the CRF tables and the IEA data (ICR 2013). In response to that it was explained that Austria uses a bottom-up approach to estimate fuel consumption whilst IEA relies on top-down approach based on fuel consumption statistics reported by Statistics Austria.

After having discussed this issue with Statistics Austria an Explanatory Note (30/09/2013) has been compiled by Statistics Austria declaring that a regular adoption of inventory data for the split between national and international fuel consumption in civil aviation and navigation in the national statistics will be adopted in the future, as far as the data can be submitted in time (early November).

As part of regular QA/QC the energy split between national and international navigation is provided to Statistics Austria for the IEA statistics based on the bottom up model used to calculate the annual emission inventory.

Completeness

In response to a question raised by the ERT (ICR 2013) Austria explained that emissions of ground activities at domestic harbours are also included, even if they are not separately reported under CRF *1.A.3.e.2 Other.* All registered road vehicles – including those in ports - are taken into account in the emission calculation of CRF *1.A.3.b*. Fuel consumption and emissions of any other port handling equipment are included in the overall calculation. This is ensured because Austria reports emissions from **total fuel sold** from the national energy balance (see chapter on *1.A.3.b. Road Transport - Top down Methodology – Fuel sold*).

Recalculations

Energy consumption was updated according to revised numbers in the national energy balance.

Planned improvements

No category-specific improvements are planned.

3.2.13.5 1.A.3.e.i Other Transportation – Pipeline Compressors

Key Source: Yes (CO_2: gaseous)

Category *1.A.3.e Other Transportation* enfolds emissions from pipeline transport by gas turbine driven compressors. The share in GHG emissions from sector *1.A* is 0.4% for the year 1990 and 0.7% for the year 2021. The increase of emissions is mainly caused by the increase of natural gas transfer through Austria.

Methodology

The IPCC Tier 2 methodology is applied for CO_2 and a Tier 1 methodology is applied for CH_4 and N_2O.

Activity data

Activity data (fuel consumption) is taken from (IEA JQ 2022) as presented in Annex 4.

Emission factors

The CO_2 emission factor for natural gas is taken from a national study (BMWA-EB 1996).

N_2O and CH_4 emission factors are default values from the IPCC 2006 Guidelines.

Table 91: Emission factors of Category 1.A.3.e.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Natural Gas	55.60	1.00	0.10

Recalculations

Any changes in activity data are based on a revision of the energy balance as described in Annex 4.

3.2.13.6 1.A.3.e.II Other – Airport Ground Activities

Key Source: No

This sector includes emissions from airport ground activities at all Austrian airports. Freight and car traffic to and from the airport is excluded and part of CRF *1.A.3.b*.

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology. Country-specific technology-based emission factors (IEFs taken from CRF *1.A.3.b*) are available.

Based on a recommendation made by the UNFCCC during the 2020 Review, Austria collected fuel consumption data of mobile sources used for aircraft handling from Vienna's International Airport. Based on this information emissions for aircraft handling on all Austrian airports were estimated and are now reported separately under CRF *1.A.3.e.2*. Emissions from this source were previously part of CRF *1.A.3.b.*

The share between the biggest airport VIE (Vienna) and the other five Austrian airports (GRZ, INN, KLU, LNZ, SZG) was calculated on the basis of the most recent evaluation of FC and CO_2 emissions from all Austrian airports for 2010 (MATHÄ & ELLINGER 2011). With the help of absolut FC numbers at VIE airport in 2019 (ELLINGER & KRACHER 2020) and the share for the sum of the other Austrian airports in 2010 the total activity data for CRF *1.A.3.e.2* was calculated for 2019. Second, a constant fuel consumption factor per flight movement was calculated and multiplied with yearly IFR flight movements (with departure airport in Austria) to create the FC time series for 1990 - 2020. Third, for the calculation of emissions time series, the activity data of each fuel type have been multiplied with yearly fuel type specific IEFs for road trucks (RT) and passenger cars (PC) taken from CRF *1.A.3.b*:

- *HDV-RT Gasoline Size I*
- *HDV-RT Diesel Size II*
- *PC CNG Average*

Activity Data & Emission Factors

Activities include liquid fuels (diesel, gasoline and biofuels) and gaseous fuels (CNG). The quantities of liquid and gaseous fuels used at airports represent only a very small proportion of total national fuel sales (0.01% petrol; 0.03% diesel; 0.3% natural gas).

Table 92: Activities from 1.A.3.e.2 Other Transportation – Airport Ground Activities: 1990–2021.

Year	Liquid fuels (incl. Biofuels and Other) [TJ]	Gaseous fuels [TJ]
1990	65	-
1991	73	-
1992	79	-
1993	84	-
1994	88	-
1995	98	-
1996	109	-
1997	113	-
1998	117	-
1999	115	-

Year	Liquid fuels (incl. Biofuels and Other) [TJ]	Gaseous fuels [TJ]
2000	125	-
2001	126	-
2002	125	-
2003	126	-
2004	139	5
2005	146	6
2006	149	6
2007	159	6
2008	162	6
2009	148	6
2010	151	6
2011	164	7
2012	159	6
2013	152	6
2014	152	6
2015	150	6
2016	174	7
2017	167	7
2018	186	7
2019	199	8
2020	91	3
2021	103	5
1990–2021	**59%**	**-10%**[62]

Due to the minor dimension of CRF *1.A.3.e.2* IEFs for all years and air pollutant are not being displayed separately.

Recalculations

No category specific recalculations have been carried out.

Planned improvements

No category-specific improvements are currently planned.

3.2.14 1.A.4 Other Sectors

Category *1.A.4 Other Sectors* enfolds emissions from stationary fuel combustion in the small combustion sector. It also includes emissions from mobile sources in households and gardening including snow cats and skidoos as well as from agriculture and forestry.

The share in total GHG emissions from sector *1.A* is 28% for the year 1990 and 19% for the year 2021.

[62] Trend compared to 2004

3.2.14.1 1.A.4 Other Sectors – Stationary Combustion

Key Source: CO_2 from liquid (*1.A.4*), solid (*1.A.4*), gaseous (*1.A.4.a* and *1.a.4.b*) and other fuels (*1.A.4.a*); CH_4 from biomass and solid fuels (*1.A.4.b*), N_2O from biomass and solid fuels (*1.A.4.b*)

Category *1.A.4 Other Sectors – Stationary Combustion* includes emissions from stationary fuel combustion in the small combustion sector. Emissions from public district heating plants are included in category *1.A.1.a Public Electricity and Heat Production*. Emissions of district heat generation delivered to third parties by industry are included in *1.A.2 Manufacturing Industries and Construction*.

3.2.14.1.1 Methodology

For calculation of CO_2 emissions from fossil fuels and CH_4 emissions from solid biomass (fuel wood and wood waste), the IPCC Tier 2 methodology is applied. For calculation of CH_4 emissions from liquid, solid and gaseous fuels, other biomass (biogas, sewage sludge gas and landfill gas, charcoal), peat and other fuels and for calculation of N_2O emissions from all fuel types, the Tier 1 methodology is applied.

Total fuel consumption for each of the sub categories of *1.A.4 Other Sectors – Stationary Combustion* is taken from (IEA JQ 2022) and the national energy balance (STATISTIK AUSTRIA 2022c). This approach provides the most detailed data over time series, while both data sources are different in structure but consistent. From the view of energy statistics compilers this sector is sometimes the residual of gross inland fuel consumption because fuel consumption data of energy industries and manufacturing industry is collected each year in more detail and therefore of higher quality. However, in case of the Austrian energy balance fuel consumption of the small combustion sector is modelled over time series in consideration of heating degree days, micro census data and service industries survey panel.

Information about type of heating is derived from an energy demand model for space heating based on heating market surveys and on federal provinces data validated by micro census surveys and calibrated according to the energy statistics supplier. A clear distinction between "real" public district heating or micro heating networks which serve several buildings under the same ownership cannot always be made by the interviewed person or interviewers.

The energy demand model for space heating, consists of five consecutive modules:

- **Building and dwelling stock:** by building type, year of construction, type of residence (number of buildings and dwellings, net floor area, useful area, number of residents) (BML 2022a, STATCUBE 2014a, 2014b, 2014c, 2022a, 2022b, STATISTIK AUSTRIA 1973, 1982, 1992a, 2004, 2013, 2022a, 2022b)
- **Heating type by energy carrier:** by categories of module 'building and dwelling stock' and energy carrier including heat pumps, district heating, solar thermal and electric heating (number of buildings and dwellings, net floor area, useful area, number of residents) (STATISTIK AUSTRIA 2019, 2021, 2022c)
- **Heating type by technology:** by categories of module 'building and dwelling stock', type of application (as main or auxiliary heating) and twenty-two technology and fuel dependent subcategories (number of buildings and dwellings, net floor area, useful area, residents) (AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 2021, AMT DER VORARLBERGER LANDESREGIERUNG 2021, BEKAT 2021, E7 ENERGIE MARKT ANALYSE GMBH 2009, 2017, LAND SALZBURG 2021, STADT WIEN 2017, UMWELTBUNDESAMT 2014d)

- **Building energy performance:** by categories of module 'building and dwelling stock' based on type of energy-efficient building renovation, year of construction and residents (space heating demand, hot water demand) (AEA 2015, BMWFW 2014)
- **Final energy demand by technology:** by categories of module 'heating type by technology' based on results of module 'building energy performance' considering heating degree days (ZAMG 2022) and calibrated according to the energy statistics supplier to maintain consistency with fuel demand reported in (IEA JQ 2022) and (STATISTIK AUSTRIA 2022c)

There are twenty-two technology and fuel dependent main subcategories (heating types) for category *1.A.4 Other Sectors – Stationary Combustion* as presented in the following table.

Table 93: Heating types of category 1.A.4. Other Sectors – Stationary Combustion

No.	Heating type	Fuel
#1	Fuel oil boilers	Light fuel oil, medium fuel oil, heavy fuel oil, diesel, petroleum, other petroleum products
#2	Gas oil stoves	Gas oil
#3	Vapourizing burners	Gas oil
#4	Yellow burners	Gas oil
#5	Blue burners with conventional technology	Gas oil
#6	Blue burners with low temperature or condensing technology	Gas oil
#7	Natural gas convectors	Natural gas
#8	Atmospheric burners	Natural gas, biogas, sewage sludge gas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, biogas, sewage sludge gas and landfill gas
#10	LPG stoves	Liquefied petroleum gases
#11	LPG boilers	Liquefied petroleum gases
#12	Wood stoves and cooking stoves	Fuel wood
#13	Tiled wood stoves and masonry heaters	Fuel wood
#14	Mixed-fuel wood boilers	Fuel wood
#15	Natural-draft wood boilers	Fuel wood
#16	Forced-draft wood boilers	Fuel wood
#17	Wood chips boilers with conventional technology	Wood waste
#18	Wood chips boilers with oxygen sensor emission control	Wood waste
#19	Pellet stoves	Wood waste
#20	Pellet boilers	Wood waste
#21	Coal stoves	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat
#22	Coal boilers	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat, industrial waste

In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to *#12 Wood stoves and cooking stoves* and calculated separately. For each technology a fuel dependent emission factor is applied.

3.2.14.1.2 Activity Data

Total fuel consumption for each of the sub categories of *1.A.4* is taken from (IEA JQ 2022) and (Statistik Austria 2022c) as presented in Annex 4 (further details also given in section *Methodology* above).

Fuel Consumption by Fuel Group

Total fuel consumption of *1.A.4.a.1*, *1.A.4.b.1* and *1.A.4.c.1* is divided into 6 fuel groups (liquid, solid, gaseous, biomass, peat and other) (see Table 94, Table 95 and Table 96).

Table 94: Fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021

CRF	1.A.4.a.1						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
1990	35.39	18.66	0.96	12.60	2.06	NO	1.11
1991	37.60	17.91	1.27	15.37	2.08	NO	0.97
1992	45.67	18.29	0.92	23.84	1.93	NO	0.69
1993	49.89	17.69	0.86	28.43	2.59	NO	0.33
1994	41.22	15.57	0.80	21.83	2.50	NO	0.51
1995	50.64	17.64	0.64	29.29	2.55	NO	0.52
1996	50.95	23.72	0.67	23.61	2.40	NO	0.55
1997	51.47	27.53	0.92	19.72	2.73	NO	0.58
1998	49.02	24.73	0.74	20.23	2.71	NO	0.61
1999	58.41	27.78	0.92	25.10	4.00	NO	0.61
2000	47.43	17.84	1.10	23.67	4.26	NO	0.56
2001	62.22	23.65	1.22	33.44	3.29	NO	0.63
2002	59.19	24.92	0.86	29.67	3.13	NO	0.62
2003	68.23	30.58	1.18	32.21	3.62	NO	0.65
2004	67.53	23.40	0.82	38.51	4.27	NO	0.52
2005	54.73	26.86	0.71	23.16	2.92	NO	1.07
2006	58.37	28.67	0.52	24.80	3.66	NO	0.72
2007	43.90	19.87	0.41	19.38	3.91	NO	0.33
2008	46.96	20.92	0.25	21.39	4.34	NO	0.05
2009	37.59	16.92	0.19	16.87	3.56	NO	0.05
2010	31.09	9.49	0.22	17.19	4.13	NO	0.06
2011	27.33	8.83	0.15	14.99	3.32	NO	0.05
2012	25.61	6.05	0.00	16.90	2.66	NO	NO
2013	25.78	5.87	0.01	17.01	2.82	NO	0.07
2014	22.72	6.01	0.00	14.27	2.36	NO	0.08
2015	24.24	5.95	0.00	15.25	2.96	NO	0.08
2016	22.56	5.60	NO	14.37	2.49	NO	0.09
2017	26.63	7.73	NO	15.10	3.73	NO	0.08
2018	25.97	6.71	NO	15.43	3.74	NO	0.09
2019	26.52	6.24	NO	16.11	4.07	NO	0.10

CRF				1.A.4.a.1			
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year				**[PJ]**			
2020	25.13	6.00	NO	15.15	3.97	NO	0.01
2021	29.60	8.45	NO	16.60	4.55	NO	0.01
Trend 1990–2021	**-16%**	**-55%**	**-100%**	**+32%**	**+121%**	**NO**	**-99%**
Trend 2020–2021	**+18%**	**+41%**	**NO**	**+9.5%**	**+15%**	**NO**	**+12%**

NO...not occurring

Table 95: Fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021

CRF				1.A.4.b.1			
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year				**[PJ]**			
1990	191.02	72.50	26.62	33.50	58.40	0.0044	NO
1991	213.40	79.16	29.12	40.08	65.04	0.0044	NO
1992	198.42	72.69	25.06	39.17	61.50	0.0044	NO
1993	200.39	73.98	20.81	42.80	62.79	0.0044	NO
1994	186.59	69.12	18.52	40.79	58.16	0.0044	NO
1995	200.23	75.59	17.56	44.28	62.80	0.0044	NO
1996	217.93	83.89	16.64	48.46	68.94	0.0044	NO
1997	194.75	68.05	12.58	49.73	64.39	0.0044	NO
1998	197.75	71.31	11.05	52.50	62.89	0.0044	NO
1999	200.25	73.12	10.22	52.85	64.06	0.0044	NO
2000	190.62	72.60	9.05	48.90	60.07	0.0044	NO
2001	198.47	71.55	8.57	54.56	63.79	0.0044	NO
2002	187.16	68.92	6.87	51.63	59.73	0.0044	NO
2003	189.06	69.07	5.78	55.09	59.11	0.0044	NO
2004	183.09	66.55	5.49	54.16	56.89	0.0044	NO
2005	192.43	63.88	3.97	65.71	58.86	0.0044	NO
2006	190.56	61.36	3.77	63.49	61.93	0.0044	NO
2007	177.58	53.50	3.22	57.59	63.27	0.0044	NO
2008	181.47	54.33	3.28	59.16	64.69	0.0044	NO
2009	180.26	50.63	2.39	60.39	66.85	0.0044	NO
2010	199.36	55.88	2.63	65.47	75.38	0.0044	NO
2011	179.92	48.34	1.69	58.18	71.71	0.0044	NO
2012	180.81	44.01	1.77	59.22	75.81	0.0044	NO
2013	186.20	47.32	1.35	59.83	77.69	0.0044	NO
2014	163.15	41.46	1.11	52.40	68.18	0.0044	NO
2015	173.49	43.18	0.91	56.84	72.55	0.0044	NO
2016	181.09	42.84	0.87	62.82	74.56	NO	NO
2017	180.66	43.35	0.96	61.50	74.85	NO	NO
2018	164.63	38.58	0.82	56.28	68.95	NO	NO

CRF	1.A.4.b.1						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
2019	169.63	38.84	0.83	59.49	70.46	NO	NO
2020	171.20	39.80	0.58	60.05	70.78	NO	NO
2021	191.94	43.26	0.64	68.18	79.86	NO	NO
Trend 1990–2021	**+0.5%**	**-40%**	**-98%**	**+104%**	**+37%**	**-100%**	**NO**
Trend 2020–2021	**+12%**	**+8.7%**	**+11%**	**+14%**	**+13%**	**NO**	**NO**

NO...not occurring

Table 96: Fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990-2021

CRF	1.A.4.c.1						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
1990	10.26	5.34	0.55	0.37	4.01	NO	NO
1991	10.25	4.71	0.61	0.44	4.49	NO	NO
1992	9.50	4.21	0.56	0.43	4.29	NO	NO
1993	8.23	2.89	0.44	0.47	4.42	NO	NO
1994	6.96	2.10	0.39	0.45	4.01	NO	NO
1995	7.68	2.30	0.39	0.49	4.49	NO	NO
1996	8.46	2.60	0.37	0.55	4.95	NO	NO
1997	8.40	2.70	0.30	0.56	4.83	NO	NO
1998	8.28	2.87	0.24	0.61	4.56	NO	NO
1999	9.08	3.17	0.23	0.58	5.10	NO	NO
2000	8.46	2.79	0.18	0.54	4.95	NO	NO
2001	9.09	2.73	0.16	0.60	5.60	NO	NO
2002	8.32	2.28	0.12	0.56	5.36	NO	NO
2003	8.90	2.56	0.09	0.59	5.66	NO	NO
2004	9.13	2.44	0.09	0.58	6.03	NO	NO
2005	8.11	1.47	0.12	0.77	5.75	NO	NO
2006	7.84	1.34	0.11	0.73	5.67	NO	NO
2007	7.29	1.02	0.13	0.74	5.40	NO	NO
2008	7.48	1.04	0.14	0.75	5.54	NO	NO
2009	7.06	0.62	0.05	0.74	5.64	NO	NO
2010	7.80	0.53	0.06	0.84	6.37	NO	NO
2011	7.30	0.42	0.04	0.72	6.13	NO	NO
2012	7.56	0.42	0.04	0.46	6.64	NO	NO
2013	8.34	0.53	0.03	0.51	7.28	NO	NO
2014	7.84	0.56	0.02	0.56	6.70	NO	NO
2015	8.02	0.50	0.02	0.62	6.88	NO	NO
2016	8.41	0.60	0.02	0.74	7.05	NO	NO
2017	8.68	0.28	0.03	1.01	7.37	NO	NO

CRF	1.A.4.c.1						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
2018	7.86	0.25	0.02	0.90	6.68	NO	NO
2019	7.47	0.16	0.02	1.09	6.20	NO	NO
2020	7.35	0.17	0.02	0.91	6.26	NO	NO
2021	8.20	0.18	0.02	0.96	7.04	NO	NO
Trend 1990–2021	**-20%**	**-97%**	**-97%**	**163%**	**+76%**	**NO**	**NO**
Trend 2020–2021	**+12%**	**+9.7%**	**-2.8%**	**+5.9%**	**+13%**	**NO**	**NO**

NO…not occurring

Fuel Consumption by Fuel

Fuel consumption of liquid fuels, solid fuels and biomass fuels is further subdivided (from *1.A.4.a.1* see Table 97, Table 98 and Table 99, from *1.A.4.b.1* see Table 100, Table 101 and Table 102, from *1.A.4.c.1* see Table 103, Table 104 and Table 105). All fuel consumption of biogas, sewage sludge gas and landfill gas is assigned to *1.A.4.a.1*. Gaseous fuel consumption applies to natural gas only. All fuel consumption of peat (fuel group) is occuring in *1.A.4.b.1* and is peat (fuel) only. Other fuel consumption is industrial waste only.

1.A.4.a.1 Commercial/Institutional: Stationary Combustion

Table 97: Share of liquid fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021

CRF	1.A.4.a.1							
Fuel group	**Liquid**							
Fuel	**Total**	**Light fuel oil**	**Medium fuel oil**	**Heavy fuel oil**	**Diesel**	**Petroleum and other petroleum products**	**Gas oil**	**Liquefied petroleum gases**
Year	**[% TJ]**							
1990	100.0	48.3	24.0	8.7	NO	5.1	5.9	8.0
1991	100.0	27.1	26.8	4.4	NO	8.7	20.7	12.2
1992	100.0	27.1	20.1	6.1	NO	6.9	19.5	20.2
1993	100.0	25.9	19.8	2.4	0.1	3.5	28.6	19.8
1994	100.0	32.6	18.4	2.4	0.1	0.6	24.4	21.6
1995	100.0	44.2	13.1	2.6	0.1	1.5	22.3	16.1
1996	100.0	43.1	7.0	1.1	0.0	2.2	40.1	6.6
1997	100.0	3.5	7.5	0.6	0.0	1.6	83.6	3.2
1998	100.0	1.9	8.6	1.0	0.0	3.0	81.5	3.9
1999	100.0	18.8	7.8	0.6	0.0	2.5	64.3	5.9
2000	100.0	19.8	8.2	0.8	0.0	1.5	63.4	6.3
2001	100.0	32.7	6.0	0.0	0.0	0.2	54.7	6.4
2002	100.0	27.2	7.7	NO	NO	0.7	52.9	11.6

CRF	1.A.4.a.1							
Fuel group	Liquid							
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petroleum and other petroleum products	Gas oil	Liquefied petroleum gases
Year	[% TJ]							
2003	100.0	19.5	7.4	NO	NO	0.7	61.2	11.2
2004	100.0	6.6	9.8	NO	NO	0.7	65.6	17.3
2005	100.0	12.5	NO	NO	0.0	NO	75.6	11.8
2006	100.0	23.7	NO	NO	NO	NO	65.2	11.1
2007	100.0	14.3	NO	NO	NO	NO	73.6	12.1
2008	100.0	6.7	NO	NO	0.0	NO	83.9	9.3
2009	100.0	11.0	NO	NO	0.0	NO	76.4	12.6
2010	100.0	2.3	NO	NO	0.0	NO	68.5	29.2
2011	100.0	8.4	NO	NO	0.0	NO	65.8	25.9
2012	100.0	7.2	NO	NO	0.0	NO	89.9	2.9
2013	100.0	8.3	NO	NO	0.0	NO	88.8	2.8
2014	100.0	10.4	NO	NO	0.0	NO	87.4	2.2
2015	100.0	9.3	NO	NO	0.0	NO	88.3	2.4
2016	100.0	20.1	NO	NO	0.0	NO	77.7	2.2
2017	100.0	7.8	NO	NO	0.0	NO	88.1	4.1
2018	100.0	5.0	NO	NO	0.0	NO	90.7	4.3
2019	100.0	0.3	NO	NO	0.0	NO	94.6	5.1
2020	100.0	0.2	NO	NO	0.0	NO	94.7	5.2
2021	100.0	9.8	NO	NO	NO	NO	86.0	4.2

NO...not occurring

Table 98: Share of solid fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021

CRF	1.A.4.a.1				
Fuel group	Solid				
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% TJ]				
1990	100.0	33.5	10.4	16.5	39.6
1991	100.0	32.6	11.7	21.3	34.4
1992	100.0	29.4	6.7	19.4	44.5
1993	100.0	35.3	11.9	17.7	35.0
1994	100.0	27.6	13.3	25.9	33.2
1995	100.0	34.4	8.1	19.2	38.3

CRF	1.A.4.a.1				
Fuel group	**Solid**				
Fuel	**Total**	**Hard coal and hard coal bri-quettes**	**Lignite and brown coal**	**Brown coal bri-quettes**	**Coke**
Year	**[% TJ]**				
1996	100.0	45.4	4.0	17.1	33.5
1997	100.0	36.3	3.5	42.1	18.1
1998	100.0	45.6	4.3	30.0	20.1
1999	100.0	57.0	3.6	22.2	17.2
2000	100.0	23.3	3.4	59.1	14.2
2001	100.0	16.7	3.8	64.2	15.3
2002	100.0	42.4	3.5	31.4	22.7
2003	100.0	35.8	2.4	48.6	13.2
2004	100.0	39.9	2.8	41.2	16.0
2005	100.0	38.5	1.4	45.1	14.9
2006	100.0	35.6	2.2	46.2	16.0
2007	100.0	23.2	0.6	61.4	14.9
2008	100.0	4.8	1.1	78.9	15.2
2009	100.0	6.4	2.9	70.8	19.8
2010	100.0	6.2	2.8	70.9	20.2
2011	100.0	7.8	1.5	65.1	25.5
2012	100.0	NO	NO	NO	100.0
2013	100.0	94.8	NO	NO	5.2
2014	100.0	NO	NO	NO	100.0
2015	100.0	NO	NO	NO	100.0
2016	100.0	NO	NO	NO	NO
2017	100.0	NO	NO	NO	NO
2018	100.0	NO	NO	NO	NO
2019	100.0	NO	NO	NO	NO
2020	100.0	NO	NO	NO	NO
2021	100.0	NO	NO	NO	NO

NO...not occurring

Table 99: Share of biomass fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021

CRF			**1.A.4.a.1**		
Fuel group			**Biomass**		
Fuel	**Total**	**Fuel wood**	**Wood waste**	**Biogas, sewage sludge gas and landfill gas**	**Charcoal**
Year			**[% TJ]**		
1990	100.0	64.6	30.9	NO	4.5
1991	100.0	62.2	33.3	NO	4.5
1992	100.0	61.0	34.2	NO	4.8
1993	100.0	44.3	23.6	27.4	4.8
1994	100.0	43.8	23.5	29.0	3.7
1995	100.0	45.8	23.6	25.8	4.9
1996	100.0	44.3	22.5	28.0	5.2
1997	100.0	32.1	39.9	23.5	4.5
1998	100.0	18.0	52.7	24.7	4.6
1999	100.0	12.0	72.6	13.1	2.3
2000	100.0	8.1	77.1	11.9	2.9
2001	100.0	14.9	67.7	13.6	3.8
2002	100.0	15.2	70.4	9.5	4.9
2003	100.0	13.2	73.4	8.3	5.1
2004	100.0	12.4	72.1	11.2	4.4
2005	100.0	20.2	61.4	13.5	4.9
2006	100.0	15.6	67.3	12.6	4.4
2007	100.0	14.5	72.0	9.7	3.7
2008	100.0	13.2	75.3	7.7	3.8
2009	100.0	15.7	72.0	8.4	3.9
2010	100.0	14.7	71.0	10.7	3.6
2011	100.0	15.4	67.7	12.7	4.2
2012	100.0	6.8	71.9	15.3	6.0
2013	100.0	6.7	75.2	12.7	5.4
2014	100.0	5.5	69.2	19.2	6.1
2015	100.0	3.2	74.9	15.8	6.0
2016	100.0	3.8	65.8	22.9	7.5
2017	100.0	5.7	74.6	15.5	4.3
2018	100.0	5.1	77.2	12.8	4.8
2019	100.0	5.2	78.9	11.5	4.4
2020	100.0	5.2	78.2	12.0	4.6
2021	100.0	5.2	80.0	10.8	4.0

NO...not occurring

1.A.4.b.1 Residential: Stationary Combustion

Table 100: Share of liquid fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021

CRF	**1.A.4.b.1**							
Fuel group	**Liquid**							
Fuel	**Total**	**Light fuel oil**	**Medium fuel oil**	**Heavy fuel oil**	**Diesel**	**Petro-leum and other pe-troleum products**	**Gas oil**	**Liquefied petro-leum gases**
Year	**[% TJ]**							
1990	100.0	26.6	NO	NO	NO	0.9	71.4	1.0
1991	100.0	21.3	NO	NO	NO	0.4	77.2	1.1
1992	100.0	20.7	NO	NO	NO	0.0	78.1	1.2
1993	100.0	13.6	NO	NO	NO	0.0	84.9	1.4
1994	100.0	10.4	NO	NO	NO	0.0	88.1	1.5
1995	100.0	10.4	NO	NO	NO	0.0	88.0	1.6
1996	100.0	10.5	NO	NO	NO	NO	87.8	1.7
1997	100.0	13.4	NO	NO	NO	NO	84.1	2.5
1998	100.0	13.6	NO	NO	NO	NO	83.8	2.6
1999	100.0	14.7	NO	NO	NO	NO	82.6	2.7
2000	100.0	13.3	NO	NO	NO	NO	83.5	3.2
2001	100.0	13.5	NO	NO	NO	NO	83.7	2.8
2002	100.0	11.6	NO	NO	NO	NO	85.8	2.6
2003	100.0	13.2	NO	NO	NO	NO	84.5	2.3
2004	100.0	13.0	NO	NO	NO	NO	84.6	2.3
2005	100.0	7.3	NO	NO	NO	NO	89.6	3.1
2006	100.0	6.8	NO	NO	NO	NO	90.0	3.2
2007	100.0	5.5	NO	NO	NO	NO	90.7	3.8
2008	100.0	5.5	NO	NO	NO	NO	90.6	3.8
2009	100.0	3.3	NO	NO	NO	NO	93.9	2.8
2010	100.0	2.2	NO	NO	NO	NO	95.0	2.7
2011	100.0	1.1	NO	NO	NO	NO	96.7	2.3
2012	100.0	0.6	NO	NO	NO	NO	96.8	2.6
2013	100.0	0.4	NO	NO	NO	NO	96.9	2.7
2014	100.0	NO	NO	NO	NO	NO	97.4	2.6
2015	100.0	NO	NO	NO	NO	NO	97.5	2.5
2016	100.0	NO	NO	NO	NO	NO	97.4	2.6
2017	100.0	NO	NO	NO	NO	NO	97.0	3.0
2018	100.0	NO	NO	NO	NO	NO	96.8	3.2
2019	100.0	NO	NO	NO	NO	NO	96.8	3.2
2020	100.0	NO	NO	NO	NO	NO	96.8	3.2
2021	100.0	NO	NO	NO	NO	NO	96.7	3.3

NO…not occurring

Table 101: Share of solid fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021

CRF			**1.A.4.b.1**		
Fuel group			**Solid**		
Fuel	**Total**	**Hard coal and hard coal briquettes**	**Lignite and brown coal**	**Brown coal briquettes**	**Coke**
Year			**[% TJ]**		
1990	100.0	18.5	8.5	15.5	57.5
1991	100.0	17.4	7.7	15.3	59.6
1992	100.0	12.2	7.3	15.6	65.0
1993	100.0	18.8	6.9	16.0	58.3
1994	100.0	20.4	6.3	15.5	57.7
1995	100.0	21.8	6.2	16.0	56.0
1996	100.0	23.9	5.4	16.5	54.3
1997	100.0	25.5	4.8	16.5	53.1
1998	100.0	25.7	4.9	15.3	54.1
1999	100.0	22.6	5.7	17.2	54.5
2000	100.0	22.4	6.6	14.9	56.1
2001	100.0	22.2	7.7	14.6	55.5
2002	100.0	22.1	8.2	13.9	55.9
2003	100.0	23.9	9.4	13.5	53.2
2004	100.0	24.9	8.1	13.8	53.3
2005	100.0	28.2	3.8	15.7	52.3
2006	100.0	28.1	3.8	15.7	52.4
2007	100.0	30.3	1.9	17.0	50.7
2008	100.0	30.8	1.7	17.3	50.2
2009	100.0	26.3	4.4	15.9	53.4
2010	100.0	25.1	4.4	15.9	54.6
2011	100.0	25.8	2.5	16.0	55.7
2012	100.0	26.5	2.2	17.3	54.0
2013	100.0	28.2	3.5	21.6	46.7
2014	100.0	28.6	2.8	21.6	47.0
2015	100.0	29.4	4.1	21.5	45.0
2016	100.0	28.8	3.1	20.5	47.7
2017	100.0	37.2	3.9	26.1	32.8
2018	100.0	39.8	3.7	29.3	27.2
2019	100.0	37.7	3.9	23.1	35.3
2020	100.0	19.5	5.2	32.9	42.5
2021	100.0	18.1	5.9	36.4	39.6

Table 102: Share of biomass fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021

CRF			**1.A.4.b.1**		
Fuel group			**Biomass**		
Fuel	**Total**	**Fuel wood**	**Wood waste**	**Biogas, sewage sludge gas and landfill gas**	**Charcoal**
Year			**[% TJ]**		
1990	100.0	98.5	1.3	NO	0.2
1991	100.0	98.3	1.5	NO	0.2
1992	100.0	98.1	1.7	NO	0.3
1993	100.0	97.7	2.0	IE[1], NO[2]	0.2
1994	100.0	97.7	2.1	IE[1], NO[2]	0.2
1995	100.0	97.5	2.2	IE[1], NO[2]	0.2
1996	100.0	97.5	2.3	IE[1], NO[2]	0.2
1997	100.0	96.5	3.2	IE[1], NO[2]	0.2
1998	100.0	95.8	4.0	IE[1], NO[2]	0.2
1999	100.0	93.4	6.3	IE[1], NO[2]	0.2
2000	100.0	92.2	7.5	IE[1], NO[2]	0.3
2001	100.0	90.7	9.0	IE[1], NO[2]	0.3
2002	100.0	90.0	9.7	IE[1], NO[2]	0.3
2003	100.0	88.1	11.5	IE[1], NO[2]	0.4
2004	100.0	88.1	11.5	IE[1], NO[2]	0.4
2005	100.0	90.1	9.5	IE[1], NO[2]	0.4
2006	100.0	89.4	10.2	IE[1], NO[2]	0.4
2007	100.0	86.8	12.8	IE[1], NO[2]	0.3
2008	100.0	86.4	13.2	IE[1], NO[2]	0.4
2009	100.0	86.0	13.7	IE[1], NO[2]	0.3
2010	100.0	85.5	14.2	IE[1], NO[2]	0.3
2011	100.0	83.5	16.3	IE[1], NO[2]	0.3
2012	100.0	82.6	17.1	IE[1], NO[2]	0.3
2013	100.0	81.8	18.0	IE[1], NO[2]	0.3
2014	100.0	80.7	19.0	IE[1], NO[2]	0.3
2015	100.0	78.4	21.2	IE[1], NO[2]	0.4
2016	100.0	78.2	21.5	IE[1], NO[2]	0.4
2017	100.0	77.9	21.8	IE[1], NO[2]	0.3
2018	100.0	77.1	22.5	IE[1], NO[2]	0.4
2019	100.0	76.4	23.2	IE[1], NO[2]	0.4
2020	100.0	76.2	23.4	IE[1], NO[2]	0.4
2021	100.0	75.6	24.1	IE[1], NO[2]	0.3

IE…included elsewhere

NO…not occuring

[1)]Biogas included elsewhere in category 1.A.4.a.1

[2)]Sewage sludge gas and landfill gas not occurring in category 1.A.4.b.1

1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion

Table 103: Share of liquid fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990-2021

CRF	**1.A.4.c.1**							
Fuel group	**Liquid**							
Fuel	**Total**	**Light fuel oil**	**Medium fuel oil**	**Heavy fuel oil**	**Diesel**	**Petroleum and other petroleum products**	**Gas oil**	**Liquefied petroleum gases**
Year	**[% TJ]**							
1990	100.0	97.8	NO	NO	NO	NO	0.8	1.4
1991	100.0	97.0	NO	NO	NO	NO	1.1	1.9
1992	100.0	96.9	NO	NO	NO	NO	1.0	2.1
1993	100.0	94.6	NO	NO	NO	NO	1.8	3.6
1994	100.0	92.7	NO	NO	NO	NO	2.3	5.0
1995	100.0	92.3	NO	NO	NO	NO	2.3	5.4
1996	100.0	92.0	NO	NO	NO	NO	2.3	5.7
1997	100.0	91.7	NO	NO	NO	NO	2.0	6.3
1998	100.0	91.8	NO	NO	NO	NO	1.8	6.5
1999	100.0	92.0	NO	NO	NO	NO	1.5	6.5
2000	100.0	89.9	NO	NO	NO	NO	1.6	8.6
2001	100.0	92.1	NO	NO	NO	NO	2.0	6.0
2002	100.0	91.2	NO	NO	NO	NO	2.3	6.5
2003	100.0	92.9	NO	NO	NO	NO	2.1	5.1
2004	100.0	92.7	NO	NO	NO	NO	2.1	5.2
2005	100.0	82.2	NO	NO	NO	NO	4.0	13.8
2006	100.0	81.0	NO	NO	NO	NO	4.2	14.8
2007	100.0	74.9	NO	NO	NO	NO	4.8	20.3
2008	100.0	74.8	NO	NO	NO	NO	4.7	20.4
2009	100.0	69.0	NO	NO	NO	NO	7.5	23.6
2010	100.0	61.1	NO	NO	NO	NO	9.7	29.2
2011	100.0	62.9	NO	NO	NO	NO	10.6	26.5
2012	100.0	61.9	NO	NO	NO	NO	10.7	27.4
2013	100.0	66.8	NO	NO	NO	NO	8.3	24.9
2014	100.0	72.9	NO	NO	NO	NO	6.9	20.2
2015	100.0	69.6	NO	NO	NO	NO	8.0	22.4
2016	100.0	74.7	NO	NO	NO	NO	6.6	18.8
2017	100.0	35.8	NO	NO	NO	NO	15.1	49.1
2018	100.0	NO	NO	NO	NO	NO	48.6	51.4
2019	100.0	NO	NO	NO	NO	NO	20.6	79.4
2020	100.0	NO	NO	NO	NO	NO	21.0	79.0
2021	100.0	NO	NO	NO	NO	NO	19.4	80.6

NO…not occurring

Table 104: Share of solid fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990-2021

CRF	1.A.4.c.1				
Fuel group	**Solid**				
Fuel	**Total**	**Hard coal and hard coal briquettes**	**Lignite and brown coal**	**Brown coal briquettes**	**Coke**
Year	**[% TJ]**				
1990	100.0	5.1	NO	30.0	64.8
1991	100.0	4.6	NO	29.0	66.4
1992	100.0	5.0	NO	27.5	67.5
1993	100.0	6.4	NO	30.0	63.6
1994	100.0	7.2	NO	29.4	63.4
1995	100.0	14.2	NO	28.3	57.5
1996	100.0	15.0	NO	29.1	55.9
1997	100.0	18.5	NO	30.3	51.1
1998	100.0	11.6	NO	31.0	57.4
1999	100.0	11.8	NO	33.2	55.0
2000	100.0	NO	NO	33.7	66.3
2001	100.0	NO	NO	33.4	66.6
2002	100.0	NO	NO	35.4	64.6
2003	100.0	NO	NO	36.7	63.3
2004	100.0	NO	NO	37.4	62.6
2005	100.0	6.7	NO	54.9	38.4
2006	100.0	7.4	NO	49.5	43.1
2007	100.0	5.5	NO	65.4	29.1
2008	100.0	5.4	NO	66.5	28.1
2009	100.0	8.2	NO	37.3	54.5
2010	100.0	8.2	NO	32.8	59.0
2011	100.0	8.8	NO	32.3	58.9
2012	100.0	8.6	NO	34.7	56.8
2013	100.0	8.7	NO	42.8	48.5
2014	100.0	8.1	NO	42.9	49.0
2015	100.0	9.8	NO	43.1	47.2
2016	100.0	8.9	NO	41.0	50.0
2017	100.0	9.3	NO	64.4	26.3
2018	100.0	9.8	NO	69.3	21.0
2019	100.0	13.1	NO	48.2	38.7
2020	100.0	4.9	NO	58.9	36.2
2021	100.0	5.0	NO	60.5	34.5

NO...not occurring

Table 105: Share of biomass fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990-2021

CRF			**1.A.4.c.1**		
Fuel group			**Biomass**		
Fuel	**Total**	**Fuel wood**	**Wood waste**	**Biogas, sewage sludge gas and landfill gas**	**Charcoal**
Year			**[% TJ]**		
1990	100.0	90.5	9.5	NO	NO
1991	100.0	89.6	10.4	NO	NO
1992	100.0	88.5	11.5	NO	NO
1993	100.0	87.5	12.5	IE[1], NO[2]	NO
1994	100.0	89.3	10.7	IE[1], NO[2]	NO
1995	100.0	86.0	14.0	IE[1], NO[2]	NO
1996	100.0	85.6	14.4	IE[1], NO[2]	NO
1997	100.0	81.1	18.9	IE[1], NO[2]	NO
1998	100.0	83.3	16.7	IE[1], NO[2]	NO
1999	100.0	74.0	26.0	IE[1], NO[2]	NO
2000	100.0	70.5	29.5	IE[1], NO[2]	NO
2001	100.0	65.2	34.8	IE[1], NO[2]	NO
2002	100.0	63.3	36.7	IE[1], NO[2]	NO
2003	100.0	58.0	42.0	IE[1], NO[2]	NO
2004	100.0	52.4	47.6	IE[1], NO[2]	NO
2005	100.0	70.6	29.4	IE[1], NO[2]	NO
2006	100.0	70.0	30.0	IE[1], NO[2]	NO
2007	100.0	64.1	35.9	IE[1], NO[2]	NO
2008	100.0	63.6	36.4	IE[1], NO[2]	NO
2009	100.0	64.2	35.8	IE[1], NO[2]	NO
2010	100.0	63.8	36.2	IE[1], NO[2]	NO
2011	100.0	61.5	38.5	IE[1], NO[2]	NO
2012	100.0	59.4	40.6	IE[1], NO[2]	NO
2013	100.0	55.0	45.0	IE[1], NO[2]	NO
2014	100.0	51.7	48.3	IE[1], NO[2]	NO
2015	100.0	52.2	47.8	IE[1], NO[2]	NO
2016	100.0	52.1	47.9	IE[1], NO[2]	NO
2017	100.0	49.9	50.1	IE[1], NO[2]	NO
2018	100.0	50.1	49.9	IE[1], NO[2]	NO
2019	100.0	54.8	45.2	IE[1], NO[2]	NO
2020	100.0	54.3	45.7	IE[1], NO[2]	NO
2021	100.0	54.0	46.0	IE[1], NO[2]	NO

IE…included elsewhere

NO…not occuring

[1]Biogas included elsewhere in category 1.A.4.a.1

[2]Sewage sludge gas and landfill gas not occurring in category 1.A.4.c.1

Fuel Consumption by Heating Type

The fuel consumption reported in (IEA JQ 2022) and (STATISTIK AUSTRIA 2022c) is assigned to twenty-two heating types (see section *Methodology* above).

If occuring, all fuel consumption of light fuel oil, medium fuel oil, heavy fuel oil, diesel, and petroleum and other petroleum products is assigned to heating type *#1 Fuel oil boilers*. Fuel consumption of gas oil is assigned to 5 different heating types *(#2 Gas oil stoves*, *#3 Vapourizing burners*, *#4 Yellow burners*, *#5 Blue burners with conventional technology*, *#6 Blue burners with low temperature or condensing technology*). Fuel consumption of liquefied petroleum gas is assigned to 2 different heating types *(#10 LPG stoves*, *#11 LPG boilers*) (from *1.A.4.a.1* see Table 106, from *1.A.4.b.1* see Table 109).

If occuring, all fuel consumption of hard coal and hard coal briquettes, lignite and brown coal, brown coal briquettes and coke is assigned to two different types of heating *(#21 Coal stoves*, *#22 Coal boilers)* with the same share (from *1.A.4.a.1* see Table 107, from *1.A.4.b.1* see Table 110).

Fuel consumption of natural gas is assigned to three different heating types *(#7 Natural gas convectors*, *#8 Atmospheric burners*, *#9 Forced-draft natural gas burners*) (from *1.A.4.a.1* see Table 107, from *1.A.4.b.1* see Table 110).

If occuring, fuel consumption of biogas, sewage sludge gas and landfill gas is assigned to two different heatiny types (#8 Atmospheric burners, #9 Forced-draft natural gas burners) (from *1.A.4.a.1* see Table 107, from *1.A.4.b.1* see Table 110).

Fuel consumption of fuel wood (log wood) is assigned to five different heating types *(#12 Wood stoves and cooking stoves*, *#13 Tiled wood stoves and masonry heaters*, *#14 Mixed-fuel wood boilers*, *#15 Natural-draft wood boilers*, *#16 Forced-draft wood boilers*). Fuel consumption of wood waste (wood chips, pellets and other biomass) is assigned to 4 different heating types (*#17 Wood chips boilers with conventional technology*, *#18 Wood chips boilers with oxygen sensor emission control*, *#19 Pellet stoves*, *#20 Pellet boilers*) (from *1.A.4.a.1* see Table 108, from *1.A.4.b.1* see Table 111). In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to central heating and calculated separately.

If occuring, all fuel consumption of industrial waste is assigned to heating type *#22 Coal boilers*.

1.A.4.a.1 Commercial/Institutional: Stationary Combustion

The fuel consumption from category *1.A.4.a.1* reported in (IEA JQ 2022) and (STATISTIK AUSTRIA 2022c) is assigned to twenty-two heating types derived from an energy demand model for space heating based on heating market surveys and federal provinces data and calibrated according to the energy statistics supplier (see section *Methodology* above).

Table 106: Percentual liquid fuel consumption by type of heating from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021

CRF	1.A.4.a.1							
Fuel group	**Liquid**							
Fuel	**Other liquid fuels**	**Gas oil**					**Liquefied petroleum gases**	
Heating type No.	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#10**	**#11**
Year	**[% TJ]**	**[%TJ]**					**[%TJ]**	
1990	100.0	10.2	2.3	78.5	1.7	7.4	87.0	13.0
1991	100.0	10.2	2.1	77.1	1.8	8.8	86.5	13.5
1992	100.0	10.0	2.0	75.3	2.2	10.5	86.1	13.9
1993	100.0	10.0	1.9	73.5	2.8	11.9	85.7	14.3
1994	100.0	9.8	1.8	71.1	3.7	13.6	85.2	14.8
1995	100.0	9.7	1.7	68.7	4.8	15.1	84.9	15.1
1996	100.0	9.6	1.6	65.2	6.2	17.4	84.6	15.4
1997	100.0	9.4	1.5	62.7	7.2	19.3	84.0	16.0
1998	100.0	9.3	1.4	59.5	8.2	21.6	83.5	16.5
1999	100.0	9.1	1.3	58.0	8.8	22.9	82.9	17.1
2000	100.0	8.8	1.2	56.9	9.1	23.9	82.2	17.8
2001	100.0	8.8	1.2	55.8	9.4	24.9	80.9	19.1
2002	100.0	8.6	1.1	54.7	9.7	25.9	79.7	20.3
2003	100.0	8.5	1.1	54.2	9.8	26.4	78.7	21.3
2004	100.0	8.4	1.1	52.8	10.0	27.6	77.7	22.3
2005	100.0	8.3	1.0	52.5	9.6	28.5	76.9	23.1
2007	100.0	8.2	1.0	52.3	9.2	29.3	76.0	24.0
2007	100.0	8.1	0.9	51.7	8.7	30.6	75.2	24.8
2008	100.0	8.0	0.9	51.0	8.1	32.0	74.6	25.4
2009	100.0	7.9	0.8	50.2	7.5	33.5	74.0	26.0
2010	100.0	7.9	0.7	49.3	6.8	35.3	73.6	26.4
2011	100.0	7.7	0.6	48.2	6.0	37.4	72.8	27.2
2012	100.0	7.6	0.5	47.0	5.1	39.7	72.3	27.7
2013	100.0	7.5	0.4	45.6	4.1	42.3	71.8	28.2
2014	100.0	7.4	0.3	44.1	2.9	45.4	70.9	29.1
2015	100.0	7.4	0.1	42.2	1.4	48.9	70.5	29.5
2016	100.0	6.7	0.1	41.6	1.3	50.3	69.1	30.9
2017	100.0	6.0	0.1	40.9	1.1	51.8	67.5	32.5
2018	100.0	5.2	0.1	40.2	1.0	53.5	65.6	34.4
2019	100.0	4.4	0.1	39.5	0.8	55.2	63.5	36.5
2020	100.0	3.5	0.1	38.9	0.6	57.0	61.1	38.9
2021	100.0	2.4	0.1	38.2	0.4	59.0	58.5	41.5

Table 107: Percentual solid, gaseous and biomass fuel consumption by type of heating from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021

CRF	1.A.4.a.1						
Fuel group	**Solid**		**Gaseous**			**Biomass**	
Fuel	**All solid fuels**		**Natural gas**			**Biogas, sewage sludge gas and land-fill gas**	
Heating type No.	**#21**	**#22**	**#7**	**#8**	**#9**	**#8**	**#9**
Year	**[% TJ]**		**[%TJ]**			**[%TJ]**	
1990	81.3	18.7	27.0	59.4	13.6	NO	NO
1991	78.5	21.5	25.0	59.9	15.1	NO	NO
1992	78.9	21.1	23.6	59.7	16.7	NO	NO
1993	75.3	24.7	22.5	59.4	18.1	76.6	23.4
1994	79.0	21.0	21.5	58.5	20.0	74.5	25.5
1995	81.4	18.6	19.8	58.1	22.1	72.5	27.5
1996	82.4	17.6	18.5	57.5	24.0	70.5	29.5
1997	82.0	18.0	17.5	56.5	26.0	68.5	31.5
1998	84.9	15.1	16.5	55.6	27.8	66.6	33.4
1999	85.2	14.8	15.4	54.8	29.8	64.7	35.3
2000	86.2	13.8	14.6	53.9	31.5	63.1	36.9
2001	86.0	14.0	14.5	52.8	32.7	61.8	38.2
2002	87.2	12.8	14.7	51.7	33.6	60.6	39.4
2003	85.6	14.4	14.6	50.9	34.5	59.6	40.4
2004	85.8	14.2	14.9	49.9	35.2	58.7	41.3
2005	90.0	10.0	14.9	49.4	35.7	58.1	41.9
2007	89.1	10.9	15.2	48.8	36.0	57.5	42.5
2007	85.5	14.5	15.6	48.3	36.2	57.1	42.9
2008	79.1	20.9	15.5	48.0	36.5	56.8	43.2
2009	79.0	21.0	15.7	47.7	36.6	56.6	43.4
2010	77.9	22.1	15.6	47.6	36.8	56.4	43.6
2011	77.2	22.8	16.0	47.3	36.7	56.3	43.7
2012	69.9	30.1	16.0	47.3	36.7	56.3	43.7
2013	95.4	4.6	16.0	47.3	36.6	56.4	43.6
2014	99.5	0.5	16.9	47.0	36.1	56.5	43.5
2015	99.5	0.5	16.7	47.4	36.0	56.9	43.1
2016	NO	NO	16.0	47.5	36.5	56.5	43.5
2017	NO	NO	15.4	47.4	37.2	56.0	44.0
2018	NO	NO	15.0	47.0	38.0	55.2	44.8
2019	NO	NO	14.3	46.7	39.0	54.5	45.5
2020	NO	NO	13.6	46.5	40.0	53.8	46.2
2021	NO	NO	12.5	46.4	41.2	53.0	47.0

NO...not occurring

Table 108: Percentual biomass fuel consumption by type of heating from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990-2021 (continued)

CRF	1.A.4.a.1								
Fuel group	**Biomass**								
Fuel	**Fuel wood**					**Wood waste**			
Heating type No.	**#12**	**#13**	**#14**	**#15**	**#16**	**#17**	**#18**	**#19**	**#20**
Year	**[%TJ]**					**[%TJ]**			
1990	1.6	64.9	32.7	NO	0.9	89.8	10.0	NO	0.2
1991	1.4	64.2	33.1	NO	1.3	77.5	10.4	0.0	12.1
1992	1.6	63.2	33.6	NO	1.7	65.1	12.3	0.0	22.6
1993	1.6	62.3	34.0	NO	2.1	55.8	12.8	0.1	31.2
1994	1.7	61.2	34.4	NO	2.6	47.4	13.5	0.4	38.7
1995	1.6	60.5	34.7	NO	3.2	40.5	13.8	0.9	44.8
1996	1.5	59.8	35.0	NO	3.7	35.2	13.4	1.3	50.0
1997	1.6	58.6	35.4	NO	4.4	30.6	13.1	1.7	54.7
1998	1.7	57.6	35.7	NO	5.0	26.4	12.8	2.1	58.7
1999	1.8	56.5	36.0	NO	5.8	22.9	12.5	2.5	62.2
2000	2.0	55.3	36.2	NO	6.5	19.6	12.3	2.8	65.3
2001	1.9	58.2	33.2	NO	6.7	21.9	15.9	3.3	58.9
2002	2.0	60.7	30.3	0.0	6.9	21.9	18.2	3.5	56.4
2003	1.9	63.6	27.4	0.1	7.0	21.3	20.1	3.7	54.9
2004	2.1	66.1	24.6	0.2	7.0	20.4	21.8	3.7	54.0
2005	2.0	68.8	22.5	0.2	6.4	10.9	14.4	5.0	69.7
2007	2.2	71.3	20.4	0.2	5.9	14.6	23.4	4.2	57.8
2007	2.5	73.6	18.4	0.2	5.3	14.7	27.5	3.9	53.9
2008	2.6	76.3	16.3	0.1	4.7	17.1	38.7	3.0	41.2
2009	2.7	79.0	14.1	0.1	4.1	13.9	38.1	3.3	44.7
2010	2.4	82.1	11.9	0.1	3.4	13.4	43.3	3.1	40.3
2011	2.9	84.7	9.5	0.1	2.7	10.6	40.3	3.4	45.6
2012	2.9	87.8	7.2	0.1	2.1	11.3	50.0	2.7	35.9
2013	3.0	90.8	4.8	0.0	1.4	9.1	45.8	3.2	42.0
2014	3.8	93.0	2.4	0.0	0.7	6.5	36.8	3.9	52.8
2015	3.6	96.4	NO	NO	NO	8.5	53.6	2.6	35.2
2016	3.5	96.5	NO	NO	NO	5.5	37.4	4.0	53.2
2017	3.4	96.6	NO	NO	NO	4.5	33.5	4.3	57.6
2018	3.8	96.2	NO	NO	NO	5.3	42.2	3.6	49.0
2019	3.8	96.2	NO	NO	NO	4.9	42.5	3.5	49.1
2020	3.7	96.3	NO	NO	NO	4.5	43.0	3.4	49.0
2021	3.2	96.8	NO	NO	NO	4.1	42.8	3.4	49.8

NO…not occurring

1.A.4.b.1 Residential: Stationary Combustion

Energy consumption from category *1.A.4.b.1* by type of fuel and by type of heating is derived from an energy demand model for space heating based on heating market surveys and federal provinces data validated with a statistical evaluation of micro census data 1990, 1992, 1999/2000, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018 and 2020 (STATISTIK AUSTRIA 1990, 1992b, 2002, 2019, 2021, 2022c). The calculated shares are used to subdivide total final energy consumption to the several technologies. For the years in between the shares are interpolated. Because the newest census data is always reconsidered to improve previous years' census data evaluation this implies a periodic recalculation in time series. The energy demand model is calibrated according to the energy statistics supplier (see section *Methodology* above).

Table 109: Percentual liquid fuel consumption by type of heating from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021

CRF	**1.A.4.b.1**							
Fuel group	**Liquid**							
Fuel	**Other liquid fuels**	**Gas oil**					**Liquefied petroleum gases**	
Heating type No.	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#10**	**#11**
Year	**[%TJ]**	**[%TJ]**					**[%TJ]**	
1990	100.0	15.0	12.3	64.2	1.4	7.1	24.5	75.5
1991	100.0	15.0	12.0	62.6	1.6	8.8	21.5	78.5
1992	100.0	14.4	11.8	61.4	1.8	10.6	20.5	79.5
1993	100.0	13.8	11.5	60.1	2.2	12.4	18.8	81.2
1994	100.0	13.3	11.1	58.7	2.9	14.1	18.1	81.9
1995	100.0	12.7	10.6	57.2	3.7	15.9	16.0	84.0
1996	100.0	12.1	10.0	55.7	4.7	17.5	13.7	86.3
1997	100.0	11.5	9.5	54.2	5.7	19.1	13.3	86.7
1998	100.0	10.9	9.0	53.2	6.4	20.5	12.6	87.4
1999	100.0	10.4	8.5	52.4	7.0	21.8	11.7	88.3
2000	100.0	10.4	8.1	51.3	7.4	22.8	11.6	88.4
2001	100.0	9.1	7.8	51.2	7.8	24.0	10.8	89.2
2002	100.0	7.9	7.6	51.3	8.1	25.0	11.1	88.9
2003	100.0	6.7	7.5	51.5	8.4	25.9	10.6	89.4
2004	100.0	5.0	7.5	52.0	8.7	26.9	10.6	89.4
2005	100.0	4.3	7.3	51.9	8.4	28.1	9.9	90.1
2007	100.0	3.7	7.1	51.8	8.0	29.3	10.0	90.0
2007	100.0	3.1	6.9	51.5	7.7	30.9	10.5	89.5
2008	100.0	2.9	6.5	50.7	7.2	32.6	12.2	87.8
2009	100.0	2.8	6.2	49.8	6.7	34.5	14.9	85.1
2010	100.0	2.6	5.8	48.9	6.2	36.5	14.5	85.5
2011	100.0	2.5	5.4	47.6	5.5	39.0	16.8	83.2
2012	100.0	2.4	4.9	46.4	4.8	41.5	15.3	84.7
2013	100.0	2.4	4.3	44.9	3.9	44.5	14.4	85.6
2014	NO	2.4	3.7	43.1	2.9	47.9	18.3	81.7
2015	NO	2.3	2.9	41.1	1.7	52.0	18.6	81.4
2016	NO	2.1	2.6	40.7	1.5	53.0	16.4	83.6
2017	NO	2.0	2.2	40.3	1.3	54.1	15.2	84.8
2018	NO	2.0	1.8	39.9	1.2	55.1	18.7	81.3

CRF	1.A.4.b.1							
Fuel group	Liquid							
Fuel	Other liquid fuels	Gas oil					Liquefied petroleum gases	
Heating type No.	#1	#2	#3	#4	#5	#6	#10	#11
Year	[%TJ]	[%TJ]					[%TJ]	
2019	NO	2.0	1.5	39.5	0.9	56.2	20.8	79.2
2020	NO	2.1	1.0	39.1	0.7	57.0	23.4	76.6
2021	NO	2.2	0.6	38.8	0.5	57.9	24.9	75.1

NO…not occurring

Table 110: Percentual solid, gaseous and biomass fuel consumption by type of heating from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021

CRF	1.A.4.b.1						
Fuel group	Solid		Gaseous			Biomass	
Fuel	All solid fuels		Natural gas			Biogas, sewage sludge gas and landfill gas	
Heating type No.	#21	#22	#7	#8	#9	#8	#9
Year	[%TJ]		[%TJ]			[%TJ]	
1990	30.0	70.0	39.1	53.7	7.2	NO	NO
1991	29.3	70.7	37.6	54.2	8.2	NO	NO
1992	28.6	71.4	36.2	54.6	9.2	NO	NO
1993	27.9	72.1	34.8	54.9	10.3	IE[1], NO[2]	IE[1], NO[2]
1994	27.2	72.8	33.3	55.2	11.5	IE[1], NO[2]	IE[1], NO[2]
1995	26.5	73.5	31.9	55.3	12.8	IE[1], NO[2]	IE[1], NO[2]
1996	25.8	74.2	30.5	55.5	14.0	IE[1], NO[2]	IE[1], NO[2]
1997	25.1	74.9	29.1	55.5	15.5	IE[1], NO[2]	IE[1], NO[2]
1998	24.5	75.5	27.6	55.5	16.9	IE[1], NO[2]	IE[1], NO[2]
1999	23.8	76.2	26.2	55.3	18.5	IE[1], NO[2]	IE[1], NO[2]
2000	23.1	76.9	24.8	55.3	20.0	IE[1], NO[2]	IE[1], NO[2]
2001	22.4	77.6	23.3	55.3	21.4	IE[1], NO[2]	IE[1], NO[2]
2002	21.7	78.3	21.9	55.3	22.8	IE[1], NO[2]	IE[1], NO[2]
2003	21.0	79.0	20.5	55.3	24.2	IE[1], NO[2]	IE[1], NO[2]
2004	20.3	79.7	19.0	55.5	25.5	IE[1], NO[2]	IE[1], NO[2]
2005	17.9	82.1	16.7	56.0	27.3	IE[1], NO[2]	IE[1], NO[2]
2007	18.0	82.0	16.6	55.1	28.4	IE[1], NO[2]	IE[1], NO[2]
2007	18.0	82.0	16.5	54.0	29.4	IE[1], NO[2]	IE[1], NO[2]
2008	15.8	84.2	15.8	53.4	30.8	IE[1], NO[2]	IE[1], NO[2]
2009	12.5	87.5	15.3	52.6	32.1	IE[1], NO[2]	IE[1], NO[2]
2010	16.6	83.4	15.0	51.6	33.4	IE[1], NO[2]	IE[1], NO[2]
2011	22.3	77.7	15.5	50.1	34.4	IE[1], NO[2]	IE[1], NO[2]
2012	21.5	78.5	13.2	50.2	36.6	IE[1], NO[2]	IE[1], NO[2]
2013	20.8	79.2	11.2	49.9	38.9	IE[1], NO[2]	IE[1], NO[2]

CRF	1.A.4.b.1						
Fuel group	Solid		Gaseous			Biomass	
Fuel	All solid fuels		Natural gas			Biogas, sewage sludge gas and landfill gas	
Heating type No.	#21	#22	#7	#8	#9	#8	#9
Year	[%TJ]		[%TJ]			[%TJ]	
2014	18.2	81.8	12.1	48.0	39.9	IE[1], NO[2]	IE[1], NO[2]
2015	15.2	84.8	11.5	47.6	40.9	IE[1], NO[2]	IE[1], NO[2]
2016	16.6	83.4	11.0	46.8	42.1	IE[1], NO[2]	IE[1], NO[2]
2017	17.8	82.2	10.7	45.8	43.5	IE[1], NO[2]	IE[1], NO[2]
2018	19.7	80.3	11.7	43.8	44.4	IE[1], NO[2]	IE[1], NO[2]
2019	21.6	78.4	12.2	42.2	45.6	IE[1], NO[2]	IE[1], NO[2]
2020	26.5	73.5	12.7	40.7	46.7	IE[1], NO[2]	IE[1], NO[2]
2021	30.5	69.5	12.6	39.4	48.0	IE[1], NO[2]	IE[1], NO[2]

IE…included elsewhere

NO…not occuring

[1)]Biogas included elsewhere in category 1.A.4.a.1

[2)]Sewage sludge gas and landfill gas not occurring in category 1.A.4.b.1

Table 111: Percentual biomass fuel consumption by type of heating from 1.A.4.b.1 Residential: Stationary Combustion 1990-2021 (continued)

CRF	1.A.4.b.1								
Fuel group	Biomass								
Fuel	Fuel wood					Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]					[%TJ]			
1990	22.6	8.7	66.6	NO	2.1	89.9	10.1	NO	NO
1991	22.2	8.7	66.1	NO	2.9	71.5	10.2	NO	18.3
1992	21.5	8.6	65.9	NO	4.0	59.0	11.0	NO	29.9
1993	20.7	8.6	65.6	NO	5.1	50.4	12.0	NO	37.6
1994	20.2	8.3	65.2	NO	6.3	43.9	12.9	NO	43.1
1995	19.5	8.2	64.9	NO	7.5	39.2	13.6	NO	47.2
1996	18.7	8.2	64.4	NO	8.8	35.3	14.4	NO	50.3
1997	17.9	8.0	63.8	NO	10.2	31.9	15.2	NO	52.9
1998	17.2	7.9	63.4	NO	11.5	28.9	16.1	NO	55.0
1999	16.5	7.9	62.8	NO	12.9	26.2	17.0	NO	56.8
2000	16.3	8.1	61.4	NO	14.3	23.7	18.0	NO	58.3
2001	14.3	7.6	62.0	NO	16.1	28.6	25.6	0.2	45.6
2002	12.4	7.1	62.5	0.1	17.9	31.6	32.7	0.3	35.4
2003	10.5	6.5	63.1	0.3	19.6	33.4	39.5	0.7	26.4
2004	10.3	6.7	61.8	0.5	20.7	28.7	38.6	0.8	31.9
2005	9.3	6.5	60.8	0.9	22.4	23.3	38.2	1.0	37.5
2007	9.9	7.0	57.9	1.6	23.5	18.3	35.6	1.2	44.9

CRF	1.A.4.b.1								
Fuel group	Biomass								
Fuel	Fuel wood					Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]					[%TJ]			
2007	10.3	7.5	56.1	2.1	24.0	15.1	33.3	1.3	50.3
2008	9.5	7.4	55.8	2.7	24.6	13.4	34.8	1.3	50.5
2009	8.9	7.3	55.0	3.2	25.6	10.6	32.3	1.5	55.6
2010	8.6	7.4	53.9	3.7	26.3	8.3	29.1	1.7	60.8
2011	8.2	7.2	53.2	4.1	27.4	6.5	25.8	1.8	66.0
2012	8.4	7.6	51.5	4.4	28.0	4.9	22.3	1.6	71.2
2013	8.7	8.0	50.1	4.7	28.5	6.6	33.4	1.2	58.8
2014	8.8	8.2	49.0	5.0	29.0	5.9	33.0	1.1	59.9
2015	9.0	8.5	47.8	5.2	29.5	3.7	22.7	1.4	72.2
2016	8.9	8.4	46.8	5.6	30.3	3.5	22.9	1.5	72.2
2017	8.9	8.3	45.6	6.0	31.2	4.1	29.2	1.4	65.3
2018	9.3	8.6	43.9	6.3	31.8	2.4	18.3	1.8	77.5
2019	9.8	9.0	42.1	6.7	32.5	1.6	12.6	2.1	83.7
2020	10.3	9.3	40.0	7.1	33.3	1.3	11.1	2.3	85.3
2021	10.7	9.8	37.7	7.6	34.2	1.1	10.8	2.8	85.3

NO...not occurring

1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion

The fuel consumption reported in (IEA JQ, 2022) and (Statistik Austria 2022c) for category *1.A.4.c.1* is predominantly assigned to implied emission factors derived from category *1.A.4.a.1* assuming similar structure of heating types in both categories (see section *Fuel Consumption by Heating Type* above).

Fuel Consumption by Subcategory of Heating Type

The following table shows biomass share of wood stoves and cooking stoves stock from 2001 which are considered with lower CH_4 emissions than equipment installed before 2001. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 112: Share of new and conventional wood stoves and cooking stoves stock 2001–2021

Heating type No.	#12			
Subcategory	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)	
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1	1.A.4.b.1
Year	[% TJ]		[%TJ]	
2001	3.2	2.3	96.8	97.7
2002	5.8	3.5	94.2	96.5
2003	8.0	4.2	92.0	95.8
2004	9.9	5.3	90.1	94.7

Heating type No.	#12			
Subcategory	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)	
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1	1.A.4.b.1
Year	[% TJ]		[%TJ]	
2005	11.8	7.2	88.2	92.8
2006	13.9	8.0	86.1	92.0
2007	15.8	7.6	84.2	92.4
2008	17.4	7.5	82.6	92.5
2009	19.3	8.7	80.7	91.3
2010	21.6	10.6	78.4	89.4
2011	23.3	11.9	76.7	88.1
2012	24.9	14.3	75.1	85.7
2013	26.3	17.0	73.7	83.0
2014	28.0	19.4	72.0	80.6
2015	29.6	22.1	70.4	77.9
2016	30.1	23.6	69.9	76.4
2017	31.0	25.7	69.0	74.3
2018	31.8	26.2	68.2	73.8
2019	32.8	26.9	67.2	73.1
2020	34.0	27.8	66.0	72.2
2021	35.6	28.9	64.4	71.1

The following table shows biomass share of mixed-fuel wood boilers stock with (comparatively) advanced technology which are considered with (slightly) lower CH_4 emissions than conventional equipment. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 113: Share of advanced and conventional mixed-fuel wood boilers stock 1990–2021

Heating type No.	#14			
Subcategory	Mixed-fuel wood boilers (advanced)		Mixed-fuel wood boilers (conventional)	
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1	1.A.4.b.1
Year	[% TJ]		[% TJ]	
1990	2.9	2.1	97.1	97.9
1991	5.3	3.8	94.7	96.2
1992	7.8	5.3	92.2	94.7
1993	10.1	6.7	89.9	93.3
1994	12.1	7.8	87.9	92.2
1995	13.6	8.8	86.4	91.2
1996	15.1	9.6	84.9	90.4
1997	16.3	10.3	83.7	89.7
1998	17.2	10.9	82.8	89.1
1999	18.0	11.4	82.0	88.6
2000	18.7	11.9	81.3	88.1

Heating type No.	#14			
Subcategory	Mixed-fuel wood boilers (advanced)		Mixed-fuel wood boilers (conventional)	
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1	1.A.4.b.1
Year	[% TJ]		[% TJ]	
2001	19.2	12.3	80.8	87.7
2002	19.6	13.0	80.4	87.0
2003	19.9	13.8	80.1	86.2
2004	20.0	14.5	80.0	85.5
2005	19.9	14.4	80.1	85.6
2007	20.0	14.3	80.0	85.7
2007	20.0	14.2	80.0	85.8
2008	20.0	14.1	80.0	85.9
2009	19.9	13.9	80.1	86.1
2010	19.9	13.8	80.1	86.2
2011	19.9	13.7	80.1	86.3
2012	19.9	13.6	80.1	86.4
2013	20.0	13.6	80.0	86.4
2014	20.0	13.5	80.0	86.5
2015	19.9	13.4	80.1	86.6
2016	19.5	13.3	80.5	86.7
2017	19.0	13.3	81.0	86.7
2018	18.5	13.2	81.5	86.8
2019	17.9	13.1	82.1	86.9
2020	17.3	13.0	82.7	87.0
2021	17.1	13.0	82.9	87.0

3.2.14.1.3 Emission Factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996, 1999), elementary analysis of natural gas (UMWELTBUNDESAMT 2002, until 2018), newly recommended CO_2 emission factor for natural gas (BMNT 2019a, starting from 2019), and the IPCC Guidelines 1996 whereas N_2O emission factors from the IPCC Guidelines 2006 are used. CO_2 and N_2O emission factors are identical for the different heating types burning the same fuels. The studies also provide CH_4 respectively VOC and C_{org} emission factors for different fuels and heating types.

The C_{org} (Organic Carbon) emission factors provided in (BMWA-EB 1999) are converted into VOC emission factors with the formula VOC = 1.3 * C_{org}. The factor of 1.3 is an expert judgement by Umweltbundesamt as no factor was available from literature. It is based on analytical data of the composition of VOC emissions from the combustion of fuel wood for residential heating.

In some cases only VOC emission factors are provided in the studies, CH_4 emission factors are determined assuming that a certain percentage of VOC emissions is released as NMVOC as listed in Table 114. The split follows closely (STANZEL et al. 1995).

Table 114: Share of CH_4 and NMVOC in VOC for small combustion devices

Pollutant		CH_4	NMVOC	VOC
Fuel group	**Fuel**		**[% VOC]**	
Liquid	Light fuel oil, Medium fuel oil, Heavy fuel oil	25,0	75,0	100,0
	Petroleum, Gas oil	20,0	80,0	100,0
	Liquefied petroleum gases	80,0	20,0	100,0
Solid	All solid fuels	25,0	75,0	100,0
Gaseous	Natural gas	80,0	20,0	100,0
Biomass	All biomass fuels	25,0	75,0	100,0

From 2001 on new wood stove and cooking stove subtypes are considered which have lower VOC emissions and thus lower CH_4 emissions than conventional wood stoves and cooking stoves. In addition, mixed-fuel wood boilers stock with (comparatively) advanced technology are considered with (slightly) lower CH_4 emissions than conventional equipment.

The selected emission factors for 2021 are presented in the following table.

Table 115: Emission factors of category 1.A.4 heating types for the year 2021

CRF		1.A.4	1.A.4.a.1	1.A.4.b.1	1.A.4.c.1	1.A.4
Pollutant		**CO_2**		**CH_4**		**N_2O**
Fuel	**Heating type No.**	**[t/TJ]**		**[kg/TJ]**		**[kg/TJ]**
Light fuel oil	#1	77.00	10.00	10.00	10.00	0.60
Medium fuel oil	#1	78.00	10.00	10.00	10.00	0.60
Heavy fuel oil	#1	78.00	10.00	10.00	10.00	0.60
Diesel	#1	75.00	10.00	10.00	10.00	0.60
Petroleum	#1	78.00	10.00	10.00	10.00	0.60
Other petroleum products	#1	64.00	10.00	10.00	10.00	0.60
Gas oil	#2, #3, #4, #5, #6	75.00	3.00	3.00	3.00	0.60
Natural gas	#7, #8, #9	55.60	5.00	5.00	5.00	0.10
Biogas, sewage sludge gas and landfill gas	#8, #9	54.60[1)]	5.00	5.00	5.00	0.10
Liquefied petroleum gases	#10, #11	64.00	5.00	5.00	5.00	0.10
Fuel wood	#12	112.00[1)]	182.87[2)]	189.86[2)]	300.00	4.00
	#13	112.00[1)]	115.61	115.61	300.00	4.00
	#14	112.00[1)]	145.11[3)]	146.29[3)]	300.00	4.00
	#15	112.00[1)]	121.42	121.42	300.00	4.00
	#16	112.00[1)]	112.74	112.74	300.00	4.00
Wood waste	#17	112.00[1)]	150.00	150.00	300.00	4.00
	#18	112.00[1)]	27.06	27.06	300.00	4.00
	#19	112.00[1)]	19.84	19.84	300.00	4.00
	#20	112.00[1)]	11.27	11.27	300.00	4.00

CRF		1.A.4	1.A.4.a.1	1.A.4.b.1	1.A.4.c.1	1.A.4
Pollutant		**CO_2**		**CH_4**		**N_2O**
Fuel	**Heating type No.**	**[t/TJ]**		**[kg/TJ]**		**[kg/TJ]**
Hard coal and hard coal briquettes	#21, #22	93.00	10.00	300.00	300.00	1.50
Lignite and brown coal	#21, #22	108.00	10.00	300.00	300.00	1.50
Brown coal briquettes	#21, #22	97.00	10.00	300.00	300.00	1.50
Coke	#21, #22	92.00	10.00	300.00	300.00	1.50
Peat	#21, #22	106.00	10.00	10.00	10.00	1.40
Industrial waste *(fossil)*	#22	66.38[4)]	12.00	12.00	12.00	4.00
Industrial waste *(biogenic)*	#22	50[1)]	12.00	12.00	12.00	4.00
Charcoal	–	112.00[1)]	200.00	200.00	200.00	1.00

[1)]Reported as CO_2 emissions from biomass

[2)]Implied emission factor based on CH_4 emission factors of new and conventional wood stoves and cooking stoves stock (see Table 116) weighted with fuel consumption by subcategory of heating type (see Table 112)

[3)]Implied emission factor based on CH_4 emission factors of advanced and conventional mixed-fuel boilers stock (seeTable 117) weighted with fuel consumption by subcategory of heating type (see Table 113)

[4)]Implied emission factor based on fossil fraction of industrial waste

Because no measurements are available, CH_4 emission factors for new wood stoves and cooking stoves (Table 116) are derived from conventional devices emission factors with the ratio of conventional and new devices NMVOC emission factors (BMWA-EB 1999, LANG et al. 2003):

$$EF(CH_4)_{new} = EF(CH_4)_{conventional} * EF(NMVOC)_{new} / EF(NMVOC)_{conventional}$$

Table 116: CH_4 emission factors of category 1.A.4 for conventional and new wood stoves and cooking stoves

Pollutant			CH_4	
CRF			**1.A.4.a.1**	**1.A.4.b.1**
Fuel	**Heating type No.**	**Subcategory**	**[kg/TJ]**	
Fuel wood	#12	Wood stoves and cooking stoves (new)	115.61	115.61
		Wood stoves and cooking stoves (conventional)	220.00	220.00

Because no measurements are available, CH_4 emission factors for advanced mixed-fuel boilers (Table 117) are derived from conventional devices emission factors with the ratio of conventional and advanced devices NMVOC emission factors (BMWA-EB 1999, LANG et al. 2003):

$$EF(CH_4)_{advacned} = EF(CH_4)_{conventional} * EF(NMVOC)_{advanced} / EF(NMVOC)_{conventional}$$

Table 117: CH_4 emission factors of category 1.A.4 for conventional and advanced mixed-fuel boilers

Pollutant			CH_4	
CRF			**1.A.4.a.1**	**1.A.4.b.1**
Fuel	**Heating type No.**	**Subcategory**	**[kg/TJ]**	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)	121.42	121.42
		Mixed-fuel wood boilers (conventional)	150.00	150.00

3.2.14.1.4 Recalculations

For 1990 to 2020, minor changes in greenhouse gas emissions of categories *1.A.4.a.1 Commercial/Institutional: Stationary Combustion* and *1.A.4.b.1 Residential: Stationary Combustion* occur because of updated heating stock data and newly allocated shares of combustion technologies per energy carrier (updated energy demand model for space heating).

In particular, the following shares with an effect on certain implied emission factors have been revised:

- Share of new and conventional wood stoves and cooking stoves stock 2001–2020 (CH_4) (see Table 112)
- Share of advanced and conventional mixed-fuel wood boilers stock 1990–2020 (CH_4) (see Table 113)

Changes in total fuel consumption are based on the revisions of the energy balance. Please refer to chapter *Recalculations and Improvements* below.

3.2.14.1.5 Planned Improvements

In order to improve the inventory on accurate heating type information it is planned to award a service-contract for an updated market survey of heating type stock, age distribution, final energy demand and type of heating use by CRF category. In order to determine the user-related impact on emissions from biomass (and coal), it is envisaged to collect data on national conditions within this study. It is planned to implement the study results into the inventory of submission 2024.
No further category-specific improvements are planned.

3.2.14.2 1.A.4 Other sectors – mobile sources

1.A.4.a.2 Commercial/institutional

Key Source: No

Currently there is neither a statistical basis nor any new study on NRMM (Non-Road Mobile Machinery) which would enable Austria to report emissions from mobile sources of *1.A.4.a.ii Commercial/institutional* separately. Commercial and institutional NRMM are reported as IE and included in *1.A.2.g.7 Industry* and *1.A.4.c.2 Agriculture and Forestry*.

1.A.4.b.ii Residential – Off-road vehicles and other machinery

Key Source: No

In addition to NRMM used in household and gardening this category contains ski slope machineries and snow vehicles.

Table 118: Greenhouse gas emissions from mobile sources of 1.A.4.b.ii Residential 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	173	0.40	0.02	190
1991	173	0.40	0.02	190
1992	174	0.40	0.02	191
1993	174	0.40	0.02	191
1994	173	0.39	0.02	190
1995	172	0.37	0.03	189

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1996	170	0.36	0.03	187
1997	168	0.34	0.03	184
1998	166	0.32	0.03	181
1999	165	0.31	0.03	180
2000	164	0.30	0.03	179
2001	163	0.29	0.03	178
2002	162	0.28	0.03	177
2003	161	0.28	0.03	176
2004	159	0.26	0.02	173
2005	156	0.24	0.02	169
2006	151	0.21	0.02	163
2007	147	0.19	0.02	158
2008	141	0.16	0.02	151
2009	137	0.14	0.02	146
2010	134	0.12	0.02	142
2011	132	0.10	0.02	139
2012	129	0.09	0.01	135
2013	127	0.08	0.01	133
2014	124	0.08	0.01	129
2015	120	0.07	0.01	125
2016	117	0.07	0.01	121
2017	114	0.06	0.01	118
2018	110	0.06	0.01	114
2019	108	0.06	0.01	112
2020	106	0.05	0.01	109
2021	104	0.05	0.01	108
1990–2021	**-40%**	**-87%**	**-70%**	**-43%**

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology and is described in the subchapter on mobile sources of CRF *1.A.2.g.vii*.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of CRF *1.A.4.b.ii* are presented below. In the following table the activity data includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.vii*.

Table 119: Emission factors and activity data for mobile sources of 1.A.4.b.ii Residential 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	2 286	75.5	173.7	10.6
1991	2 287	75.5	173.7	10.6
1992	2 303	75.5	173.0	10.7

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1993	2 307	75.5	172.3	10.7
1994	2 289	75.5	169.8	10.8
1995	2 286	75.5	163.2	11.1
1996	2 255	75.5	158.4	11.3
1997	2 225	75.5	153.1	11.4
1998	2 196	75.5	147.6	11.6
1999	2 181	75.5	142.1	11.7
2000	2 173	75.5	137.1	11.9
2001	2 165	75.5	133.1	12.1
2002	2 152	75.5	130.3	12.1
2003	2 135	75.4	129.2	11.9
2004	2 110	75.4	123.6	11.7
2005	2 071	75.2	113.7	11.3
2006	2 032	74.3	103.9	11.0
2007	1 991	73.9	93.4	10.6
2008	1 942	72.6	83.0	10.1
2009	1 903	71.8	72.4	9.5
2010	1 870	71.7	63.0	8.9
2011	1 842	71.6	55.2	8.2
2012	1 807	71.4	49.3	7.6
2013	1 773	71.7	46.4	7.0
2014	1 739	71.3	44.7	6.5
2015	1 689	71.1	43.2	6.0
2016	1 631	71.7	41.9	5.7
2017	1 583	71.9	40.4	5.4
2018	1 547	71.4	38.7	5.2
2019	1 510	71.5	37.5	5.0
2020	1 481	71.3	36.6	4.9
2021	1 461	71.4	35.9	4.9

Recalculations

No recalculations have been made.

Planned improvements

No category-specific improvements are planned.

1.A.4.c.ii Agriculture and Forestry – Off-road vehicles and other machinery

Key Source: No

In this category emissions from NRMM used in agriculture and forestry (mainly tractors) are considered.

Table 120: Greenhouse gas emissions from mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2021.

Year	**CO_2 [kt]**	**CH_4 [kt]**	**N_2O [kt]**	**CO_2e [kt]**
1990	852	852	852	852
1991	861	861	861	861
1992	852	852	852	852
1993	861	861	861	861
1994	852	852	852	852
1995	861	861	861	861
1996	852	852	852	852
1997	861	861	861	861
1998	852	852	852	852
1999	861	861	861	861
2000	852	852	852	852
2001	861	861	861	861
2002	852	852	852	852
2003	861	861	861	861
2004	852	852	852	852
2005	861	861	861	861
2006	852	852	852	852
2007	861	861	861	861
2008	852	852	852	852
2009	861	861	861	861
2010	852	852	852	852
2011	861	861	861	861
2012	852	852	852	852
2013	861	861	861	861
2014	852	852	852	852
2015	861	861	861	861
2016	852	852	852	852
2017	861	861	861	861
2018	852	852	852	852
2019	861	861	861	861
2020	852	852	852	852
2021	861	861	861	861
1990–2021	**4%**	**-73%**	**-50%**	**-2%**

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology. The general methodology applied is described in the subchapter on mobile sources of CRF *1.A.2.g.vii*.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of CRF *1.A.4.c* are presented below. In the following table the activity data includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Activities of mobile machinery in CRF *1.A.4.c.ii* also contain commercially/institutionally used machinery. They could not be split into commercial/institutional and non-commercial/non-institutional use due to a lack of data.

Table 121: Emission factors and activity data for mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	10 366	74.2	16.4	24.5
1991	10 331	74.2	13.2	24.7
1992	10 421	74.2	13.7	24.7
1993	10 472	74.2	13.6	24.8
1994	10 559	74.2	14.9	25.0
1995	10 106	74.2	14.7	25.4
1996	10 509	74.2	14.9	25.8
1997	11 036	74.2	14.0	26.3
1998	10 836	74.2	13.5	26.7
1999	10 939	74.2	13.2	27.0
2000	10 610	74.2	12.8	27.3
2001	10 936	74.2	12.5	27.6
2002	10 887	74.2	13.1	27.3
2003	10 457	74.2	14.6	26.7
2004	10 760	74.2	13.1	26.0
2005	11 434	73.6	11.5	25.2
2006	11 347	71.7	11.9	24.3
2007	11 286	71.7	11.8	23.2
2008	12 225	71.4	10.1	22.1
2009	11 195	70.4	8.1	21.0
2010	10 901	70.4	7.7	19.8
2011	11 818	70.3	6.8	18.7
2012	10 909	70.2	6.3	17.6
2013	10 560	70.4	5.8	16.6
2014	11 667	70.2	4.9	15.7
2015	10 793	69.8	5.0	14.9
2016	11 611	70.3	4.3	14.1
2017	10 775	70.7	4.6	13.3
2018	10 872	70.6	4.7	12.6
2019	11 455	70.7	4.3	12.1
2020	11 592	70.7	3.8	11.6
2021	11 307	70.6	4.1	11.1

Recalculations

No category-specific improvements are planned.

Planned improvements

No category-specific improvements are currently planned.

3.2.15 1.A.5 Other

In this category emissions of NRMM used for military transport (off-road and aviation) are reported.

1.A.5.b Mobile combustion – Military

Key Source: No

Military Off-Road (ground operations)

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3 methodology for road transport. The applied methodology is described in the subchapter on mobile sources of CRF *1.A.2.g.vii.*

Emission estimates for military activities were taken from (HAUSBERGER 2000). Information on the fleet composition was taken from official data presented in the internet as no other data was available.

Activity Data

No information on the road performance of military vehicles was available, that's why emission estimates only present rough estimations, which were obtained making the following assumptions: for passenger cars and motor cycles the yearly road performance as calculated for civil cars was used. The yearly road performance for other vehicles was estimated to be 30 h/year (as a lot of vehicles are old and many are assumed not to be in actual use anymore).

Emission Factors

For tanks and other special ground military vehicles the emission factors for diesel engines > 130 kW were used (for these vehicles a power of 300 kW was assumed). Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.7.*

Military Aviation

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 1 (simple) methodology for aviation with country specific emission factors. Methodology is based on hours of operation and average fuel consumption per hour for the years 1990-1998 with a linear trend extrapolation for the years from 1998 onwards. The calculation of emissions from military aviation does not distinguish between LTO and cruise.

Activity Data

For the years 1990–1998 fuel consumption for military flights was reported once by the Austrian Ministry of Defence and used in the course of the general flight study to calculate emissions from military aviation (KALIVODA/KUDRNA 2002).

In response to a recommendation of the UNFCCC Review 2020 on Austria's methodology for estimating emissions from military aviation 2000–2018, data on kerosene consumption was re-evaluated.

However, after several official attempts to allocate data from the Austrian Ministry of Defence, no data was provided. Therefore, the historical number of aircrafts (fighter jets, airplanes, helicopters) was compared with current data found on the Internet on the number of operating military aircraft assuming constant flight hours. [63] Starting with the year 2009, fuel consumption was interpolated according to the trend until the year 2020. The year 2020 is planned to kept constant in the future until new data is available. According to the trend shown in the table below fuel consumption is now declining from 2009 onwards.

Table 122: Military aircraft stock 2008 and 2020

	Helicopters	Fighter jets and airplanes	Total number ofmilitary aircraft
2008	78	96	174
2020	82	43	125
Trend 2008-2020	**5%**	**-55%**	**-28%**

As no aircraft data prior to 2008 could be found (PÖTSCHER 2008), the subsequent revision of activity data refers to the years 2009-2019 only; for the years 1999-2008 the previously applied method (linear extrapolation) has been retained, while for the years 1990-1998 the results of the flight study have been used directly as in previous submissions.

The change in methodology results in recalculations for 2009–2019 (-17.7 kt CO_2e in 2019).

Emission Factors

Country specific IEFs (t/t fuel) taken from a national flight study (KALIVODA/KUDRNA 2002) and based on fuel consumption and emissions in the year 2000 have been used to estimate GHG emissions from military flights.

Table 123: Emission factors used for military flights.

	Amount in 2000 [t]	IEF [t/t]
Fuel	13 613	
CO_2	42 880	3.1500
N_2O	2.69	0.0002
CH_4	1.41	0.0001

Overall activities and emissions

The table below shows GHG emissions for the complete military sector (sum of ground operations and military aviation).

Table 124: Greenhouse gas emissions from 1.A.5.b Military 1990–2021.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	35	0.001	0.0028	36
1991	37	0.001	0.0029	38
1992	34	0.001	0.0028	35
1993	39	0.001	0.0032	40
1994	42	0.001	0.0032	43

[63] https://de.wikipedia.org/wiki/Luftstreitkr%C3%A4fte_(Bundesheer); 5.12.2021

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1995	33	0.001	0.0027	33
1996	39	0.001	0.0031	40
1997	37	0.001	0.0029	38
1998	42	0.001	0.0032	43
1999	42	0.001	0.0031	43
2000	41	0.001	0.0032	42
2001	41	0.001	0.0033	42
2002	42	0.001	0.0033	43
2003	42	0.001	0.0033	43
2004	43	0.001	0.0033	44
2005	44	0.001	0.0033	45
2006	44	0.001	0.0032	45
2007	45	0.001	0.0032	46
2008	45	0.001	0.0032	46
2009	44	0.001	0.0031	45
2010	43	0.001	0.0030	44
2011	42	0.001	0.0029	43
2012	41	0.001	0.0028	42
2013	40	0.001	0.0027	41
2014	39	0.001	0.0026	40
2015	38	0.001	0.0025	39
2016	37	0.001	0.0025	38
2017	36	0.001	0.0024	37
2018	35	0.001	0.0023	36
2019	34	0.001	0.0023	35
2020	33	0.001	0.0022	34
2021	30	0.001	0.0020	30
1990–2021	**-15%**	**-21%**	**-30%**	**-15%**

Activities used for estimating the emissions of the total CRF *1.A.5.b* are presented below (activity data includes all energy sources). The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 125: Emission factors and activity data for 1.A.5.b Military 1990–2021.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	481	72.8	2.4	5.8
1991	510	72.8	2.4	5.7
1992	463	72.8	2.4	6.0
1993	541	72.8	2.4	5.8
1994	571	72.8	2.4	5.7
1995	447	72.8	2.4	6.1
1996	534	72.8	2.4	5.8
1997	509	72.8	2.4	5.7
1998	582	72.8	2.4	5.4
1999	553	75.2	2.5	5.6

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2000	561	72.8	2.4	5.8
2001	568	72.8	2.4	5.8
2002	576	72.8	2.4	5.7
2003	583	72.8	2.4	5.7
2004	591	72.8	2.4	5.6
2005	599	72.7	2.4	5.5
2006	606	72.7	2.4	5.3
2007	614	72.7	2.4	5.2
2008	622	72.7	2.3	5.1
2009	608	72.6	2.3	5.0
2010	594	72.6	2.3	5.0
2011	580	72.6	2.3	4.9
2012	566	72.6	2.3	4.9
2013	552	72.6	2.3	4.9
2014	539	72.5	2.3	4.9
2015	524	72.5	2.3	4.8
2016	510	72.6	2.3	4.8
2017	496	72.6	2.3	4.8
2018	482	72.6	2.3	4.8
2019	469	72.5	2.3	4.8
2020	455	72.5	2.3	4.8
2021	386	77.1	2.4	5.1

Recalculations

No recalculations have been carried out.

Planned Improvements

Austria will launch a new attempt to receive activity data from the Austrian Ministry of Defence for the inventory years 2000-2022 (to be included in the submission 2024).

3.2.16 Uncertainties and time series consistency

As the overall fuel balance for Austria is expected to be considerably more accurate than source specific information (Statistik Austria, pers. communication), also assessment of uncertainties was performed on the level of the overall energy balance. It was not possible, however, to strictly use this straightforward approach because dealing with all fuel related activities at the same time would make it difficult to provide separation of major source categories; as domestic combustion, industry and power plant would fall in the same category with traffic.

For these reasons, an arbitrary split was drawn between energy use in large sources (covering IPCC sectors *1.A.1*, refineries as they are included in *1.B.2*, and energy in iron and steel production covered in *2.C.1*), transport sources (IPCC sector *1.A.3*, but including transport related machinery in *1.A.2*, manufacturing industry, and *1.A.4*, other sectors like agriculture, forestry and households) and small sources (covering all other combustion sources, specifically the rest of manufacturing industry, *1.A.2*, as well as other sectors, *1.A.4*. Also *1.A.5*, "other" is included which basically covers military energy consumption including transport). Activity uncertainty was assessed separately by fuel for fossil solids (fuel code 102–110), biomass and waste fuels (fuel code 111–118), liquid fuels (fuel codes 203–224 except for black liquor, code 215 which is treated separately) and gaseous fuels (fuel codes above 300). Uncertainty factors have been maintained from previous studies (WINIWARTER & ORTHOFER 2000; CHARLES et al. 1998) and are listed in Table 126. For transport, the respective factors are new and have been taken from an assessment of the overall transport GHG emissions (HAUSBERGER 2005).

Table 126: Uncertainty parameters for fuel combustion activities.

	Fossil solid	Biomass & waste	liquid	Black liquor	Gas
large sources	0.5	5.0*	0.5	–	1.0*
small sources	1.0	10	1.0	10.0	5.0
transport		5.0*	3.0		

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Uncertainty factors presented account for the generally high quality level of Austrian fuel statistics, which is based on physical measurements (weighing, flow-metering), but data reported in statistics are derived from the respective heat content of fuels. Transformation requires analysis or measurement of the heat content in the fuel. Biomass, waste and black liquor, which are not contained in detail by trade statistics, exhibit a much larger uncertainty.

Emission factors in fuel combustion are also considered to be well-known. CO_2 emissions can be derived from stoichiometry. Carbon content of fuels (within gaseous/liquid/solid fuels, respectively) is largely proportional to its heat content. Thus we estimate uncertainty of the emission factor – separately for solid, liquid and gaseous fuels – at 0.2% to 0.5%. Within these respective fuel classes we consider uncertainty correlated.

Even more interesting is the case of methane. A considerable number of seemingly independent emission factors for different emission situation are available. At closer inspection, however, it appears that data presented by STANZEL et al. (1995) and used in OLI actually derive from HC measurements. The fraction of CH_4 in total HC combustion exhaust has been estimated by ORTHOFER (1991) at 75% in gaseous fuels, 20% in solid fuels and 25% in liquid fuels. As this percentage is what drives overall uncertainty for methane emission factors, we again have to treat gaseous, liquid and solid fuels as dependent (correlated) parameters. As an indicator of overall uncertainty we may refer to CHARLES et al. (1998) who reported 50% for methane from combustion sources. For the transport Sector we use 30% for methane.

For nitrous oxide, emission measurements have been performed by VITOVEC (1991) and resulting uncertainty has been estimated at 20%. This figure has previously been used for Austria, but is not sustainable any more considering the fact that emission factors originally used for an Austrian inventory by ORTHOFER et al. (1995) are now more than 20 years old and refer to a considerably different combustion regime. We now apply 50% (taken from MONNI & SYRI 2003; see also RAMIREZ et al. 2006), a figure which we understand to also include uncertainty due to limited knowledge on the fraction of fluidized bed combustion in the installation park. Emission factors reported for nitrous oxide by STANZEL et al. (1991) and used in OLI originally derive from the GEMIS modelling system, again just one source. Thus they again need to be considered correlated within each fuel class (solid, liquid and gaseous).

3.2.17 Recalculations

This chapter presents the recalculation difference of emissions from fuel combustion activities and its sub categories with respect to the previous submission.

The whole time series of recalculations is included in Annex 8 to the NIR.

3.2.17.1 Revision of energy balance

The federal statistics office "Statistik Austria" revised the energy balance (mainly for year 2020) with the following **main implications** for energy consumption as used in the inventory and the corresponding CO_2 emissions:

- Natural gas 2020: Gross inland consumption has been revised by +1.5 PJ (+ 85 kt CO_2) and allocated to final energy consumption, of which 0.8 PJ (+ 44 kt CO_2) has been allocated to *1.A.2* (+10 kt CO_2 for *1.A.2.a*, +5 kt CO_2 for *1.A.2.b*, +23 kt CO_2 for *1.A.2.c*, +28 kt CO_2 for 1.A.2.d, +14 kt CO_2 for *1.A.2.e*, -36 kt for *1.A.2.g*). Another 0.7 PJ of final consumption (+ 41 kt CO_2) has been allocated to *1.A.4* (mainly to *1.A.4.b.1*).
- Gasoil 2020: Minor shifts between *1.A.2* (-0.06 PJ), *1.A.4.a* (-0.29 PJ) and *1.A.4.b* (+0.43 PJ)
- LPG 2020: Minor shifts from non-energy use (-0.07 PJ) to *1.A.4.b.1*.
- Hard coal 2020: 0.2 PJ (-19 kt CO_2) have been shifted from *1.A.4.b.1* residential to *1.A.2.f* non-metallic minerals industry although *1.A.2.f* has not been revised because hard coal consumption is 100% covered by the ETS.
- Coke oven coke 2020: 0.06 PJ (- 5 kt CO_2) have been shifted from *1.A.4.b* to *1.A.2.a* final consumption.

Solid biomass: 0.07 PJ of fuel wood has been shifted from *1.A.4.c* agriculture to *1.A.4.a* commercial. For the years 2018-2020, 0.05 to 0.3 PJ have been shifted between *1.A.2* and *1.A.4* sub categories.

3.2.17.2 CO_2 recalculations 1.A

Table 127 shows the recalculations of CO_2 emissions for the subcategories of sector *1.A Fuel Combustion.*

Recalculations of CO_2 emissions 1990-2020 are mainly because solid fuels have been shifted from*1.A.2.a Iron and Steel* (combustion emissions) to *2.C.1 Iron and Steel Production* (process emissions).

Table 127: Recalculation difference of CO_2 emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	-229.95	-	-229.95	0.00	-	-
1991	-260.83	-	-260.83	0.00	-	-
1992	-185.33	-	-185.33	0.00	-	-
1993	-164.74	-	-164.74	0.00	-	-
1994	-253.97	-	-253.97	0.00	-	-
1995	-171.60	-	-171.60	0.00	-	-
1996	-205.92	-	-205.92	0.00	-	-

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1997	-24.02	-	-24.02	0.00	-	-
1998	-0.32	-	-0.32	-	-	-
1999	-10.30	-	-10.30	0.00	-	-
2000	0.00	-	-	0.00	-	-
2001	-51.48	-	-51.48	0.00	-	-
2002	-89.23	-	-89.23	0.00	-	-
2003	-97.62	-	-97.62	0.00	-	-
2004	-106.39	-	-106.39	0.00	-	-
2005	-166.24	-	-166.25	0.00	0.00	-
2006	-45.05	-	-45.06	0.02	-	-
2007	-117.44	-	-117.51	0.07	0.00	-
2008	-175.88	-	-176.09	0.21	0.00	-
2009	-130.13	-	-130.39	0.26	0.00	-
2010	-149.86	-	-150.26	0.40	-	-
2011	-126.39	-	-126.87	0.48	0.00	0.00
2012	-123.29	-	-123.90	0.62	-	0.00
2013	-151.75	-	-152.59	0.84	0.00	-
2014	-148.18	-	-149.06	0.88	-	-
2015	-11.11	-	-12.12	1.01	-	-
2016	-13.88	-	-15.00	1.12	-	-
2017	-9.41	-	-10.54	1.13	-	-
2018	-11.87	-	-12.14	0.27	0.00	0.00
2019	-27.32	-	-26.40	-0.92	-	-
2020	8.21	-	-16.07	-0.61	24.89	0.00

3.2.17.3 CH_4 recalculations 1.A

Table 128 shows the recalculations of CH_4 emissions for the subcategories of sector *1.A Fuel Combustion.* Minor recalculations were reported for *1.A.4* due to model revisions in relation with biofuels (updated energy demand model for space heating).

Table 128: Recalculation difference of CH_4 emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	-0.28	-	0.00	0.00	-0.28	-
1991	-0.07	-	0.00	0.00	-0.06	-
1992	-0.03	-	0.00	0.00	-0.03	-
1993	0.00	-	0.00	0.00	0.00	-
1994	0.02	-	0.00	0.00	0.03	-
1995	0.11	-	0.00	0.00	0.11	-
1996	0.07	-	0.00	0.00	0.07	-
1997	0.08	-	0.00	0.00	0.08	-
1998	0.08	-	0.00	0.00	0.08	-
1999	0.09	-	0.00	0.00	0.09	-
2000	0.20	-	-	0.00	0.20	-
2001	0.13	-	0.00	0.00	0.13	-
2002	0.07	-	0.00	0.00	0.07	-

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2003	0.03	-	0.00	0.00	0.03	-
2004	0.00	-	0.00	0.00	0.00	-
2005	0.00	-	0.00	0.00	0.00	-
2006	0.00	-	0.00	0.00	0.00	-
2007	0.00	-	0.00	0.00	0.00	-
2008	0.00	-	0.00	0.00	0.00	-
2009	0.00	-	0.00	0.00	0.00	-
2010	0.00	-	0.00	0.00	0.00	-
2011	0.00	-	0.00	0.00	0.00	-
2012	0.00	-	0.00	0.00	0.00	-
2013	0.00	-	0.00	0.00	0.00	-
2014	0.00	-	0.00	0.01	0.00	-
2015	0.01	-	0.00	0.00	0.00	-
2016	0.02	-	0.00	0.00	0.01	-
2017	0.01	-	0.00	0.00	0.01	-
2018	-0.02	-	0.00	-0.02	0.00	-
2019	-0.03	-	0.00	-0.02	0.00	-
2020	-0.12	0.00	0.00	-0.02	-0.10	0.00

3.2.17.4 N_2O recalculations 1.A

Table 129 shows the recalculations of N_2O emissions for the subcategories of sector *1.A Fuel Combustion.*

Recalculations of N_2O emissions 1990-2020 are mostly following the revisions o the energy balance or minor revisions of the transport model.

Table 129: Recalculation difference of N_2O emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	0.000	-	0.000	0.000	-	-
1991	0.000	-	0.000	0.000	-	-
1992	0.000	-	0.000	0.000	-	-
1993	0.000	-	0.000	0.000	-	-
1994	0.000	-	0.000	0.000	-	-
1995	0.000	-	0.000	0.000	-	-
1996	0.000	-	0.000	0.000	-	-
1997	0.000	-	0.000	0.000	-	-
1998	0.000	-	0.000	0.000	-	-
1999	0.000	-	0.000	0.000	-	-
2000	0.000	-	-	0.000	-	-
2001	0.000	-	0.000	0.000	-	-
2002	0.000	-	0.000	0.000	-	-
2003	0.000	-	0.000	0.000	-	-
2004	-0.001	-	0.000	-0.001	-	-
2005	0.001	-	0.000	0.001	-	-
2006	0.001	-	0.000	0.001	-	-

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2007	0.000	-	0.000	0.001	-	-
2008	0.000	-	0.000	0.000	0.000	-
2009	0.000	-	0.000	0.000	-	-
2010	-0.001	-	0.000	0.000	-	-
2011	-0.001	-	0.000	-0.001	-	-
2012	-0.001	-	0.000	-0.001	-	-
2013	-0.001	-	0.000	0.000	-	-
2014	0.000	-	0.000	0.000	-	-
2015	0.000	-	0.000	0.000	-	-
2016	-0.001	-	0.000	-0.001	-	-
2017	-0.003	-	0.000	-0.003	-	-
2018	-0.013	-	0.000	-0.013	-	-
2019	-0.024	-	-0.001	-0.023	-	-
2020	-0.007	-	-0.001	-0.005	0.000	0.000

3.2.17.5 GHG recalculations [kt CO_2e] 1.A

Table 130 shows the recalculations in [kt CO_2 equivalent] for the subcategories of sector *1.A Fuel Combustion.* Values smaller than ± 0.005 kt CO_2 equivalent are not displayed.

Table 130: Recalculation difference of GHG emissions in [kt CO_2e] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	-237.97	-	-230.08	-	-7.89	-
1991	-262.79	-	-260.98	-0.01	-1.80	-
1992	-186.22	-	-185.44	-0.01	-0.78	-
1993	-164.77	-	-164.83	-0.01	0.07	-
1994	-253.37	-	-254.12	-0.01	0.75	-
1995	-168.50	-	-171.70	-0.01	3.21	-
1996	-204.03	-	-206.04	-	2.02	-
1997	-21.84	-	-24.04	-	2.20	-
1998	2.01	-	-0.32	-	2.34	-
1999	-7.79	-	-10.30	-	2.51	-
2000	5.71	-	-	-	5.71	-
2001	-47.89	-	-51.51	-	3.62	-
2002	-87.35	-	-89.28	-	1.93	-
2003	-96.93	-	-97.68	-	0.75	-
2004	-106.50	-	-106.45	-0.15	0.10	-
2005	-166.07	-	-166.34	0.24	0.03	-
2006	-44.74	-	-45.09	0.32	0.03	-
2007	-117.35	-	-117.58	0.21	0.02	-
2008	-175.94	-	-176.19	0.25	-0.01	-
2009	-130.28	-	-130.46	0.22	-0.04	-
2010	-150.09	-	-150.35	0.35	-0.09	-
2011	-126.58	-	-126.94	0.43	-0.07	-
2012	-123.44	-	-123.97	0.57	-0.05	-
2013	-151.80	-	-152.68	0.85	0.03	-

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2014	-148.15	-	-149.14	0.97	0.02	-
2015	-11.04	-	-12.13	1.04	0.05	-
2016	-13.81	-	-15.01	0.85	0.35	-
2017	-9.77	-	-10.54	0.49	0.28	-
2018	-15.80	-	-12.23	-3.71	0.13	-
2019	-34.36	-	-26.71	-7.63	-0.02	-
2020	3.10	-	-16.52	-2.54	22.16	-

3.2.18 Planned Improvements

No improvements are planned.

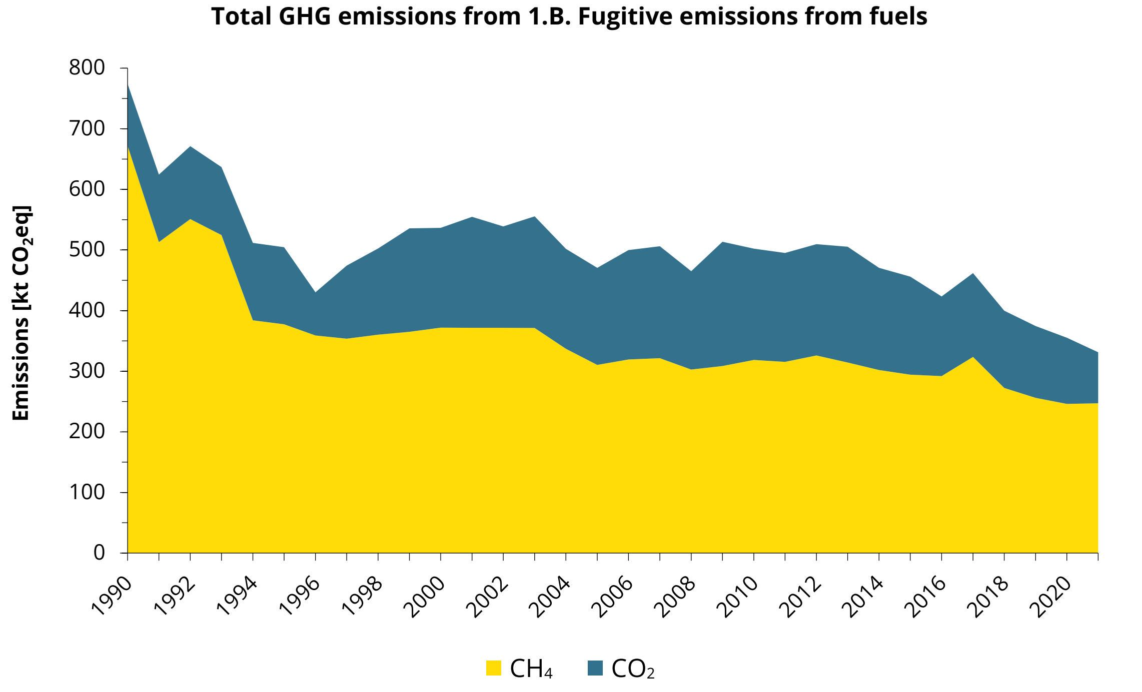
3.3 Fugitive Emissions (Category 1.B)

Fugitive emissions are intentional or unintentional releases of GHG, which arise during the extraction, processing and delivery of fossil fuels (coal, oil and natural gas) to the point of final use. The emissions of fugitive emissions are reported in CRF Category 1.B. whereas emissions from fuel combustion during these processes are reported under CRF Category 1.A.

3.3.1 Emission Trends

In 2021 0.4% of national total emissions arose from IPCC category *1.B Fugitive Emissions*. Figure 16 presents GHG emissions arising from this category and the trend from 1990 to 2021.

Figure 16: Greenhouse gas emissions from Category 1.B Fugitive Emissions



Source: Umweltbundesamt

Table 131: Greenhouse gas emissions from Category 1.B Fugitive Emissions

	GHG emissions [kt CO_2e]		
	Total	**CO_2**	**CH_4**
1990	774	102	672
1991	624	111	513
1992	671	120	551
1993	637	112	525
1994	512	128	384
1995	505	127	377
1996	430	71	359
1997	474	121	354
1998	502	142	360
1999	536	171	365
2000	537	165	372
2001	555	183	372
2002	539	167	372
2003	555	184	371
2004	502	165	337
2005	471	160	311
2006	500	180	319
2007	506	185	322
2008	465	162	303
2009	513	205	309
2010	502	184	319

	GHG emissions [kt CO_2e]		
	Total	**CO_2**	**CH_4**
2011	495	180	315
2012	510	184	326
2013	505	191	314
2014	471	169	302
2015	456	162	294
2016	423	131	292
2017	462	138	324
2018	400	127	273
2019	374	118	256
2020	355	109	246
2021	331	84	247
1990-2021	**-57%**	**-18%**	**-63%**

3.3.2 Completeness

Table 132 gives an overview of the IPCC categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated. As can be seen in the table, emissions from solid fuel transformation (production of coke oven coke) are included in the energy sector (sub category *Iron and Steel*), because the only solid fuel transformation for production of coke oven coke in Austria is occurring in one coking plant as part of an integrated iron and steel site.

Furthermore, emissions from oil and gas exploration, oil and gas production and gas processing are reported together under gas production (as oil and gas are extracted together at most sites) except CO_2 emissions from sour gas processing, which is reported separately under *1.B.2.b.3 Processing*.

Regarding petroleum refining, all CO_2 emissions, thus including flaring, are reported in the Energy Sector, as these are emissions due to combustion. Fugitive CO_2 losses are considered negligible. In category *1.B* only CH_4 and NMVOC emissions, included venting, are considered.

Table 132: Overview of subcategories of Category 1.B Fugitive Emissions: transformation into SNAP Codes and status of estimation.

IPCC Category	SNAP	Status	
		CO_2	**CH_4**
1.B.1.a Coal Mining and Handling			
i Underground Mines			
1 Mining	050102 Underground mining	NA	✓
2 Post-mining seam gas emissions	050103_X55 Underground mines – Post mining activities	NA	✓
3 Abandoned underground mines	050102_X53 Underground mines – Abandoned mines	NA	NA[1)]
4 Flaring of drained methane or conversion of methane to CO_2		NA	NA
ii Surface Mines			

IPCC Category	SNAP	Status	
		CO_2	CH_4
1 Mining	050101 Open cast mining	NA	✓
2 Post-mining seam gas emissions	050103_X54 Surface mines - Postmining activities	NA	✓
1.B.1.b Solid fuel transformation		**IE[2)]**	**IE[2)]**
1.B.2.a Oil			
1 Exploration	0502 Extraction, 1st treatment and loading of liquid fossil fuels	IE[3)]	IE[3)]
2 Production and Upgrading		IE[3)]	IE[3)]
3 Transport	050601_X50 Oil pipelines	✓	✓
4 Refining	0401 Processes in Petroleum Industries	NA[4)]	✓
5 Distribution of Oil Products	050502 Transport and depots 050503 Service stations	NA	NA[5)]
1.B.2.b Natural Gas			
1 Exploration	0503 Extraction, 1st treatment and loading of gaseous fossil fuels	NA[3)]	IE[3)]
2 Production		✓[3)]	✓[3)]
3 Processing		✓	NA
4 Transmission and Storage	050601 Pipelines/Storage	✓	✓
5 Distribution	050603 Distribution networks	✓	✓
6 Other		NO	NO
1.B.2.c Venting/Flaring		**IE[6)]**	**IE[7)]**
1.B.2.d Other		**NA[8)]**	**NA[8)]**

[1)] *according to an expert judgement all abandoned underground mines in Austria are flooded*

[2)] *the production of coke oven coke is included in 1.A.2.a Iron and Steel*

[3)] *included in 1.B.2.b.2 are: 1.B.2 a.1 Oil Exploration, 1.B.2.a.2 Oil Production and Upgrading, 1.B.2.b.1 Natural Gas Exploration (CH_4 emissions only, CO_2 emissions are NA), and 1.B.2.b.3 Natural Gas Processing, except CH_4 (NA) and CO_2 emissions from processing of sour gas*

[4)] *CO_2 emissions due to combustion are included in 1.A.1.b Petroleum Refining, fugitive CO_2 emissions are assumed to be negligible*

[5)] *also includes storage in storage tanks and refinery dispatch station – only NMVOC emissions are estimated as CH_4 emissions are assumed to be negligible.*

[6)] *included in 1.A.1.b Petroleum Refining*

[7)] *included in 1.B.2.a.iv Refining/Storage*

[8)] *fugitive emissions from geo thermal energy are assumed to be negligible*

3.3.3 Methodology

Category *1.B.1.a* Fugitive Emissions from Fuels – Coal Mining covers methane emissions from one brown coal surface mine and underground mines, and is calculated applying a Tier 1 Method. Fugitive Emissions from Oil and Gas (*1.B.2.a* and *1.B.2.b*) are calculated using an IPCC Tier 1 methodology except *1.B.2.b.4* (Transmission and Storage) and *1.B.2.b.5* (Distribution) which is calculated with a Tier 2 methodology.

3.3.3.1 1.B.1 Solid fuels

1.B.1.a Fugitive Emissions from Fuels – Coal Mining

Key category: yes (CH_4; LA 1990)

1.B.1.a.i Underground mines

Emissions: CH_4

This category addresses methane emissions from mining and post-mining seam gas activities of brown coal underground mines. CH_4 emissions from mining as well as seam gas from post-mining activities decreased by 97% from 1990 to 1995 due to lower mining activities until it was stopped in 1995.

Mining

Emissions from underground mines (*1.B.1.a.i.1 Mining*) are calculated by multiplying the amount of coal produced (= activity data) with the IPCC 2006 Guidelines average default emission factor of 18 m^3 CH_4/t and using the conversion factor of $0.67 \bullet 10^{-6}$ kt/m^3. Activity data are taken from the national energy balance.

Post mining seam gas emissions

Post-mining methane emissions from underground mining (*1.B.1.a.i.2*) are calculated – according to the IPCC 2006 Guidelines – by multiplication of the underground coal production with the average default emission factor of 2.5 m^3 CH_4/t and the conversion factor of $0.67 \bullet 10^{-6}$ kt/m^3.

Table 133: Activity data (brown coal produced) and CH_4 emissions from mining and post mining activities for Fugitive Emissions from underground mines 1990–2021

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
1990	870 403	10.50	1.46
1991	422 350	5.09	0.71
1992	478 095	5.77	0.80
1993	396 549	4.78	0.66
1994	82 625	1.00	0.14
1995	26 713	0.32	0.04
1996	NO	NO	NO
1997	NO	NO	NO
1998	NO	NO	NO
1999	NO	NO	NO
2000	NO	NO	NO
2001	NO	NO	NO
2002	NO	NO	NO
2003	NO	NO	NO
2004	NO	NO	NO
2005	NO	NO	NO
2006	NO	NO	NO
2007	NO	NO	NO
2008	NO	NO	NO
2009	NO	NO	NO
2010	NO	NO	NO
2011	NO	NO	NO
2012	NO	NO	NO
2013	NO	NO	NO

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
2014	NO	NO	NO
2015	NO	NO	NO
2016	NO	NO	NO
2017	NO	NO	NO
2018	NO	NO	NO
2019	NO	NO	NO
2020	NO	NO	NO
2021	NO	NO	NO

1.B.1.a.ii Surface mines

Emissions: CH_4

This category addresses methane emissions from one brown coal surface mine. CH_4 emissions from this category decreased by almost 30% from 1990 to 1999 due to lower mining activities. Before coal mining was stopped in 2007 emissions decreased sharply between 2003 and 2004 (80%), see Table 134.

Mining

Emissions from brown coal surface mines (*1.B.1.a.ii.1 Mining*) are calculated by multiplying the amount of brown coal produced (= activity data) by the IPCC 2006 Guidelines average default emission factor of 1.2 m^3 CH_4/t coal and using the conversion factor of 0.67•10-6 kt/m^3. Activity data are taken from the national energy balance and statistical year books (WKÖ 2005, WKÖ 2006).

Post mining seam gas emissions

Post-mining methane emissions from surface mining (*1.B.1.a.ii.2*) are calculated – according to the IPCC 2006 Guidelines – by the multiplication of the surface coal production with the average default emission factor of 0.1 m^3/t and the conversion factor of 0.67•10-6 kt/m^3.

Activity data are taken from the national energy balance and statistical year books (e.g. WKÖ 2005, WKÖ 2006).

Table 134: Activity data (brown coal produced) and CH_4 emissions from mining and post mining activities for Fugitive Emissions from surface mines 1990–2021

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
1990	1 577 307	1.27	0.11
1991	1 658 382	1.33	0.11
1992	1 292 768	1.04	0.09
1993	1 294 644	1.04	0.09
1994	1 286 091	1.03	0.09
1995	1 270 718	1.02	0.09
1996	1 108 081	0.89	0.07
1997	1 130 303	0.91	0.08
1998	1 140 101	0.92	0.08
1999	1 137 388	0.91	0.08

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
2000	1 248 869	1.00	0.08
2001	1 205 618	0.97	0.08
2002	1 411 819	1.14	0.09
2003	1 152 383	0.93	0.08
2004	235 397	0.19	0.02
2005	6 168	0.00	0.00
2006	6 677	0.01	0.00
2007	NO	NO	NO
2008	NO	NO	NO
2009	NO	NO	NO
2010	NO	NO	NO
2011	NO	NO	NO
2012	NO	NO	NO
2013	NO	NO	NO
2014	NO	NO	NO
2015	NO	NO	NO
2016	NO	NO	NO
2017	NO	NO	NO
2018	NO	NO	NO
2019	NO	NO	NO
2020	NO	NO	NO
2021	NO	NO	NO

3.3.3.2 1.B.2 Oil and natural gas

1.B.2.a Fugitive Emissions from Fuels – Oil

Emissions: CH_4, CO_2

Key Source: No

In this category, fugitive emissions from oil refining (CH_4) and CO_2 and CH_4 emissions from transport are considered. CO_2 emissions from the refinery resulting from combustion processes (including flaring) are included in *1.A.1.b Petroleum Refining*.

CH_4 emissions contribute 99.95% to GHG emissions from *1.B.2.a*. In 2021 fugitive CH_4 and CO_2 emissions from oil contributed 0.01% to total greenhouse gas emissions in Austria.

Transport

Both CH_4 and CO_2 emissions from transport are calculated by using the IPCC Tier 1 methodology.

To calculate CH_4 emissions from this source, the default emission factor of the IPCC 2006 Guidelines (Table 4.2.4) of $5.4 \bullet 10^{-06}$ kt CH_4 per 1 000 m^3 oil transported by pipeline is used. For the calculation of CO_2 emissions, the default emission factor of $4.9 \bullet 10^{-07}$ kt CO_2 per 1 000 m^3 oil transported in pipelines is applied.

The amount of transported crude oil in pipelines (= activity data) is reported by the Association of the Austrian Petroleum Industry. Emissions of CO_2 and CH_4 of this source are then calculated by multiplying the activity data by the emission factor of the respective greenhouse gas.

Refining

Methane emissions from refining are calculated using IPCC Tier 1 methodology.

For the calculation an emission factor of 31.66 g CH_4/t crude oil input is used. It is in the range of default emission factors in the IPCC Guidelines between $2.6 \bullet 10^{-6}$ and $41.0 \bullet 10^{-6}$ kt per 10^3 m^3 oil refined. (The conversion from kt per 10^3 m^3 to g per t was calculated with a density for crude oil of 840 kg/m^3). This emission factor is assumed to be conservative since crude oil is being transported by pipeline and, therefore, it is stored for a short period only, which reduces the potential to release fugitive CH_4 emissions compared to the processes represented by the IPCC default emission factors. Further, high standards for the recovery of fugitive CH_4 emissions in accordance with the Austrian Best Available Technology regulations are implemented.

Emissions are then calculated by multiplying the amount of crude oil input (= activity data, taken from the national energy balance) by this converted emission factor of 31.66 g CH_4 /t crude oil.

Table 135: Activity data (Crude Oil Refined) and emissions for Fugitive Emissions from Fuels – Oil Transport and Refining 1990–2021

Year	Crude Oil Refined [kt]	Transport CH_4 [kt]	Refining CH_4 [kt]
1990	7 952	0.051	0.252
1991	8 273	0.054	0.262
1992	8 732	0.056	0.276
1993	8 522	0.055	0.270
1994	8 898	0.057	0.282
1995	8 619	0.055	0.273
1996	8 754	0.058	0.277
1997	9 376	0.061	0.297
1998	9 190	0.062	0.291
1999	8 636	0.058	0.273
2000	8 240	0.055	0.261
2001	8 799	0.056	0.279
2002	8 947	0.057	0.283
2003	8 819	0.059	0.279
2004	8 442	0.057	0.267
2005	8 743	0.057	0.277
2006	8 472	0.056	0.268
2007	8 496	0.058	0.269
2008	8 710	0.060	0.276
2009	8 286	0.057	0.262
2010	7 719	0.053	0.244
2011	8 170	0.057	0.259
2012	8 349	0.058	0.264
2013	8 584	0.059	0.272
2014	8 435	0.059	0.267
2015	8 853	0.060	0.280
2016	8 184	0.057	0.259
2017	8 064	0.057	0.255
2018	8 970	0.062	0.284
2019	9 124	0.064	0.289

Year	Crude Oil Refined [kt]	Transport CH_4 [kt]	Refining CH_4 [kt]
2020	8 168	0.055	0.259
2021	8 243	0.053	0.261
1990-2021	**+3.7%**	**+5.1%**	**+3.7%**

1.B.2.b Fugitive Emissions from Fuels – Natural Gas

Emissions: CH_4, CO_2

Key Source: yes (CH_4)

In this category CO_2 emissions from sour gas processing, CH_4 emissions from gas storage and CO_2 and CH_4 emissions from oil and gas exploration, production and processing and gas transmission and distribution are reported.

CO_2 emissions from this category mainly arise from combined oil and gas production and sour gas processing; the general trend is that CO_2 emissions decreased due to decreasing oil and gas production. The exceptional low CO_2 emissions in 1996 in natural gas processing (land based desulfuration, see Table 139) was due to a break in processing during the implementation of pollution control measures. Gas transmission is only a minor source of CO_2 emissions. The drop of -36% of raw gas throughput in 2016 was due to the failure of one sour gas tube in one plant.

In 2021 fugitive CH_4 and CO_2 emissions from natural gas contributed 0.42% to total greenhouse gas emissions in Austria.

CH_4 emissions from *1.B.2.b* contributed 74% to total GHG emissions from this category in 2021. CH_4 emissions from natural gas decreased by 18% between 1990 and 2021. Although the natural gas distribution network has almost tripled in length since 1990, CH_4 emissions from this source (*1.B.2.b.5*) have decreased by 27% during this period due to replacement of old pipelines made of cast iron with high emission factors by pipelines made of plastics with low emission factors (see Table 138). About 66% of CH_4 emissions for category *1.B.2.b* were estimated using a tier 2 method (2021).

Due to the implementation of technical measures there is only an increase of 70% in CH_4 emissions from storage between 1990 and 2021 although the storage capacity and volume increased by 345% within the same period of time.

According to information from the *Austrian Oil and Gas Association*, flaring at the only refinery in Austria does not take place on a regular basis but is usually limited to unplanned shutdowns or emergency cases as a safety system. Therefore, CO_2 emissions from this source are very low. As described in chapter 3.2.10.2 *1.A.1.b Petroleum Refining* fugitive CH_4 emissions from category *1.B.2.a Fugitive Emissions from Fuels – Oil – Refining/storage* are reported in category *1.A.1.b* which includes emissions from fuel combustion, flaring and thermal cracking. The installation is included in the EU ETS. According to the Commission Regulation (EU) No 601/2012, Annex IV, emissions from flaring are included in the reported ETS emission data. The emission factors and caloric value of flared gas are based on analysis and the activity data are measured.

It has to be noted that there is only one refinery in Austria and separate reporting of emissions from flaring could enable drawing conclusions about the operating conditions in this refinery and this would cause a confidentiality issue. ETS data gained for inventory purpose is in general considered confidential, and emissions are only reported in aggregated form as provided by the operators. Thus "IE" [64] is used for the reporting of emissions from flaring together with all other components from this source.

There are several legal bases that consider the protection of personal and company-related data:

- The protection of confidentiality is e.g. one of the fundamental principles of national statistical agencies (NSA), committing them[65] "to safeguarding information that plainly reveals the operations, belongings, attitudes or any other characteristics of individual respondents".
- The Federal Statistics Act[66] prohibits the evaluation and publication of data in a manner that allows conclusions on characteristics of persons or individual operators.
- Confidential transfer of emissions data e.g. is regulated in the Commission Implementing Regulation (EU) 2018/2066[67], ensuring that "data is only accessible to the party for which it was intended and that no data can be read, written or updated by unauthorised parties".
- Also the Comission Delegated Regulation (EU) 2019/1122[68] regulates in Art. 80 the confidential treatment of "all information held in the EUTL and the Union Registry".

As we use plant specific data of individual operators provided by the Austrian statistical agency ("Statistik Austria") and the Union Registry, we also comply with the related specifications regarding confidentiality and the corresponding principles.

Production

Emissions of *1.B.2 a.1 Oil Exploration*, *1.B.2.b.1 Natural Gas Exploration* (CH_4 emissions only, CO_2 emissions are NA), *1.B.2.b.2 Natural Gas Production* and *1.B.2.b.3 Natural Gas Processing*, except CO_2 emissions from processing of sour gas, are included in one category (*1.B.2.b.2*).

The amount of natural gas produced and the related CO_2 emissions from combined oil and gas production were reported by the *Association of the Austrian Petroleum Industry* [FVMI 2022] (see Table 136).

CH_4 emissions from oil and gas production are calculated applying a IPCC Tier 1 method with an aggregate production-based emission factor of 0.0026 t CH_4/t oil and gas produced (OGP Tier 1 EF) and national production data annually received by the *Association of the Austrian Petroleum Industry*.

64 The UNFCCC Reporting GL (Ar. 37) state that "Where "IE" is used in an inventory, the Annex I Party should indicate, in the CRF completeness table, where in the inventory the emissions or removals for the displaced source/sink category have been included, and the Annex I Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality"

65 http://unstats.un.org/unsd/methods/statorg/

66 BGBl. I Nr. 163/1999: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10006095

67 COMMISSION IMPLEMENTING REGULATION (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council" \\umweltbundesamt.at\Projekte\20000\20690_QS-Inventur\Intern\2_Basisnorm, Gesetze u. Leitfäden\Gesetze, RL, GL, GB, etc. (fachlich)\Regulation_EU_2018-2066_engl.pdf

68 COMMISSION DELEGATED REGULATION (EU) 2019/1122 of 12 March 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council as regards the functioning of the Union Registry" \\umweltbundesamt.at\Projekte\20000\20690_QS-Inventur\Intern\2_Basisnorm, Gesetze u. Leitfäden\Gesetze, RL, GL, GB, etc. (fachlich)\Regulation (EU) 2019-1122_UnionRegistry_EU-ETS_engl.pdf

Activity data on natural gas from the *Association of the Austrian Petroleum Industry* is reported as a total of natural gas and oil gas. Since those two components have a different density an intermediate step to convert data from m³ to tonnes was introduced based on assumptions on the composition of raw gas, derived from the Executive Summaries of the Austrian Petroleum Industry [FVMI 1999–2021]. The OGP Tier 1 emission factor per tonnes oil and gas produced was then (applied for the whole time series.

Table 136: Activity data (natural gas produced) and emissions for Fugitive Emissions from Fuels – Production 1990–2021

			Production		
Year	**Natural Gas produced [Mio m^3]**	**Oil produced [1 000 t]**	**CH_4 [kt]**	**CO_2 [kt]**	**IEF CO_2 [kg/1 000 m^3]**
1990	1 288	1 149	5.77	43	33
1991	1 326	1 280	6.19	43	32
1992	1 437	1 180	6.17	40	28
1993	1 488	1 154	6.21	37	25
1994	1 355	1 099	5.78	48	35
1995	1 482	1 035	5.89	38	26
1996	1 492	992	5.82	41	27
1997	1 428	972	5.61	31	22
1998	1 568	959	5.87	61	39
1999	1 741	1 002	6.35	90	52
2000	1 805	971	6.41	72	40
2001	1 954	957	6.69	88	45
2002	2 014	941	6.76	84	42
2003	2 030	922	6.76	84	41
2004	1 963	891	6.55	77	39
2005	1 637	855	5.80	77	47
2006	1 819	856	6.14	88	48
2007	1 848	854	6.20	89	48
2008	1 531	862	5.56	85	56
2009	1 670	852	5.83	103	61
2010	1 816	876	6.24	91	50
2011	1 684	854	5.86	91	54
2012	1 807	837	6.07	91	51
2013	1 467	846	5.38	103	70
2014	1 247	883	5.02	89	72
2015	1 166	848	4.73	89	77
2016	1 253	753	4.65	84	67
2017	1 742	705	5.54	71	41
2018	969	664	3.82	64	66
2019	891	627	3.56	58	65
2020	743	595	3.16	50	67
2021	655	560	2.90	40	61
1990-2021	**-49%**	**-51%**	**-50%**	**-7.0%**	

Sour Gas Processing

Activity data and CO_2 emissions from natural gas production (sour gas processing) are reported by the *Association of the Austrian Petroleum Industry* and were calculated from sour gas composition.

Distribution, Transmission (pipelines) and Storage

Detailed information on fugitive CH_4 emissions from natural gas distribution, transmission and storage in Austria is included in a national study conducted for the year 1999 (WARTHA 2005). In this study emissions were collected for each transport system, for each storage site and for each distribution system. The study accounted for the different emission sources with the respective emission factors. The study was updated in 2011 (WARTHA 2011) to reflect technical measures that were implemented to reduce fugitive emissions from the natural gas supply network. For this update, providing data for 2009, a detailed survey and a literature review were performed.

Fugitive CH_4 emissions from **gas storage** mainly result from storage sensors, compressors, separators and venting. As the information on these emissions is limited to the years 1999 and 2009 (WARTHA 2005, WARTHA 2011) and no detailed information could be collected for the other years a country-specific emission factor was developed based on the bottom-up emission calculation described in the national study. The amount of gas injection and withdrawal was given as reference in the national study (WARTHA 2005) and was considered to be appropriate as emissions are directly related to the amount of gas handled. The 1999 and 2009 emissions from storage as compiled in the national studies were divided by the mean value of the annual amount of gas injection and withdrawal for the year 1999 and 2009 respectively. The resulting EFs equal to 541 kg CH_4 per Mm^3 natural gas for 1999 and 207 kg CH_4 per Mm^3 natural gas for 2009.

The lower emission factor in 2009 is due to technical improvements such as the exchange of valves and the reduction of gas that is released to the atmosphere during tests. It was assumed that technical improvements to reduce fugitive emissions from gas storage have been made continuously since the year that was assessed in the original study (WARTHA 2005), thus interpolation between the emission factor from (WARTHA 2005) and (WARTHA 2011) was done to derive annual emission factors for 2000-2008.

The emission factors were then applied to the respective mean value of the annual amount of gas injection and withdrawal for all years thus the method applied equals to a Tier 2 methodology.

Activity data is taken from E-Control (Austrian Energy Regulator, E-control 2022a).

Fugitive CH_4 emissions from **gas transmission** mainly result from compressors, connections, pneumatic aggregates, venting and accidental releases. Fugitive emissions due to diffusion through pipeline material are small because in Austria the material used is nearly 100% insulated steel. Detailed information on the main emission sources could be obtained for 1999 and 2009 thus the same approach as for storage emissions was chosen applying a Tier 2 approach for emission calculation. The country-specific emission factor was developed using the results of the detailed bottom-up approach (WARTHA 2005, WARTHA 2011) and relating them to the total length of the pipeline system. The developed EFs equal to 495 kg (based on WARTHA 2005) and 386 kg (based on WARTHA 2011) CH_4 per km pipeline and year for 1999 and 2009 respectively. The lower emission factor in 2009 is due to technical improvements such as recompression and smart plug and the exchange of gas-pneumatic to electric valves. It was assumed that the technical improvements to reduce fugitive emissions from gas transmission were made continuously, thus interpolation was done to derive emission factors for 2000-2008.

The annual pipeline length is annually provided by the Austrian Natural Gas and District Heat Association.

The natural **gas distribution** system consists of pipelines working under low pressure. Fugitive emissions from natural gas distribution mainly result from diffusion through the pipelines and emission factors largely depend on the pipeline material see Table 137. Small emission sources are also connections to dwellings, pressure regulating valves and accidental releases.

CH_4 emissions were calculated applying a Tier 2 approach. Specific distribution pipeline lengths separated by material are provided annually by the Austrian Natural Gas and District Heat Association (FVGW 2022), which are then multiplied with material specific emissions factors taken from a national study (WARTHA 2005). As the updated study (WARTHA 2011) does not provide detailed emission data per pipeline material the same emission factors (based on WARTHA 2005) are applied for the whole time series.

For calculation of CO_2 emissions from distribution of natural gas (*1.B.2.b.5*) the same ratio of CH_4 to CO_2 was applied as also in category transmission of natural gas (*1.B.2.b.4*).

Table 138 gives an overview of the development of the structure of the gas-distribution network in Austria since 1990. Specific annual information on the smaller emission sources except connections to dwellings were not available thus these emissions were kept constant at the rate of 69 t CH_4. Nevertheless the uncertainty introduced by this approach is small because these small emission sources contribute less than 5% to the total emissions from natural gas distribution in Austria.

Table 137: Emission factors applied for the gas distribution network.

Gas distribution network Material	Emission factors [kg CH_4/km and year]
Insulated steel	25
Plastics (HDPE PVC)	13
Ductile cast iron	701
Grey cast iron	892

Table 138: Structure of the gas distribution network.

Year	Length of distribution network				
	Insulated steel	Plastics (HDPE PVC)	Ductile cast iron	Grey cast iron	Total
	[km]	[km]	[km]	[km]	[km]
1990	2 881	6 368	2 213	210	11 672
1991	2 998	7 376	2 124	202	12 700
1992	2 957	8 521	2 184	207	13 869
1993	3 048	9 806	2 102	200	15 156
1994	3 239	11 163	1 979	188	16 569
1995	3 384	12 270	1 925	183	17 762
1996	3 416	13 523	1 866	177	18 981
1997	3 468	14 797	1 769	168	20 203
1998	3 504	15 932	1 729	164	21 329
1999	3 561	17 284	1 692	161	22 697
2000	3 746	18 501	1 720	118	24 086

Year	Length of distribution network				
	Insulated steel	Plastics (HDPE PVC)	Ductile cast iron	Grey cast iron	Total
	[km]	[km]	[km]	[km]	[km]
2001	3 894	19 331	1 694	117	25 035
2002	3 540	18 909	1 649	114	24 212
2003	3 571	20 373	1 638	109	25 691
2004	3 546	20 990	1 521	98	26 155
2005	3 566	21 778	1 522	89	26 955
2006	3 579	22 195	1 568	47	27 389
2007	3 591	22 733	1 560	37	27 921
2008	3 589	23 159	1 547	29	28 324
2009	3 550	23 404	1 533	24	28 511
2010	3 532	23 645	1 516	18	28 711
2011	3 523	23 935	1 531	13	29 002
2012	3 499	24 196	1 515	9.2	29 220
2013	3 488	24 494	1 489	5.1	29 476
2014	3 488	24 850	1 467	2.8	29 808
2015	3 454	25 131	1 462	1.7	30 048
2016	3 452	25 307	1 436	1.7	30 197
2017	3 537	25 541	1 411	1.7	30 490
2018	3 394	25 289	1 389	1.4	30 073
2019	3 377	25 521	1 364	0.7	30 263
2020	3 359	25 855	1 339	0.4	30 553
2021	3 349	25 917	1 311	0.4	30 577
1990-2021	**+16%**	**+307%**	**-41%**	**-100%**	**+162%**

Table 139: Activity data and emissions for 1.B.2.b.5 Natural Gas Distribution and 1.B.2.b.3 Sour Gas Processing 1990–2021

Year	Natural Gas Distribution			Sour Gas Processing	
	Gas network	CH_4 Emissions	CO_2 Emissions	Crude gas throughput	CO_2 Emissions
	[km][69]	[kt]	[kt]	[1 000 m^3]	[kt]
1990	11 672	1.99	0.07	248 090	59
1991	12 700	1.93	0.07	285 901	68
1992	13 893	1.99	0.07	357 135	80
1993	15 178	1.95	0.07	321 653	75
1994	16 589	1.87	0.07	363 582	80
1995	17 778	1.85	0.07	405 638	89
1996	18 995	1.82	0.07	136 737	30
1997	20 219	1.76	0.07	406 177	89
1998	21 339	1.74	0.06	367 195	81
1999	22 701	1.73	0.07	352 318	81
2000	24 099	1.73	0.07	358 357	93
2001	25 042	1.73	0.08	393 492	95

[69] Including "other material" not further defined in the statistics.

Year	Natural Gas Distribution			Sour Gas Processing	
	Gas network	CH_4 Emissions	CO_2 Emissions	Crude gas throughput	CO_2 Emissions
	[km][69]	[kt]	[kt]	[1 000 m³]	[kt]
2002	24 216	1.68	0.08	347 513	83
2003	25 699	1.71	0.08	408 198	100
2004	26 158	1.62	0.07	373 099	88
2005	26 958	1.63	0.08	338 349	83
2006	27 413	1.63	0.08	402 990	92
2007	27 945	1.62	0.08	444 029	95
2008	28 348	1.61	0.08	372 406	77
2009	28 533	1.60	0.08	466 628	102
2010	28 733	1.58	0.08	397 132	92
2011	29 023	1.60	0.08	375 168	88
2012	29 260	1.58	0.08	375 420	92
2013	29 496	1.56	0.07	335 874	88
2014	29 826	1.55	0.07	307 475	79
2015	30 067	1.55	0.07	279 102	72
2016	30 215	1.53	0.07	179 474	47
2017	30 507	1.52	0.06	252 837	67
2018	30 089	1.50	0.07	237 622	63
2019	30 279	1.48	0.07	227 559	60
2020	30 569	1.47	0.07	219 605	59
2021	30 591	1.45	0.06	159 693	44
1990-2021	**+162%**	**-27%**	**-9.3%**	**-36%**	**-25%**

Table 140: Activity data and emissions for 1.B.2.b.4 Fugitive Emissions from Fuels – Natural Gas Transmission and Storage 1990–2021

Year	Natural Gas Transmission (Pipelines Fugitive & Venting)			Natural Gas Storage	
	Pipelines	CH_4 Emissions	CO_2 Emissions	Natural Gas Stored	CH_4 Emissions
	[km]	[kt]	[kt]	[Mm³]	[kt]
1990	3 628	1.79	0.09	1 500	0.81
1991	3 696	1.83	0.09	1 500	0.81
1992	5 278	2.61	0.13	1 625	0.88
1993	5 265	2.60	0.13	1 980	1.07
1994	5 546	2.74	0.14	1 329	0.72
1995	5 972	2.95	0.15	1 820	0.99
1996	5 876	2.91	0.14	1 820	0.99
1997	5 924	2.93	0.15	1 820	0.99
1998	5 918	2.93	0.14	1 820	0.99
1999	6 052	2.99	0.15	1 172	0.63
2000	5 966	2.89	0.15	1 665	0.85
2001	6 213	2.94	0.15	1 132	0.54
2002	6 232	2.88	0.15	861	0.38
2003	6 243	2.82	0.15	1 574	0.64
2004	6 288	2.77	0.15	1 507	0.56

Year	Natural Gas Transmission (Pipelines Fugitive & Venting)			Natural Gas Storage	
	Pipelines	CH_4 Emissions	CO_2 Emissions	Natural Gas Stored	CH_4 Emissions
	[km]	[kt]	[kt]	[Mm^3]	[kt]
2005	6 290	2.70	0.15	1 828	0.62
2006	6 354	2.66	0.16	2 112	0.65
2007	6 495	2.65	0.16	2 530	0.69
2008	6 545	2.60	0.16	2 949	0.71
2009	6 574	2.54	0.16	3 560	0.74
2010	6 798	2.62	0.17	3 070	0.64
2011	6 983	2.69	0.17	3 850	0.80
2012	7 109	2.74	0.17	4 449	0.92
2013	7 177	2.77	0.18	5 747	1.19
2014	7 227	2.79	0.18	5 334	1.10
2015	7 242	2.79	0.18	5 317	1.10
2016	7 231	2.79	0.18	5 519	1.14
2017	7 250	2.80	0.18	6 745	1.40
2018	7 248	2.80	0.18	6 168	1.28
2019	7 231	2.79	0.18	4 669	0.97
2020	7 230	2.79	0.18	5 100	1.06
2021	7 203	2.78	0.18	6 668	1.38
1990-2021	**+99%**	**+55%**	**+99%**	**+345%**	**+70%**

3.3.4 Category-specific QA/QC

3.3.4.1 1.B.1 – Coal Mining

An external expert was consulted and confirmed the correctness of the methodology to estimate historical emissions from *1.B.1 Coal mining*.

3.3.4.2 1.B.2. – Oil and natural gas

Before the studies Life Cycle Inventory Austria 2000 – Review (WARTHA 2005) and Life Cycle Inventory „Erdgasbereitstellung Austria – Update 2010 (WARTHA 2011) were used for the Austrian National Inventory, QA checks were made to ensure that the data quality was appropriate. These QA checks included consultations with the Association of Gas- and District Heating Supply Companies. Only after QA checks and consultations were finished and the quality of the data was approved, the data was used for the calculation of the national GHG emissions following the internal QA/QC requirements.

To validate the developed country-specific emission factors, they were compared with gas losses described in the 2006 IPCC Guidelines (Table 4.2.8).

For storage the developed emission factor for 1999 (541 kg CH_4 per Mm^3) lies well above the Tier 1 emission factor for Gas Storage (25 kg CH_4 per Mm^3 marketable gas) given in the 2006 IPCC GL (Table 4.2.4). Emissions in 2012 equal to 0.02% of the working gas capacity, which is classified as low (0.05%) as in the IPCC 2006 Guidelines.

For transmission the developed EFs (1999: 495 kg CH_4 per km pipeline and year, 2009: 386 kg CH_4 per km pipeline and year) are lower than the range given in the IPCC. Nevertheless, the gas losses in 2012 of 497 m^3/km/a are classified between low (200 m^3/km/a) and medium (2 000 m^3/km/a) in the 2006 IPCC Guidelines.

For distribution the IEFs range between 0.05 and 0.17 t/km/a, this is lower than the range given by IPCC 2006 GL. The mean gas losses of 107 m^3/km/a are classified between low (100 m^3/km/a) and medium (1 000 m^3/km/a) in the IPCC 2006 GL. Material specific emission factors of pipelines are not provided in the IPCC 2006 GL for comparison.

Based on the above-described validation it was concluded that the developed country-specific EFs are reasonable.

3.3.5 Uncertainty

For *1.B.2.b* Natural Gas – CH_4 an uncertainty estimate was made that was calculated from the combination of estimated uncertainties of the sub-sources.

Transmission: Pipeline length (medium and high pressure) is provided by the Austrian Natural Gas and District Heat Association that collects these numbers directly from the operators. The associated uncertainty is assumed to be low (5%). The uncertainty of the country-specific EF is estimated to be very accurate for the year that was under investigation, but the uncertainty for other years is assumed to be higher (10%).

Storage: The amount of natural gas injected and withdrawn from the storage sites is well known (uncertainty 5%). For the uncertainty of the country-specific EF the same assumption as for transmission was applied (uncertainty 10%).

Distribution: The length of distribution pipelines is directly obtained from the operators. Kilometres by material are provided, thus the uncertainty is considered to be low (4%). Emission factors are material specific and from international literature, thus the associated uncertainty is assumed to be low (7%).

This leads to the combined uncertainty (using the Tier 1 approach, with weights for the contribution to total source emissions) of 5% for AD, 10% for EF, resulting in a total uncertainty of emissions of 11%.

3.3.6 Recalculations

Minor recalculations (+ 0.08 kt CO_2e in 2020) are reported for *1.B.2.a.4 Refining/Storage* due to revisions (refinery intake data 2020) of the annual energy balance as well as to a lesser extent for *1.B.2.b.2 Natural Gas Production* for some historical years due to the correction of rounding errors.

The whole time series of recalculations is included in Annex 8 to the NIR.

3.3.7 Planned improvements

To increase the transparency it is planned to investigate on the possibility to disaggregate emissions data currently reported under category *1.B.2.b.2* into sub-categories *1.B.2.a.2* and *1.B.2.b.2*.

In order to improve the inventory on natural gas transmission, storage and distribution a service contract was awarded in 2021 (Forschung Burgenland GmbH) to collect greenhouse gas emissions data via survey from the Austrian gas supply network. It is planned to implement study results into the inventory of submission 2024.

3.4 CO_2 transport and storage (CRF Category 1.C)

CO_2 transport and CO_2 storage is not occurring in Austria.

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF SECTOR 2)

4.1 Sector Overview

This chapter includes information on and descriptions of methodologies used for estimating greenhouse gas emissions as well as references for activity data and emission factors reported under IPCC Sector *2 Industrial Processes and Product Use (IPPU)* for the period from 1990 to 2021.

Emissions from this category comprise emissions from the following sub categories: *Mineral Industry*, *Chemical Industry*, *Metal Industry*, *Non-energy products from fuels and solvent use*, *Electronic Industry*, *Product uses as substitutes for ODS* and *Other product manufacture and use*.

Only process related emissions are considered in this sector; emissions due to fuel combustion in manufacturing industries are reported in IPCC Category *1.A.2 Fuel Combustion – Manufacturing Industries and Construction* (see Chapter 3). Not all sub sectors for which emissions due to combustion are reported in 1.A.2 additionally emit process specific emissions that would be reported in IPCC Category 2. For the categories *pulp and paper* as well as *food and drink industry* for example the additional (process related) emissions are of biogenic origin, which is why – in line with the guidelines – they are not accounted for.

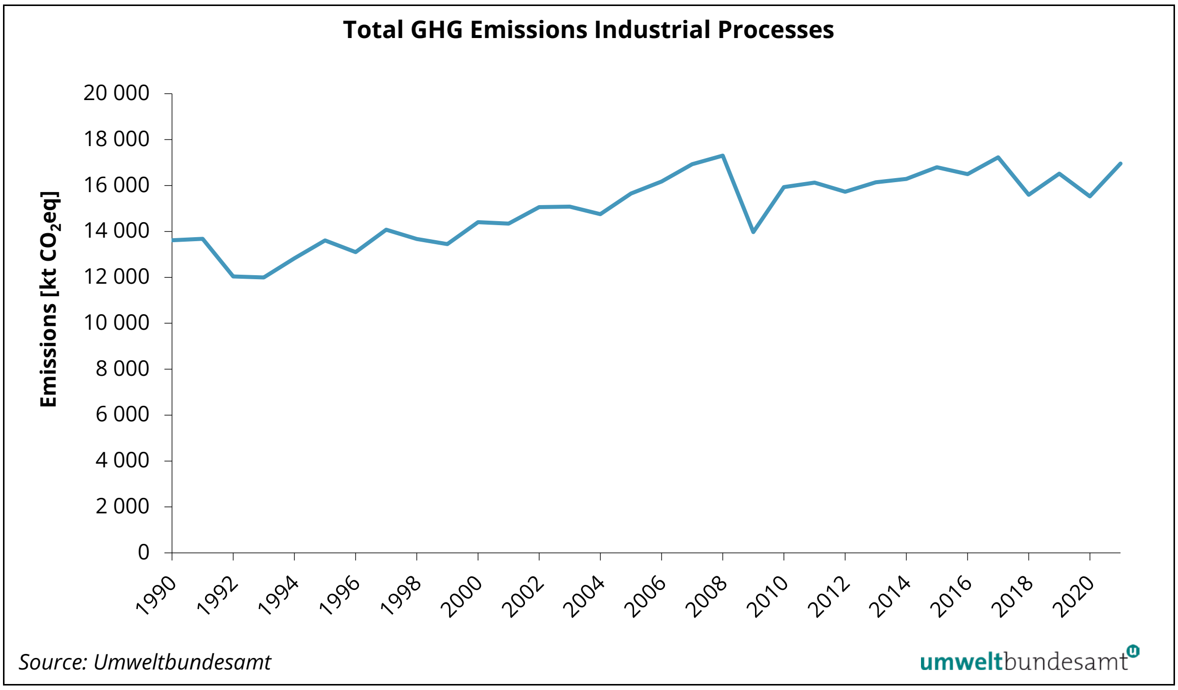
An overview on categories relevant in Austria as well as the status of emission reporting is presented in Table 147

4.1.1 Emission Trends

In 2021, greenhouse gas emissions from Sector *2 Industrial Processes and Product Use* amounted to 16 959 kt CO_2 equivalent, compared to 13 615 kt in 1990. These emissions constituted 22% of Austria's total greenhouse gas emissions (excluding LULUCF) in 2021 and 17% of total emissions in 1990.

Greenhouse gas emissions from this sector show a long term increasing trend until 2008, fluctuating since then, with the metal industry being the dominat sub-sector. The minimum in 1992/1993 resulted from the termination of primary aluminium production in Austria. In the following years, emissions increased due to extended activities in the iron and steel industry. The trend from 2008 onwards is characterised by the effects of the economic crisis, followed by its recovery. The dip in 2018 is due to revision works at a blast furnace, the one in 2020 due to the Covid pandemic and its effects on production (reduced demand due to production stops in all major customer segments). In 2021 emissions recovered as the economy recovered, they increased by 9% compared to 2020.

Figure 17: GHG emissions from Sector 2 Industrial Processes and Product Use 1990–2021



The following table presents greenhouse gas emissions from the IPPU sector as well as their share in total greenhouse gas emissions in 1990 and in 2021.

Table 141: GHG emissions from Sector 2 Industrial Processes and Product Use by gas.

GHG	Emissions [kt CO_2e]		*Trend*	Percent of total	
	1990	2021	*1990-2021*	1990	2021
Total	**13 615**	**16 959**	**+25%**	**100%**	**100%**
CO_2	11 123	14 935	*+34%*	81.7%	88.1%
CH_4	46	59	*+28%*	0.3%	0.3%
N_2O	897	74	*-92%*	6.6%	0.4%
HFCs	2	1 486	*+72 653%*	0.0%	8.8%
PFCs	1 063	23	*-98%*	7.8%	0.1%
SF_6	485	371	*-24%*	3.6%	2.2%
NF_3	0	12	*NA*	0.0%	0.07%

Carbon dioxide constitutes the most important greenhouse gas of the IPPU sector, contributing 88.1% of emissions to this sector in 2021, followed by HFCs with 8.8%, SF_6 with 2.2%, N_2O with 0.4%, CH_4 with 0.3% and PFCs with 0.1%% and finally NF_3 with 0.07%.

Table 142: Emissions from IPCC Sector 2 Industrial Processes and Product Use by gas from 1990 to 2021 and overall trend.

	Emissions [kt CO_2e]							
	Total	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
1990	**13 615**	11 123	46	897	2	1 063	485	NO/NA
1991	**13 681**	11 018	45	910	3	1 072	633	NO/NA
1992	**12 043**	10 026	44	833	5	459	676	NO/NA

	Emissions [kt CO_2e]							
	Total	**CO_2**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF_6**	**NF_3**
1993	**11 996**	10 044	45	868	215	57	767	NO/NA
1994	**12 827**	10 703	45	822	237	64	955	1
1995	**13 606**	11 172	46	850	324	75	1 134	6
1996	**13 097**	10 504	45	864	391	72	1 213	7
1997	**14 073**	11 459	46	854	473	106	1 120	15
1998	**13 673**	11 222	47	883	565	50	897	9
1999	**13 452**	11 067	46	906	656	72	697	8
2000	**14 408**	12 073	46	930	677	80	592	10
2001	**14 338**	11 940	46	779	808	106	649	10
2002	**15 061**	12 535	47	787	957	93	632	10
2003	**15 081**	12 465	45	842	1 027	116	566	20
2004	**14 751**	12 625	45	317	1 095	145	499	25
2005	**15 652**	13 514	48	301	1 104	150	509	26
2006	**16 178**	14 052	61	298	1 113	156	467	31
2007	**16 926**	14 775	61	286	1 162	209	378	56
2008	**17 303**	15 085	57	330	1 208	188	385	50
2009	**13 970**	12 030	55	184	1 311	33	352	4
2010	**15 935**	13 932	56	101	1 426	71	346	4
2011	**16 126**	14 080	56	84	1 518	66	317	4
2012	**15 730**	13 615	56	84	1 599	46	321	8
2013	**16 139**	13 939	59	83	1 689	45	315	9
2014	**16 289**	13 983	56	81	1 787	48	324	10
2015	**16 800**	14 391	57	78	1 897	45	319	13
2016	**16 498**	14 032	56	69	1 884	46	405	6
2017	**17 231**	14 750	56	69	1 892	40	412	11
2018	**15 596**	13 068	55	84	1 946	29	398	15
2019	**16 520**	14 058	56	108	1 802	35	450	13
2020	**15 524**	13 187	59	80	1 705	27	455	11
2021	**16 959**	14 935	59	74	1 486	23	371	12
1990–2021	**+3 343**	**+3 811**	**+13**	**-823**	**+1 484**	**-1 040**	**-115**	**+12**

Concerning sub-categories of the sector, 65% of GHG emissions (expressed in CO_2 equivalent) originate from *Metal Industry* (mainly *Iron and Steel Production*) and 18% from *Mineral Industry*. 8.7% originate from *Product Uses as Substitutes for ODS*, and 4.6% from *Chemical Industry* (mainly *Ammonia Production*).

CO_2 emissions

As can be seen in in Figure 18, CO_2 emissions from the *Industrial Processes and Product Use* sector showed a strong increase in the period from 1999 to 2008, mainly due to increasing emissions from metal production. The effect of the economic crisis is strongly visible in 2009. In 2021, CO_2 emissions from industrial processes amounted to -14 935 kt, making up 88% of total emissions from *Industrial Processes and Product Use. Emissions increased by* 34% compared to 1990 levels.

CH_4 emissions

Only 0.3% of IPPU emissions are CH_4 emissions. They solely arise from *Chemical Industry (Production of Ethylene, Urea, Fertilizers and Ammonia).* As can be seen in Figure 18, CH_4 emissions from industrial processes remained quite stable until 2005. The increase in 2006 can be attributed to an increase in ethylene production capacity. In the following years, emissions remained at similar levels and in 2021 were 28% above 1990 levels.

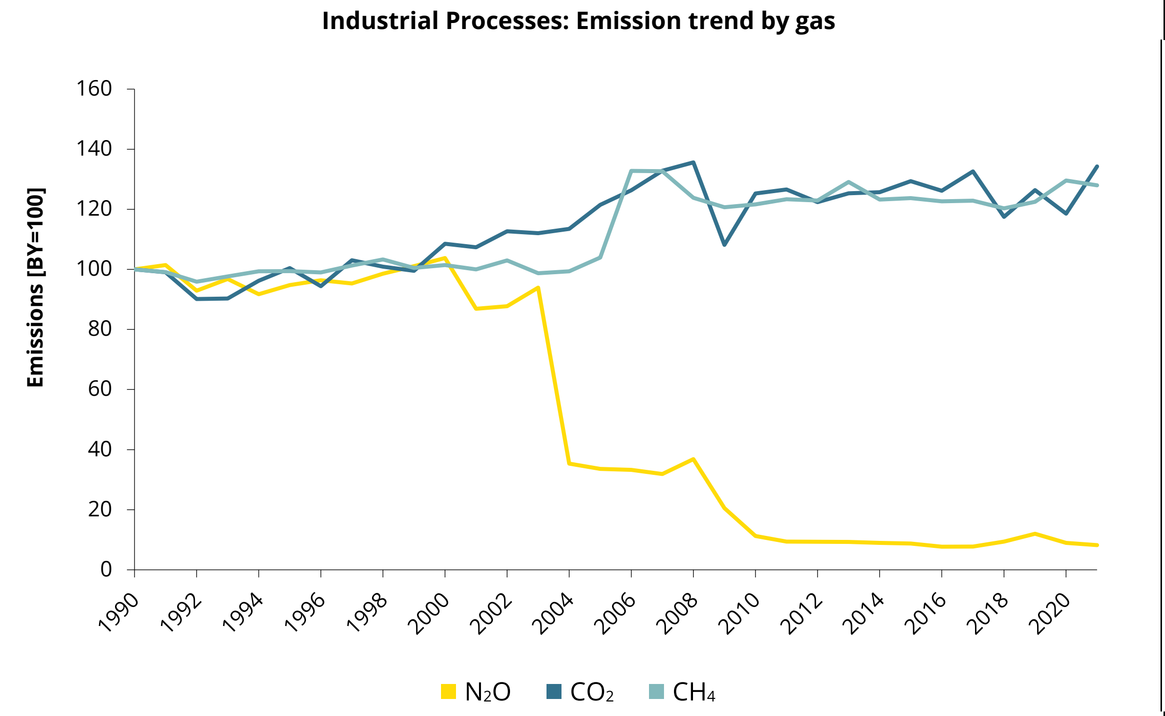
N_2O emissions

N_2O emissions arise from *Nitric Acid Production (Chemical Industry)* which in Austria takes place at one site with two (and for some years three) plants. As can be seen in Figure 18, N_2O emissions remained quite stable until 2000. The decreases since then are due to the introduction of emission control measures:

- 2001: installation of a new catalyst
- 2004: installation of a N_2O decomposition facility
- 2009 (May): installation of a second catalyst in the nitric acid plant
- 2010: full operation of the second catalyst
- 2011: further optimisation of the production process as well as slightly reduced production

In 2021, N_2O emissions from *Industrial Processes* were 92% below the level of 1990, and now only contribute 0.4% of the sectoral emissions.

Figure 18: CO_2, CH_4 and N_2O emissions from Industrial Processes 1990–2021 (base year = 100)



Source: Umweltbundesamt

HFC emissions

As can be seen in Figure 19, HFC emissions increased remarkably during the period from 2 kt CO_2 equivalents in 1990 to 1 486 kt CO_2 equivalents in 2021 due to the use of these gases as substitutes for ozone depleting substances. HFC emissions mainly arise from the subcategory *Refrigeration and Air Conditioning*. Other important (sub-) categories include *Foam Blowing Agents and Electronics Industry*.

Because of the significant second step of the phase-down according to the EU F-gas regulation HFC emissions peak 2018 and have been decreasing since then.

PFC emissions

As can also be seen in Figure 19, PFC emissions decreased remarkably during the period from 1990 to 1993 – from 1 063 kt CO_2 equivalents to 57 kt CO_2 equivalents – due to the termination of primary aluminium production in 1992 which was the major source for PFC emissions. From 1993 onwards, PFC emissions solely arise from semiconductor manufacture, where a strong increase in production capacity was partly counterbalanced by emission reduction measures.

In 2021, PFC emissions amounted to 23 kt CO_2 equivalents, which is 98% below the level of 1990.

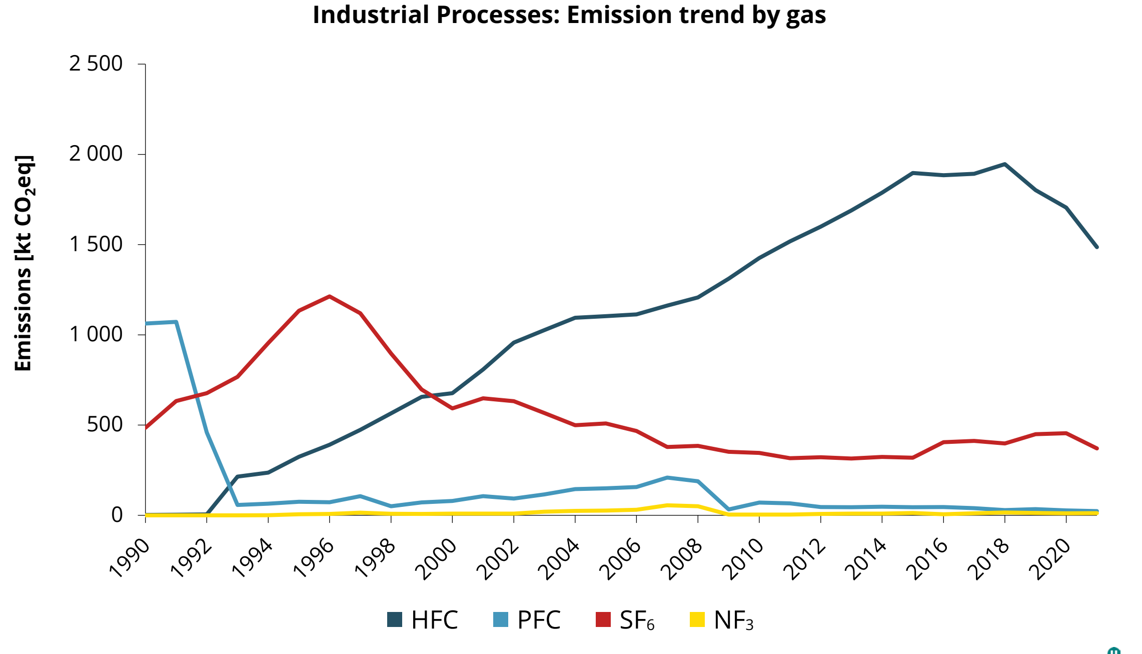
SF_6 emissions

As depicted in Figure 19, SF_6 emissions increased at the beginning of the reporting period and reached a maximum in 1996 as a result of increasing emissions from metal production and semiconductor manufacture, which decreased in the subsequent years. Current emissions mainly result from disposal of noise insulating windows. In 2021, SF_6 emissions amounted to 371 kt CO_2 equivalents corresponding to a reduction of 24% compared to the 1990 level.

NF_3 emissions

NF_3 emissions solely arise from semiconductor manufacture. NF_3 was first introduced to the Austrian market in 1994. In 2021, NF_3 emissions amounted to 12 kt CO_2 equivalents.

Figure 19: HFC, PFC, SF_6 and NF_3 emissions from Industrial Processes 1990–2021



Source: Umweltbundesamt

Emission trends by sources

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Industry* and *Mineral Industry*, causing 65% and 18% respectively, of the emissions from this sector in 2021 (see Table 143).

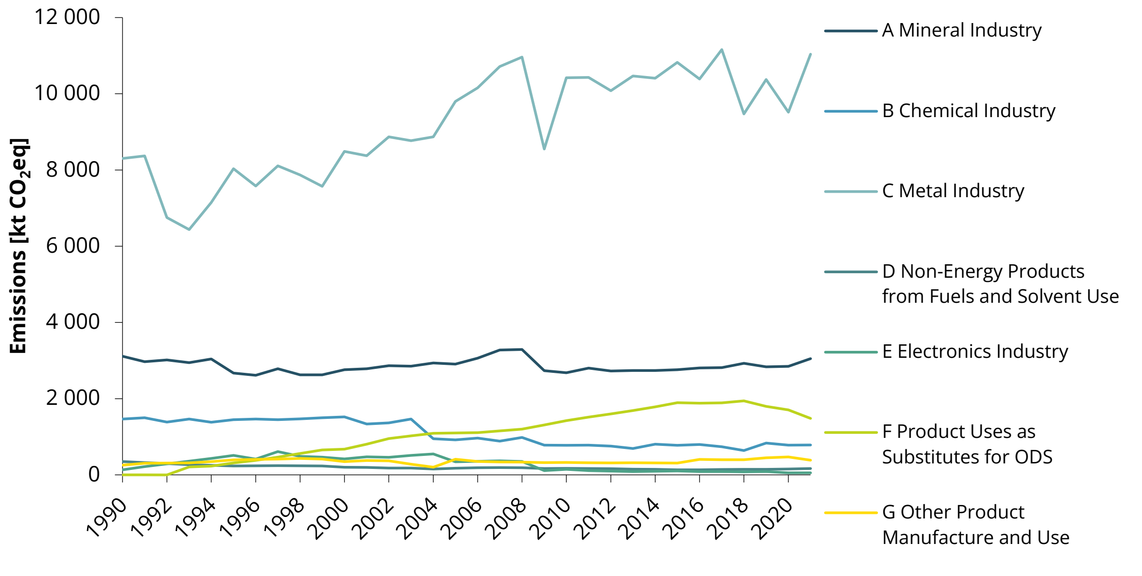
Emissions from processes in *Iron and Steel Production* are the most important single source of the industry sector. It is also one of the ten most important sources regarding Austria's total greenhouse gas emissions (see below and Chapter 4.4.1).

Table 143: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use by Category, their share and trend for 1990 and 2021.

	Emissions [kt CO_2e]		Share [%]		Trend 1990–2021
	1990	2021	1990	2021	
2 Industrial Processes	13 615	16 959	100%	100.0%	*+24.6%*
A Mineral Industry	3 114	3 050	23%	18.0%	*-2.0%*
B Chemical Industry	1 463	784	11%	4.6%	*-46.4%*
C Metal Industry	8 304	11 039	61%	65.1%	*+32.9%*
D Non-Energy Products from Fuels and Solvent Use	349	165	3%	1.0%	*-52.6%*
E Electronics Industry	133	53	1%	0.3%	*-60.0%*
F Product Uses as Substitutes for ODS	0	1 483	0%	8.7%	*NA*
G Other Product Manufacture and Use	252	383	2%	2.3%	*+52%*

Figure 20 and Table 144 present greenhouse gas emissions from IPCC Sector *2 Industrial Processes and Product Use* by category for the years 1990 to 2021.

Figure 20: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use per category 1990–2021



Source: Umweltbundesamt

Table 144: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes (total and per category),1990–2021.

Year	GHG emissions [kt CO_2e]							
	2.A	**2.B**	**2.C**	**2.D**	**2.E**	**2.F**	**2.G**	**2 total**
1990	3 114	1 463	8 304	349	133	NO	252	13 615
1991	2 970	1 498	8 369	323	215	NO	305	13 681
1992	3 014	1 385	6 751	295	288	0.01	310	12 043
1993	2 945	1 466	6 436	266	360	209	314	11 996
1994	3 042	1 382	7 147	250	432	229	346	12 827
1995	2 673	1 447	8 033	234	512	315	394	13 606
1996	2 613	1 466	7 578	239	413	380	407	13 097
1997	2 785	1 449	8 111	242	610	463	414	14 073
1998	2 623	1 471	7 868	236	485	562	429	13 673
1999	2 625	1 499	7 569	231	463	653	412	13 452
2000	2 761	1 521	8 489	198	420	673	346	14 408
2001	2 785	1 334	8 373	194	474	804	374	14 338
2002	2 866	1 365	8 869	179	460	953	369	15 061
2003	2 853	1 467	8 769	180	512	1023	278	15 081
2004	2 936	947	8 872	155	548	1091	201	14 751
2005	2 906	920	9 800	174	342	1099	409	15 652
2006	3 060	963	10 154	188	356	1108	350	16 178
2007	3 275	886	10 714	192	367	1154	338	16 926
2008	3 290	981	10 962	188	349	1200	334	17 303
2009	2 732	778	8 550	167	112	1310	321	13 970
2010	2 677	776	10 420	169	144	1424	325	15 935
2011	2 800	780	10 429	168	113	1516	319	16 126
2012	2 725	754	10 082	160	97	1597	314	15 730
2013	2 739	692	10 468	151	86	1687	315	16 139
2014	2 739	806	10 407	146	93	1786	313	16 289
2015	2 760	777	10 823	132	102	1895	311	16 800
2016	2 804	797	10 387	134	88	1883	405	16 498
2017	2 815	739	11 159	142	87	1889	399	17 231
2018	2 926	639	9 469	145	78	1942	397	15 596
2019	2 833	834	10 375	147	85	1798	448	16 520
2020	2 846	779	9 518	154	54	1702	470	15 524
2021	3 050	784	11 039	165	53	1483	383	16 959

2.A Mineral Industry

Greenhouse gas emissions from this category remained quite stable over the period, with an overall decrease of 2% from 1990 to 2021, and effects of the economic crisis 2009 clearly visible. The dominating sub category in total emissions and trend is *Cement Production,* other important subcategories are *Lime Production* with increasing and *Other Process Uses of Carbonates: Non-metallurgical Magnesium* with decreasing emissions over the considered period. Only CO_2 emissions arise from this category.

2.B Chemical Industry

For the source category *Chemical Industry*, greenhouse gas emissions remained quite stable over the period from 1990 to 2003, with nitric acid production as the main emission source (53% in 1990). Due to the implementation of emission reduction measures, ammonia production is now the main source, contributing 64% to total emissions from this category in 2021. Another 20% are contributed by emissions from the sub category "Other", which mainly comprises of CO_2 emissions from organic chemical industry production. Minor sources in 2021 include nitric acid, carbide and ethylene production.

In 2021, emissions were 46% below the level of 1990.

2.C Metal Industry

Greenhouse gas emissions from *Metal Industry* fluctuated over the reporting period, which is mainly a result of a drop in PFC emissions from primary aluminium production which was terminated in 1992 and a strong increase in CO_2 emissions from *Iron and Steel Production* (+61%) over the whole time series*.* Dips in the time series relate to the economic crisis in 2009, a makeover at the iron & steel plant in 2018 and the pandemic in 2020.

From 1990 to 2021 emissions increased by 33%. The main source of this category is CO_2 emissions from *Iron and Steel P*roduction.

2.D Non-energy products from fuels and solvent use

Emissions from non-energy products from fuels and solvent use are 53% below 1990 level. This is due to several legal measures (see chapter 4.4.1) that resulted in a decrease of emissions due to a lower solvent content of solvents in products e.g. paints as well as use of alternatives to solvents, implemented abatement measures and decreased use of lubricants.

2.E Electronic Industry

Emissions from this sector are solely attributed to semiconductor manufacturing, and contain HFC, PFC, SF_6 and NF_3 emissions. Emissions in 2021 are 60% lower compared to 1990, which is due to abatement measures taken by the companies.

2.F Product uses as substitutes for ODS

Emissions from products used as substitutes for ozone depleting substances (ODS) contribute 8.7% to the total emissions of the IPPU sector. HFCs as substitutes for ODS were introduced in the early 1990 and their use in the expanding refrigeration- air conditioning- and heat pumps- (RACHP) sector and with it emissions from use increased strongly since then.
Because of the significant second step of the phase-down according to the EU F-gas regulation HFC emissions peak 2018 and have been decreasing since then.

2.G Other product manufacture and use

Emissions from this sector contain emissions from the use of electrical equipment, as well as other product manufacture and use (use in tyres, shoes, soundproof windows, research etc.). Emissions in this sector are now 52% higher than in 1990, because high amounts of SF_6 are being released during the disposal of sound proof windows that were produced in the 1990ies.

2.H Other

No GHG emissions are reported in this category.

4.1.2 Key Categories

The following table summarizes the key categories in IPCC Sector *2 Industrial Processes and Product Use*.

Table 145: Key sources of sector IPPU (T1, excl. LULUCF).

IPCC Category	Source Categories	Key Categories	
		GHG	KS-Assessment
2.A.1	Cement Production	CO_2	LA
2.A.2	Lime Production	CO_2	LA
2.A.4.c	Non-metallurgical Magnesium	CO_2	LA
2.B.1	Ammonia Production	CO_2	LA
2.B.2	Nitric Acid Production	N_2O	LA 1990; TA
2.C.1	Iron and Steel Production	CO_2	LA
2.C.3	Aluminium Production	CO_2	TA
2.C.3	Aluminium Production	PFCs	LA 1990
2.C.4	Magnesium Production – Mg Foundries	SF_6	LA 1990; TA
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	LA 1990
2.F.1	Refrigeration and Air conditioning	HFC	LA 2021; TA
2.G.2	Other Product Manufacture and Use-SF_6 and PFCs from other product use	SF_6	LA 2021

LA = Level Assessment (if not further specified – for the years 1990 and 2021)
TA = Trend Assessment 1990–2021

4.1.3 Methodology

The general method for estimating emissions for the *Industrial Processes and Product Use* sector, as recommended by the IPCC, involves multiplying production data for each process by an emission factor per unit of production.

In some categories, emission and production data were reported directly by industry or associations of industries and thus represent plant specific data and for some (e.g. *2.B.1 Ammonia Production*) very detailed methodologies trying to reflect the actual production proess is applied.

Detailed information on the methodologies can be found in the corresponding subchapters.

Emission data reported under the European Emission Trading System

Verified CO_2 emissions reported under the EU ETS are available for the years 2005–2021, this data is used for emissions reporting of *2.A.1 Cement Production, 2.A.2 Lime Production, 2.A.3 Glass Production, 2.A.4.a Ceramics, 2.A.4.c Non Metallurgical Magnesia Production, 2.A.4.d Other Process Uses of Carbonates , 2.C.1 Iron and Steel production*. With the extension of the ETS in 2014, data for additional categories became available: *2.B.10 Chemical Industry – Other and 2.C.3 (Secondary) Aluminium Production.* Special attention was given to time-series consistency. Furthermore, background data for emission calculations under the ETS were used for further QA/QC checks.

4.1.4 Uncertainty Assessment

In this year's submissions uncertainty estimates for all key sources based on the IPCC GL, on the uncertainty study by WINIWARTER (2007) and on estimates by Umweltbundesamt are provided (see Table 146, for explanations see the respective subchapters).

Table 146: Uncertainty assessment of 2021 estimates for key sources of Sector 2 Industrial Processes and Product Use.

IPCC Category	Source Categories	Uncertainty [%]		
		Activity data	Emission factor	Combined Uncertainty
2.A.1	Cement Production – CO_2	1.1	2.0	2.3
2.A.2	Lime Production – CO_2	1.6	5.0	5.3
2.A.4.c	Non-metallurgical Magnesium– CO_2	2.0	5.0	5.4
2.B.1	Ammonia Production – CO_2	2.0	5.0	5.4
2.B.2	Nitric Acid Production – N_2O	2.0	5.0	5.4
2.C.1	Iron and Steel Production – CO_2	0.5	0.5	0.7
2.C.3	Aluminium Production – CO_2	2.0	0.5	2.1
2.C.3	Aluminium Production – PFC	2.0	50.0	50.0
2.C.3	Aluminium Production – Al Foundries – SF_6	2.0	50	50
2.C.4	Magnesium Production – Mg Foundries – SF_6	5.0	5.0	7.1
2.D	Non-Energy Products from Fuels and Solvent Use – CO_2	20	30.0	36
2.F.1	Refrigeration and Air Conditioning Equipment – HFC	10	50.0	51.0
2.G.2	SF_6 from other product use – SF_6	25.0	50.0	55.9
2.G	Other Product Manufacture and Use – N_2O	100	0	100

4.1.5 Quality Assurance and Quality Control (QA/QC)

For the Austrian Inventory an internal quality management system has been established. The QC procedures defined in the QMS correspond to general QC Tier 1 procedures. For further information see Chapter 1.2.3.

Concerning measurement and documentation of emission data within the EU ETS (Emission Trading System; former Emission Trading Scheme), Commission Decision 2004/156/EC established guidelines for monitoring and reporting of greenhouse gas emissions. This decision provided general guidelines on emission reporting and verification as well as sector specific guidelines on the methodologies to account for process specific CO_2 emissions. These include guidance on calculations and measurements at different level of detail similar to the different Tier methods in the IPCC guidelines. The original Commission Decision was replaced by Commission Decision 2007/589/EC and, most recently, Commission Regulation (EU) No 601/2012.

In Austria, the EU ETS is implemented by specific national regulations: the Austrian Emissions Allowance Trading Act[70] and the Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions[71].

Furthermore most of the plants that report emission data – this includes plants that are not obliged to participate in the EU ETS – have quality management systems in place according to the ISO 9000 series or similar systems.

4.1.6 Recalculations

This chapter presents the recalculation difference of emissions in the IPPU sector with respect to the previous submission.
The whole time series of recalculations is included in Annex 8 to the NIR.

Reallocation of emissions

2.A.1 Cement Production / 2.A.2 Lime Production / 2.A.3 Glass Production/ 2.A.4.a Bricks and Tiles / 2.A.4.c Magnesia Production / 2.B.2.10.b CO_2 emissions from chemical industry (ETS)

During comprehensive quality checks several minor errors in the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013ff were identified for single years and categories, and subsequently corrected.

2.A.2 Lime Production / 2.A.4.d Other Use of Carbonates

Following a recommendation from the 2022 UNFCCC review, all emissions from lime production i.e. those previously reported under *2.A.4.d* (desulphurization) and *2.C.5.a* Carbide Production are now reported together with emissions from lime kilns, as well as from processes using or producing PCC (precipitated calcium carbonate) under *2.A.2*.

2.B.1 Ammonia Production / 2.D.3 Other: Urea used as a catalyst

Updated urea amounts used in road traffic for the years 2005–2020 led to a redistribution of minor amounts between these two categories.

2.C.1.a Steel

During additional quality checks, it became obvious that one process stream (tar) was considered incorrectly in the disaggregation of total CO_2 emissions from Iron & Steel production (which is verified ETS data) into process specific and energy related emissions reported under *1.A.2.a*. The correction led to a minor shift of emissions between those two categories.

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[70] *Emissionszertifikategesetz 2011*, Federal Law Gazette I No. 118/2011, as amended

[71] Überwachungs-, Berichterstattungs- und Prüfungsverordnung, Federal Law Gazette II No. 339/2007, as amended

Update of activity or emissions data

2.B.10.ii Fertilizer Production

During comprehensive quality checks, a minor error of the year 2010 was found and corrected (-0.04 kt CO_2 in 2010).

2.C.5 Lead Production

Activity data from the year 2016 onwards were updated (+0.5 kt CO_2 in 2020).

2.D.3 Solvent Use

During additional quality checks several minor errors of the VOC directive data analysis used as basis for the bottom up approach for the years 2015 and 2019 were identified and subsequently corrected. As data from 2002 to 2015 is interpolated, this affected emissions from 2003 onwards (+0.01 kt CO_2e in 2020).

2.F.1.d Transport Refrigeration

Additional research identified an additional supplier of transport refrigeration equipment and furthermore showed that refill data previously used was incomplete. Therefore new assumptions on stock and especially stock composition were made, taking into account all available information. This affected emissions from 2007 onwards (-6.4 kt CO_2e in 2020).

2.F.1.e MAC

A minor correction of the amounts filled into new equipment for trains in 2019 led to recalculations of the stock back to 1996, as stocks are calculated back in time using newly filled in amounts (+0.03 kt CO_2e in 2020).

2.F.3 Fire protection

Disposal emissions from 2019 had mistakenly not been considered in previous submissions, but are now included (+0.2 kt CO_2e in 2019).

2.G.1 Electrical equipment

Updated stock data for 2020 became available, and was included in this year's inventory (+ 1.0 kt CO_2e).

2.G.2 Other uses of SF6- particle accelerators.

Activity data for some new equipment were updated for 2020 (+1.4 kt CO_2e).

Improvements of methodologies and emission factors

2.A.2 Lime Production

CO_2 recovery in the process of PCC production of one site, for which emissions from the calcination step have been considered in the inventory, was included in the calculation. This affected emissions from 1990-2019, e.g. -1.1 kt CO_2 in 2019).

2.B.5.b Calcium Carbide Production

Following a recommendation from the 2022 UNFCCC review, the EF for carbide production was reevaluated and emissions from acetylene production were included for the first time. As already described above, emissions from the calcination step in carbide production were reallocated to *2.A.2 Lime Production*. The overall effect on emissions from this category is -5.4 kt CO_2 in 2020.

2.C.1.b Pig Iron

Methane emissions from coke production are now estimated using plant specific data. Furthermore emissions reported for sinter production were corrected, as previously only CH_4-C was reported (+2.2 kt CO_2e in 2020).

2.F.1.a Commercial refrigeration, 2.F.1.c Industrial Refrigeration and 2.F.1.f Stationary air conditioning

Additional research on stationary air conditioning showed that

1. less equipment was filled on site than previously assumed. Thus, the gap between quantities surveyed bottom up and import figures is now higher, raising both stocks and emission from stocks for the categories **commercial and industrial refrigeration**, those two categories where the residual amounts are allocated to.
2. for one type of equipment the assumed filling capacity for the years 2009ff was too low, increasing the stock and emissions for **stationary air conditioning** from 2009 onwards.
3. furthermore, as the GWP was changed to AR5, also the blend categories used for modelling the residual amounts of refrigerants not surveyed bottom up, had to be revised.

The overall effect of recalculations in these three sub categories is + 58.5 kt CO_2e in 2020.

4.1.7 Completeness

Table 147 gives an overview of the IPCC categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated.

Table 147: Overview of subcategories of Sector 2 Industrial Processes and Product Use: transformation into SNAP Codes and status of estimation.

	IPCC Category	SNAP		Status		
				CO_2	CH_4	N_2O
2.A	**MINERAL PRODUCTS**					
2.A.1	Cement Production	040612	Cement (decarbonising)	✓	NA	NA
2.A.2	Lime Production	040614	Lime (decarbonising)	✓	NA	NA
		040618_X4T	Limestone and dolomite use – carbide			
		040618_X4U	Limestone and dolomite use – PCC			
		040618_X4V	Limestone and dolomite use - desulfurization			
2.A.3	Glass Production	040613	Glass (decarbonizing)	✓	NA	NA
2.A.4	Other Process Uses of Carbonates					
	2.A.4.a Ceramics	040617	Bricks and Tiles (decarbonizing)	✓	NA	NA
	2.A.4.b Other uses of soda ash	040619	Soda ash production and use	✓	NA	NA
	2.A.4.c Non Metallurgical Magnesia Production	040617	Magnesia sinter production	✓	NA	NA

	IPCC Category	SNAP		Status		
				CO_2	CH_4	N_2O
2.B	**CHEMICAL INDUSTRY**					
2.B.1	Ammonia Production	040403	Ammonia	✓	✓	NA
2.B.2	Nitric Acid Production	040402	Nitric acid	NA[1)]	NA	✓
2.B.3	Adipic Acid Production	040521	Adipic acid	NO	NA	NO
2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid Production			NO	NA	NO
2.B.5	Carbide Production					
	2.B.5.a Silicon Carbide			NO	NO	NO
	2.B.5.b Calcium Carbide	040412	Calcium carbide production	✓	NA	NA
2.B.6	Titanium Dioxide Production			NO	NA	NA
2.B.7	Soda Ash Production	040619	Soda ash production and use	NO	NA	NA
2.B.8	Petrochemical and Carbon Black Production					
	2.B.8.a Methanol			NO	NO	NO
	2.B.8.b Ethylene	040501	Ethylene production	IE	✓	NA
	2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer			NO	NO	NO
	2.B.8.d Ethylene Oxide			NO	NO	NO
	2.B.8.e Acrylonitrite			NO	NO	NO
	2.B.8.f Carbon Black			NO	NO	NO
2.B.9	Fluorochemical Production			NO (F-gases)		
2.B.10	Other					
	2.B.10.i CO_2 from Nitric Acid Production	040402	Nitric acid	✓	NA	NA
	2.B.10.ii Other chemical industry	040407 040408 040416 040527_X4S 040527	NPK fertilisers Urea Other inorganic chemical industries Other chemical bulk production	✓	✓	NA
2.C	**METAL INDUSTRY**					
2.C.1	Iron and Steel Production					
	2.C.1.a Steel	040206	Basic oxygen furnace steel plant	✓	NA[2)]	NA
	2.C.1.b Pig Iron	040202	Blast furnace charging	IE[3)]	✓	NA
	2.C.1.c Direct Reduced Iron			NO	NO	NO
	2.C.1.d Sinter	040209	Sinter and pelletizing plant	IE[3)]	IE[4)]	NA
	2.C.1.e Pellet			NO	NO	NA
	2.C.1.f Other: Electric Furnace Steel	040207	Electric furnace steel plant	✓	NA	NA
2.C.2	Ferroalloys Production	040302	Ferro alloys	✓	NA	NA
2.C.3	Aluminium Production	040301	Aluminium Production	✓	NA	NA
2.C.3	Aluminium Production – By-product emissions and Al Foundries			✓[5)] (PFC, SF_6)		
2.C.4	Magnesium Production – Mg Foundries			✓ (SF_6)		
2.C.5	Lead Production	030307	Secondary Lead production	✓	NA	NA

	IPCC Category		SNAP	Status		
				CO_2	CH_4	N_2O
2.C.6	Zinc Production			NO	NO	NO
2.D	**Non-Energy Products from Fuels and Solvent Use**					
2.D.1	Lubricant Use			✓	NA	NA
2.D.2	Paraffin Wax Use			✓	NA	NA
2.D.3	Other (Solvent Use)					
	2.D.3.1 Solvent use	0601-0604	Solvent and other product use	✓	NA	NA
	2.D.3.2 Road paving with asphalt	040611	Road paving with asphalt	NA	NA	NA
	2.D.3.3 Roof covering with asphalt materials	040610	Roof covering with asphalt materials	NA	NA	NA
2.E	**Electronics Industry**			**✓ (F-gases)**		
2.F	**Product Uses as Substitutes for ODS**					
2.F.1	Refrigeration and Air Conditioning	060502	Refrigeration and air conditioning equipments	✓ (F-gases)		
2.F.2	Foam Blowing Agents	060504	Foam blowing (except 060304)	✓ (F-gases)		
2.F.3	Fire Protection	060505	Fire extinguishers	✓ (F-gases)		
2.F.4	Aerosols	060506	Aerosol cans	✓ (F-gases)		
2.F.5	Solvents		Solvents	✓ (F-gases)		
2.F.6	Other applications			✓ (F-gases)		
2.G	**Other Product Manufacture and Use**					
2.G.1	Electrical Equipment			✓ (F-gases)		
2.G.2	SF_6 and PFCs from Other Product Use			✓ (F-gases)		
2.G.3	N_2O from Product Uses	0605		NA	NA	✓
2.G.4	Other			✓	NA	NA
2.H	**Other**					
2.H.1	Pulp and Paper Industry			NA	NA	NA
2.H.2	Food and Beverages Industry			NA[6)]	NA	NA

1) CO_2 emissions from nitric acid production are included in the new category "2.B.10.i CO_2 from Nitric Acid Production

2) reported as "NA" as no default EF is provided in the IPCC 2006 GL

3) Emissions are included in category 2.C.1.a.

4) Emissions are included in category 2.C.1.b.

5) Primary aluminium production was terminated in 1992.

6) CO_2 emissions from this source are of biogenic origin.

4.2 Mineral Products (Category 2.A)

4.2.1 Cement Production (2.A.1)

4.2.1.1 Source Category Description

Emissions: CO_2

Key Source: Yes (CO_2)

CO_2 emissions from cement production are a key category because of their contribution to the level of the greenhouse gas inventory in 1990 and in 2020. In 2021, CO_2 emissions from cement production contributed 2.4% to total greenhouse gas emissions in Austria (without LULUCF).

In this category, process specific CO_2 emissions are reported only; emissions due to combustion are reported in the energy sector (category *1.A.2.f*).

Process specific CO_2 is emitted during the production of clinker (calcination process) when carbonates (mainly $CaCO_3$) are heated in a cement kiln up to temperatures of about 1 300°C. During this process, calcium carbonate is converted into lime (CaO – Calcium Oxide) and CO_2.

Table 148 presents process-related CO_2 emissions from cement production for the period from 1990 to 2021. To increase transparency (in response to a question in the course of the UNFCCC review 2012), data on raw meal used was incorporated into the table.

Table 148: CO_2 emissions from decarbonising in cement production, clinker production, raw meal used and implied emission factor, 1990–2021

Year	Clinker [t]	Raw meal used [t]	Process specific CO_2 emissions [kt]	IEF [kg CO_2/t Clinker]
1990	3 693 539	5 832 777	2 033	551
1991	3 635 462	5 748 943	2 005	552
1992	3 820 397	6 037 658	2 105	551
1993	3 678 293	5 830 089	2 032	552
1994	3 791 131	6 032 917	2 102	555
1995	2 929 973	4 671 693	1 631	557
1996	2 915 956	4 688 132	1 634	560
1997	3 103 312	5 056 336	1 761	567
1998	2 869 035	4 614 457	1 599	557
1999	2 891 785	4 648 493	1 607	556
2000	3 052 974	4 890 919	1 712	561
2001	3 061 338	4 911 083	1 720	562
2002	3 118 227	5 014 871	1 736	557
2003	3 119 808	5 016 291	1 754	562
2004	3 222 802	5 179 877	1 790	555
2005	3 221 167	5 148 317	1 797	558
2006	3 653 477	5 804 052	1 954	535
2007	3 992 376	6 297 527	2 131	534
2008	3 996 243	6 326 187	2 133	534
2009	3 428 140	5 376 515	1 799	525
2010	3 097 043	4 854 280	1 622	524

Year	Clinker [t]	Raw meal used [t]	Process specific CO_2 emissions [kt]	IEF [kg CO_2/t Clinker]
2011	3 175 642	4 947 150	1 666	525
2012	3 206 055	4 942 334	1 673	522
2013	3 156 286	4 858 175	1 656	525
2014	3 143 495	4 842 710	1 639	521
2015	3 256 561	5 033 733	1 701	522
2016	3 299 974	5 093 970	1 729	524
2017	3 313 459	5 057 751	1 710	516
2018	3 551 969	5 421 197	1 827	514
2019	3 422 866	5 264 330	1 771	517
2020	3 522 299	5 404 367	1 821	517
2021	3 662 612	5 623 758	1 889	516
1990-2021	**-0.8%**	**-3.6%**	**-7.1%**	

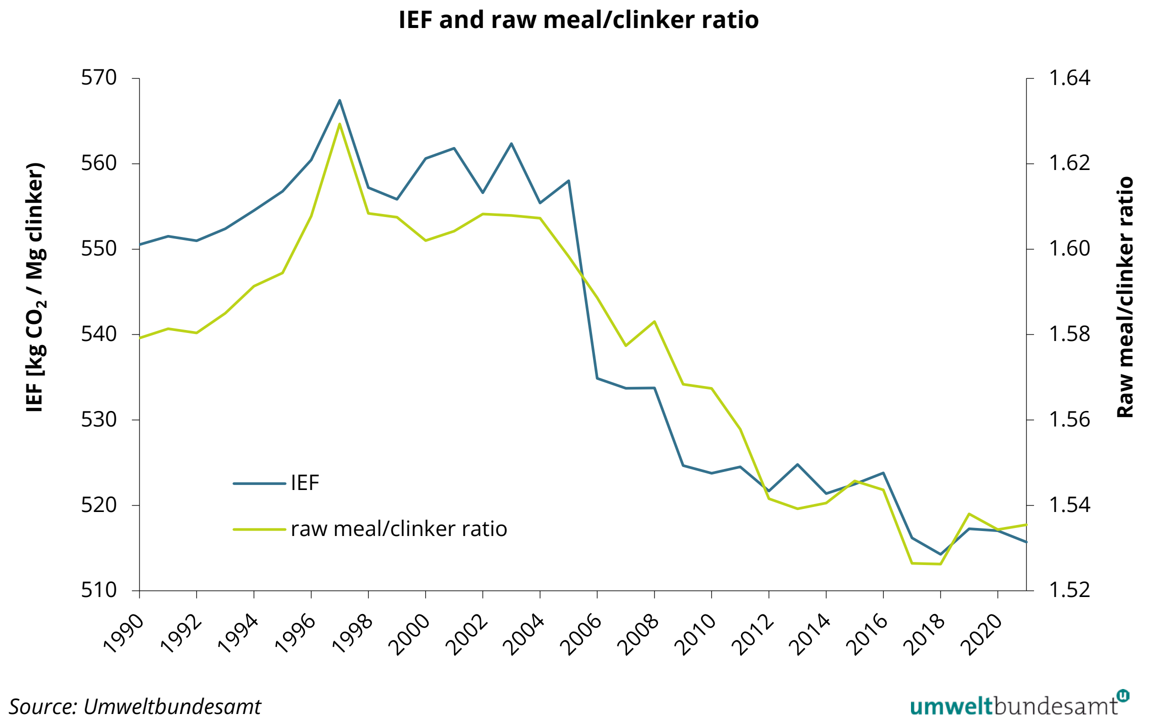
CO_2 emissions mainly follow production figures: they remained quite constant from 1990 to 1994 and dropped afterwards due to an economic downturn in the cement industry and the shutdown of one clinker oven. After 1995, emissions as well as production of clinker increased slowly, following cement demand, with minor fluctuations only. The trend from 2008 onwards is a result of the economic crisis followed by a (slow) recovery in the cement industry.

The overall emission trend from 1990 to 2021 is minus 7.11%. Production decreased by 0.84% during that period.

As process specific emissions are considered only, the IEF solely depends on the raw materials used (carbonate contents of fresh materials but also of secondary raw materials such as clay substitute, brick chips, and recycled gypsum) – smaller fluctuations of the IEF are also a result of opening/closing or shifting of production between plants that operate under different conditions (such as differing use of secondary materials). Currently, nine plants operate in Austria.

As can be seen in Figure 21, the IEF largely follows the trend of the raw meal/clinker ratio as it is a result of the raw materials used.

Figure 21: Time series of the implied emission factor (IEF) for cement production and ratio of raw meal used to clinker produced



Source: Umweltbundesamt

In an effort to enhance transparency, information on the composition of raw material and its calcium carbonate and magnesium carbonate was collected. In 2011, the average $CaCO_3$ content was 76.3% and the average $MgCO_3$ content was 3.1%. In 2012, the values were 75.0% and 3.7%, respectively; in 2013, 74.9% and 3.8%, respectively. In 2014, the average $CaCO_3$ content was 74.8% and the average $MgCO_3$ content was 3.7% in the plants in operation.

It has to be noted that from 2005 onwards, emissions are calculated for each plant in line with the requirements of the EU ETS. Total carbonate contents of the raw meal are determined for each plant individually. However, the specific shares of $CaCO_3$ and $MgCO_3$ are not determined under this approach as this is not required for the determination of process emissions. Contents of various carbonates cannot be measured individually, but are calculated based on estimates in the individual plants. The procedures in the individual plants may differ and the percentages given above were calculated without weighing the percentages reported by the plant operators.

4.2.1.2 Methodological Issues

Until 2004, CO_2 emissions from cement production were estimated using a country specific method similar to the IPCC Tier 2 methodology. CO_2 emissions from raw meal calcination (decarbonising) were calculated based on the raw meal composition:

$$M_{(CO2\ calc)} = \sum_k (m_{(raw\ meal)})_k \cdot (x_{(MeCO3)k} \cdot M)$$

Where:

m mass stream [kg/a]
x mass portion
k for the k^{th} cement plant
M molecular weight CO_2/molecular weight Me-carbonate
Me Ca, Mg

Based on raw meal data and plant specific production data, total emissions from this source were calculated. With this methodology, no cement kiln dust (CKD) correction factor has to be considered.

Activity data (clinker production) as well as emission data were taken from studies on emissions from the Austrian cement production industry (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003 and MAUSCHITZ 2004). The studies cover the years 1988 to 2003. In these studies process-specific CO_2 emissions and CO_2 emissions due to combustion are presented separately. In the course of these studies all cement production plants in Austria were investigated. The determination of the emission data took place by inspection of every single plant, recording and evaluation of plant specific records and also plant specific measurements and analysis carried out by independent scientific institutes.

Activity data and emissions for 2004–2021 conform to verified CO_2 emissions data of the EU ETS. A summary of the data is also published in annual reports (e.g. MAUSCHITZ 2004-2022). The methodology for these emission calculations is the same as in the years before.

4.2.1.3 Category-specific QA/QC

Raw material analysis was carried out by independent scientific institutes. Clinker production data was compared with publications from the Association of the Austrian Cement Industry to ensure completeness.

During various reviews, the Austrian IEF has been considered high compared to other Parties and the IPCC default value. A possible explanation can be found in (HACKL & MAUSCHITZ 2003), where the authors apply both methods, based on clinker and on raw meal, to calculate CO_2 emissions and find that if CO_2 emissions are calculated from clinker instead of raw meal, this leads to 4% lower emissions.

For 2005–2021, verified CO_2 emissions (total of all plants) were checked against national emissions taken from the studies – no deviations were identified.

4.2.1.4 Uncertainty Assessment

As the applied methodology is based on plant specific data, the uncertainty of activity data is assumed to be low: it was assumed 5% for the base year and 1.1% for the recent year as now this data is verified under the EU ETS scheme. According to the IPCC 2006 GL the uncertainty of the CO_2 emission factor for Tier 2 is 1–2%. In the Austrian method, the uncertainty basically derives from the raw meal composition as the uncertainty for the stochiometric emission factor is negligible; thus, the uncertainty of the emission factor is assumed to be 2%. This results in a combined uncertainty of 2.3%.

4.2.1.5 Recalculations

During comprehensive quality checks several minor errors in the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013ff were identified for single years and categories, and subsequently corrected.

4.2.2 Lime Production (2.A.2)

4.2.2.1 Source Category Description

Emissions: CO_2

Key Source: Yes (CO_2)

CO_2 emissions from lime production are a key category because of their contribution to the total inventory's level in 1990 and in 2021, as well as because of their contribution in terms of their trend. In 2021, emissions from this category contributed 0.9% to the total amount of greenhouse gas emissions in Austria.

In this category the following sources are considered, which consider both marketed and non-marketed lime:

- Lime production in all lime kilns in Austria
- Lime production for calcium carbide production
- Lime production for PCC (precipitated calcium carbonate) production as well as CO_2 recovery from PCC use
- Limestone use for desuphurisation

CO_2 is emitted during the calcination step of lime production. Calcium carbonate ($CaCO_3$) in limestone and calcium/magnesium carbonates in dolomite rock ($CaCO_3 \cdot MgCO_3$) are decomposed to form CO_2 and quicklime (CaO) or dolomite quicklime ($CaO \cdot MgO$) respectively.

Table 149 presents activity data for this category (lime produced) as well as CO_2 emissions from lime production for the period from 1990 to 2021.

Table 149: CO_2 emissions, activity data and implied emission factors for lime production 1990–2021

Year	Lime Produced [t]	CO_2 [kt]	IEF *(not considering CO_2 recovery)* [kg CO_2/t lime produced]
1990	675 985	439	650
1991	636 592	403	633
1992	642 457	402	626
1993	655 022	408	623
1994	670 059	429	641
1995	683 635	435	636
1996	678 715	427	629
1997	718 430	457	636
1998	766 519	499	651
1999	760 963	497	653
2000	829 733	550	663
2001	834 989	558	669
2002	879 726	591	672
2003	906 773	621	684
2004	934 053	641	686
2005	934 345	623	667
2006	957 436	614	642
2007	979 414	633	647
2008	1 023 415	661	646

Year	Lime Produced [t]	CO_2 [kt]	IEF *(not considering CO_2 recovery)* [kg CO_2/t lime produced]
2009	861 880	546	634
2010	921 944	610	662
2011	980 954	643	656
2012	922 773	605	656
2013	942 406	623	661
2014	963 420	624	647
2015	936 248	617	659
2016	946 682	617	652
2017	933 821	617	660
2018	905 272	581	642
2019	915 044	616	673
2020	862 598	588	681
2021	996 516	663	665
1990-2021	**+47%**	**+51%**	**+2.3%**

CO_2 emissions from this category have been increasing since 1990, with a pronounced dip due to the economic crisis in 2009. In the year 2021, emissions were 51% higher than in 1990 (see Table 149).

4.2.2.2 Methodological Issues

Lime produced at lime kilns

Emissions were estimated using a country specific method based on detailed production data.

Activity data for the whole time series and emission data until 2004 were reported by the *Association of the Stone & Ceramic Industry.* For 2005–2021, verified CO_2 emissions reported under the ETS were used for the inventory: some plants calculate emissions based on raw material data, most calculate emissions from lime produced; thus the activity data reported under the ETS for some plants is production volumes, others report the amount of raw materials used. For the calculation of an overall IEF, the overall value of Austrian lime production as reported by the *Association of the Stone & Ceramic Industry* is used.

Also reported emissions for the years before 2005 are based on detailed data of each of the seven lime production plants in Austria, including production volumes and the respective CaO and MgO contents of lime produced in the respective plant.

The IEF depends on the quality ($CaCO_3$/$MgCO_3$ content) of the limestone used; it ranges between 0.73 and 0.77 tonnes CO_2 per tonne lime produced – which corresponds to the default range for purity of high calcium lime of 93–98%.

Lime production for calcium carbide production

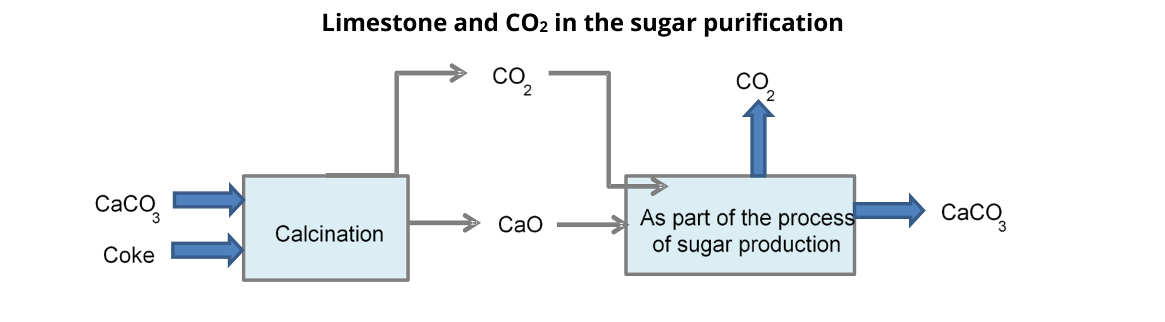
Calcium carbide production as well as the plant specific emission factor for the lime production step (0.7153 t CO_2/t carbide) is reported by the only producer in Austria.

Lime production for PCC (precipitated calcium carbonate) production as well as CO_2 recovery from PCC use

Lime used for sugar purification

In Austria, two sugar processing plants are in operation, owned by the same company and integrated in the EU ETS. In these plants, limestone is converted into lime, using coke as fuel to maximise the amount of CO_2 available for the internal process. Both lime and CO_2 produced in the decarbonising step are fed into the raw sugar solution (this takes place in the sugar purification unit, see Figure 22). At this point, the lime re-reacts with CO_2 forming a limestone sediment which binds impurities in the raw sugar solution. Surplus CO_2 leaves the system. The sediment, the by-product of the sugar purification step, is known as 'Carbokalk'. It also contains the bound impurities (organic substances and minerals) and is used as a fertilizer (WASNER 2009).

Figure 22: Purification step in the sugar production: lime production (calcination) and reaction of CO_2 and lime back to limestone (sediment).



Source: Umweltbundesamt

The majority of CO_2 originating from lime is contained in the sediment. However, following the recommendation by the Expert Review Team, mass balance data were obtained from the producer. Based on this mass balance, it was found that part of the CO_2 originating from limestone does not end up in the sediment but is emitted, and an emission factor of 2.07 kg CO_2 per t $CaCO_3$ input was calculated.

Lime used for production of PCC

Until 2019 PCC (precipitated calcium carbonate) was produced at one site in Austria. The process is basically the same as in sugar purification explained above (limestone calcination and subsequent precipitation using i.a. the CO_2 emitted in the calcination step), only that the precipitation step takes place under definded conditions to produce calcium carbonate with the desired physical parameters concerining particle size, crystal structure, surface area, purty, opacity etc.

For the years 2005 to 2019 CO_2 emissions data was available from the EU ETS, for the years before the value of 2005 was used. For CO_2 recovered data was only available for the years 2017 and 2018, for 2019 the data was not complete as the production was terminated in this year. Therefore the share of recovered data 2017 and 2018 was used for calculating CO_2 recovered for the other years.

Limestone use for desulphurisation

Activity data for limestone used for desulphurization were taken from a national report on desulphurization technologies in Austria (WINDSPERGER & HINTERMEIER 2002). The time series was constructed with the help of plant specific SO_2 emission declarations from the Austrian steam boiler database.

For calculation of CO_2 emissions, the IPCC default emission factors of 440 kg CO_2/t limestone and 477 kg CO_2/t dolomite were used. From 2005 onwards, ETS background data provided more detailed information on the actual carbon content of the limestone and dolomite used. Therefore, the IEFs from 2005 onwards are slightly different to the IPCC default values.

4.2.2.3 Category-specific QA/QC

The emission values for 2005 onwards are verified under the EU ETS. IEFs are compared with IPCC default values. The *Association of the Stone & Ceramic Industry* reported total CO_2 emissions, which were compared to ETS data.

For limestone use for desulfurisation it was checked whether data cover all industrial activities of this type in Austria.

4.2.2.4 Uncertainty Assessment

As emissions from lime klins cover about 95% of total emissions from this category, the uncertainty assessment was made for this main sub category only:

The uncertainty of the emission factor derives basically from the raw-material composition and is assumed to be 5%. Uncertainties for activity data are considered to be low as they are based on verified plant specific data of all Austrian plants, we assumed 1.6%. This leads to a combined uncertainty of 5.25%.

4.2.2.5 Recalculations

During additional quality checks several minor errors in the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013ff were identified for single years and categories, and subsequently corrected.

Following a recommendation from the 2022 UNFCCC review, all emissions from lime production, also those of non-marketed lime, i.e. those previously reported under *2.A.4.d* (desulphurization) and *2.C.5.a* Carbide Production are now reported together with emissions from lime kilns, as well as from processes using or producing PCC (precipitated calcium carbonate) under *2.A.2*. CO_2 recovery in the process of PCC production of one site, for which emissions from the calcination step have been considered in the inventory, was included in the calculation. This affected emissions from 1990-2019, e.g. -1.1 kt CO_2 in 2019).

4.2.3 Glass Production (2.A.3)

4.2.3.1 Source Category Description

Emissions: CO_2

Key Source: no

In this category CO_2 emissions from decarbonising of soda, limestone, dolomite and other carbonates used for glass production is considered. This category contributed 0.05% to total greenhouse gas emissions in Austria (without LULUCF).

4.2.3.2 Methodological Issues

Emissions are calculated based on the input of carbonates and a CO_2 emission factor for the different types of carbonates.

For years 2002 to 2004 input data on carbonates (limestone, dolomite and soda) was reported by the *Association of Glass Industry*. The factor of tonne carbonate used/ tonne glass for 2002 (the only year were both glass production and carbonate input was available) was also applied for 1990-2001.. For the calculation of CO_2 emissions the IPCC 2006 default emission factors of 414.92 kg CO_2/t soda ash, 439.71 kg CO_2/t limestone and 477.32 kg CO_2/t dolomite were applied for the years 1990 to 2004.

Since 2005 verified CO_2 emissions and activity data reported under the ETS is used for the inventory.

Table 150 presents activity data and CO_2 emissions from this category for the period from 1990 to 2021.

Table 150: CO_2 emissions and carbonate use in glass production 1990–2021

Year	Glass Prod. [t]	CO_2 emissions [kt]
1990	398 515	39
1991	458 666	44
1992	405 863	39
1993	406 222	39
1994	434 873	42
1995	435 094	42
1996	435 094	42
1997	405 760	39
1998	405 760	39
1999	445 069	43
2000	375 348	36
2001	440 865	43
2002	389 497	38
2003	476 901	42
2004	356 702	28
2005	417 685	35
2006	448 176	37

Year	Glass Prod. [t]	CO_2 emissions [kt]
2007	496 709	40
2008	504 213	44
2009	442 515	41
2010	498 156	40
2011	474 222	36
2012	472 040	37
2013	487 359	39
2014	496 782	37
2015	497 368	40
2016	480 781	38
2017	501 881	38
2018	487 341	38
2019	525 624	41
2020	503 490	39
2021	509 577	36
1990-2021	**+28%**	**-7.2%**

4.2.3.3 Category-specific QA/QC

The country-specific EFs for limestone, dolomite and soda ash have been compared with the IPCC default values. They deviate from the IPCC default values less than 1%.

4.2.3.4 Uncertainty assessment

The uncertainty of activity data is assumed to be 10%. The uncertainty of the emission factor is estimated to be about 1%. This leads to a combined uncertainty of 10.1%.

4.2.3.5 Recalculations

During comprehensive quality checks several minor errors in the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013ff were identified for single years and categories, and subsequently corrected.

4.2.4 Other Process Uses of Carbonates (2.A.4)

In this category ceramics (bricks) magnesia sinter production and soda ash use are addressed.

4.2.4.1 Ceramics (2.A.4.a)

Source Category Description

Emissions: CO_2

Key Source: No

This category includes CO_2 emissions from the production of bricks where CO_2 is generated through decomposition of the carbonate content of the raw materials.

Table 151 presents CO_2 emissions from bricks production for the period from 1990 to 2021. CO_2 emissions from bricks production showed a maximum in 1995/1996 due to a peak in brick production. In 2021, emissions from this category contributed 0.12% to total greenhouse gas emissions in Austria and were 17.6% lower than in 1990.

Methodological Issues

Activity data for the production of bricks was taken from national statistics (STATISTIK AUSTRIA), for 1996 the value of 1995 was used due to lack of data. Since 2006 the volumes sold of the short-term statistics are directly provided by the Statistik Austria on annual basis.

Emission values for the years 1998–2001 were reported by the *Association of the Stone & Ceramic Industry*. The reported CO_2 emission data is based on data of the different brick production sites in Austria, also considering the carbonate contents of raw materials used for bricks production at the respective plants. From the IEF for 1998, emissions of the years prior to 1998 were calculated and the IEF of 2001 was used to calculate emissions of 2002 to 2004.

For 2005–2020, verified CO_2 emissions reported under the ETS were used for the inventory (2006 IPCC GL, Tier 3). This data covers all brick production sites in Austria.

Table 151 presents activity data for production of bricks and CO_2 emissions for this category for the period from 1990 to 2021.

Table 151: Activity data and CO_2 emissions for bricks production 1990–2021

Year	Bricks [m^3]	CO_2 emissions [kt]	IEF [kg CO_2/m^3]
1990	2 230 000	116	52
1991	2 333 852	122	52
1992	2 412 902	126	52
1993	2 593 236	135	52
1994	2 675 473	140	52
1995	2 848 716	149	52
1996	2 848 716	149	52
1997	2 625 046	137	52
1998	2 557 448	134	52
1999	2 184 773	122	56
2000	1 954 855	116	59

Year	Bricks [m³]	CO_2 emissions [kt]	IEF [kg CO_2/m³]
2001	1 959 395	124	63
2002	1 904 142	120	63
2003	1 833 557	116	63
2004	2 116 786	134	63
2005	2 170 069	128	59
2006	2 130 866	130	61
2007	2 331 709	130	56
2008	2 029 947	110	54
2009	1 729 542	94	54
2010	1 789 882	81	45
2011	2 371 494	99	42
2012	1 749 297	93	53
2013	1 671 812	80	48
2014	1 615 127	94	58
2015	1 698 612	91	54
2016	1 800 235	91	51
2017	1 715 450	95	55
2018	1 693 833	105	62
2019	1 976 520	104	53
2020	1 915 919	106	55
2021	1 730 891	96	55
1990–2021	**-22%**	**-18%**	

The increasing IEF between 1998 and 2001 is due to a switch in porous material used in brick production. Previously mainly sawdust was used, whereas nowadays residual fibre material from paper industry is used. Furthermore, $CaCO_3$ is added for moisture compensation.

Generally, fluctuations in the IEF occur because of different brick types produced. High and low density bricks have different properties, and different raw materials with different carbon contents are used. The higher the density of the particular brick, the more CO_2 is emitted during production. For example, in 2010 and 2011, raw material (loam) with lower carbon content was used (verified by chemical analysis: loss on ignition), resulting in a lower average implied emission factor for these two years.

Uncertainty Assessment

The uncertainty of activity data is assumed to be low (2%).The uncertainty of the emission factor is estimated to be about 5%. This leads to a combined uncertainty of 5.4%

Recalculations

During additional quality checks several minor errors in the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013ff were identified for single years and categories, and subsequently corrected.

4.2.4.2 Other Uses of Soda Ash (2.A.4.b)

Source Category Description

Emissions: CO2

Key Source: No

In this category CO_2 emissions from soda ash use in metallurgy and other industries is considered, CO_2 emissions from soda ash used in glass production are reported in *2.A.7.c Glass production*.

Soda ash was produced in Austria until 2005. However, als it was produced by the Solvay process which is CO_2-neutral (except for coke used for calcination of limestone which is accounted for as fuel in the energy sector subcategory *1.A.2.c*), the category 2.*B.7 Soda ash production* is reported as NO for all years.was

In 2021, CO_2 emissions from soda ash use contributed 0.01% to total GHG emissions in Austria. The following table presents CO_2 emissions from this category.

Table 152: Activity data and CO_2 emissions for soda ash use 1990–2021

Year	Soda ash used [t]	CO_2 emissions [kt]
1990	12 374	5
1991	10 837	4
1992	13 081	5
1993	13 545	6
1994	13 062	5
1995	13 531	6
1996	14 007	6
1997	15 465	6
1998	15 941	7
1999	15 102	6
2000	18 247	8
2001	16 195	7
2002	18 533	8
2003	19 876	8
2004	37 552	16
2005	30 208	13
2006	29 241	12
2007	27 489	11
2008	24 814	10
2009	22 269	9
2010	23 325	10
2011	27 234	11
2012	29 585	12
2013	24 816	10
2014	26 820	11
2015	23 461	10
2016	25 828	11
2017	24 712	10
2018	24 960	10
2019	21 221	9

Year	Soda ash used [t]	CO_2 emissions [kt]
2020	22 710	9
2021	24 640	10
1990–2021	**+99%**	**+99%**

Methodological Issues

Emissions were estimated using the methodology and the default emission factor of the IPCC Guidelines 2006 Tier 2 (415 kg CO_2/t soda ash).

The amount of total marketed soda ash is not available from national statistics. That is why the only Austrian producer Solvay Österreich GmbH was contacted (personal communication), providing data for 1990 and from 2008–2013. Activity data for the years in between was interpolated, for the years 2014ff the value of 2013 was used. From this total amount, the amount used in glass production that is already considered in category *2.A.3* was subtracted. Also Soda used for the production of detergents is subtracted as it is a non-emissive use. From the remaining soda ash use CO_2 emissions are calculated using the IPCC default EF.

Uncertainty Assessment

The uncertainty of activity data is assumed to be 10%. The uncertainty of the emission factor is estimated to be about 5%. This leads to a combined uncertainty of 11.2%.

Recalculations

During comprehensive quality checks several minor errors in the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013, 2014, 2018 and 2020 were identified and subsequently corrected.

4.2.4.3 Magnesia Sinter Production (2.A.4.c)

Emissions: CO2

Key Source: Yes (CO_2)

This category includes CO_2 emissions from the production of magnesia sinter. CO_2 emissions from magnesia sinter production are a key category due to their contribution to total emissions in 1990 and in 2020. In 2021, this category contributed 0.5% to the total amount of greenhouse gas emissions in Austria.

During production of magnesia sinter, CO_2 is generated in the calcination step, when magnesite ($MgCO_3$) is sintered at high temperatures in a kiln to produce MgO. Magnesia sinter is processed to refractory materials such as bricks.

Table 153 presents CO_2 emissions from production of magnesia sinter for the period from 1990 to 2021. CO_2 emissions from magnesia sinter plants vary over the period from 1990 to 2021, with an overall decreasing trend. Fluctuations in CO_2 emissions from this category are explained by:

- Varying implied emission factors that reflect different qualities of sinter produced and proportions of sinter/caustic sinter production.
- Varying production figures. For example, magnesia sinter production showed a distinct dip in 2009 due to the economic crisis.

Methodological Issues

No IPCC methodology is available for this source.

Emission values and activity data were directly reported by the only company in Austria sintering magnesia. For 2005–2021, verified CO_2 emissions, reported under the ETS, were used for verification of the reported emissions. Emissions are calculated according to "calculation method B: alkali oxides" in Annex II of the EU ETS monitoring and reporting guidelines[72]. The composition of the oxides is measured using X-ray fluorescence analysis.

Table 153 presents activity data and CO_2 emissions from this category for the period from 1990 to 2021.

Table 153: CO_2 emissions from magnesia sinter production 1990–2021

Year	Magnesite [t]	CO_2 Emissions [kt]	IEF [kg CO_2/t magnesite]
1990	966 066	481	498
1991	795 932	392	492
1992	675 284	336	498
1993	670 294	325	484
1994	669 260	323	482
1995	753 575	410	544
1996	744 726	355	477
1997	801 273	384	480
1998	716 869	345	482
1999	716 959	350	488
2000	699 707	339	485
2001	691 278	334	483
2002	766 887	374	487
2003	651 332	311	478
2004	655 236	329	501
2005	638 749	310	485
2006	608 737	312	513
2007	691 994	329	476
2008	648 704	332	512
2009	461 482	244	529
2010	627 612	314	500
2011	710 573	345	486
2012	625 259	305	488
2013	669 414	330	494
2014	676 263	334	494
2015	609 517	301	494
2016	643 350	318	495
2017	684 322	345	504
2018	744 227	365	490
2019	615 710	293	475
2020	579 845	282	487

[72] Commission Decision 2004/156/EC of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

Year	Magnesite [t]	CO_2 Emissions [kt]	IEF [kg CO_2/t magnesite]
2021	724 655	357	492
1990–2021		**-26%**	

Source specific QA/QC

The calculation is based on a recognised European standard method. Order of magnitude and time-series checks are performed. The operator is contacted in case of inconsistencies. The operator reported total CO_2 emissions, which were compared with EU ETS data and found to accord.

Uncertainty Assessment

The uncertainty of the emission factor equals the uncertainty of raw material composition which is estimated to be about 5%. The uncertainty of activity data is assumed to be low (2%) as there is only one plant in Austria and data is obtained from this plant. This leads to a combined uncertainty of 5.4%.

Recalculations

During additional quality checks several minor rounding errors in the ETS data for the years 2013 and 2014 were identified and subsequently corrected.

4.3 Chemical Industry (Category 2.B)

4.3.1 Ammonia Production (2.B.1)

4.3.1.1 Source Category Description

Emissions: CO_2 and CH_4

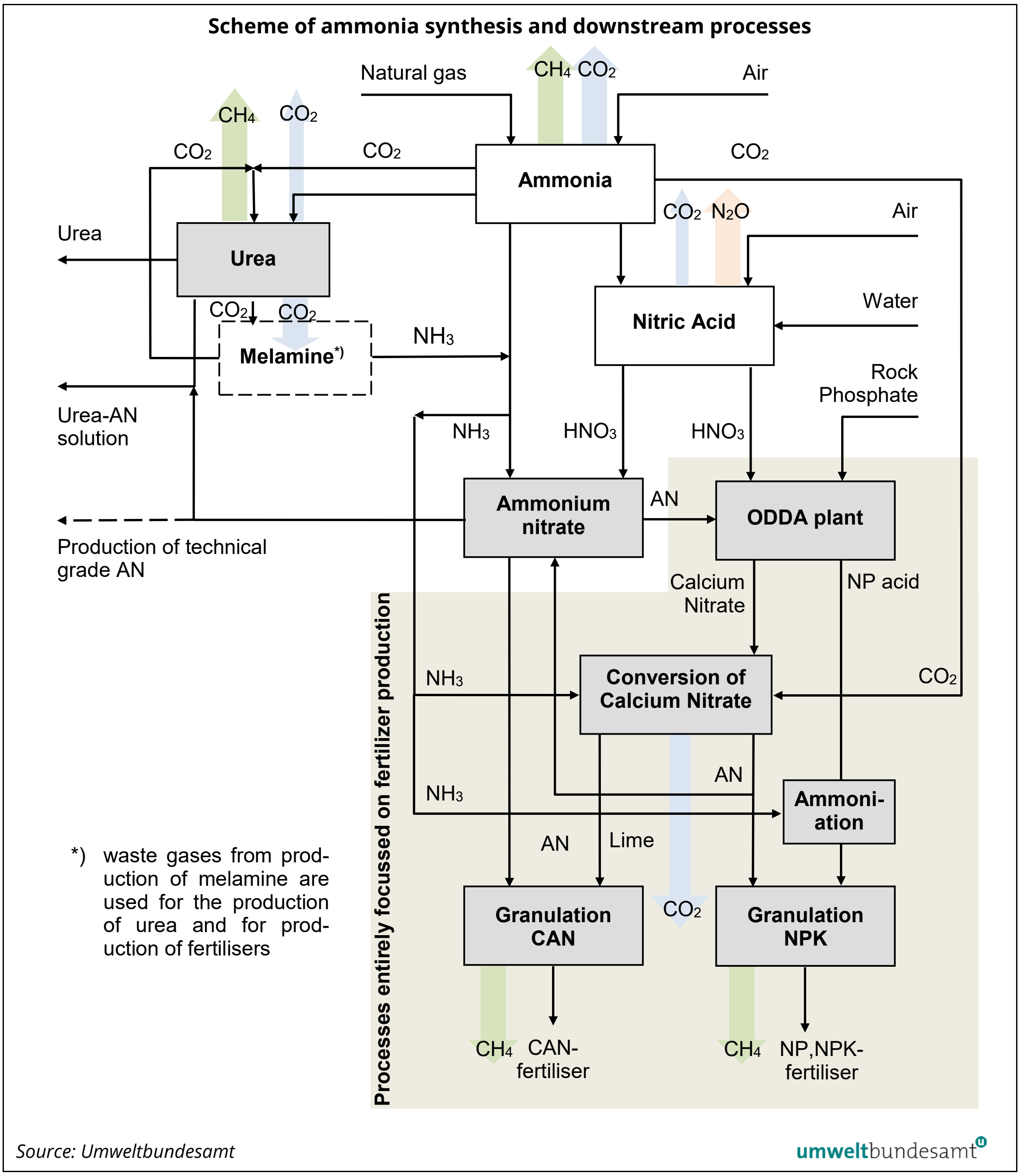
Key source: Yes (CO_2)

Ammonia production is a key category due to its contribution of sectoral CO_2 emissions to total greenhouse gas emissions in Austria in 1990 and in 2021. In 2021, this category contributed 0.7% to Austria's total greenhouse gas emissions.

Ammonia (NH_3) is produced by catalytic steam reforming of natural gas or other light hydrocarbons (e.g. liquefied petroleum gas, naphtha) – in Austria, natural gas is used. In this process, the feedstock is reformed with steam in a heated primary reformer and subsequently with air in a second reformer in order to produce the synthesis gas. CO_2 is produced by stoichiometric conversion and is mainly emitted during the primary reforming step (UMWELTBUNDESAMT 2001f).

Ammonia is produced at one plant in Austria. The process chart below (Figure 23) shows the scheme of ammonia synthesis and downstream processes at the integrated plant: the main production lines (ammonia, urea, melamine, nitric acid, different types of fertilisers and intermediate products), flows of main raw materials and intermediate products as well as relevant emissions.

Figure 23: Scheme of ammonia synthesis and downstream processes at Austria's integrated ammonia plant. Note: Grey coloring highlights those processes related to fertilizer production.



Approximately half of the methane introduced in the synthesis is CH_4 that is generated in the so called methanator: small amounts of CO and CO_2, remaining in the synthesis gas, are harmful for the ammonia synthesis catalyst and have to be removed by conversion to CH_4 in the methanator. The other half consists of recycled methane that has not been converted in the reforming step. Only a small part of the methane is actually emitted as leakage during start-ups of the ammonia production, the main part is used as a fuel in the primary reformer.

Table 155 presents CO_2 and CH_4 emissions from ammonia production as well as ammonia production figures and natural gas input for the period from 1990 to 2020

Emissions vary during the period, following closely the trend in ammonia production. In 2021, CO_2 emissions are 7.1% higher than in 1990.

4.3.1.2 Methodological Issues

Activity data (ammonia production and natural gas input) for the whole time series and CH_4 emission data from 1994 onwards were reported directly to the Umweltbundesamt by the only ammonia producer in Austria and thus represent plant specific data. The composition of the synthesis gas is measured regularly.

CH_4 emissions are calculated from the measured synthesis gas composition and the number and duration of start-ups. The implied emission factor for CH_4 that was calculated from activity and emission data from 1994 was applied to calculate emissions of the years 1990 to 1993 as no emission data was available for these years.

CH_4 emission factors of ammonia plants largely depend on the number of shutdowns and start-ups during the year. Especially a start up after a turn around with exchange of catalyst in some of the reactors of the plant needs a prolonged start up procedure resulting in an increase of the IEF.

CO_2 emissions are calculated as follows:

1. Carbon input is calculated from natural gas input – following the tier 2 method of the IPCC guidelines – with an emission factor of 55.4 t/TJ. Natural gas is the only carbon input for the ammonia synthesis and its downstream processes. Plant-specific natural gas data are available for the whole time series.
2. Subtraction of carbon that is accounted for elsewhere or stored to avoid double counting of emissions (the total of these is reported as recovery):
   a) Fugitive CH_4 emissions during start-ups of the **ammonia** production reported in *2.B.1*
   b) CO_2 and CH_4 emissions from **fertilizer** production (downstream process). These emissions are reported under CRF category 2.B.10.ii, further explanation see chapter 4.3.7.
   c) CO_2 and CH_4 emissions from **urea** production (downstream process). These emissions are reported under CRF category *2.B.10.ii*, further explanation see chapter 4.3.7.
   d) CO_2 emissions from **nitric acid** production (downstream process). These emissions are reported under CRF category *2.B.10.i CO_2 from Nitric Acid Production,* further explanation see chapter 4.3.5.
   e) CO_2 emissions from **urea use** reported in Sector *Agriculture* (see chapter 5.7)
   f) CO_2 emissions from **urea use** reported in 2.D.3 Other "Urea used as a catalyst" (Adblue)
   g) Carbon stored in **melamine[73]:**

3) the remainder carbon is accounted for as CO_2 emissions from ammonia production.

Melamine

Melamine is primarily used to produce melamine resin, which, when combined with formaldehyde, produces a very durable thermoset plastic. Melamine is fire resistant and heat tolerant and has a

[73] see description on melamine below

highly stable structure. It is mainly used for wood based panels, but also everyday objects such as kitchenware. The life time of these products is assumed to be 10 to 30 years, as for other plastics.

The first step is the production of urea from ammonia:

$$2\ NH_3 + CO_2 \text{-->} H_2NCONH_2$$

The second step is the produciton of melamine from urea:

$$6\ H_2NCONH_2 \text{-->} C_3H_6N_6 + 6\ NH_3 + 3\ CO_2$$

So for every molecule of melamine, six molecules of CO_2 are needed, and only three molecules of CO_2 are emitted (see formulas above), so for every molecule of melamine, three CO_2 molecules are stored in the product, or – relating to urea used for the process - half of the carbon content of the urea (i.e. three C out of six) used as feedstock in step two is securely bound within the molecular structure.

According to the IPCC Guidelines no account should be taken for intermediate binding of CO_2 in downstream manufacturing processing and products. The rationale behind this guideance is that all emissions should be accounted for, and consideration of intermediate binding might result in an underestimation, if these amounts are not accounted for elsewhere, particularly as end of life emissions.

So even though the binding of carbon in melamine cannot be considered as long-time (which rather refers to several decades or centuries), the carbon stored in melamine is subtracted to avoid double counting of emissions, as the carbon in melamine is accounted for at the end of life as fossil carbon content of waste, and accounted for under the waste sector either as disposal (until 2004/2008 under *5.A*), or in the energy sector under *1.A Other Fossil Fuels*.

The Austrian approach of accounting for carbon stored in melamin is reported analoguesly to the approach used for plastics:

Plastics	**Melamine**
Production: fossil fuels used for production of plastics is accounted for as non-energy use of fuels, and thus accounted as carbon stored.	**Production:** fossil carbon used for melamine production is subtracted from carbon emissions, it is accounted for as carbon stored in melamine.

As carbon is bound within the molecular structure, no emissions during **use** occur.

End of life emissions are being accounted for as fossil carbon content of waste, and accounted for under the waste sector either as disposal (until 2004/2008 under *5.A*), or in the energy sector under *1.A Other Fossil Fuels*.

During the 2006 in-country review, the Austrian approach was explained to the ERT and accepted to be in line with the IPCC guidelines.

Table 154: CO_2 emissions from urea use

	CO_2 emissions from urea use in selective catalytic reduction (SCR) in the transport sector	CO_2 emissions from application of urea to soils in the agriculture sector
Reported in category	**2.D.3 Other**	**3.H Urea application**
Year	**[kt]**	**[kt]**
1990	NO	4.4
1991	NO	5.8
1992	NO	6.2
1993	NO	5.8
1994	NO	6.6
1995	NO	7.9
1996	NO	7.7
1997	NO	8.7
1998	NO	10.1
1999	NO	10.4
2000	NO	8.4
2001	NO	5.6
2002	NO	6.1
2003	NO	8.6
2004	NO	10.8
2005	0.4	11.8
2006	2.4	14.9
2007	6.6	17.9
2008	10.3	16.6
2009	12.8	22.0
2010	16.3	19.6
2011	16.6	18.4
2012	18.1	21.7
2013	23.4	21.5
2014	24.9	25.4
2015	26.9	26.5
2016	27.6	31.3
2017	30.5	30.0
2018	35.1	23.9
2019	40.2	19.2
2020	40.1	17.0
2021	45.8	15.7
1990-2021		**+256%**

Table 155 shows relevant parameters for the calculation of CO_2 emissions from ammonia production. The trend of the resulting CO_2 IEF (with respect to ammonia) decreases over time, when the fluctuations caused by the included melamine production are taken in account.

Table 155: Activity data, emissions and implied emission factor for ammonia production 1990–2021.

Year	Ammonia produced [t]	Natural gas input [TJ]	CO_2 Recovery[74] [kt]	CO_2 Emissions [kt]	CH_4 Emissions [t]	CO_2 IEF [kg/t ammonia]
1990	461 000	10 193	97	467	62	1 014
1991	475 000	10 441	87	492	64	1 035
1992	432 000	9 528	87	441	58	1 022
1993	469 000	10 321	78	493	63	1 052
1994	444 000	9 882	79	469	60	1 056
1995	473 000	10 516	74	509	61	1 076
1996	484 772	10 779	85	512	59	1 056
1997	479 698	10 666	85	505	81	1 054
1998	484 449	10 550	89	496	102	1 023
1999	490 493	10 689	90	502	55	1 024
2000	482 333	10 548	94	491	60	1 017
2001	448 176	9 989	105	449	51	1 001
2002	464 028	10 380	117	458	69	987
2003	510 887	11 324	132	495	47	970
2004	510 024	11 364	136	494	56	968
2005	478 427	10 719	132	462	94	966
2006	502 286	11 399	140	491	105	978
2007	441 299	10 015	132	423	141	957
2008	489 131	11 137	144	473	88	968
2009	449 395	10 214	137	429	71	954
2010	495 353	11 248	148	475	70	960
2011	502 461	11 347	134	494	77	984
2012	479 475	10 881	132	471	76	982
2013	435 244	9 840	122	423	225	971
2014	537 000	11 973	138	526	86	979
2015	519 860	11 562	139	501	91	964
2016	551 118	12 093	148	522	69	947
2017	507 689	11 071	146	467	91	921
2018	405 103	8 922	137	357	89	882
2019	552 973	12 091	152	520	67	941
2020	515 843	11 454	146	491	70	951
2021	527 858	11 614	145	500	48	948
1990-2021	**+15%**			**+7.1%**	**-22%**	

4.3.1.3 Category-specific QA/QC

The emission factor for natural gas is consistent with the emission factor used in fuel combustion. Natural gas input from the energy balance was checked for plausibility with ammonia production

[74] CO_2 emissions reported in other categories or bound in melamine.

figures using the conversion factor 0.451 t natural gas per tonne ammonia. This factor is plant specific and derived from natural gas input and ammonia output.

4.3.1.4 Uncertainty assessment

As activity data are obtained from the only ammonia plant in Austria, uncertainty is rated as very low (2%). Also the emission factor and other conversion factors are considered to have low uncertainties. Thus, the quality of emission estimates is rated as "high" (5% uncertainty). This leads to a combined uncertainty of 5.4%.

4.3.1.5 Recalculations

Updated urea amounts used in road traffic (see below, *2.D.3*) for the years 2005–2020, led to a redistribution of minor amounts between these two categories.

4.3.2 Nitric Acid Production (2.B.2)

4.3.2.1 Source Category Description

Emission: N_2O, CO_2

Key Source: Yes (N_2O)

N_2O emissions from nitric acid production are a key source due to their contribution to total greenhouse gas emissions in Austria in 1990 and in terms of their trend. In 2021, this source contributed 0.05% to the total amount of greenhouse gas emissions in Austria, whereas in 1990 the contribution was 0.99%.

In line with the IPCC 2006 Guidelines, N_2O emissions from nitric acid production are reported in category *2.B.2*. As in the CRF y only N_2O emission can be reported in this category, the CO_2 emissions are reported in *2.B.10.i CO_2 from nitric acid production*.

Nitric acid (HNO_3) is manufactured from ammonia (NH_3). In a first step, NH_3 reacts with air to NO and NO_2 and is then transformed with water to HNO_3.

Ammonia used as feedstock (gaseous or liquid) in the nitric acid plant always contains small amounts of methane, which is dissolved in ammonia. In Austria there is only one producer of nitric acid which operates two different dual pressure plants at one site. So called weak nitric acid is produced with a concentration of 59.6% HNO_3 by oxidation of ammonia produced at the same location (UMWELTBUNDESAMT 2001f). There is no production of concentrated nitric acid in Austria. Nitric acid is mainly used for the production of fertilisers.

Table 156 presents N_2O and CO_2 emissions from production of nitric acid for the period from 1990 to 2021.

N_2O emissions follow the trend of nitric acid production for the period 1990 to 2000 with only minor fluctuations. The increasing IEF between 1993 and 1994 is due to the closing down of part of a production facility that contributed to total emissions with lower specific N_2O emissions per produced unit of HNO_3. In 2007 and 2008 the IEF slightly increased again due to changes in the combustion system of one plant.

The decrease of the IEF is due to the introduction of emission reduction measures:

- 2001: installation of a new catalyst (IEF decreased from an average of 5.7 kg N_2O/t nitric acid to approx. 5.0 kg N_2O/t nitric acid)
- 2004: installation of a N_2O decomposition facility[75] called Uhde process (Envinox® process) for the combined removal of N_2O and NO_x from the tail gas of nitric acid plants. The IEF decreased from an average of 5.0 kg N_2O/t nitric acid, to approx. 1.6 kg N_2O/t nitric acid.
- May 2009: installation of a second catalyst in the nitric acid plant
- 2010: full operation of the second catalyst
- 2011 further optimisation of the production process as well as slightly reduced activities

The increase of the IEF (increase of N_2O emissions despite lower activities) in 2012 can be attributed to a combination of various reasons with the last option being the predominant one:

- Reduced activity of the catalyst over time
- Reduced activity of the catalyst at lower productivity
- Emissions dependent on which of the two plants was in operation as their N_2O emissions differ

In 2021, N_2O emissions were 94.6% below the emissions in 1990.

CO_2 emissions also varied over the period from 1990–2021, closely following the trend of nitric acid production until 1999. Specific emissions decreased since 2000 due to process optimisation (see implied emission factors in Table 156).

4.3.2.2 Methodological Issues

Following the IPCC Guidelines and monitoring and reporting guidelines[76] for the European Emission Trading System (ETS), plant specific measurement data was collected.

Activity and N_2O emission data was obtained directly from the plant operator. From 1998 onwards, emissions are measured continuously using a calibrated concentration monitor and volumetric flow meter. The monitoring method remained unchanged over time. Based on the analysed emission data of 1998 and due to the fact that the production technology has not changed between 1990 and 1998, emission factors per tonne of product were calculated for the technologies used (nitric acid has been produced at one site in five types of plants with different technologies over the years – with some of the plants closed or refurbished; currently two are in operation). With these estimates of plant specific emission factors and the production volume of the individual plants, the total emissions of N_2O per year were calculated.

Activity and emission data of CO_2 emissions from the years 1994 onwards have been reported directly to Umweltbundesamt by the plant operator and thus represent plant specific data. CO_2 emissions are measured discontinuously in the exhaust gas flow. The implied emission factor that was calculated from activity and CO_2 emission data from 1994 was applied to calculate CO_2 emissions of

[75] This facility is documented as example in BAT Reference Document LVIC-AAF, section 3.4.7 (EUROPEAN COMMISSION 2007)

[76] Commission Decision2007/587/EC of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

the years 1990 to 1993 as no CO_2 emission data was available for these years. Since 2008 the nitric acid plant is part of the EU ETS, and emissions reported are verified emissions.

Table 156: Activity data, emissions and implied emission factors for N_2O and CO_2 from nitric acid production 1990–2021

Year	Nitric acid produced [t]	N_2O emissions [t]	CO_2 emissions [kt]	N_2O IEF [kg/t]	CO_2 IEF [kg/t]
1990	529 998	2 942	0.41	5.55	0.78
1991	534 910	2 991	0.42	5.59	0.78
1992	484 731	2 702	0.38	5.57	0.78
1993	513 224	2 835	0.40	5.52	0.78
1994	467 391	2 662	0.36	5.70	0.78
1995	484 016	2 765	0.37	5.71	0.76
1996	495 738	2 820	0.38	5.69	0.76
1997	489 376	2 783	0.36	5.69	0.73
1998	504 977	2 893	0.38	5.73	0.75
1999	512 797	2 979	0.40	5.81	0.78
2000	533 715	3 070	0.37	5.75	0.69
2001	510 800	2 537	0.36	4.97	0.71
2002	522 410	2 604	0.37	4.98	0.70
2003	558 226	2 850	0.41	5.10	0.73
2004	572 719	906	0.41	1.58	0.71
2005	557 870	884	0.41	1.59	0.74
2006	579 623	904	0.42	1.56	0.72
2007	499 402	871	0.36	1.74	0.71
2008	561 749	1 051	0.40	1.87	0.71
2009	495 711	534	0.35	1.08	0.70
2010	547 699	205	0.40	0.37	0.73
2011	542 289	154	0.40	0.28	0.74
2012	534 641	170	0.39	0.32	0.74
2013	475 254	161	0.34	0.34	0.72
2014	552 041	159	0.40	0.29	0.73
2015	562 426	157	0.40	0.28	0.72
2016	567 507	120	0.41	0.21	0.72
2017	500 958	129	0.36	0.26	0.72
2018	429 840	189	0.32	0.44	0.73
2019	575 262	272	0.42	0.47	0.72
2020	556 936	176	0.40	0.32	0.71
2021	519 516	156	0.39	0.30	0.74
1990-2021	**-2.0%**	**-95%**	**-6.9%**		

4.3.2.3 Category-specific QA/QC

Measurements are done by an accredited testing body with internationally recognized standard methods. In the Austrian Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions[77], the requirements for laboratories carrying out the analysis are described in § 15 and in Annex 2, section 5 the methods for determination of the flue gas are described.

Furthermore at Austrian plants, continuous measurements of N_2O and NO_x are state-of-the-art technology and the emission values are forwarded online to the local authority.

Order of magnitude and time-series checks are performed and the operator is contacted in case of inconsistencies.

Further QA/QC checks:

- Comparison with BAT
  - Modern M/H-type plant complies with BAT
  - For older L/M-type plants no BAT conclusions have been drawn
- Comparison with international studies: ENTEC UK LIMITED (2006) page 15 and ECOFYS et al. (2009)

4.3.2.4 Uncertainty assessment

An uncertainty of 5% was considered for the EF as N_2O emissions are continuously measured. The uncertainty of activity data is assumed to be low (2%) as it is collected from the only plant in Austria. This results in a combined uncertainty of 5.4%.

4.3.2.5 Recalculations

No recalculations were performed for this year's submission.

4.3.3 Calcium Carbide Production (2.B.5.b)

4.3.3.1 Source Category Description

Emission: CO_2

Key Source: No

In this category the production of calcium carbide by reducing lime with carbon as well as production of acetylene from calcium carbide is considered – both processes lead to emissions of CO_2. Emissions from the preceding lime production step are reported in category 2.A.2 Lime production.

This category is a minor source of CO_2 emissions in Austria. In 2021, it contributed 0.06% of national total emissions.

[77] Überwachungs-, Berichterstattungs- und Prüfungsverordnung, Federal Law Gazette II No. 339/2007, as amended

For calcium carbid production quick lime is heated mixed with coke in an electric arc funace:

$$CaO + 3\,C \rightarrow CaC_2 + CO$$

$$CO + ½\,O_2 \rightarrow CO_2$$

Some of the produced carbid is used for production of acetylene, which is needed for welding:

$$CaC_2 + 2\,H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

4.3.3.2 Methodological Issues

Activity data (carbid production as well as cabid used for acetylene production) were directly reported by the plant operator of the only carbide production plant in Austria.

Emissions from carbide production were estimated using a country specific methodology.

The country specific emission factor was derived from a carbon balance of the process for 2020, accounting for the following carbon input/outputs and parameters:

Carbon input to the process was derived from coke and electrode use and purity of the materials

Carbon outputs:

- Stochimetrical CaC_2-carbon in product, considering the purity of the produced calcium carbide
- Elementary carbon in product
- Elementary carbon in waste from flue gas treatment

Balancing input with the outputs leaves carbon which is emitted as CO_2; from these emissions an EF related to carbide production is calculated: 0.589 t CO_2/ t of technical carbide.

It has to be noted, that the emission factor is low compared to the IPCC default value, as the IPCC default value considers excess coke is used for the generation of heat needed for the process, whereas in Austria an electric arc furnace is used.

Emissions from acetylene production are calculatied using the IPCC default valule of 1.1 t CO_2/ t of carbide used.

Table 157: Activity data and CO_2 emissions from calcium carbide and subsequent acetylene production 1990–2021 reported in CRF Category 2.B.5.b

Year	Calcium Carbide [t]	CO_2 Emissions [kt]
1990	28 951	38
1991	27 159	37
1992	31 896	40
1993	25 374	35
1994	19 406	31
1995	20 236	32
1996	25 324	35
1997	25 313	35
1998	27 043	36
1999	25 047	34
2000	37 130	43
2001	36 026	42
2002	31 488	39

Year	Calcium Carbide [t]	CO_2 Emissions [kt]
2003	32 010	39
2004	27 613	36
2005	27 677	38
2006	23 557	35
2007	28 004	38
2008	31 404	40
2009	32 459	41
2010	33 041	37
2011	38 155	44
2012	37 606	43
2013	37 159	43
2014	36 022	42
2015	40 639	46
2016	36 752	43
2017	33 361	41
2018	37 078	43
2019	35 545	42
2020	34 979	40
2021	36 322	44
1990-2021	**+25%**	**+17%**

4.3.3.3 Uncertainty Assessment

The uncertainty of the emission factor is estimated with about 10% and the uncertainty of activity data with 5% (default uncertainty from the IPPC 2006 Guidelines). This leads to a combined uncertainty of 11.2%.

4.3.3.4 Recalculations

Following a recommendation from the 2022 UNFCCC review, the EF for carbide production was reevaluated and emissions from acetylene production were included for the first time. Emissions from the calcination step in carbide production were reallocated to *2.A.2 Lime Production*. The overall effect on emissions from this category is -5.4 kt CO_2 in 2020.

4.3.4 Chemical Industry – Ethylene (2.B.8.b)

4.3.4.1 Source Category Description

Emission: CH_4

Key Source: No

Ethylene is produced by steam cracking of petrochemical feedstock (naphta). This production process leads to fugitive methane emissions. This category is a minor source of CH_4 emissions in Austria (1.50 kt CH_4 in 2019). In Austria, there is only one plant, which produces ethylene. This plant is located on the same general site as the refinery. According to information from the plant operator, no other products for which a guidance is provided in the IPCC 2006 Guidelines are produced at this site. Emissions from combustion including flaring are reported under *1.A.2.c*. All the GHG emissions of the plant have been verified under the EU-ETS.

4.3.4.2 Methodological Issues

Emissions were estimated using the IPCC default methodology.

Activity data are equal to the capacity of the only ethylene producing plant in Austria and amount to 350 000 t ethylene per year until 2005. In 2006, the capacity of the ethylene plant was expanded to 500 000 t. The IPCC default emission factor of 3 kg CH_4/t ethylene produced was used to calculate the emissions that amount to 1 050 tonnes CH_4 until 2005 and 1 500 tonnes CH_4 from 2006 onwards.

Depending on the further use of steam cracking by-products, this process may be a source of substantive CO_2 emissions. At the Austrian ethylene plant, all by-products are returned to the refinery, because this plant is located on the refinery site. Somehow it can be seen as a sub process of the refinery, but this ethylene plant does not belong to the same company as the refinery.

As the refinery and its related emissions are covered under sector 1, all CO_2 emissions related to by-products of ethylene production are reported in this sector. Hence, "IE" is reported under CO_2 emissions from category *2.B.8.b Ethylene*.

4.3.4.3 QA/QC

It was checked in 2021 that the production capacity used is still valid.

Uncertainty AssessmentThe uncertainty for *2.B.8* activity data is assumed to be 10%. The uncertainty of the emission factor is estimated to be about 10%. This leads to a combined uncertainty of 14.1%.

4.3.4.4 Recalculations

No recalculations were required for this year's submission.

4.3.5 Chemical Industry – Other: CO_2 from Nitric Acid Production (2.B.10.i)

Emission: CO_2

Key Source: No

As in category *2.B.2 Nitric Acid Production* only N_2O emission are to be reported, this category was incerted under "Chemical Industry - Other" to report CO_2 emissions from Nitric Acid production. For further details, please refer to chapter 4.3.2.

4.3.6 Chemical Industry – Other: Production of bulk chemicals (2.B.10.ii)

4.3.6.1 Source Category Description

Emission: CO_2

Key Source: No

The production of formaldehyde, maleic anhydride and phthalic anhydride involves process emissions of CO_2. Total CO_2 emissions from these processes amounted to 120 kt in 2021.

4.3.6.2 Methodological Issues

Detailed information on process emissions for the years 2013 onwards are available as these processes were included in the ETS in 2013. For the years prior 2013, the emission factors obtained in 2013 were used and applied to activity data obtained from industry.

4.3.6.3 Uncertainty Assessment

The uncertainty for *2.B.10* activity data is assumed to be 2%.The uncertainty of the emission factor is estimated to be about 5%. This leads to a combined uncertainty of 5.4%

4.3.6.4 Recalculations

During additional quality checks, a minor error of the year 2010 was found and corrected (-0.04 kt CO_2 in 2010).

4.3.7 Chemical Industry – Other: Production of Fertilizers and Urea (2.B.10.ii)

4.3.7.1 Source Category Description

Emission: CH_4, CO_2

Key Source: No

This category includes CH_4 and CO_2 emissions from the production of urea and from the production of fertilizers (NPK as well as calcium ammonium nitrate). There is only one producer of urea in Austria; it is also the main producer of fertilizers in Austria, both processes are downstream processes of ammonia production at that plant (see Figure 23).

This category is a minor GHG emission source in Austria: in 2021, total emissions from this category contributed 0.04% to national total emissions. They remained quite constant over the reporting period, basically following the trend of fertilizer production as CO_2 from fertilizer production is the main emission source of this category. In 2021, overall emissions from this category were 13% lower than in 1990.

4.3.7.2 Methodological Issues

No IPCC methodology is available for these sources.

Data for urea production were directly reported by the Austrian producer of urea and thus represent plant-specific data. Urea is a downstream manufacturing process of ammonia production. The input gases for urea production are NH_3 and CO_2; the latter is a by-product of ammonia production. In urea production, CO_2 is emitted at start-ups of the process and emissions are calculated from the number and duration of start-ups. The ammonia stream entering the process contains a small amount of non-reacted CH_4 that is released when NH_3 reacts to urea. These CH_4 emissions are calculated from the ammonia input into the urea production process and the methane content of the ammonia stream.

Urea production

CH_4 emissions from the production of urea were reported for the years 2002–2021. For earlier years, no emission data is available; therefore the implied emission factor for the year 2002 was used for all years. CO_2 emissions are reported by the operator since 1995. The IEF from this year was applied to calculate emissions for previous years.

Fertilizer production

Activity data for fertilizer production for 1990 to 1994 were taken from national statistics (STATISTIK AUSTRIA), for 1995 to 2020, production data were reported directly by the main producer of fertilizers in Austria.

Emission data for CO_2 emissions from the production of fertilizers for 1992 to 2021 were directly reported by industry and thus represent plant–specific data. The average implied emission factor of the years 1992-2003 was applied to the years 1990 and 1991. CO_2 emissions from fertilizer production were calculated by the plant operator using a mass-balance approach.

CH_4 emissions from the production of fertilizers were reported for the years 2002–2021; these data became available due to a measurement programme for CH_4 at the plant starting in 2002. For earlier years, no data is available; therefore the implied emission factor for the year 2002 was used for these years.

Table 158 presents activity data, emissions and implied emission factors for CH_4 and CO_2 emissions from *Fertilizer Production* and *Urea Production* for the period from 1990 to 2021.

Table 158: Activity data, emissions and implied emission factors for CO_2 and CH_4 from NPK fertilizer production and urea production, 1990–2021

Year	Urea Production				Fertilizer Production			
	Urea production [t]	**CO_2 [kt]**	**CH_4 [t]**	**IEF CO_2 [kg CO_2/t urea]**	**Fertilizer production [t]**	**CO_2 [kt]**	**CH_4 [t]**	**IEF CO_2 [kg CO_2/t fertilizer]**
1990	282 000	0.27	108	0.97	1388 621	30	184	22
1991	295 000	0.29	113	0.97	1273 467	28	168	22
1992	259 000	0.25	100	0.97	1182 595	38	156	32
1993	305 000	0.30	117	0.97	1250 804	34	165	27
1994	360 000	0.35	138	0.97	1222 578	22	162	18
1995	393 000	0.40	151	1.02	916 265	20	121	21
1996	417 705	0.30	161	0.73	940 313	18	124	19
1997	392 017	0.35	151	0.90	924 856	17	122	19
1998	395 288	0.29	152	0.73	977 212	19	129	19

Year	Urea Production				Fertilizer Production			
	Urea production [t]	CO_2 [kt]	CH_4 [t]	IEF CO_2 [kg CO_2/t urea]	Fertilizer production [t]	CO_2 [kt]	CH_4 [t]	IEF CO_2 [kg CO_2/t ferti-lizer]
1999	408 386	0.24	157	0.59	988 662	20	131	20
2000	390 185	0.22	150	0.57	1022 983	21	135	20
2001	367 218	0.26	141	0.70	959 698	20	127	21
2002	389 574	0.35	150	0.90	1013 767	24	134	23
2003	447 450	0.18	163	0.39	1073 940	24	134	22
2004	442 252	0.14	166	0.33	1090 069	24	126	22
2005	416 407	0.21	156	0.50	1043 916	24	149	23
2006	429 243	0.22	162	0.52	1092 182	26	149	24
2007	384 402	0.43	144	1.12	892 680	20	118	23
2008	419 711	0.34	157	0.80	1042 098	25	138	24
2009	400 420	0.29	151	0.72	859 852	16	120	19
2010	419 997	0.49	156	1.16	1051 087	26	140	25
2011	426 861	0.26	160	0.60	1058 249	26	138	24
2012	421 659	0.22	156	0.53	1034 833	28	137	27
2013	351 921	0.46	131	1.32	890 501	19	106	21
2014	433 364	0.20	159	0.46	1046 152	22	126	21
2015	434 587	0.20	160	0.46	1044 451	22	125	21
2016	446 020	0.22	165	0.50	1065 611	24	128	22
2017	420 106	0.40	156	0.95	949 667	24	113	25
2018	351 697	0.19	141	0.55	796 968	22	96	28
2019	448 535	0.22	167	0.50	1093 985	26	130	24
2020	438 127	0.16	202	0.37	1022 319	22	197	22
2021	456 800	0.11	236	0.25	990 179	22	159	23
1990-2021	**+62%**	**-59%**	**+117%**		**-29%**	**-26%**	**-14%**	

4.3.7.3 Uncertainty Assessment

The uncertainty for *2.B.10* activity data is assumed to be 2%. The uncertainty of the emission factor is estimated to be about 5%. This leads to a combined uncertainty of 5.4%.

4.3.7.4 Recalculations

During comprehensive quality checks a minor error of the 2010 value for CO_2 emissions from fertilizer production was identified and subsequently corrected.

4.4 Metal Production (Category 2.C)

4.4.1 Iron and Steel (2.C.1)

4.4.1.1 Source Category Description

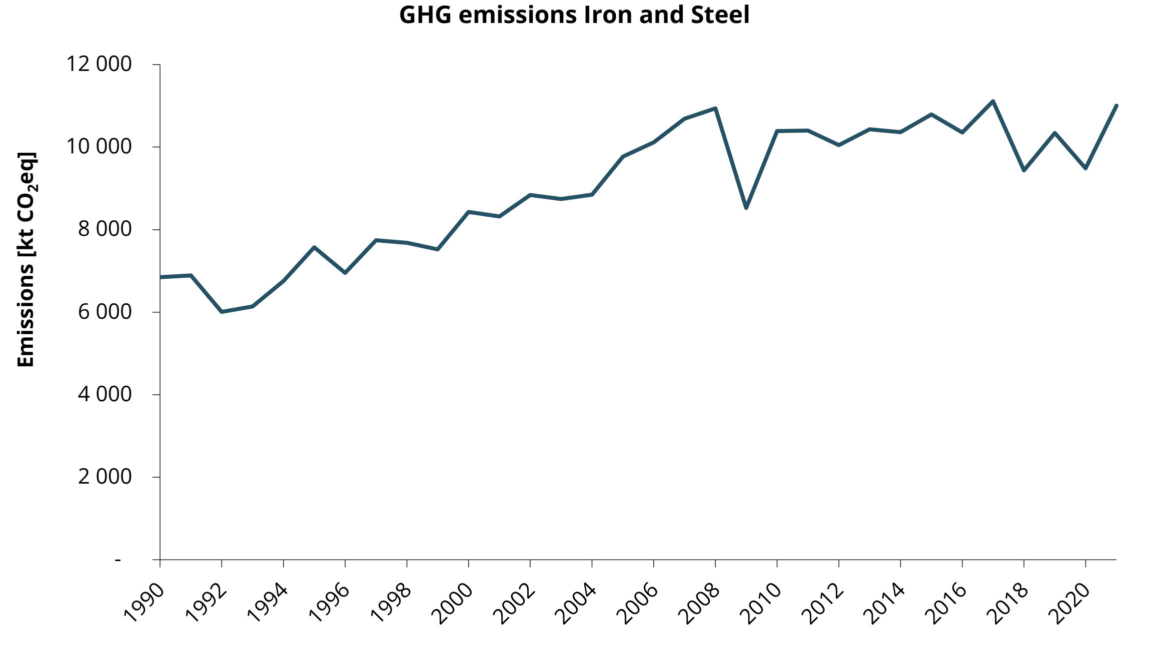
Emissions: CO_2
Key Category: Yes (CO_2)

CO_2 emissions from iron and steel production are an important key category of the Austrian greenhouse gas inventory because of their contribution to the total emission level for 1990 and for 2021 and in terms of their trend. In the year 2021, total emissions from production of iron and steel contributed 14.2% to total greenhouse gas emissions in Austria (see Chapter 1.5). In Austria, iron and steel production is concentrated at two integrated sites operated by the same company. It is the only company operating blast furnaces in Austria. Additionally there are companies operating electric arc furnaces, contributing approx. 10% to total steel production in Austria. Figure 24 presents total CO_2 emissions from the production of iron and steel for the period from 1990 to 2021.

The main driver behind CO_2 emissions from Iron and Steel Production is the production of iron and steel. The dip in 2009 was due to the economic downturn in 2009, the one in 2018 due to a shut down for upgrading of a blast furnace. Also the Covid pandemic 2020 led to lower production due to the economic effects of the pandemic. These effects were largely compensated in 2021: Iron and steel production increased significantly, almost reaching the same level as 2017. In 2021, CO_2 emissions were 61% above the level of 1990.

Also minor CH_4 emissions arise from this sector, the contribution to total GHG emissions from iron and steel production in Austria is below 0.05%.

Figure 24: GHG emissions from iron and steel production



Source: Umweltbundesamt

4.4.1.2 Methodological Issues

CO_2 emissions from integrated iron and steel plants

Process specific CO_2 emissions result from the use of reducing agents in pig iron production (in blast furnaces) and in steel production (lowering of the carbon content of pig iron).

Total CO_2 emissions from the two integrated iron and steel plants in Austira are reported in the ETS scheme since 2005, where they are also independently verified. They are calculated based on analysis of the carbon content and measurements of all relevant inputs such as coke, coal, natural gas, heating oil, plastics used as a substitute fuel, ore, limestone, scrap and additives, as well as outputs in iron and steel products and the carbon contained in coal tar, benzene, slag, dust and sludges.

According to the IPCC 2006 Guidelines, all emissions from iron and steel production should be reported under category *2.C.1*, irrespective of their role as reducing agent or fuel. However, as there is on site power generation taking place at the iron and steel production site, and also a coke oven is operated there, a carbon balance is applied to calculate CO_2 emissions that theoretically are attributable to iron and steel production itself and which are reported in *2.C.1.a*. The remainder of the verified total is then attributed to the energy sector as it is related to on site power plants and the coke oven operation. The carbon balance is based on the detailed ETS data on carbon inputs and outputs, but considers different system boundaries (only process directly related to iron and steel production and not the overall iron and steel production site). For this approach the ETS data is complemented with data taken from the national energy balance and data directly reported from the plant operator. As the detailed ETS data is only available since 2005, correlation techniques had to be used for the years 1990-2004. It has to be noted, that total CO_2 emissions for all years were calculated by the company on a detailed level (IPCC T3), the correlation techniques only add uncertainty to the split not to total emissions. Emissions of category *2.C.1.b* (pig iron) are reported as "IE", they are included in *2.C.1.a (steel)* as a further disaggregation is not feasible.

CH_4 emissions from integrated iron and steel plants

CH_4 emissions from sinter and coke production were calculated using plant specific EFs based on measurements. In 2003 and 2008 abatement measures were implemented, resulting in lower EFs.

CO_2 emissions from electric arc furnace steel production

Emissions were estimated using a country specific methodology.

CO_2 emissions for the year 2003 have been reported by each electric steel site in Austria. The IEF calculated for this year (52 kg/t steel) was also used to calculate emissions for earlier years and for 2004. For 2005–2020, verified CO_2 emissions, reported under the ETS, were used for the inventory.

The plant operators calculate emissions on the basis of the Austrian Monitoring, Reporting and Verification Ordinance[3]. The important part is §8(3) which defines the mass balance approach as the methodology to be used. Annex 2, (5) provides the relevant Tiers for this approach and the formula regarding carbon content.

The CO_2 emissions and production data are based on data of each of the three electric arc furnace plants in Austria. All CO_2 emissions from electric arc furnaces are allocated in *2.C.1* according to IPCC guidelines. There are no fuel related emissions.

[3] Überwachungs-, Berichterstattungs- und Prüfungs-Verordnung, Federal Law Gazette II No. 339/2007, as amended

The IEF depends on

- the raw material (carbon content of the used scrap)
- the production process (different processes with more or less input of electrical power and different additions of surcharges)

The increase of the IEF in 2005 is due to a change in the production process in one plant in Austria. The average IEF for the years 2005 to 2020 (approx. 0.066 kt CO_2 per kt steel) is in the range of the IPCC default value of 0.08.

Table 159 presents iron, steel and electric steel production and CO_2 emissions from this category.

Table 159: Activity data, emissions and implied emission factors for CO_2 from steel production 1990–2021

Year	**Iron and Steel Production**				**Electric Steel Production**		**Total**
	Iron [kt]	**Steel [kt]**	**CO_2 [kt]**	**CH_4 [t]**	**Electric Steel [kt]**	**CO_2 [kt]**	**CO_2 eq [kt]**
1990	3 444	3 921	6 821	231	370	20	6 847
1991	3 442	3 896	6 867	224	290	15	6 888
1992	3 074	3 592	5 982	203	361	19	6 007
1993	3 070	3 738	6 111	200	411	22	6 139
1994	3 320	3 968	6 726	214	431	23	6 754
1995	3 888	4 538	7 540	242	454	24	7 571
1996	3 432	4 032	6 927	224	396	21	6 954
1997	3 972	4 718	7 710	251	466	25	7 742
1998	4 032	4 801	7 648	256	503	27	7 681
1999	3 912	4 722	7 489	250	486	26	7 522
2000	4 320	5 183	8 391	263	541	29	8 427
2001	4 380	5 346	8 284	266	546	29	8 320
2002	4 669	5 647	8 803	281	538	28	8 839
2003	4 677	5 707	8 707	220	568	30	8 743
2004	4 861	5 901	8 810	226	614	32	8 849
2005	5 458	6 408	9 718	251	622	45	9 771
2006	5 565	6 487	10 060	254	643	49	10 116
2007	5 888	6 871	10 621	266	708	58	10 687
2008	5 846	6 873	10 876	142	723	57	10 938
2009	4 376	5 077	8 479	131	588	42	8 525
2010	5 644	6 570	10 341	123	637	47	10 391
2011	5 822	6 786	10 347	142	689	49	10 400
2012	5 751	6 746	9 999	140	674	46	10 049
2013	6 144	7 290	10 386	147	664	40	10 430
2014	6 015	7 185	10 318	144	691	39	10 361
2015	5 795	7 020	10 750	147	667	37	10 791
2016	5 634	6 766	10 315	143	672	36	10 356
2017	6 326	7 412	11 069	148	723	40	11 113
2018	5 263	6 176	9 390	141	721	41	9 435
2019	5 741	6 882	10 300	139	710	39	10 343
2020	5 286	6 187	9 448	150	680	34	9 486
2021	6 131	7 195	10 962	150	687	40	11 006
1990-2021	**+78%**	**+83%**	**+61%**	**-35%**	**+86%**	**+102%**	**+61%**

4.4.1.3 Category-specific QA/QC

Coke input from the energy balance is compared with coke input reported by the operator. Pig iron and steel production figures are compared with international published data (International Iron and Steel Institute) to ensure completeness. For 2005–2020, detailed information on the carbon mass balance applied by the company to calculate total emissions from pig iron and basic oxygen furnace steel were available from the EU ETS. Thus it was possible to validate CO_2 emissions with this background data.

The annual emission reports of the plant covered by the above mentioned ordinance regarding monitoring, reporting and verification of GHG emissions are checked by independent verifiers before submitting to the competent authority. On behalf of the Federal Ministry of Agriculture, Forestry, Environment and Water Management, the Umweltbundesamt conducts spot checks of the annual emissions and verification reports, time series consistency and consistency with monitoring plans.

In addition, the data included in the annual emission reports were checked regarding completeness and plausibility and they were also compared with national and international statistics (Statistic Austria and World Steel association[78]).

4.4.1.4 Uncertainty Assessment

The iron and steel industry is related to the energy sector, as the major share of CO_2 emissions results from the use of fossil fuel as reducing agent and for combustion. Thus, the same uncertainty values as for solid fuel combustion in large point sources have been applied, namely 0.5% for activity data and 0.5% for emission factor; this leads to an overall uncertainty for CO_2 emissions of 0.7% (WINIWARTER 2007).

4.4.1.5 Recalculations

During additional quality checks, it became obvious that one process stream (tar) was incorrectly included in the disaggregation of total CO_2 emissions from iron & steel production (which is verified ETS data) into process specific and energy related emissions reported under *1.A.2.a*. The correction resulted in a minor shift of emissions between these two categories.

Methane emissions from coke production are now estimated using plant specific data. Furthermore emissions reported for sinter production were corrected, as previously only CH_4-C was reported (+2.2 kt CO_2e in 2020).

[78] World Steel Association statistics archive, https://www.worldsteel.org/steel-by-topic/statistics.html

4.4.2 Ferroalloys Production (2.C.2)

4.4.2.1 Source Category Description

Emissions: CO_2

Key source: No

Ferroalloy production involves a metallurgical reduction process which results in CO_2 emissions.

This category is a minor source of CO_2 emissions in Austria: in 2021, emissions from this source contributed 0.02% to national total emissions.

4.4.2.2 Methodological Issues

Emissions were estimated using the IPCC Tier 1b methodology.

Only one company produces ferroalloys in Austria. Activity data of ferro-molybdenum, ferro-vanadium and ferro-nickel production from 1995 to 2010 were taken from publications of the *British Geological Survey* (BRITISH GEOLOGICAL SURVEY 2001, 2005–2010). As no data were available for 1990–1994, the value from 1995 was taken as a proxy for these years. For 2011, data was directly obtained from industry (personal communication) due to the late publication of the relevant report by the British Geological Survey. Similarly, data for 2012 to 2020 were obtained via personal communication from the British Geological Survey (BRITISH GEOLOGICAL SURVEY 2021), as the report had not been published at the time of emission calculation and the producer does not directly pass on information to the Umweltbundesamt. The identical value reported for 2018 and 2019 was confirmed by the British Geological Survey as the company's data.

The emission factor for ferro-nickel of 1.36 t CO_2/t product was taken from SJARDIN (2003) and applied to all ferroalloys as no specific emission factors for ferro-molybdenum and ferro-vanadium were available. Investigations were carried out in order to find adequate emission factors for ferro-molybdenum and ferro-vanadium. However, other countries where the production of ferroalloys is relevant are using country/plant specific emission factors. Therefore the emission factor used at present (based on a company specific report) was maintained.

Table 160: Activity data and emissions from ferroalloys production 1990–2021

Year	Ferroalloys production [kt]	CO_2 emissions [kt]
1990	15.3	20.8
1991	15.3	20.8
1992	15.3	20.8
1993	15.3	20.8
1994	15.3	20.8
1995	15.3	20.8
1996	13.8	18.8
1997	14.2	19.3
1998	14.1	19.2
1999	13.9	18.9
2000	13.9	18.9
2001	13.3	18.1
2002	12.6	17.1

Year	Ferroalloys production [kt]	CO_2 emissions [kt]
2003	12.3	16.7
2004	12.4	16.9
2005	13.8	18.7
2006	13.8	18.7
2007	14.5	19.7
2008	12.8	17.4
2009	12.7	17.3
2010	14.5	19.7
2011	14.5	19.7
2012	14.5	19.7
2013	14.5	19.7
2014	14.5	19.7
2015	14.5	19.7
2016	14.5	19.7
2017	14.5	19.7
2018	13.5	18.4
2019	13.5	18.4
2020	12.5	17.0
2021	12.5	17.0
1990-2021		**-18%**

4.4.2.3 Uncertainty Assessment

The uncertainty of activity data is assumed to be 5%.The uncertainty of the emission factor is estimated to be about 25%. This leads to a combined uncertainty of 25.5%.

4.4.2.4 Recalculations

No recalculations were made for this year's submission.

4.4.3 Aluminium Production (2.C.3)

4.4.3.1 Source Category Description

Emissions: PFCs, SF_6 and CO_2

Key Source: Yes (PFCs, SF_6 and CO_2)

This category includes emissions of CO_2, PFCs and SF_6 from aluminium production and is now a minor source of GHG in Austria: in 2021, emissions from this source amounted to 0.01% of the national total.

It is a key category for PFC emissions because of the contribution to the total level of greenhouse gas emissions in 1990; and a key source for both SF_6 and CO_2 emissions in terms of emission trends.

Primary aluminium production in Austria was terminated in 1992. Two PFCs, tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) are emitted from the process of primary aluminium smelting.

They are formed during the phenomenon known as the anode effect (AE). CO_2 emissions arise from the consumption of the anode in the production process.

During secondary aluminium production CO_2 emissions occur and SF_6 is used. Since 2000 SF_6 is used in minor amounts for special not regular needed applications. In 2019, the plant using SF_6 was closed SF_6 from 2020 onwards was thus set to NO, as production only ran until January 2019.

Table 161 presents CO_2 and PFC emissions from primary aluminium production for the period from 1990 to 1992 and the SF_6 and CO_2 emissions from secondary aluminium production.

Table 161: CO_2 and PFC emissions from primary aluminium production from 1990 to 1992 as well as SF_6 and CO_2 emissions from secondary aluminium production from 1990 until 2021

	Primary aluminium production		Secondary aluminium production	
Year	**CO_2 emissions [kt]**	**PFC emissions [t]**	**CO_2 emissions [kt]**	**SF_6 emissions [kg]**
1990	150	148	0.62	600.0
1991	150	148	0.62	600.0
1992	60	59	0.62	600.0
1993	NO	NO	0.62	600.0
1994	NO	NO	0.62	600.0
1995	NO	NO	0.62	600.0
1996	NO	NO	0.62	600.0
1997	NO	NO	1.95	600.0
1998	NO	NO	1.95	770.0
1999	NO	NO	1.95	690.0
2000	NO	NO	1.95	0.0
2001	NO	NO	1.84	0.0
2002	NO	NO	1.72	0.0
2003	NO	NO	1.61	0.0
2004	NO	NO	1.49	0.0
2005	NO	NO	1.38	0.0
2006	NO	NO	1.27	29.9
2007	NO	NO	1.15	12.6
2008	NO	NO	1.04	13.4
2009	NO	NO	2.91	3.3
2010	NO	NO	3.85	12.0
2011	NO	NO	3.96	6.8
2012	NO	NO	3.94	3.0
2013	NO	NO	4.09	1.5
2014	NO	NO	4.98	12.0
2015	NO	NO	4.92	1.5
2016	NO	NO	4.72	3.0
2017	NO	NO	5.43	3.0
2018	NO	NO	4.70	4.2
2019	NO	NO	4.93	0.3
2020	NO	NO	4.86	NO
2021	NO	NO	6.22	NO
1990-2021	**-100%**	**-100%**	**+910%**	**-100%**

4.4.3.2 Methodological Issues

For **primary aluminium production** CO_2 emissions were calculated by applying the IPCC default emission factor of 1.7 t CO_2/t aluminium produced taken from the IPCC 2006 Guidelines.

PFC emissions were estimated using the IPCC Tier 3b methodology. The specific CF_4 emissions (and C_2F_6 emissions respectively) of the anode effect were calculated by applying the following formula (BARBER 1996), (GIBBS & JACOBS 1996), (TABERAUX 1996):

$$\text{kg } CF_4/t_{Al} = (1.7 \times AE/pot/day \times F \times AE_{min})/CE$$

Where:
AE/pot/day = frequency of occurrence of the anode effect (dependent on type of oxide supply (1,2/day)
t_{Al} = effective production capacity per year [t]
CE = current efficiency (85%)
AE_{min} = anode effect duration in minutes (5 min)
1.7 = constant resulting from Faraday's law
F = fraction of CF_4 in the anode gas (13%)

In Austria so called "Søderberg" anodes were used. The technology applied was head to head HSS. The frequency of the anode effect (AE/pot/day) was about 1.2 per day. The duration of the anode effect (AE_{min}) was in the range of 4 to 6 minutes. The average fraction of CF_4 formed in percent of the anode gas (F) can be determined as a function of the duration of the anode effect. International values are about 10% after two minutes, 12% after three minutes and after that there is only a marginal increase. Therefore for Austrian aluminium production a CF_4 fraction in the anode gas of 13% was assumed.

Because C_2F_6 is formed only during the first minute of the anode effect, the rate of C_2F_6 is the higher the shorter the duration of the anode effect is. For the aluminium production in Austria the rate of C_2F_6 is about 8% and the current efficiency (CE) about 85.4%.

Activity data were taken from national statistics (88 021 t for 1990 and 1991, and 35 000 t in 1992).

By inserting these data into the formula mentioned above an emission factor of 1.56 kg CF_4/t aluminium was calculated. The resulting emission factor for C_2F_6 was 0.1248 kg per tonne of aluminium produced.

For **secondary aluminium production**, detailed information on process CO_2 emissions for the year 2013 is available as this process was included in the ETS in that year. For the years prior 2013, the emission factors obtained in 2013 were used and applied to activity data obtained from industry.

For **aluminium casting** SF_6 as a fire quencher was used until 1999. From the (formerly) six secondary aluminium smelters only one started the use of SF_6 as cleaning gas again from 2006 onwards until 2019 when the plant was closed. For these recent years an EF of 1.5% of SF_6 consumed was applied. This EF is based on measurements in a German aluminium plant that have shown significant destruction of SF_6 (decomposition into sulphur and fluorine) during the process (SCHWARZ & GSCHREY 2009).

4.4.3.3 Uncertainty Assessment

The uncertainty for the PFC emission factors ("Søderberg" process) is between 30–80% according to the IPCC. Activity data do not influence the uncertainty of emissions to that extent, because PFCs are formed during the anode effect that is associated with the EF. Assuming a mean value for the emission factor, the uncertainty of PFC emissions is 50%.

Uncertainty of CO_2 emissions is assumed to be 2%, mainly deriving from AD uncertainty (WINIWARTER 2007).

4.4.3.4 Recalculations

No recalculations were made for this year's submission.

4.4.4 Magnesium Production - Magnesium Foundries (2.C.4)

4.4.4.1 Source Category Description

Emissions: SF_6

Key Source: Yes (SF_6)

This category includes emissions of SF_6 from magnesium foundries. This source is a key category due to its trend in emissions.

In 1990, SF_6 emissions from magnesium foundries contributed 0.003% to the total amount of greenhouse gas emissions in Austria, in the year 2021 very low emissions arose from this category.

Molten magnesium spontaneously burns in the presence of atmospheric oxygen. Therefore, in magnesium casting SF_6 is used in small amounts in blends with carrier gases as a protective cover gas to prevent oxidation and ignition and to quench fires of molten magnesium. It has been a common assumption that the SF_6 in magnesium cover gas will not be destroyed but more or less completely emitted. Recent studies showed that SF_6 undergoes destruction to some degree. The low intensity of this process depends on specific operation conditions. Industry introduced alternative cover gases in the last years.

Table 162 presents SF_6 emissions from magnesium for the period from 1990 to 2021.

As can be seen in the table below, SF_6 emissions have been fluctuating during the period, but the overall trend has been decreasing SF_6 emissions; from 1990 to 2021 they decreased by 98%. This decreasing trend is explained by technological advances (rebuilt magnesium foundry) and the replacement of SF_6 by other substances ($N/CO_2/SO_2$; SO_2/N_2) used as a cover gas; since 2008 the use of SF_6 per foundry is limited to 850 kg per year in Europe[79]. Currently, only one magnesium foundry uses SF_6 as a cover gas for one particular magnesium alloy that is produced irregularly.

Table 162: SF_6 emissions from magnesium foundries 1990–2021

Year	SF_6 emissions [t] from magnesium production
1990	10.00
1991	11.00
1992	10.00

[79] Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases.

Year	SF_6 emissions [t] from magnesium production
1993	11.00
1994	15.00
1995	17.94
1996	24.95
1997	14.01
1998	6.10
1999	0.24
2000	1.55
2001	1.20
2002	0.30
2003	0.15
2004	0.00
2005	0.20
2006	0.50
2007	0.00
2008	0.00
2009	0.02
2010	0.00
2011	0.00
2012	0.19
2013	0.39
2014	0.67
2015	0.10
2016	0.10
2017	0.67
2018	0.24
2019	0.14
2020	0.20
2021	0.20
1990-2021	**-98%**

4.4.4.2 Methodological Issues

Emissions were estimated following the IPCC methodology using annual consumption data of SF_6.

Information about the amount of SF_6 used was obtained directly from the magnesium producer in Austria and thus represents plant-specific data. Actual emissions of SF_6 equal potential emissions and correspond to the annual consumption of SF_6 for magnesium casting. During the last ten years, two magnesium casting companies existed in Austria which at some point used SF_6 as fire-extinguishing cover gas. One company changed to a $N_2/CO_2/SO_2$-system. The other company changed to fluorinated ketone (Novec) as an alternative cover gas, but continued the use of SF_6 to quench fires.

4.4.4.3 Category-specific QA/QC

The IEFs for magnesium casting (based on the amount of magnesium cast) are below the value of 1.0 kg SF_6 emissions cited in the IPCC 2006 Guidelines (p. 4.66).

4.4.4.4 Uncertainty Assessment

According to the IPCC 2006 Guidelines the uncertainty associated with plant SF_6 use data is very low (5%).

4.4.4.5 Recalculations

No recalculations were made for this year's submission.

4.4.5 Lead production (2.C.5)

4.4.5.1 Source Category Description

Emission: CO_2

Key Source: No

Primary lead production existed in Austria until 1993. CO_2 emissions originate from the use of coke as reducing agent. These emissions are reported in Sector 1, because this coke use is included in the energy balance together with the energetic use of coke.

In the secondary lead production CO_2 emissions are caused by the content of substances in the secondary raw material. The secondary lead production from 1990 until 2021 has a fluctuation range of ± app.20%.

This category is a minor source of CO_2 emissions in Austria: in 2021, emissions from this source contributed less than 0.01% to national total CO_2 emissions.

4.4.5.2 Methodological Issues

Activity data until 2016 are taken from the Montanhandbuch (BMWFW 2017), which provides annual data of the Austrian secondary lead production. The CO_2 emissions of secondary lead production are calculated with the IPCC default emission factor of 0.2 t CO_2/t lead produced. Since 2016 there are no data available, the annual production for 2015 was used.

Table 163: Activity data and CO_2 emissions from secondary lead production 1990–2021

Year	Secondary lead production [t]	CO_2 Emissions [kt]
1990	23 511	4.7
1991	22 679	4.5
1992	18 203	3.6
1993	17 857	3.6
1994	21 869	4.4
1995	21 869	4.4
1996	21 891	4.4
1997	21 912	4.4
1998	21 934	4.4
1999	21 955	4.4
2000	21 977	4.4
2001	21 998	4.4

Year	Secondary lead production [t]	CO_2 Emissions [kt]
2002	22 020	4.4
2003	22 041	4.4
2004	23 826	4.8
2005	24 357	4.9
2006	28 120	5.6
2007	28 564	5.7
2008	26 902	5.4
2009	22 197	4.4
2010	25 499	5.1
2011	26 208	5.2
2012	24 504	4.9
2013	24 971	5.0
2014	25 136	5.0
2015	24 399	4.9
2016	25 000	5.0
2017	26 000	5.2
2018	27 000	5.4
2019	27 000	5.4
2020	27 000	5.4
2021	27 000	5.4
1990-2021		**+14.8%**

4.4.5.3 Uncertainty Assessment

The uncertainty of the emission factor is estimated with about 50% and the uncertainty of activity data with 10%. This leads to a combined uncertainty of 50.1%. These uncertainties are IPPC default values for the Tier 1 method in the secondary lead production.

4.4.5.4 Recalculations

Activity data from the year 2016 onwards were updated (+0.5 kt CO_2 in 2020).

4.5 Non-Energy Products from Fuels and Solvent Use (Category 2.D)

4.5.1 Source Category Description

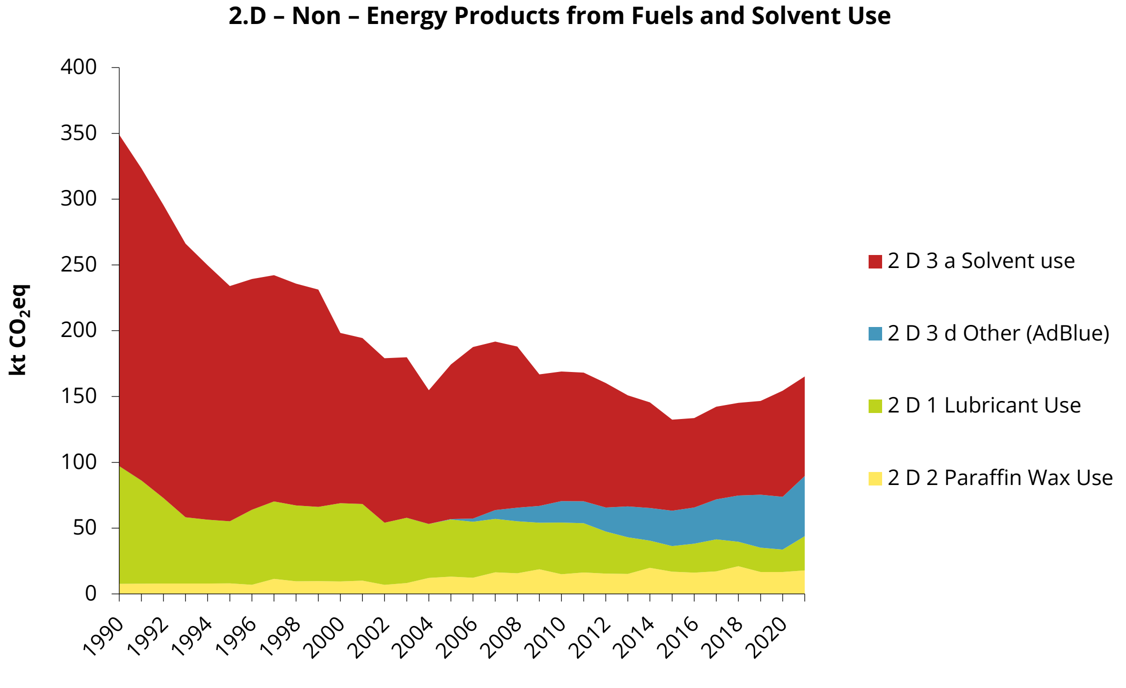
Emissions: CO_2 (some of those are emitted indirectly)

Key category: Yes (CO_2)

This chapter entails CO_2 emissinos from non-energy products from fuels and indirect CO_2 emissions from solvent use in Austria. The direct emissions arise from lubricant use and from paraffin waxes, indirect emissions are calculated from NMVOC emissions from solvent use.

In the year 2021, 0.2% of total GHG emissions in Austria (165.3 kt CO_2 equivalents) originated from category *2.D Non-Energy Products from Fuels and Solvent Use*. The overall trend in greenhouse gas emissions in this sector shows decreasing emissions, with a decrease of 52.6% from 1990 to 2021, due to legal measures related to solvent use.

Figure 25: Emissions from Sector 2.D, Non-Energy Products from Fuels and Solvent Use, 1990–2021



Source: Umweltbundesamt

Table 164 presents the trend in total greenhouse gas emissions by subcategories.

Table 164: Total greenhouse gas emissions and trend from 1990–2021

	2.D.1	2.D.2	2.D.3.a	2.D.3.d
Year	**Lubricant Use**	**Paraffin Wax Use**	**Solvent use**	**Other (AdBlue)**
1990	89.5	7.7	251.8	NO
1991	78.5	7.8	237.2	NO
1992	65.0	7.8	222.6	NO
1993	50.3	7.9	208.0	NO
1994	48.4	7.9	193.4	NO
1995	47.2	8.0	178.8	NO
1996	57.0	6.9	175.4	NO
1997	58.9	11.4	172.0	NO
1998	57.6	9.6	168.6	NO
1999	56.4	9.7	165.2	NO
2000	59.5	9.5	129.4	NO
2001	58.2	10.1	126.1	NO
2002	47.2	6.9	125.0	NO
2003	49.7	8.2	121.9	NO
2004	41.1	12.1	101.6	NO

	2.D.1	2.D.2	2.D.3.a	2.D.3.d
Year	**Lubricant Use**	**Paraffin Wax Use**	**Solvent use**	**Other (AdBlue)**
2005	43.4	13.1	117.5	0.4
2006	42.6	12.2	130.3	2.4
2007	40.6	16.5	128.1	6.6
2008	39.5	15.7	122.5	10.3
2009	35.4	18.7	100.0	12.8
2010	39.3	14.9	98.5	16.3
2011	37.5	16.2	97.8	16.6
2012	32.1	15.4	94.7	18.1
2013	27.9	15.2	84.4	23.4
2014	20.6	19.9	80.3	24.9
2015	19.5	16.9	69.2	26.9
2016	22.0	16.1	68.0	27.5
2017	24.3	17.1	70.4	30.5
2018	18.6	21.0	70.4	35.1
2019	18.5	16.6	71.3	40.2
2020	17.1	16.6	80.7	40.1
2021	26.0	17.8	75.7	45.8
1990-2021	**-71%**	**+132%**	**-70%**	

4.5.2 Methodological issues

4.5.2.1 Lubricant Use (2.D.1)

Emission calculation follows the methodology of the IPCC 2006 Guidelines: The amount of lubricants used in Austria was taken from the Energy Balance (total final non energy use consumption).

Lubricants used for 2-stroke engines were not reported separately due to lack of data. As a rough estimate of the amount of lubricants used in the 431 million km driven by 2 stroke engines per year amount to only 1 kt CO_2, these emissions are considered to be taken into account by using an ODU factor of 0.2 for the total lubricant use of Austria.

Lubricant Use was estimated according to the IPCC Tier 1 method described in the Guidelines:

$$CO_2\ emissions = LC * CC_{Lubricant} * ODU_{Lubricant} * 44/12$$

Where: *LC = total lubricant consumption in TJ (taken from the Austrian Energy Balance)*

$CC_{Lubricant}$= default value of carbon content of lubricants (20 t C/TJ)

$ODU_{Lubricant}$ = ODU factor (0.2), based on default composition of oil and grease)

44/12 = mass ratio of CO_2/C

4.5.2.2 Paraffin Wax Use (2.D.2)

Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants and many others. Emissions from the use of waxes derive primarily when the waxes or derivates of paraffins are combusted during use (e.g. candles) when they are incinerated with or without heat recovery or in wastewater treatment. In the cases of incineration and wastewater treatment, the emissions should be reported in the energy or waste sectors respectively. It is also assumed that boxes and papers, as well as food production are accounted for in the respective sectors.

Activity data for paraffin wax use is taken from the import and export statistics of candles and wax products, as well as the production statistics of candles. Production statistics on candles are only available for the past 8 years, for the years before the average of available data was used for the rest of the reporting period. As statistical data on the imports and exports was only available until 1995, the years before were correlated with population growth.

The amount of candles used in Austria was then converted into TJ, using a Net Calorific Value of 40.2 TJ/kt, from this CO_2 emissions were calculated according to the IPCC Guidelines Tier 1 method:

$$CO_2\ Emissions = PW * CC_{wax} * ODU_{wax} * 44/12$$

Where: *PW = total wax consumption in TJ*
CC_{wax} = carbon content of paraffin wax (default, 20 t C/TJ)
ODU_{wax} = ODU factor for paraffin wax, fraction (0.2)
44/12 = mass ratio of CO2/C

4.5.2.3 Other: Solvent Use (2.D.3)

This chapter describes the methodology used for calculating NMVOC emissions from *Solvent and Other Product Use* in Austria. Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). After application of these substances or other procedures of solvent use most of the solvents are released into air. Because solvents consist mainly of NMVOC, solvent use is a major source for anthropogenic NMVOC emissions in Austria. Once released into the atmosphere NMVOCs react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2.

Already in the early 1990ies the VOC content of products such as paints, varnishes, preservatives and glues was limited in Austria, the use of CKWs and benzene was largely prohibited, the content of aromatic compounds limited and measures for installations applying VOC containing products were set:

- Solvent Ordinance (1991)[80] (repealed by Solvent Ordinance 1995)
- Solvent Ordinance 1995[81] (repealed by Solvent Ordinance 2005)
- Paint finishing systems Ordinance (1995)[82] (repealed by VOC Installations Ordinance)

In the subsequent years the legislation was adapted to be in line with European legislation:

[80] Verordnung des Bundesministers für Umwelt, Jugend und Familie über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung**), BGBl. Nr. 492/1991

[81] Verordnung des Bundesministers für Umwelt über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung 1995 – LMVO 1995**), BGBl 872/1995

[82] Verordnung des Bundesministers für wirtschaftliche Angelegenheiten über die Begrenzung der Emission von luftverunreinigenden Stoffen aus Lackieranlagen in gewerblichen Betriebsanlagen (**Lackieranlagen-Verordnung**), BGBl. Nr. 873/1995

- VOC Installations Ordinance (2002)[83], implementation of "Solvent Emission Directive"[84]
- VOC Ordinance 2005[85] – implementation of "Paints Directive"[86]
- Amendment of VOC Ordinance (2005) [87] – implementation of "Industrial Emissions Directive" 2010/75/EC[88]

Measures implemented in emission intensive activity areas such as coating, painting and printing as well as in the pharmaceutical industry range from primary measures such as substitution of solvents, reduction of solvent contents and shift to lower or non-solvent emitting processes to secondary measures which basically is waste gas treatment.

Indirect CO_2 emissions from solvent use were calculated from NMVOC emissions of this sector.

NMVOC emissions

Emissions are estimated using a combination of

- Top-down data from national statistics which provide information on the overall solvent use in Austria
- with bottom-up information from company solvent balances in solvent consuming sectors

Top down data:

From national import/export and production statistics the national consumption of solvents is obtained:

National consumption of Substance$_i$ = (Substance$_i$ Import – Substance$_i$ Export + Substance$_i$ Production)

The non-solvent use of substances (i.e. where the substance is used as a reagent) is subtracted from national consumption:

Solvent Use per Substance$_i$ = Solvent Balance per Substance$_i$ - Non Solvent Use of Substance$_i$

For products containing solvents, such as paints and glues, a balance of imports and exports is made, and the solvent content is estimated. The production of solvent containing products is not

[83] Verordnung des Bundesministers für Wirtschaft und Arbeit zur Umsetzung der Richtlinie 1999/13/EG über die Begrenzung der Emissionen bei der Verwendung organischer Lösungsmittel in gewerblichen Betriebsanlagen (VOC-Anlagen-Verordnung – VAV) BGBL II Nr. 301/2002

[84] Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations

[85] Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Begrenzung der Emissionen flüchtiger organischer Verbindungen durch Beschränkung des Inverkehrsetzens und der Verwendung organischer Lösungsmittel in bestimmten Farben und Lacken (**Lösungsmittelverordnung 2005 – LMV 2005**), BGBl. II Nr. 398/2005

[86] Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in decorative paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC

[87] Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, mit der die Lösungsmittelverordnung 2005 geändert wird (**Änderung der Lösungsmittelverordnung 2005**), BGBl. II Nr. 25/2013

[88] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

accounted for in this equation, as the amount of solvents used for their production are already accounted for in the above mentioned consumption of solvents:

Solvents in Product$_p$ = (Solvent-containing Product$_p$ Import – Solvent-containing Product$_p$ Export) Solvent content of Product$_p$*

The overall solvent use in Austria is then calculated as the sum of the balances per substance and the amounts of solvents contained in products imported and exported:

Overall solvent use in Austria = $\sum_i$ Solvent Consumption of Substance$_i$ + $\sum p$ Solvents in Product$_p$

Bottom up data

Domestic solvent use

For the year 2000, data for domestic solvent use was obtained through a survey of 1 800 households (WINDSPERGER et al. 2002a). In this survey, the use of solvent-containing products of 37 categories in 5 main groups was collected: cosmetic, do-it-yourself, household cleaning, car, pesticides and insecticides. In addition, solvent use in the context of moonlighting besides commercial work and do-it-yourself (DIY) was estimated.

For 2015ff data from import/export statistics were used to index the annual changes in consumption.

For the emission factors an expert judgment for households was available (WINDSPERGER et al. 2002a) which was updated in 2015 based on information from the German inventory.

Data for the years in between was intrapolated.

Paints used in construction and domestic paint use

Statistical data was combined with information on the average solvent content of paints derived from studies of the effects of the Ecopaint Directive. Activity data reflects the solvent content of paints and not the amount of paints used, thus an emission factor of 95% is applied.

Industrial and commercial solvent use

The time series is mainly based on suveys of the years 2000, 2015 and 2019.

For 2000 and 2002 an extensive survey on the use of solvents was carried out in 1 300 Austrian companies (WINDSPERGER et al. 2002b). In this survey data about the solvent content of paints, cleaning agents etc. and on solvents used (both substances and substance categories) like acetone or alcohols were collected. Furthermore information were gathered about:

- type of application of the solvents
  - final application,
  - cleaner,
  - product preparation;
- type of waste gas treatment
  - open application,
  - waste gas collection,
  - waste gas treatment.

For every category of application and waste gas treatment an emission factor was estimated to calculate solvent emissions in the year 2000 (see Table 165).

Table 165: Emission factors for NMVOC emissions from Solvent Use.

Category	Factor
final application	1.00
cleaner	0.85
product preparation	0.05
open application	1.00
waste gas collection	0.50
waste gas treatment	0.20

The above mentioned survey was carried out in all industrial branches with solvent applications; results for solvent use per substance category were collected at NACE-level-4. The total amounts of collected solvents were extrapolated using the number of employees to upscale to the total industrial branch (STATISTIK AUSTRIA 2000 & 1998 and using information from KSV1870 INFORMATION 2000). Furthermore, the data set was extrapolated to historical years using the same (1980, 1990, 1995) factor "solvent use per employee" , where the number of employees of the respective year were again taken from national statistics (Statistik Austria 2001) (WINDSPERGER et al. 2004). For the pillar year 2005 the structural business statistics (number of employees (NACE Rev.1.1)) were taken from (EUROSTAT 2008).

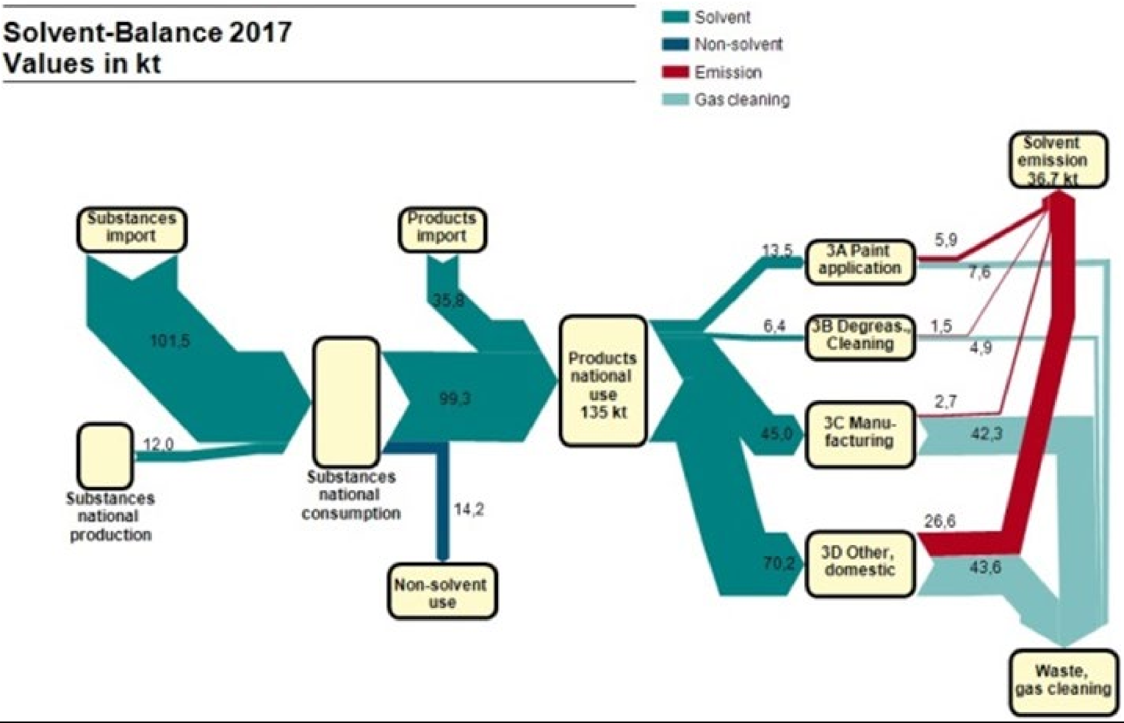
To finally estimate emissions from AD, development of the economic and technical situation in relation to the year 2000 was also considered. The information were collected for three pillar years (1980, 1990, 1995) and were taken from several studies (SCHMIDT et al. 1998, BARNERT 1998) and expert judgements from associations of industries (chemical industry, printing industry, paper industry) and other stakeholders.

For the year 2015 and again for the year 2019 an extensive research was based on solvent balances of those companies that were obliged to report their use of solvents as well as emissions under directive 1999/13/EC (VOC Solvents Directive). Some of these reports did not offer information on activity data, so gap filling was provided by the IIÖ (Windsperger et al. 2019). The companies were then allocated to the different NACE categories, and – for categories where the reporting obligation does not affect all companies as there is a certain threshold – the collected emissions and activity data were scaled up using the number of employees as explained above.

Activity Data (i.e. total amount of solvents used) was linearly interpolated between all years for which data was not available (1991-1994, 1996-1999, 2001, and 2003–2015, between 2015 and 2019; for 2020 the data of 2019 was used).

Figure 26: Sankey model of the calculation of solvent emission.

Sankey model of the calculation of solvent emission



Source: WINDSPERGER et al. (2019) umweltbundesamt

Top down / bottom up combination

Data from the top down approach (for the reference year 2000, up to 2002 as well as 2015 and 2019) were compared with data from the /bottom up approach, and as there where large discrepancies further investigations were performed. Additional solvent uses were identified (such as windscreens wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism, cement- respectively pulp industry as well as additionally identified non-solvent uses) and added to the model (WINDSPERGER et al. 2002a und b).

The remaining gap is 4-20%. Finally, the bottom up data was adjusted to finally match the top down sum. For the years 2000-2003 all sub-categories were adjusted equally. From 2015 onwards the up-scaling was done only for those sub-categories in which no full survey had been achieved.

For the 2022 submission only top-down data was updated. The increase in the overall solvent use in Austria was verified with industry to be in the range of expected increased disinfectant use due the pandemic. Therefore, and because no information on the development in other categories was available, this increase was soley attributed to the domestic use sub category. To avoid underestimation of emissions, another 1 kt of desinfectant was added to the total sum, as due to emergency law, pharmacies and small companies were allowed to produce disinfectants and denaturate ethanol themselves without customs officials being present.

4.5.3 Category-specific QA/QC

Generally, the methodology includes an internal validation as data from the bottom up approach is checked against data from the top down approach: whilst bottom-up activity data calculated for the year 2015 matched the top-down sum by 87%, the gap for the year 2019 was only 4%.

Top down input data, which are statistical data for production as well as import and export, time series are checked for plausibility. As the categories change from time to time it also has to be checked if all relevant substances and products are still accounted for.

As a QA measure, an input data audit was held concerning import/export as well as production statistics to better understand the statistic as well as its drawbacks and uncertainty.

For non-solvent use data obtained from industry are checked against data taken from the statistics, typically a relatively constant amount of the substance remains after subtraction of non-solvent use.

Bottom up data has been checked on installation basis on plausibility by industrial processes experts.

4.5.3.1 Other (2.D.3.d)

This contains emissions of the additive 'AdBlue' which is used in transportation. 'AdBlue' is the generic name of a 32.5% urea-water solution used to reduce NO_x emissions in SCR catalytic converters used in road- and off-road transportation. During that process, CO_2 emissions occur that are taken into consideration in this sector. 'AdBlue' has been in use since 2004 for heavy vehicles, and since 2014 for passenger cars. In literature, the 'AdBlue' consumption is usually given as a volumetric ratio of the fuel consumption (litres of 'AdBlue' equivalent to litres of diesel). Common values for this are, for example, 3–5% for EURO IV vehicles and 4-6% for Euro V SNF. For the inventory a more detailed approach is used which considers the specific operating condition of the SCR exhaust gas after-treatment system in any driving condition (REXEIS et al. 2013).

4.5.4 Uncertainty Assessment

For the subcategory 2.D.3 uncertainty for the emission factors is estimated to be 30%, and for activity data 20%.

There is no statistical recording of activity data for the lubricant 'AdBlue'. The activity data is calculated with a detailed bottom-up approach and the uncertainty for activity data is estimated to be +/–20% (expert judgement by Technical University Graz 2015).

4.5.5 Recalculations

During comprehensive quality checks several minor errors of the VOC directive data analysis used as basis for the bottom up approach for the years 2015 and 2019 were identified and subsequently corrected. As data from 2002 to 2015 is interpolated, this affected emissions from 2003 onwards (+0.01 kt CO_2e in 2020).

4.5.6 Planned Improvements

It is panned to collect bottom up data reported by industrial installations under the Austrian Solvents Ordinance framework and to re-evaluete the emission estimate for domestic solvent use.

4.6 Electronics Industry (Category 2.E) – Integrated Circuit or Semiconductor Manufacturing (2.E.1)

4.6.1 Source Category Description

Emissions: HFC, PFC, SF_6, NF_3

Key Source: no

All emissions from 2.E Electronics Industry arise from subcategory 2.E.1 Integrated Circuit or Semiconductor.

4.6.2 Methodological Issues

Three semiconductor manufacturing companies in Austria currently emit CF_4, CHF_3, C_2F_6, C_3F_8, C_4F_8, NF_3 and SF_6. Emissions are calculated by the companies from the annual consumption of each fluid by plant and the effectiveness of the respective abatement technologies (Tier 2a according to IPCC 2006). According to the reporting obligation under the Austrian Industrial Gas Ordinance (see next chapter for more information), semiconductor manufacturers have to report their use of fluorinated gases every year. Therefore, plant specific data is available since 1999. In the manufacturing plants of one operator, fluorinated gases are used in a closed system, where they are recycled for repeated use. These gases were reported as potential emissions in earlier years.

Because of confidentiality claimed for consumption data in this industry emissions are reported in the CRF only for the sum of HFC and PFC. Gases and their applications are presented below:

- SF_6: Isolation gas for high-voltage measurement / process gas for plasma-etching,
- CF_4, C_2F_6, C_3F_8, C_4F_8, NF_3: Process gas for plasma-etching / cleaning chemical vapour deposition,
- CHF_3: Process gas for plasma-etching

Emission Trends

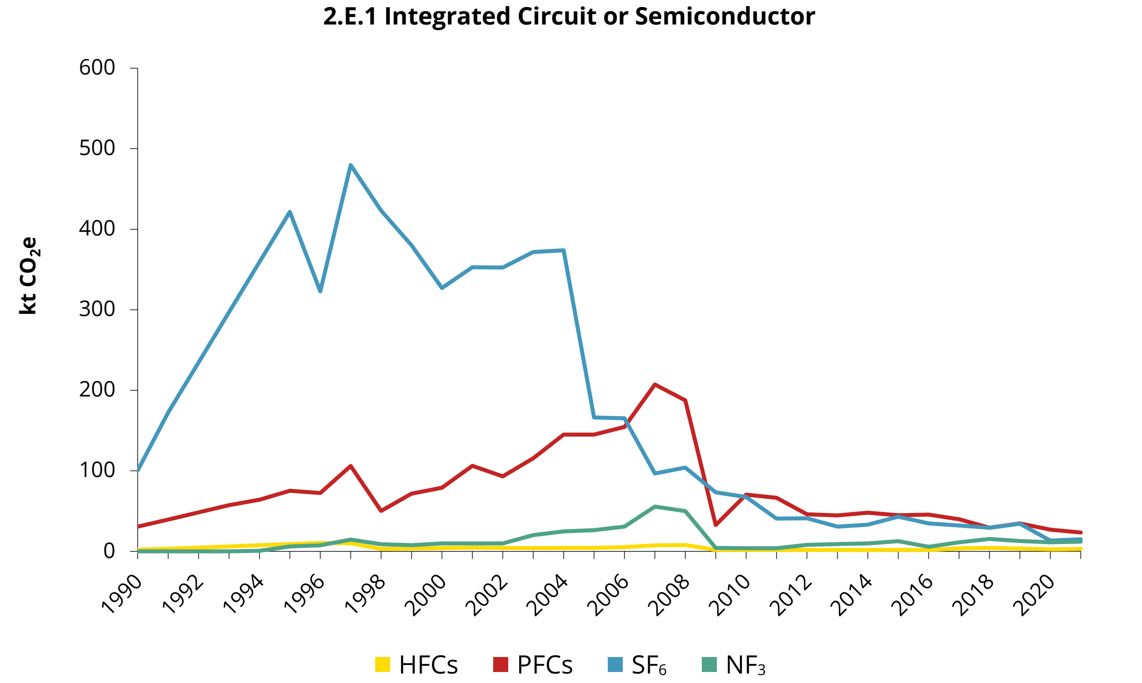
Emissions of this sector amount to 0.3% of the emissions of the IPPU sector, and to 0.07% of the national total. Emissions in 2021 were 60% lower than in 1990.

Emissions of PFCs and SF_6 were constantly increasing during the 1990s, until one semiconductor manufacturer quadrupled its exhaust air purification capacity between 1997 and 1998, reducing emissions remarkably. The increasing emissions of CF_4, C_2F_6 and SF_6 in the other years are due to an increase of semiconductor production. The lower emissions in 2009 compared to 2008 are due to the economic crisis that very strongly affected the manufacture of semiconductors. From 2019 to 2020, emission dropped by 36% due to the economic downtorn as a result of the Covid 19 pandemic. In 2021, emissions levels are similar to the ones reported for 2020.

Table 166: Emissions of Sector 2.E Electronics Industry.

Year	**HFCs**	**PFCs**	**SF_6**	**NF_3**	**Total**
			[kt CO_2e]		
1990	2.04	30.62	100.39	0.00	133.05
1991	3.26	39.52	172.30	0.00	215.08
1992	4.71	48.42	234.62	0.00	287.75
1993	6.16	57.32	296.95	0.00	360.43
1994	7.61	64.07	359.27	0.71	431.66
1995	9.04	75.28	421.59	6.03	511.93
1996	10.32	72.47	322.80	7.42	413.01
1997	10.00	106.08	479.68	14.53	610.30
1998	3.14	50.27	423.24	8.83	485.47
1999	3.42	71.59	380.04	7.71	462.77
2000	4.01	79.09	327.10	9.84	420.03
2001	4.70	106.13	352.88	9.84	473.55
2002	4.28	93.07	352.37	9.84	459.56
2003	4.12	115.59	371.75	20.18	511.63
2004	4.30	145.06	374.00	24.84	548.21
2005	4.22	144.93	166.31	26.36	341.82
2006	5.33	154.50	165.34	30.64	355.81
2007	7.49	207.21	96.74	55.59	367.04
2008	7.83	187.55	103.96	50.05	349.39
2009	1.81	32.63	73.32	4.25	112.01
2010	1.72	70.51	67.57	3.85	143.65
2011	1.73	66.43	40.69	3.84	112.69
2012	1.75	45.95	41.11	8.02	96.83
2013	1.77	44.62	30.62	9.13	86.14
2014	1.68	48.02	33.18	9.89	92.78
2015	1.98	44.89	42.95	12.60	102.43
2016	1.79	45.65	34.60	5.75	87.79
2017	3.77	39.75	32.17	11.24	86.93
2018	4.30	29.40	29.26	15.46	78.41
2019	3.39	34.70	34.31	12.74	85.13
2020	2.58	27.02	13.35	11.27	54.22
2021	2.90	23.40	15.02	11.96	53.28
1990-2021	**+42%**	**-24%**	**-85%**		**-60%**

Figure 27: Emissions from 2.E.1 Integrated Circuit or semiconductor



Source: Umweltbundesamt

According to the Association of Electronics Industry (FEEI – Fachverband der Elektro- und Elektronikindustrie), all three producers emphasized that no specific use of gases as 'Heat Transfer Fluids' can be reported, as these are competing processes. This is why there is no activity data reported under *2.E.4*.

4.6.3 Category-specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values.

4.6.4 Uncertainty Assessment

Activity data (consumption) uncertainty is estimated to be low (5%) because information from all considered producers is used for inventory preparation. The uncertainty for emission factors is estimated to be 10%. This leads to a combined uncertainty of emissions of 11.2%.

4.6.5 Recalculations

No recalculations were made in this year's submission.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (Category 2.F)

4.7.1 Source Category Description

Emissions: HFC, PFC

Key Source: yes (2.F.1: HFC)

This category includes the following emission sources:

- refrigeration and air conditioning equipment
- foam blowing
- fire extinguishers
- aerosols
- solvents

There is no production of Halocarbons in Austria.

On the European level, the so-called F-gas Regulation[89] includes a number of measures to reduce emissions such as recovery of equipment containing F-gases for e.g. refrigeration, air conditioning and heat pump equipment, equipment containing F-gas based solvents, fire protection systems and fire extinguishers, high-voltage switchgear (Article 4 of the F-gas Regulation).[90]

This Regulation is implemented by the Austrian Ordinance on Qualification and Certification measures. According to Article 2(2) of this Ordinance, personnel in charge of handling, refilling etc., have to prove their knowledge about recovery techniques and prevention of emissions.

The F-gas regulation was repealed in 2014, and replaced by Regulation (EU) No 517/2014 of the European Parliament and of the council of 16 April 2014 on fluorinated greenhouse gases. This new regulation provides, in addition to the above mentioned measures, the legislative background to cutting back the amount of F-gases placed on the market inside the EU. This will mostly affect emissions in sector *2.F*.

Emission Trends

For the category *2.F Product Uses as Substitutes for Ozone Depleting Substances*, greenhouse gas emissions started to occur in 1993 due to the use of HFCs as substitutes for ozone depleting substance (ODS Substitutes[91]) mainly for foam blowing. From 2000 onwards the main use is as a refrigerant.

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[89] Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases.

- HFKW-FKW-SF6-Verordnung BGBl. II Nr. 447/2002 (Industriegasverordnung)
- Ordinance on the limitation of emission during the use of solvents containing lightly volatile halogenated hydrocarbons in industrial facilities and installations Federal Law Gazette II No. 411/2005[90].
- F-Gas Regulation 2006, replaced by F gas regulation 2017/2014

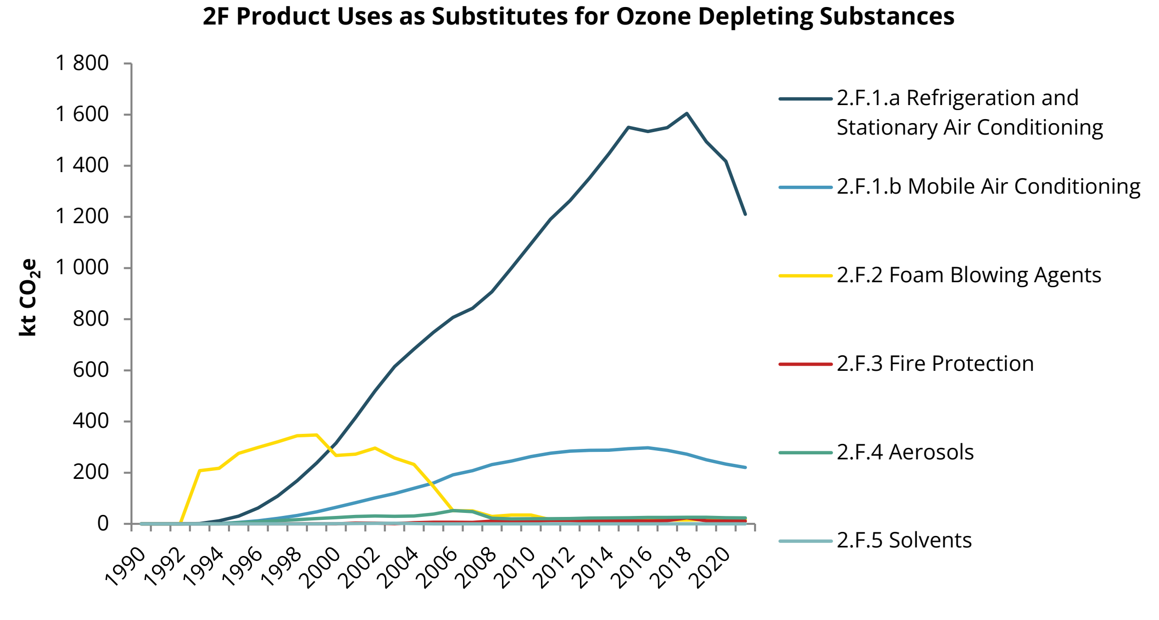
[91] ODS are regulated under the Montreal Protocol and are therefore not considered under the UNFCCC and the Kyoto Protocol

In 2020, F-Gas emissions from Category *2.F* amounted to 1.75 Mio t CO_2 equivalents. Emissions strongly increased since 1993 as HCF have been used increasingly as refrigerant, as well as other uses described below. In 2019, emissions from this sector started to decline for the first time, which is due to the effects of the EU F-Gas regulation (Regulation No. 2017/2014) and the MAC directive.

Table 167: Emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances.

Year	2.F.1.a Refrigeration and Stationary Air Conditioning	2.F.1.e Mobile Air Conditioning	2.F.2 Foam Blowing Agents	2.F.3 Fire Protection	2.F.4 Aerosols	2.F.5 Solvents
			[kt CO_2e]			
1990	133.05	NO	NO	NO	NO	NO
1991	215.08	NO	NO	NO	NO	NO
1992	287.75	0.01	NO	NO	NO	NO
1993	360.43	0.94	NO	NO	NO	NO
1994	431.66	11.68	NO	NO	NO	NO
1995	511.93	29.96	4.09	NO	NO	NO
1996	413.01	61.74	8.18	NO	NO	NO
1997	610.30	108.58	12.27	NO	NO	NO
1998	485.47	168.65	16.36	NO	NO	NO
1999	462.77	237.87	20.45	NO	NO	NO
2000	420.03	315.62	24.53	NO	NO	0.38
2001	473.55	415.19	28.61	NO	NO	1.15
2002	459.56	519.93	30.72	NO	NO	1.91
2003	511.63	614.84	29.55	NO	NO	2.30
2004	548.21	683.09	30.94	NO	NO	1.16
2005	341.82	748.83	38.44	NO	NO	NO
2006	355.81	806.99	51.94	NO	NO	NO
2007	367.04	842.72	47.42	NO	NO	NO
2008	349.39	907.20	21.82	NO	NO	NO
2009	112.01	999.68	19.43	NO	NO	NO
2010	143.65	1095.27	19.89	NO	NO	NO
2011	112.69	1191.05	19.93	NO	NO	NO
2012	96.83	1263.75	20.51	NO	NO	NO
2013	86.14	1351.19	22.31	NO	NO	NO
2014	92.78	1447.24	23.26	NO	NO	NO
2015	102.43	1550.33	23.84	NO	NO	NO
2016	87.79	1534.15	24.87	NO	NO	NO
2017	86.93	1549.15	24.92	NO	NO	NO
2018	78.41	1604.66	25.83	NO	NO	NO
2019	85.13	1494.13	25.70	NO	NO	NO
2020	54.22	1417.28	23.62	NO	NO	NO
2021	53.28	1210.36	23.26	NO	NO	NO
1990-2021	**-60%**					

Figure 28: Emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances.



Source: Umweltbundesamt

4.7.2 Methodological Issues

Data about consumption of HFC, PFC and SF_6 were mainly obtained directly from importers and end users.

Starting in 2004, there is also a reporting obligation under the Austrian Industrial Gas Ordinance[92] for users of fluorinated gases in the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. Data is either reported electronically with a system set up by the Umweltbundesamt or per mail (electronic or letter) to the Ministry for Environment (these reports are then forwarded to the Umweltbundesamt to be combined with data from the electronic system).

The first reporting year is 2003, from this year on the end users of fluorinated gases are obliged to report annually about the amounts used and recycled. Theoretically, almost the entire activity data used for inventory preparation is covered by the reporting obligation. Data for semiconductor manufacture *2.E*) and electrical equipment (*2.G*) and partly for other sub sectors are taken from this data base[93]. However, especially the refrigeration sector is large and diverse, there are numerous small enterprises, and not all of them are organised in an industry association, they are hard to reach and to inform about the reporting obligation. In the course of an update of the model, this problem is currently being tackled. Therefore not all enterprises reported their consumption and it was necessary to apply a top down methodology for this sector: information on total import of refrigerants was obtained from all relevant importers, refrigerants used in other subsectors were

92 Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über Verbote und Beschränkungen teilfluorierter und vollfluorierter Kohlenwasserstoffe sowie von Schwefelhexafluorid (HFKW-FKW-SF_6-V), Federal Law Gazette II No. 447/2002

93 For semiconductor manufacture, plant specific data is available for the whole time series; for the other categories the data had to be extrapolated for the other years (see respective sub chapters for description).

subtracted and the remaining quantities were allocated in the refrigeration and air conditioning sector.

Actual emissions for all subcategories were estimated using a country specific methodology; emission factors are based on information from experts from the respective industries. For most sources, emissions are calculated from annual stocks using emission factors. Additionally emissions can occur during production or disposal of halocarbon/SF_6 containing products, and all these emissions have been accounted for. Annual stocks correspond to the amounts of FCs stored in applications in the previous year, minus emissions of the previous year, plus consumption of the previous year.

The following subchapters present emission factors and data sources used for the respective subcategories.

Methodologies have been developed in studies addressing the country-specific situation:

- UMWELTBUNDESAMT (2001b): All sub categories of Category *2.F* for 1990 to 2000
- OBERNOSTERER et al. (2004): Re-evaluation of sub category foam blowing
- Austrian estimates of emissions from the sources *2.F.4* Aerosols and *2.F.5* Solvents, based on a European evaluation of emissions from this sector (HARNISCH & SCHWARZ (2003), disaggregated to provide a top-down estimate for Austria.
- LEISEWITZ & SCHWARZ (2010): All sub categories of Category *2.F* for the years 2000 to 2007; some sub categories for 2008 as well.
- LEISEWITZ (2012): Category *2.F.1* for the year 2010, which served as a basis for a further re-evaluation of the model (which included several changes described above.

For the years 2008 to 2013, additional data updates were obtained from importers and companies using fluorinated gases, based on the same contacts and data sources as in LEISEWITZ & SCHWARZ (2010).

Table 168 provides the data sources and interpolation methods for each sub-category and each year.

Table 168: Data sources for categories 2.F.1 to 2.F.9.

Category	**Data source**	
	collected	**Intra/extrapolation technique / remarks**
Import data for total FC consumption in Austria	2000, 2004, 2007[1)]	Expert judgement based on information from countries with similar structure[1)] (1990–1999)
	2010–2021	Linear (other years)
2.E.1 Electronics Industry – Integrated Circuit or Semiconductor	1990–2021	Information on activity data and measured emissions from all producers
2.F Product Uses as Substitutes for Ozone Depleting Substances		
2.F.1 a Refrigeration and Stationary Air Conditioning		
Stationary refrigeration - parameters	2007[1)]	Before 2007: expert judgement based on information from countries with similar structure[1)]
	2010	After 2010: value of 2010 is used, except for supermarkets where values for 2020 were updated.
Commercial refrigeration		
		Linear (other years)

Category	Data source	
	collected	Intra/extrapolation technique / remarks
	2021 (supermarkets)	
Room air conditioning	2000, 2017–2021	(linear) interpolation based on expert judgement No HFCs prior to 2000
Heat pumps	1990–2021	
Domestic refrigeration	1993, 1994, 2004, 2005	Linear No HFCs in new refrigerators prior to 1993 and after 2008
Transport refrigeration	2000[5], 2007, 2011[5], 2015–2021	before 2000: expert judgement based on information from countries with similar structure[1]) Linear (other years)
2.F.1.b Mobile air conditioning	1993–2021	No HFCs in vehicles prior to 1993
2.F.2 Foam blowing agents	2000–2021	Value of 2000 was used for 1993-19992). No HFCs in foams prior to 1993.
2.F.3 Fire protection	1990–2021	
2.F.4 Aerosols	2000–2021	Proportional to GDP
2.F.5 Solvents	2001, 2002	Proportional to GDP
2.G. Other Product Manufacture and Use		
2.G.1. Electrical equipment	1990–1999, 2003–2021	Linear
2.G.2: SF_6 and PFCs from Other Product Uses		
Noise insulating windows (2.G.2.a)	1999–2003	Based on production data[3]
Tyres (2.G.2.a)	1998–2003	No SF_6 in tyres in other years
Research (2.G.2.b)	1990, 2000–2014, 2016	Linear
Shoes (2.G.2.a)	2003–2005[4]	No PFCs in shoes in other years

[1] *Leisewitz & Schwarz (2010)*
[2] *Obernosterer et al. (2004)*
[3] *Production data and share of noise insulating windows*
[4] *Using data from Germany*
[5] *Using indicators (refilling volume, refilling rates)*

For more information on data sources and methods, please refer to the following subchapters. An overview of emissions of fluorinated gases by sub-category is presented in Table 169.

Table 169: Emissions of IPCC Category 2.F by sub-category 1990, 1995, 2000, 2005, 2010, 2015, 2020, 2021

GHG	GWP	Unit	1990	1995	2000	2005	2010	2015	2020	2021
2.F.1 Refrigeration and Air Conditioning Equipment										
2.F.1.a Refrigeration and Stationary Air Conditioning										
HFC-32	677	t	0.00	0.66	11.09	33.03	51.29	83.06	108.62	110.59
HFC-125	3170	t	0.00	2.66	31.06	81.52	128.40	187.60	175.90	152.71
HFC-134a	1300	t	0.00	7.24	77.32	164.48	186.79	268.28	342.16	341.66
HFC-152a	138	t	0.00	0.01	0.04	0.04	0.01	0.00	0.00	0.00
HFC-143a	4800	t	0.00	2.32	22.35	52.41	82.81	111.91	68.64	40.70
HFC-23	12400	t	0.00	0.04	0.15	0.21	1.07	1.09	0.96	0.96
C3F8	8900	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F.1.b Mobile Air Conditioning										
HFC-134a	1300	t	0.00	4.34	49.82	122.66	202.30	225.92	179.80	169.75
2.F.2 Foam Blowing Agents										
HFC-134a	1300	t	0.00	203.10	140.56	84.85	9.66	9.34	9.02	8.96
HFC-152a	138	t	0.00	81.68	595.17	204.65	134.36	0.00	0.00	0.00
HFC-245fa	858	t	0.00	0.00	1.50	4.55	2.16	1.92	3.18	3.75
HFC-365mfc	804	t	0.00	0.00	1.50	4.57	2.17	1.94	3.21	3.79
2.F.3 Fire Protection										
HFC-23	12400	t	0.00	0.00	0.00	0.43	0.86	0.86	0.86	0.86
HFC-227ea	3350	t	0.00	0.00	0.00	0.31	0.09	0.30	0.00	0.00
2.F.4 Aerosols										
HFC-134a	1300	t	0.00	3.15	18.87	29.57	15.30	18.00	17.58	17.32
HFC-227ea	3350	t	0.00	0.00	0.00	0.00	0.00	0.13	0.23	0.22
2.F.5 Solvents										
HFC-43-10mee	1650	t	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Total		**kt CO_2e**	**0**	**315**	**673**	**1099**	**1424**	**1895**	**1702**	**1483**

4.7.2.1 Refrigeration and Air Conditioning (2.F.1)

This sub sector can be divided into:

a. Category of stationary refrigeration covering large plants/facilities that are **filled on site**, emissions are estimated using a **top down model**:
   - Industrial refrigeration
   - Other commercial refrigeration (Part of CRF category commercial refrigeration)

b. Rest of the sector 2.F.1 including parts that are, **for the most part, not filled in Austria (or at least not filled on site)**, emissions are estimated using a **bottom up approach**:
   - Domestic refrigeration
   - Transport refrigeration
   - Mobile air conditioning
   - Stationary air conditioning including heat pumps
   - Supermarkets (part of CRF category commercial refrigeration)
   - Commercial stand-alone refrigeration equipment manufacturing (part of CRF category commercial refrigeration)

Details on a) top down model

1. **Total refrigerant imported/total refrigerant used**

   Data on total refrigeration imported is obtained from all relevant importers; values were available for the years 2000, 2004, 2007 and all years from 2010 onwards. There are a handful of large importers that cover about 95% of the market. Additionally there are several small importers that change over the years.

   Annual consumptions estimated bottom up (e.g. use for filling of new mobile ACs and refilling of mobile ACs and transport refrigeration in Austria) were subtracted from the total.

   For 2001 to 2009, the time series was established by interpolation for the years in between where no data on imports/use was available. For the years before 2000, the total consumed amounts were estimated based on information collected by LEISEWITZ & SCHWARZ (2010) in the Austrian industry on the use of HFCs in refrigeration equipment.

   Based on their GWPs the refrigerants were grouped into three refrigerant groups (see the following table).

Table 170: Composition of blends (in percent) as used in the top-down model for category 2.F.1.

	Mean composition				
Groups of refrigerants/blends	**R32**	**R125**	**R134a**	**R143a**	**GWP used in the model**
Low (GWP up to 1500): R134a, R449a, R513a, R32, R448a,…	5	6	81	0	1 402
Medium (1500 < GWP < 2500): R410A, R407C, R452A,…	0	48	7	45	3 792
High (GWP over 2500): R404A, R422D, R507A,…	37	38	26	0	1 952

   Only very small quantities of HFC R-23 are placed on the market. R23 is being used as a replacement of R 13 as a high pressure refrigerant (Class A1) for very low temperatures (more than –50°C) in (medical) research and development and laboratories. R-23 is modelled and considered together with small amounts of other ultra high GWP blends separately.

   For reporting of the final results a mean composition was estimated, based on the specific refrigerants used/imported over the time series. The groups of refrigerants and their mean composition are presented in Table 171.

   This simplification of the model (grouping refrigerants with similar GWP) leads to a small error in total emissions (typically around 1%), which is negligible compared to total uncertainties. Furthermore, this is outweighed by the advantage of a simple and robust, and thus fully consistent model that also allows easy modelling of measures for projections.

Refrigerant consumption in sub categories considered

   The total refrigerant use was broken down into the use in each sub category based on information from refrigeration service companies (LEISEWITZ & SCHWARZ (2010)).

Estimation of emissions

   The refrigerant consumption equals the sum of refrigerants filled in the new equipment plus refrigerants used for refilling.

In the first year, total consumption is used for filling into new equipment. For the subsequent years a part is used for refilling, where the amount refilled has to equal the amount emitted, and the remaining amount is used for filling of new equipment.

Total consumption was allocated to first-fill and re-fill by an iterative methodology, where the resulting emissions from stock (= the amounts refilled) have to be in such a relation to the calculated stock that implied emission factors correspond to the EF (expert judgement by LEISEWITZ & SCHWARZ (2010)).

Values for lifetime of equipment per sector, which are required to calculate the refrigerant stock, as well as EF for emissions from manufacturing (= emissions from first fill), and EF for disposal emissions were also taken from LEISEWITZ & SCHWARZ (2010).

Table 171: Emission factors used for the top down model (IPCC Category 2.F.1).

Sub category	Equipment lifetime	EF for first fill emissions	EF for emissions from stock*	*IPCC default EF*	EF for disposal
Industrial refrigeration	10	0.2%	9–7%	*7–25%*	30%
Stationary air conditioning	12	0.05%	10–9%	*2–15%*	30%
Other commercial refrigeration	14	0.2%	20–15%	*10–35%*	30%

* *an improvement of equipment concerning leakage was considered: the first value is related to the EF for the beginning of HFC use as refrigerants in the mid-1990s, the latter value for 2010-2012.*

No data on actually recovered amounts of F-gases is available, especially not based on singular blends. This is due to the fact that recovered gases are mixed and then destroyed most of the time, or increasingly, due to the shortage of refrigerants due to their phase-down, recycled, which is information that is not reported. Recovered amounts reported are calculated by subtracting the amount remaining in installations at decommissioning from end-of-life emissions.

For the sub-categories of 2.F.1 which are included in the top-down approach, time series of emissions are calculated for the three refrigerant groups.

In a final step, for reporting the blends are again split into their main components R32, R125, R134a and R143a according to Table 170.

Details on b) bottom up approach for the rest of the sub category 2.F.1

Domestic refrigeration

Refrigerators for domestic use are mainly imported to Austria (the little production that occurs is considered in commercial refrigeration manufacture).

R134a as refrigerant was introduced by industry at the end of 1993 as replacement of R12 which is a CFC. For this year it was assumed that 100% of the equipment operated with R134a. In the following years R134a was replaced by R600a (iso-butane), therefore – until 2005 – a share of 1% of R134a filled refrigerators was considered. For the years after the share was set to zero as the replacement in Europe was practically complete. An average charge of 0.1 kg per refrigerator was assumed.

The number of new equipment was estimated as approx. 10% of the total number of refrigerators/freezers (with 1.3 fridges/freezers per household) in 1995, amounting to 400.000 per year which was held constant from 1993 to 2005.

EF according to LEISEWITZ & SCHWARZ (2010):

- emissions from stock: 0.3%
- disposal: 30% (life time 15 years)

Transport refrigeration

This group includes refrigerated road vehicles (vans, trucks, trailers). Manufacturing of refrigeration units does not take place in Austria. Emissions occur from stock and from disposal.

LEISEWITZ & SCHWARZ (2010) estimated the stock and refilling of refrigeration units (share of stock = emissions from stocks: 29% for R134a and R410a, 15% for R404a and 10% for R422a) for the year 2007, based on information from a main furnisher of refrigeration units. For the years before 2007 data was extrapolated by LEISEWITZ & SCHWARZ (2010) using information on stock development from the industry expert. Data for 2008–2012 were extrapolated, taking into account additional data for 2011, obtained from the same industry contact person. Data on HFC amounts from 2013 onwards is based on information obtained from transport refrigeration service companys.

An EF for disposal of 30% and a life time of 10 years were estimated by LEISEWITZ & SCHWARZ (2010).

Mobile air conditioning

Sub categories considered were passenger cars, trucks, busses, agricultural machines, rail and manufacturing of vehicles for construction sites. In Austria the use of R134a for mobile AC started in 1994, for passenger cars it ended in 2017 due to the European MAC directive.

Passenger cars

Detailed data on brands and models of newly registered passenger cars was available for 2004. This information was combined by LEISEWITZ & SCHWARZ (2010) with information on HFC charge per AC and AC quota taken from a German study (SCHWARZ 2004). For the other years until 2008 data on new registrations per brand were combined with average fill levels and average AC quotas per brands taken from the same study. The fill levels and AC quotas of 2008 were also used for 2009 and 2010. For 2011 and again for 2012 the AC quotas for the main brands were updated using data from the Austrian subsidiaries. The detailed data covers 93–99% of the new registered cars, total charge for all newly registered cars were extrapolated assuming an average charge and quota of the cars with detailed data for the remaining cars.

Information on amounts filled in new cars within Austria was obtained directly from the producers.

EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from manufacturing: 0.7%
- emissions from stock: 10%
- disposal: 30% (life time 12 years)

Trucks

Vans, trucks and trailers were considered separately. R134a charge was taken from a typical model for the different types: For trucks, Mercedes Benz Atego and for trailers, Mercedes Benz Actros average values from SCHWARZ (2004) were used. AC quotas were also taken from SCHWARZ (2004).

Data on new registrations for 2004 was also used for the years until 2009. For the years before the data was estimated by LEISEWITZ & SCHWARZ (2010). From 2010 onwards data on new registrations from Austrian statistics have been used.

EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from manufacturing: 0.5%
- emissions from stock: 10%/15%
- disposal 30% (life time 10 years)

Buses

Data on new registrations were taken from Statistics Austria from 2003 onwards; for the years before the data was estimated by LEISEWITZ & SCHWARZ (2010). 55% were estimated to correspond to urban buses, and 45% to coaches. AC quotas and AC charges were taken from SCHWARZ (2004). EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from stock 15%
- disposal 30% (life time 10 years)

Agricultural machines

Tractors and harvesters were considered separately. Data on new registrations were taken from Statistics Austria from 2006 onwards, for the years before the data was estimated by LEISEWITZ & SCHWARZ (2010). AC quotas and AC charges were taken from from SCHWARZ (2004).

Data on filling in newly manufactured agricultural machines (fist fill) in Austria were obtained directly from producers.

EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from manufacturing: 0.3%
- emissions from stock: 15%/25%
- disposal: 30% (life time 10 years)

Rail

Rail includes railways, tramways and metro. Data for stocks and production (first fills) were directly obtained from operators and producers.

EF estimated by (LEISEWITZ & SCHWARZ 2010) applied for

- emissions from manufacturing: 0.04%
- emissions from stock: 5%
- disposal: 30%

Vehicles for construction sites

Figures on first fill of vehicles for construction sites were directly obtained from the producers. Emissions were calculated applying a product manufacturing factor of 0.3% (EF estimated by LEISEWITZ & SCHWARZ 2010).

Stationary air conditioning

This category includes small mobile room AC devices, split devices, Variable Refrigerant Flow (VRF), chillers as well as heat pumps.

Chillers and partly VRF devices are imported pre-filled, the assembled system is filled up, or topped up respectively, with refrigerants on site, whereas the other, smaller devices are imported prefilled.

Stationary air conditioning

Data on annual sales as well as the filling volumes, type of used refrigerants (R407C and R410A) and the market development were estimated based on information from the AC industry (LEISEWITZ & SCHWARZ 2010) for the years 2000–2008. Using further information and expert judgments from the AC industry in recent years (2019-2022) a consistant time series for all different devices was established.

Average charges were used for various types of equipment, ranging between 1 and 83 kg per unit, based on data from industry. An average lifetime of 10 years is assumed for small devices and 15 years for VRF and chillers. From this data stocks were estimated. Applied EF were taken from (LEISEWITZ & SCHWARZ 2010) combined with recent information from industry (2.5% for all years for pre-filled devices, and 10% for 1990 to 4% in 2010 for filled on-site devices).

Heat pumps

Heat pumps use energy stored in the ground, ground water or air. The installation of heat pumps with HFC started in Austria in the 1990s. The stock of equipment in 1995 was estimated to be > 50 000 units in total. About 75% of the newly installed equipment in 2017 was dedicated to space heating and about 24% to heating of water for domestic use as the main areas of application. Heat pumps are manufactured in Austria, exports roughly outweigh the imports, thus manufacture roughly equals newly installed systems. F-gases used are R-134a, R-404A, R-407C and R-410A, propane is also of importance.

Underlying data on installed heat pumps are obtained from an annual report (BIERMAYR et al. 2013–2019). The amounts of HFCs filled into the different types of heat pumps and the share of the individual HFCs were estimated by LEISEWITZ & SCHWARZ (2010) using information from industry experts; for 2017 the share of HFC used was updated. Average charges were used for various types of equipment, ranging between 0.7 and 2.5 kg per unit, based on data from industry. The Austrian Heat Pump Association is planning on commissioning a study for the inventory.

Applied EF were also estimated by LEISEWITZ & SCHWARZ (2010):

- product manufacturing 0.1%
- emissions from stock 2%
- disposal 30% (life time 15 years)

Commercial stand-alone refrigeration equipment manufacturing (part of CRF category commercial refrigeration)

Here emissions from manufacturing of small refrigeration equipment mostly for export ("stand-alone" commercial application including also some equipment for domestic refrigeration) are included.

Two Austrian companies manufacture smaller "stand-alone" equipment for commercial and domestic refrigeration (fridges, freezers) with HFC R-134a and R-404A. The equipment is mostly exported. Both companies communicated their data on F-gas consumption. Emissions from manufacturing are estimated to equal 0.1%.

Supermarkets (part of CRF category commercial refrigeration)

Data and information from (LEISEWITZ & SCHWARZ (2010)) was complemented with data from supermarkets from 2015 and 2020 resulting in a time series of consumption, stock and emissions. Information at that level is confidential. A life time of 15 years was applied, which is the upper level of the range given in the IPCC guidelines and is based on information by supermarkets.

4.7.2.2 Foam Blowing Agents (2.F.2)

According to the Austrian Industrial Gas Ordinance the usage of HFC in the area of foam manufacturing and placing on the market is generally prohibited (the ordinance established the possibility of exceptions under specific conditions which were in fact not applied).

Close Cell Foams (2.F.2.a)

XPS plates

For many years the main blowing agent for manufacturing of XPS hard foam was CO_2. In Austria, from 1995 to 2004 also products blown with R134a were sold and from 2000 to 2010 one Austrian company used R152a as blowing agent for a small portion of about 3% of its XPS production in case of short-dated lots for which CO_2 driven XPS foam is not suitable due to longer storage needs with regard to shrinking behaviour.

Data on R152a consumption were obtained directly from the producer; the total amount consumed is assumed to be emitted during production.

R134a from XPS plates was calculated by LEISEWITZ & SCHWARZ (2010) based on information from industry experts (see Table 172).

25% of consumption is emitted in the production process. Stocks were calculated from the remainder; emissions from stocks were estimated based on information from producers.

Emissions from disposal are not yet to be expected as the lifetime of the foam products is long (around 50 years).

PU hard foam

PU plates and PU sandwich panels blown with R134a were sold in Austria from 2000 to 2004 (usually hydrocarbons and CO_2 are used as blowing agents). Emissions were calculated by LEISEWITZ & SCHWARZ (2010) from information from industry experts (see Table 172).

PU pipe insulation

About 10% of the market of PU insulating foam for pipes in Austria has been blown with HFC-245fa and HFC-365mcf during 2000–2004. Emissions were calculated by LEISEWITZ & SCHWARZ (2010) based on information from industry experts (see Table 172). From 2005 onwards usage of HFC in this foam sector is prohibited as well as in the other areas.

HFC-245fa and HFC-365mfc are F-gases that are not regulated under the Convention; this is why emissions of these gases are not included in national totals, but reported in CRF Table 9(b) as additional GHG.

Table 172: PU pipe insulation.

	XPS plates	PU plates	PU sandwich panels	PU pipe insulation
Sales in Austria (estimated from production/import/ export)	350 000 to 480 000 m³/year	17 000 to 18 000 m³/year	350 000 m³ in 2003 (2% growth per year)	41 000 to 62 000 m³/year
Average density	33 kg/m³	33 kg/m³	41 kg/m³	62.5 kg/m³
Market shares of R134a	15% until 1999 10% afterwards	10%	25%	5% each
Average propellant content	6.5% R134a	3% R134a	3% R134a	12% R245fa and R365mfc
Half life time	Until 2004 100mm plates: 85 years; since 2005 80mm plates: 60 years	150 years	200 years	30 years
Annual diffusion rate (EF)	1.15% (until 2004) and 0,81% (from 2005)	0.46%	0.35%	2.28%
EF (manufacturing)	25%	10%	10%	10%

Open Cell Foams (2.F.2.b)

PU one component foam

For PU one component foam (OCF), propellants used include HFC-free formulations (flammable gases, propane and butane among others), blends of flammable gases and HFC-134a or HFC-152a. HFC-134a and HFC-152a were used as blowing agents for OCF from 1993 onwards in Austria. OCF without HFC was used in Austria for the first time in 1999. The Austrian Industrial Gas Ordinance prohibits the use of OCF with HFC from 2006 onwards. Exemptions according to Article 7(4) IV are possible for fire protection products. The European F-gas Regulation provides a ban on HFC in OCF with a GWP > 150 starting July 2008; HFC-152a (with a GWP of 140) is not affected by this ban. From 2004/2005 onwards the Industrial Gas Ordinance provoked a rigorous decrease of HFC consumption in OCF to a niche of about 5% of the OCF market.

PU OCF containing foams were produced in Austria from 1993 to 2008, data on consumption was obtained directly from industry; the EF applied for calculating manufacturing emissions is 1.5%.

The annual consumption in Austria was estimated to be 4.4 million cans in 1993 (where the first HFC containing cans were sold) 6 million cans from 2000–2010. 60% of these cans contain HFCs (from 2006 onwards only 5%); on average one can contains 660g of foam with a propellant content of 13%. The share of R134a was 67% until 1999, 50% until 2005 and 0% thereafter; the remainder is R152a.

For estimating emissions from the OFC consumption in Austria it is assumed that the blowing agent is emitted completely in the first year.

4.7.2.3 Fire Protection (2.F.3)

Stationary fire protection systems for flooding indoor spaces today mainly use inert gases. Formerly used ozone layer depleting halones were replaced by HFCs in some cases. HFC-23 and HFC-227ea in fire extinguishers were first introduced to the Austrian market in 1993 and 1996, respectively. F-gases for fire-fighting are imported in cylinders and filled in fixed installed systems. Fire protection companies re-export recovered F-gas for disposal to the foreign traders/manufacturers.

For HFC-227ea, detailed data on consumption for new equipment, the stock in existing fixed flooding systems, annual losses (refilling) and recovered F-gases for disposal are obtained directly from the fire protection companies every year.

For HFC-23, due to lack of data from the one relevant company, data of 2008 was also used for the subsequent years, which probably overestimates emissions as the 2008 emissions from stock were higher than in all years before. However, no better methodology is available as emissions from stock result from fire incidents, and information on the fire extinguisher capacity where they occur is not available (only statistics on the insurance volume of fire incidents exists, but this only poorly correlates to emissions).

HFC emissions occur from filling in fixed systems, from stocks (in case of false alarm, fire, leakage, accidents etc.) and from disposal. Test flooding, in former times an important source of emissions, did not take place from 2000 onwards. The emission factor for filling of fixed systems is calculated as 0.05%, the EF for disposal as 1%, both figures accord with literature and reports from fire protection companies. The average implied EF from bank is 1.6% for HFC-227ea and 1% for HFC-23, which is within the range given in the IPCC 2006 guidelines (page 7.63) for installed flooding systems (2 ± 1% per year).

4.7.2.4 Aerosols (2.F.4)

Metered dose inhalers

Production:

Metered dose inhalers containing R134a were produced in Austria from 1995 to 2010. Data on consumption was obtained directly from the producer from 2000 onwards, for the years before, production data was extrapolated using the Austrian GDP; the EF applied for calculating manufacturing emissions is 1.5%.

Import:

Additionally, metered dose inhaler are imported since 1995. Detailed data on imported metered dose inhalers and their R134a content from 2000 onwards is provided annually in a pharmaceutical market survey. Since 2012, a new product containing 227ea has been sold in Austria. Charges per unit are based on industry data and range between 6 and 15 g per container. Based on this data, consumption is calculated, where all propellant is assumed to be released in the same year. For the years prior 2000 consumption was extrapolated using the Austrian GDP.

Aerosols

Technical aerosols

One Austrian company manufactured a technical aerosol for cleaning of cameras (use within the country, no export) until 2008. For the years 2000 and 2003 to 2008, data on consumption was obtained directly from the producer. For the years before and in between production data was extrapolated using the Austrian GDP; the EF applied for calculating manufacturing emissions is 1.5%. All propellant is assumed to be released in the year of production (product is assumed to be consumed in the year of purchase).

Novelty aerosols

The amount of imported novelty aerosols is estimated as 0.4% of the European Union market (estimated by the *European Organisation of Aerosol Manufacturers* to range between 940 t/year in 2000 and 100 t in 2009). The value of the year 2000 is also used for the years before. This share was verified by comparison with reported data from importers. From 2004 onwards, marketing of novelty sprays is prohibited in Austria. Under the assumption that certain exceptions are allowed and remainders are sold a continuous decrease in consumption is assumed. Emissions were estimated assuming that 100% are emitted in the first year. A further decrease in 2018 is assumed as a result of the ban established under the EU F-gas Regulation. It is planned to re-evaluate this category until next submission.

4.7.2.5 Solvents (2.F.5)

Information about HFC-43-10mee used as solvent was taken from a European evaluation of emissions from this sector (HARNISCH & SCHWARZ 2003) for the years 2001 and 2002, subsequently disaggregated to provide a top-down Austrian estimate. The other years were estimated using the Austrian GDP as indicator. Since 2004 the use of HFC in solvents is prohibited in Austria. Since then no further use occurred, which has been confirmed by industry during the latest inquiries.

Emissions were estimated assuming that 100% are emitted in the first year.

4.7.3 Category-specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values. The total consumption of HFC obtained by the main importers was checked against information from retailers, service companies and producers of equipment.

4.7.4 Uncertainty Assessment

2.F.1 Refrigeration and Air Conditioning

The uncertainty of the activity data was estimated to be 10%. The amount imported is reported by the importers whereby the large importers covered 95% of the market in all the years of the time series. (The possible omission of one small importer can therefore be considered as justified).

The emission factor mainly depends on the allocation of the sub sectors which is relatively uncertain. Additionally the uncertainty of the emission factors of the sub sectors is to be considered. Hence its uncertainty is set to 50%.

2.F.2 Foam

Activity data uncertainty is estimated to be 10%. The amounts used are well documented due to the reporting obligation under the Austrian Industrial Gas Ordinance. The amount of foam sold in Austria is an estimate and their share in specific years varies.

The uncertainty of the emission factor is set to 0% as emissions were estimated assuming that 100% are emitted in the first year.

2.F.3 Fire extinguishers

The uncertainty of the activity data is estimated to be 10%. To the stock reported by the plant operators, a rate increase of 10% is added in order to ensure that all activities are covered.

The emission factor for filling and suction at demolition is very uncertain (100%), however in the years when release occurs, release is dominating and is reported.

2.F.4 Aerosols

Activity data uncertainty is estimated to be 20%. In Austria filled amounts are well documented, also the amounts of medical aerosols sold. Sale of novelty sprays is estimated based on data from the EU market, however there is a good conformity with the data reported for Austria.

Most of the aerosol used is emitted to 100%, the emissions from manufacturing are relatively uncertain, therefore total uncertainty of the emission factor is assumed to be 10%.

2.F.5 Solvents

The uncertainty of the activity data is assumed to be 100% as this is an estimation based on the EU market. The uncertainty of the emission factor is set to 0% as emissions were estimated assuming that 100% are emitted in the first year.

4.7.5 Recalculations

2.F.1.a Commercial refrigeration, 2.F.1.c Industrial Refrigeration and 2.F.1.f Stationary air conditioning

Additional research on stationary air conditioning showed that

1. less equipment was filled on site than previously assumed. Thus the gap between quantities surveyed bottom up and import figures is now higher, raising both stocks and emission from stocks for the categories **commercial and industrial refrigeration**, those two categories where the residual amounts are allocated to.
2. for one type of equipment the assumed filling capacity for the years 2009ff was too low, increasing the stock and emissions for **stationary air conditioning** from 2009 onwards.

Furthermore, as the GWP was changed to AR5, also the blend categories used for modelling the residual amounts of refrigerants not surveyed bottom up, had to be revised.

The overall effect of recalculations in these three sub categories is + 58.5 kt CO_2e in 2020.

2.F.1.d Transport Refrigeration

Additional research identified an additional supplier of transport refrigeration equipment and furthermore showed that refill data previously used was incomplete. Therefore new assumptions on stock and especially stock composition were made, taking into account all available information. This affected emissions from 2007 onwards (-6.4 kt CO_2e in 2020).

2.F.1.e MAC

A minor correction of amounts filled into new equipment for trains in 2019 led to recalculations of the stock back to 1996, as stocks are calculated back in time using newly filled in amounts (+0.03 kt CO_2e in 2020).

2.F.3 Fire protection

Disposal emissions from 2019 had mistakenly not been considered in previous submissions, but are now included (+0.2 kt CO_2e in 2019).

4.7.6 Planned Improvements

The parameters for estimating emissions from **industrial and commercial refrigeration** need to be updated to reflect advancements in technology, data on installation level will be collected.
Fire extinguishers: information on the use of R23 that is refused by the responsible company will be tried to be obtained.

It is planned to re-evaluate **novelty aerosols** until next submission.

4.8 Other Product Manufacture and Use (Category 2.G)

4.8.1 Source Category Description

Emissions: PFC, SF_6, N_2O

Key Source: yes (SF_6 – 2.G.2)

This category comprises SF_6 emissions from Electrical Equipment (*2.G.1*), SF_6 and PFC emissions from Other Product Uses (*2.G.2*), as well as N_2O emissions from Product Uses (*2.G.3*).

Emission Trends

Emissions from this category amount to 2.28% of the IPPU sector, which equals 0.5% of total emissions.

Table 173: Emissions from 2.G Other Product Manufacture and Use.

GHG	2.G.1 Other product manufacture and use – Electrical Equipment		2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use			2.G.3 N_2O from Product Use	Total
	SF_6	kt CO_2e	SF_6	C_3F_8	kt CO_2e	N_2O	kt CO_2e
GWP	[23 500]		[22 800]	[8 830]		[298]	
1990	0.47	11.13	5.30	0.00	124.44	441.13	267.02
1991	0.51	11.90	7.50	0.00	176.20	441.13	319.55
1992	0.54	12.66	7.66	0.00	180.03	441.13	324.15

GHG	2.G.1 Other product manufacture and use – Electrical Equipment		2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use			2.G.3 N_2O from Product Use	Total
	SF_6	kt CO_2e	SF_6	C_3F_8	kt CO_2e	N_2O	kt CO_2e
GWP	[23 500]		[22 800]	[8 830]		[298]	
1993	0.57	13.43	7.82	0.00	183.87	441.13	328.75
1994	0.60	14.20	9.13	0.00	214.54	441.13	360.20
1995	0.63	14.74	11.14	0.00	261.86	441.13	408.06
1996	0.62	14.68	11.71	0.00	275.13	441.13	421.27
1997	0.63	14.88	11.99	0.00	281.86	441.13	428.19
1998	0.70	16.54	12.57	0.00	295.37	441.13	443.36
1999	0.69	16.28	11.87	0.00	278.96	441.13	426.69
2000	0.75	17.55	8.98	0.00	211.01	441.13	360.01
2001	0.78	18.37	10.60	0.00	249.14	403.13	387.63
2002	0.82	19.24	10.79	0.00	253.45	365.13	381.50
2003	0.85	19.99	7.28	0.00	171.04	327.13	288.51
2004	0.91	21.39	4.40	0.00	103.47	289.13	211.03
2005	0.97	22.88	13.40	0.00	314.87	251.13	412.59
2006	1.00	23.52	11.32	0.21	266.04	221.13	355.45
2007	1.07	25.25	10.89	0.17	255.99	208.13	343.26
2008	1.13	26.66	10.81	0.11	253.96	196.13	339.07
2009	1.17	27.43	10.68	0.00	250.87	161.13	326.31
2010	1.28	30.01	10.57	0.00	248.32	175.73	330.70
2011	1.28	30.17	10.46	0.00	245.77	163.83	324.75
2012	1.39	32.55	10.35	0.00	243.20	145.13	319.00
2013	1.43	33.61	10.27	0.00	241.37	152.52	320.43
2014	1.51	35.47	10.16	0.00	238.83	144.30	317.30
2015	1.59	37.44	10.05	0.00	236.28	138.99	315.13
2016	1.68	39.55	13.97	0.00	328.33	139.93	409.57
2017	1.69	39.64	13.81	0.00	324.47	132.00	403.45
2018	1.81	42.53	13.64	0.00	320.64	128.12	401.35
2019	1.86	43.71	15.68	0.00	368.39	133.61	451.92
2020	1.93	45.41	16.64	0.00	391.06	126.21	474.08
2021	1.99	46.67	12.94	0.00	304.15	122.45	387.30

4.8.2 Methodological Issues

Due to the diversity of this sector, methodological issues are described in each sub-category.

4.8.2.1 SF_6 Electrical Equipment (2.G.1)

SF_6 is used as an arc quenching and insulating gas in high-voltage (> 36 kV [110–380 kV]) and medium-voltage (1–36 kV) switchgear and control gear. The equipment – mainly Gas-Insulates Systems (GIS) – has not been manufactured in Austria during the reporting period, all has been imported. High-voltage GIS (HV GIS) operate with a high operating pressure (up to 7 bar) and large gas quantities. They are imported with a transport filling and are filled up on site. The systems are "closed for life" and have to be replenished in their lifetime. Emissions from operating HV systems are higher than emissions from medium-voltage GIS (MV GIS). These operate with lower overpressure and small gas quantities of only some kg/system. They are already charged with SF_6 when imported and are hermetically closed ("sealed for life"). Both categories of equipment have lifetimes of 30–40 years.

According to Article 15(2) of the Austrian Industrial Gas Ordinance, the use of SF_6 is only allowed in electro-technical systems and appliances of voltage > 1 kV if specific reporting obligations are fulfilled (Article 15(4)). The sector of high and medium voltage switchgear is hence not subject to restrictions of the use of SF_6.

Information on SF_6 stocks in electrical equipment from 2003 onwards was obtained from energy suppliers and industrial facilities (as mentioned above, there is a reporting obligation for operators of SF_6 filled equipment since 2004). Data for 2000–2002: estimation based on an annual growth rate 2003–2007 of 16.9% for MV-GIS and 4.1% for HV-GIS. 2% was added to the reported stock to account for equipment used in industry that is not reported otherwise. For 1990–1999 the stock was calculated from consumption data of this sector.

Amounts of SF_6 refilled in equipment is reported each year by an association of energy suppliers; this information is the basis for the estimations. Manufacturing emissions from first filling were estimated to be 1% according to reported data, the disposal EF is assumed to equal 2%.

In Austria, no destruction of SF_6 in electrical equipment takes place when disposing. Disposed quantities are recovered, emissions from disposal are estimated to be 2%. The disposed amount is also reported by energy suppliers for the years 2004 onwards, the values 2000–2003 were estimated using average disposal rates of 2004–2008: 0.03% for HV and 0.1% for MV. For the years before the average value of 2000–2008 was used.

The amount of SF_6 used in switchgear is reported under the Austrian Industrial Gas Ordinance, by two umbrella organisations covering all switchgear in use. Thus, the amount of SF_6 currently in use, as well as SF_6 used for refill or filling of new equipment is reported.

4.8.2.2 SF_6 and PFCs from Other Product Uses (2.G.2)

Particle accelerators (Research)

SF_6 is used in particle accelerators (linear accelerators, linacs) as insulating gas to prevent electrical flash over. A small number of high voltage equipment (0.3→ 23 MV) is or has been used in Austria in academic research, in industry and medical therapy. The larger HV equipment for research and industrial purposes normally operates with an accelerator and HV generator situated in a tank insulated with SF_6 that is mostly pressurized. Gas losses occur at servicing, repair or adjustment of the device. Linear accelerators for medical radiotherapy (cancer therapy) are industrially made and prefilled. Their waveguide is SF_6 insulated; the filling volume is in the order of ~3 litres – much smaller than the above-mentioned equipment in research and industry. Electronic microscopes (> 100 kV) have a high voltage tank filled with ~5 kg SF_6.

Manufacturers and operators provided the number of devices operating in Austria. Data on filling volume and refilling have been collected from the institutions and companies operating the equipment, from manufacturers and from service companies. The annual F-gas consumption (first filling of new products) normally is very small (in the order of kg) and exceeded 400 kg in one year only. The stock is below 1 t for all years. The implied EF is in the order of 6%, but there is a wide difference between the several types of equipment.

Emissions from bank are equal to the amounts provided in company reports for refilling of losses.

Noise insulating windows

Nose insulating windows containing SF_6 were produced in Austria from 1980 to 2003, when the Austrian Industrial Gas Ordinance prohibited this use.

For the years before 1999 consumption and emissions from production were estimated from total production and the share of SF_6 production using the following information from industry:

- 16 mm gap results in about 16l/m^2 of which there are 8l SF_6 per m^2 window
- Filling from 1996 is only 6l SF_6/window
- Overfill of 3l per m^2 window (manual filling) = emissions from manufacture
- Density of SF_6: 6.18 kg/m^3

SF_6 consumption was reported by industry for the years 1999–2003; one third of the consumption is overfill (thus equals emissions from manufacture).

The leakage per year is 1% of the initial fill (which considered premature breaking).

The residual amount after the lifetime of 25 years is assumed to be emitted immediately due to breaking of glass.

Tyres

SF_6 shows a low permeability through rubber (cf. IPCC GL 2006, p. 8.31). The German tyre manufacturer Continental AG exploited this property and offered in the 1990s tyres with SF_6 as filling gas instead of air. In Austria the national tyre and automotive trade sold tyres with SF_6 as filling gas filled within the country. The gas used for this purpose was supplied by only one SF_6 importer, who reported on the amount of SF_6 sold to the Austrian tyre and automotive trade. As of 2003, the Austrian Industrial Gas Ordinance abruptly stopped the usage of SF_6 as filling gas for tyres by legal prohibition.

According to IPCC GL 2006 it is assumed that SF_6 completely emits from car tyres with their disposal three years after filling. Filling emissions are regarded to be insignificant. Disposal emissions are therefore assumed to equal the amount consumed three years earlier.

Shoes

Nike introduced sport shoes with gas cushions filled with SF_6 in the early 1990s. From 2003 to 2006 the company used as alternative PFC (C_3F_8) for the same purpose. Shoes with F-gas cushions were not manufactured in Austria but imported. SF_6 emissions from sport shoe soles occurred in Austria up to 2006, C_3F_8 emission from 2006 to 2008.

Data on the import of these products to Austria were not provided by Nike. It was accepted as plausible that the German and the Austrian market could be regarded as comparable. Data on the German market are well documented. Austria has 10% of the population compared to Germany, hence the same percentage was assumed for annual consumption of such footwear in Austria. In case of perfluoropropane the European consumption in 2003–2005 is known and the Austrian market is estimated to be 2.5% (= 10% of the German market).

Operating emissions during use of the footwear are not considered. The lifetime of sport shoes is estimated to be 3 years. At the disposal of old shoes 100% of the initial filling is released to the atmosphere (i.e. EF=100%). Disposal emissions are therefore assumed to equal the amount imported in sport shoes three years earlier.

4.8.2.3 N_2O from Product Uses (2.G.3)

Medical Applications (2.G.3.a)

This subsector contains N_2O emissions from the use of anaesthesia. The numbers for 2001–2012 were formerly obtained through an industry inquiry (OIGV 2013) for the amount of N_2O used during those years. As this inquiry is not possible anymore, the importers/producers of N_2O were asked directly.

As N_2O is used as an anaesthetic, it is presumed that 100% are emitted during reporting years. But also the N_2O use has significantly decreased due to shorter duration of anaesthesia during operations and more local anaesthetics than general anaesthesia.

Propellant for Pressure and Aerosol Products (2.G.3.b)

N_2O is used as propellant for cream; it is applied in capsules or in ready to use cans.

For **capsules** all producers reported data on amounts sold in Austria, these values were used for all years as all three producers confirmed that the market in Austria is saturated and has been stable over the years.

For **ready to use cans**, data from supermarkets and wholesale were extrapolated to the overall market in Austria using market shares for retail trade. As for capsules, the estimation is reported by companies for the whole time series.

It is assumed that all N_2O from capsules and cans sold in one year are emitted in the same year.

Organic Rankine Cycles (2.G.4.b)

So far, one plant in Austria has been identified, where Solkatherm (mixture containing HFC 365 mfc) has been in use since 2005. The plant opened in 2000, when 3 000 kg of 3m PF-5052 (PFC C5F12) were filled in. These 3 000 kg were then decommissioned in 2005, and 3 000 kg of 365mfc were filled in. Since then, no emissions (no refills) were recorded. No records are available for the time before 2005, but it is assumed that no emissions took place then.

According to expert judgement[94], 2% emissions were thus considered during filling in, and 20% at decommissioning. This results in emissions for the years 2000 and 2005.

It still cannot be ruled out that there are other ORC plants in operation in Austria, as not all ORC plant operators replied before this submission. As soon as this information is available it will be considered in the inventory.

[94] Implementierung der ab dem Berichtsjahr 2013 gültigen IPCC Guidelines for National Greenhouse Gas Inventories 2006 in die Inventarerhebung fluorierter Treibhausgase (HFKW, FKW, SF_6, NF_3), Climate Change 17/2015, Öko-Recherche

4.8.3 Category-specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values. The total consumption of N_2O, PFC and SF_6 was obtained by the main importers and this data was checked against information from professional organisations and statistics.

For N_2O used as cream propellant the estimation for capsules was estimated by two approaches: on the one hand based on data from producers, on the other hand based on retail sail data; the difference of the approaches is within the assumed uncertainty.

4.8.4 Uncertainty Assessment

2.G.1 Electrical Equipment

Activity data uncertainty is estimated to be low (5%) as data are reported from industry and additionally 2% is added to the calculation to account for equipment not covered in the reported figures. As for the emission factor, uncertainty is estimated to be very high (100%).

2.G.2 SF_6 and PFCs from Other Product Uses

According to emissions levels, the most important sub source is noise insulating windows. The uncertainty for activity data is estimated to be 25%, emission factor uncertainty is assumed to be relatively high (50%) because it is based on several assumptions.

2.G.3 N_2O from Product Uses

Uncertainty for emissions from this category were estimated to be 100%. The uncertainty of the new estimate is lower, however this has not yet been considered in this years uncertainty analysis (planned for the next submission).

4.8.5 Recalculations

2.G.1 Electrical equipment

Updated stock data for 2020 became available, and was included in this year's inventory (+ 1.0 kt CO_2e).

2.G.2 Other uses of SF6- particle accelerators.

Activity data for some new equipment were updated for 2020 (+1.4 kt CO_2e).

5 AGRICULTURE (CRF SECTOR 3)

5.1 Sector Overview

This chapter gives information about the estimation of greenhouse gas emissions from Sector *Agriculture* in correspondence to the data reported under the Sector 3 in the Common Reporting Format.

The following sources exist in Austria: domestic livestock activities with enteric fermentation and manure management, agricultural soils, field burning of agricultural residues, liming, urea application and other carbon-containing fertilizers.

As a result of previous UNFCCC reviews the ERT recommended Austria to update its information on manure management system (MMS) distribution (ARR 2006, ARR 2008). Hence, in 2008 the Umweltbundesamt commissioned the University of Natural Resources and Applied Life Sciences with the revision of the national emission model of the sector agriculture (AMON & HÖRTENHUBER 2010). Data on MMS distribution was taken from the research project "Animal husbandry and manure management systems in Austria" (AMON et al. 2007), a comprehensive survey on the agricultural practice in Austria. This study was followed by a new study in 2018 (PÖLLINGER et al. 2018).

In 2013 the Umweltbundesamt commissioned the University of Natural Resources and Applied Life Sciences with the update of the national emission model of the whole sector agriculture by using the methodologies according to the IPCC 2006 Guidelines (AMON & HÖRTENHUBER 2014).

In submission 2019, the agricultural model has been revised by implementing new input data on agricultural practices in Austria, taken from the research project "Surveys on manure management from agricultural livestock farming in Austria (TIHALO II) (PÖLLINGER et al. 2018)". For this project, as for the previous one (AMON et al. 2007), a comprehensive survey has been carried out. Furthermore, the N flow has been improved according to the newest available EMEP/EEA methodologies (EEA 2019), which also effected Austria's GHG emissions (AMON & HÖRTENHUBER 2019). In submission 2021 Austria included CO_2 emissions from calcium ammonium nitrate (CAN) in its inventory as encouraged during the ESD Review 2020.

In response to questions raised during the comprehensive ESD Review 2020 (EEA 2020) and the NEC Review 2021 (EC 2021) on Austria's feeding assumptions, the Umweltbundesamt initiated a new representative study. The feeding of cattle and swine has changed substantially in the last two decades and it was decided to update the national inventory on the basis of latest available science. Thus, from 2020 to 2022 the University of Natural Ressources and Life Sciences Vienna carried out a specific research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023). In submission 2022, Austria included updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) into the inventory.

Austria follows the N-flow approach by using country specific methodologies for the calculation of direct N_2O emissions from animal manure applied to soils (*3.D.a.2.a*) and indirect N_2O emissions from leaching and run-off (*3.D.b.2*). In response to a recommendation of the ERT (ARR 2013, para 51 and 52) additional descriptions have been included from NIR 2014 onwards (Annex 3). Methodological details regarding the calculation of gaseous N losses of NH_3, NO_x and N_2 are extensively described in Austria's Informative Inventory Report 2023 (UMWELTBUNDESAMT 2023b).

To give an overview of Austria's agricultural sector some information is provided below (according to the 2020 Farm Structure Survey – full survey) (BML, 2000–2022): Agriculture in Austria is rather small-scaled: 154 593 farms are managed, 54.9% of these farms manage less than 20 ha, whereas only 5.7% of the Austrian farms manage more than 100 ha cultivated area. 118 432 holdings are classified as situated in less favoured areas. Related to the federal territory Austria has the highest share of mountainous areas in the EU (70%). The structural change of Austria´s Agriculture is continued: the number of agricultural holdings decreased between 2010 and 2020 by 11% whereas the size of holdings increased in this period. In 2010, an average total area of 42.6 ha was managed on a holding, in 2020 it increased to 44.9 ha.

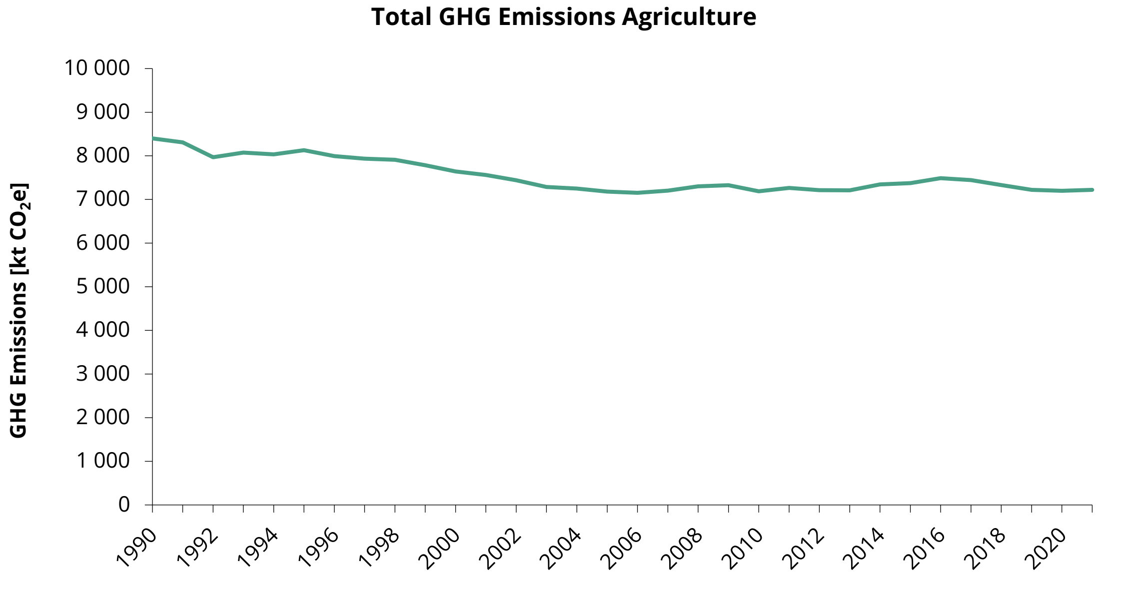
The agricultural area comprises 2.60 million hectares that is a share of ~ 31% of the total territory (forestry ~ 41%, other area ~ 11%). The shares of the different agricultural activities are as follows:

- 51% arable land,
- 22% grassland (meadows mown several times and seeded grassland),
- 24% extensive grassland (meadows mown once, litter meadows, rough pastures, alpine pastures and mountain meadows),
- 3% other types of agricultural land-use (vineyards, orchards, house gardens, vine and tree nurseries).

5.1.1 Emission Trends

In the year 2021 the sector agriculture contributed 9.3% to the total of Austria's greenhouse gas emissions (without LULUCF). The trend of GHG emissions from 1990 to 2021 shows a decrease of 14% for this sector (see Figure 29 and Table 175) due to a decrease in activity data.

Figure 29: Trend of total GHG emissions from agriculture.



Source: Umweltbundesamt

The main drivers for the trend shown in Figure 29 are decreasing livestock numbers and lower amounts of N-fertilizers applied on agricultural soils. From 2020 to 2021 GHG emissions increased slightly by 0.3%, mainly due to rising emissions from mineral fertilizer application. In addition, slightly increased cattle numbers (dairy cows and non-dairy cattle) resulted in higher emissions from 3.A *Enteric Fermentation* in 2021 compared to the previous year.

Emission trends per gas

From 1990 to 2021 CH_4 emissions from agriculture decreased by 15.4%. N_2O emissions fell by 14.0% and CO_2 emissions increased by 73.7%. Trends are presented in Table 174.

Table 174: Emissions of greenhouse gases from 1990–2021 from agriculture.

Year	GHG emissions [kt]		
	CH_4	**N_2O**	**CO_2**
1990	203.14	9.91	85.92
1991	200.74	9.82	86.63
1992	192.35	9.41	90.31
1993	197.56	9.26	87.86
1994	196.95	9.20	83.26
1995	199.90	9.24	84.22
1996	196.37	9.12	80.15
1997	193.07	9.21	89.71
1998	192.09	9.21	92.47
1999	190.05	8.98	85.84
2000	186.99	8.75	89.33
2001	183.99	8.75	92.17
2002	180.21	8.67	96.53
2003	178.01	8.33	93.94
2004	177.52	8.26	90.57
2005	175.35	8.21	95.54
2006	174.42	8.18	103.04
2007	175.13	8.26	109.92
2008	174.44	8.65	124.67
2009	176.74	8.49	126.08
2010	176.44	8.06	112.35
2011	174.76	8.48	125.99
2012	173.69	8.36	133.67
2013	174.53	8.29	127.21
2014	175.68	8.66	132.78
2015	176.20	8.67	145.49
2016	176.96	8.99	151.61
2017	177.74	8.74	150.71
2018	175.30	8.55	154.83
2019	172.79	8.42	150.78
2020	171.52	8.48	148.94
2021	171.95	8.52	149.29
Trend 1990–2021	**–15.4%**	**–14.0%**	**73.7%**

Emission trends per sub category

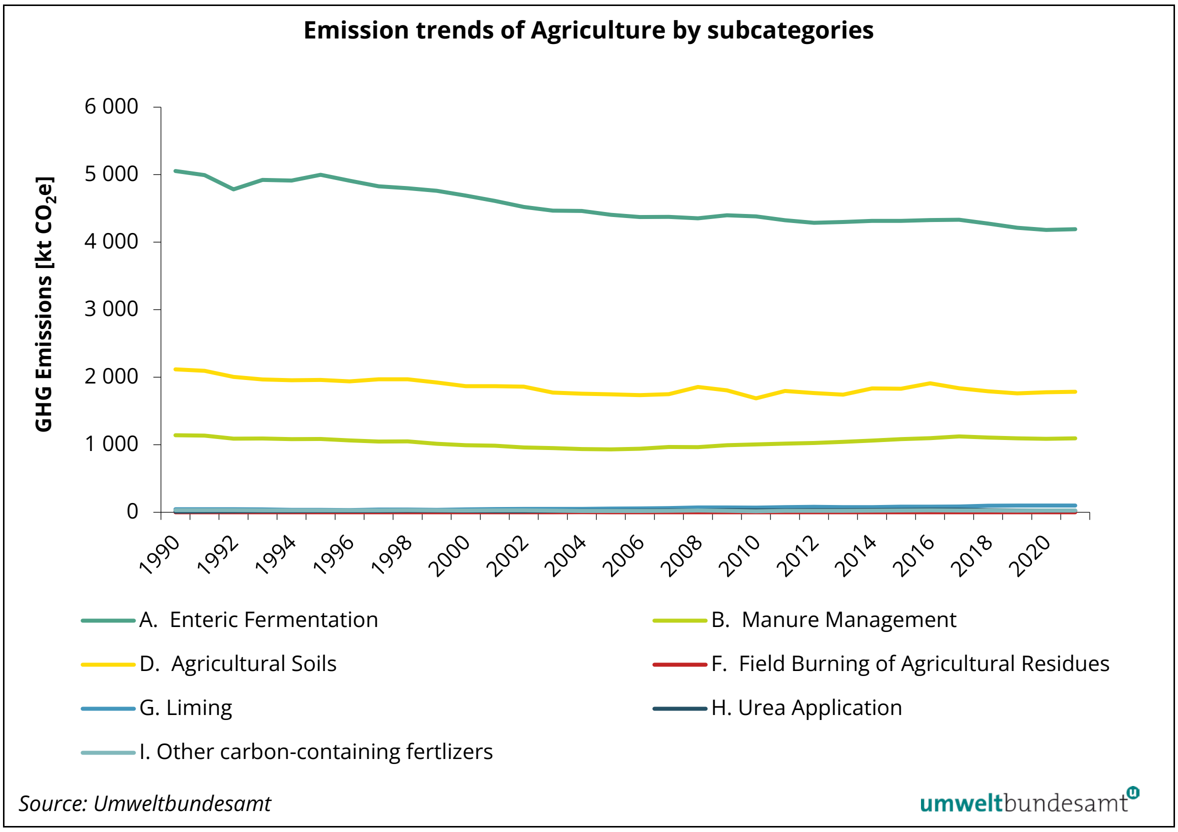
Table 175 presents total GHG emissions and trend 1990–2021 from agriculture by sub-categories as well as the contribution to the overall inventory emissions. Important categories are *3.A Enteric Fermentation* (5.4%) and *3.D Agricultural Soils* (2.3%) followed by *3.B Manure Management* (1.4%).

Table 175: GHG emissions 1990–2021 of agriculture by sub categories.

Year	**GHG emissions [kt CO_2 equivalent] by sub categories**							
	3	**3.A**	**3.B**	**3.D**	**3.F**	**3.G**	**3.H**	**3.I**
1990	8 399.71	5 054.58	1 141.11	2 116.95	1.14	45.67	9.60	30.66
1991	8 310.60	4 993.28	1 134.50	2 095.08	1.10	44.24	11.58	30.82
1992	7 968.44	4 783.11	1 089.27	2 004.63	1.12	45.67	13.62	31.02
1993	8 073.15	4 923.15	1 093.05	1 968.12	0.98	42.53	15.57	29.76
1994	8 035.80	4 912.34	1 084.08	1 955.02	1.10	36.82	17.91	28.53
1995	8 130.44	4 998.26	1 085.50	1 961.35	1.11	35.68	19.79	28.76
1996	7 994.77	4 911.60	1 063.94	1 938.04	1.04	31.97	19.37	28.81
1997	7 935.84	4 827.65	1 048.51	1 968.83	1.13	39.96	20.17	29.58
1998	7 911.02	4 799.39	1 048.94	1 969.11	1.10	41.10	21.45	29.93
1999	7 787.08	4 761.56	1 015.68	1 922.85	1.15	36.53	21.57	27.74
2000	7 643.63	4 691.74	994.32	1 867.23	1.00	42.60	19.36	27.37
2001	7 561.76	4 613.45	986.09	1 868.90	1.15	47.86	16.46	27.86
2002	7 439.39	4 521.94	960.31	1 859.51	1.09	50.59	16.77	29.17
2003	7 286.34	4 468.92	949.66	1 772.82	1.01	50.41	19.10	24.43
2004	7 249.75	4 463.80	936.87	1 756.76	1.75	50.47	21.15	18.95
2005	7 181.23	4 407.09	931.53	1 746.14	0.93	53.62	21.89	20.03
2006	7 153.30	4 372.68	941.02	1 735.73	0.83	58.08	24.88	20.08
2007	7 201.59	4 375.44	966.85	1 748.50	0.87	61.89	27.72	20.31
2008	7 300.42	4 354.16	964.29	1 856.45	0.85	71.62	26.18	26.88
2009	7 325.99	4 399.83	993.97	1 805.33	0.78	72.14	31.43	22.52
2010	7 188.18	4 382.46	1 005.19	1 687.44	0.73	68.61	28.85	14.89
2011	7 265.47	4 324.96	1 016.26	1 797.78	0.47	77.15	27.47	21.37
2012	7 212.42	4 288.00	1 025.48	1 765.00	0.27	80.84	30.63	22.20
2013	7 211.17	4 298.70	1 041.82	1 743.21	0.22	75.34	30.28	21.60
2014	7 346.22	4 316.20	1 062.36	1 834.59	0.29	75.14	34.04	23.59
2015	7 376.00	4 317.11	1 082.34	1 830.85	0.20	83.43	34.90	27.15
2016	7 488.82	4 327.40	1 098.46	1 911.15	0.21	83.80	39.26	28.55
2017	7 444.13	4 333.66	1 122.90	1 836.71	0.14	86.03	38.30	26.38
2018	7 330.20	4 276.46	1 106.07	1 792.74	0.11	96.50	32.03	26.30
2019	7 221.21	4 213.94	1 094.37	1 762.02	0.10	99.40	26.77	24.61
2020	7 197.46	4 182.08	1 089.08	1 777.34	0.00	98.94	24.54	25.47
2021	7 221.16	4 191.86	1 094.19	1 785.82	NO	99.11	23.12	27.06
Share in Austrian Total 2021	**9.3%**	**5.4%**	**1.4%**	**2.3%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**
Trend 1990–2021	**-14.0%**	**-17.1%**	**-4.1%**	**-15.6%**	**-100.0%**	**117.0%**	**140.9%**	**-11.7%**

As can be seen in Figure 30 and Table 175 the overall trend concerning emissions from most of the sub categories is decreasing with the exception of liming and urea application. The main reason for the decrease of emissions from enteric fermentation is the decrease in cattle numbers. In manure management only a slight decrease of emissions can be observed mainly due to the rising share of liquid systems, which compensates the falling cattle numbers. Fluctuations of emissions from agricultural soils are mainly due to varying underlying activity data (especially the sales figures of mineral fertilizers). Emissions from liming and urea application follow the increased application from 1990 onwards. The declining emissions trend of calcium ammonium nitrate (CAN) can be explained with decreasing activity data.

Figure 30: Emission trends of agriculture by subcategories.



As can be seen in Table 176, in 2021 about 58% of emissions from agriculture originate from enteric fermentation and 24,7% from agricultural soils. Manure management contributes about 15.2% and the source categories liming, urea application and other carbon-containing fertilisers are emitting only a negligible part (1.4%, 0.3% and 0.4%, respectively in 2021). Field burning of agricultural wastes did not occur in 2021 anymore ("NO").

Table 176: Share of sub categories of agriculture,1990 and 2021.

	GHG emissions [%] by sub categories							
Year	**3**	**3.A**	**3.B**	**3.D**	**3.F**	**3.G**	**3.H**	**3.I**
1990	100.0%	60.2%	13.6%	25.2%	0.0%	0.5%	0.1%	0.4%
2021	100.0%	58.0%	15.2%	24.7%	0.0%	1.4%	0.3%	0.4%

5.1.2 Key Categories

Key category analysis is presented in Chapter 1.5. This chapter includes information on the agriculture sector. Key categories within the sector agriculture are presented in Table 177.

Table 177: Key categories of sector Agriculture (T1, excl. LULUCF).

IPCC Category	Source Categories	Key Categories	
		GHG	KS-Assessment
3.A.1	Enteric Fermentation (Cattle)	CH_4	LA, TA
3.B.1	Manure Management (Cattle)	CH_4	LA
3.B.1	Manure Management (Cattle)	N_2O	LA
3.D.a	Direct Soil Emissions	N_2O	LA
3.D.b	Indirect Soil Emissions	N_2O	LA

LA = Level Assessment (if not further specified – for the years 1990 and 2021)

TA = Trend Assessment 1990–2021

5.1.3 Methodology

For enteric fermentation the IPCC Tier 1 method was used, except for key categories (cattle and swine). In manure management the Tier 2 method and country specific emission factors were used for cattle and swine. For the other livestock sub categories, the Tier 2 approach and default parameters were used. N_2O emissions from animal manure applied to soils were calculated using a country specific methodology following the N-flow approach.

For the calculation of emissions from enteric fermentation – poultry, Tier 2 emission factors from Switzerland (net energy ingested, methane conversion rate) were used as Tier 1. Farming practices in Switzerland are very similar to the Austrian ones.

2020 to 2022 a new research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) has been carried out by the University of Natural Resources and Life Sciences, Vienna. In submission 2022 Austria included the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) into its agriculture inventory.

MMS distributions used in manure management were taken from (KONRAD 1995), (AMON et al. 2007) and (PÖLLINGER et al. 2018). New study results of the so-called TIHALO II survey (PÖLLINGER et al. 2018) were implemented in submission 2019 within a specific project for the revision of the national inventory (AMON & HÖRTENHUBER 2019).

Country specific methane conversion factors (MCF) were applied for liquid systems of cattle and swine. The MCFs are based on studies carried out at the University of Natural Resources and Applied Life Science (BOKU), Department for Sustainable Agriculture, Division of Agricultural Engineering (DAE) (AMON et al. 2002, AMON et al. 2006, AMON et al. 2007). For all other systems emission factors of the 2006 IPCC Guidelines were used.

As recommended in the Centralized Review 2003, for the estimation of emissions from field burning of agricultural wastes the IPCC methodology using default emission factors was applied. In response to an encouragement of the ERT in the Centralized Review 2010, Austria provided a refined estimate on the basis of relevant crops.

In submission 2015 Austria introduced a national value for $Frac_{Leach}$ (0.15154) based on a national study (EDER, A. et al 2014) for the calculation of indirect emissions from nitrogen leaching and run-off.

The following table presents an overview of the country specific data used in agriculture including a short indication on the sources for this data as recommended in the ARR 2013, Table 8 (para 49).

Table 178: Information on country specific data.

Category	Parameter	Source
3.A Enteric Fermentation		
3.A.1 Cattle	GE-Intake	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.A.3 Swine	GE-Intake	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.A.4 Poultry	CH_4 EF	SBV (2007, 2021), HADORN & WENK (1996)
3.B Manure Management		
3.B (all livestock)	MMS distribution	AMON & HÖRTENHUBER (2010) AMON & HÖRTENHUBER (2019)
3.B (cattle, swine, chicken, horses)	Anaerobic digestion	AMON (2002), E-CONTROL (2022), HÖRTENHUBER (2022)
3.B.1 Cattle	VS excretion	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.B.3 Swine	VS excretion	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.B.1 Cattle, 3.B.3 Swine	MCF liquid systems	AMON et al. (2006), AMON et al. (2007a)
3.B (cattle, swine, chicken)	MCF anaerobic digestion	FNR (2010); AMON, T. (2011)
3.B (cattle, swine)	N excretion	HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023
3.B (all other livestock)	N excretion	UNTERARBEITSGRUPPE N-ADHOC (2004), BMLFUW (2017)
3.D. Agricultural Soils		
Austria's N-flow model	Country-specific consideration of N-losses	(AMON et al. 2002, 2008, 2010, 2014 & 2019)
3.D.a Direct Soil Emissions		
Sewage sludge spreading	N content data	UMWELTBUNDESAMT (1997)
Compost application		Expert judgement by UMWELTBUNDESAMT (2015)
Mineralization/immobilization of soil organic matter		C losses reported in sector LULUCF (4.B.1.3)
Cultivation of organic soils		Derived from soil inventory data, see sector LULUCF
3.D.b Indirect Soil Emissions		
Austria's N-flow model	Country-specific consideration of N-losses	(AMON et al. 2002, 2008, 2010, 2014 & 2019) (EDER, A. et al 2014)

Background information on the parameters listed above is provided in the methodological descriptions of the respective chapters of NIR.

5.1.4 Quality Assurance and Quality Control (QA/QC)

The following sector specific QA/QC procedures have been carried out:

Activity data check

- ✓ Check for transcription errors, comparison with published data (BML 2022b),
- ✓ Consistency checks of sub-categories with totals,
- ✓ Plausibility checks of dips and jumps,

Emission factors

- ✓ Check of implied emission factors (time series) and CRF background data,
- ✓ Comparison with IPCC default values and factors reported by other countries;

Calculation by spread sheets

- ✓ Consistent use of livestock characterization,
- ✓ Cross-checks through all steps of calculation,
- ✓ Documentation of sources and correct use of units;

Results (emissions)

- ✓ Check of recalculation differences,
- ✓ Plausibility checks of dips and jumps;

Documentation

- ✓ Findings and corrections marked in the spread sheets,
- ✓ Improvement list (internal and external findings).

In the Austrian QMS regularly extensive QA and verification activities are carried out (Tier 2 QA). In 2012 Agriculture was validated. Some minor inconsistencies with respect to the MMS data have been found and corrected.

Due to the revision of the Austrian inventory model for sector agriculture according to the 2006 IPCC GL and the EMEP/EEA GB 2013 an external review by Austrian Agricultural experts within the framework of a stakeholder meeting was held in 2014. Applied values and parameters were discussed and validated by the national experts.

In submission 2019 the agricultural model was revised as new data on the agricultural practice in Austria became available from the TIHALO II survey (PÖLLINGER et al. 2018) as well as due to improvements of the N-flow according to the EMEP/EEA GB 2016 (AMON & HÖRTENHUBER 2019). Within the framework of this revision a stakeholder meeting (so-called "inventory talks") was held in 2018 in order to discuss applied values, parameters, time series and study results with Austrian agricultural experts (UMWELTBUNDESAMT 2010, 2014 & 2018).

In submission 2022, Austria included updated and representative values for nitrogen and energy intake, excretion of nitrogen (Nex) and volatile solids (VSex) into the inventory taken from a specific research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023). The results were presented and discussed with Austrian agricultural experts as well.

In submission 2022, emission calculations of *3.I (Other carbon-containing fertilizers)* have been validated. Austria's import statistics were checked with regard to the assumptions on limestone and dolomite contents. The investigations confirmed the current approach using the arithmetic mean of limestone and dolomite.

Source specific procedures are presented in the respective sub-chapters. A general description of Austria's QMS (Quality Management System), activities and improvements 2022 is presented in Chapter 1.2.3.

5.1.5 Uncertainty Assessment

The following chapter gives an estimate of uncertainties with respect to N_2O, CH_4 and CO_2 emissions from enteric fermentation, manure management, agricultural soils, field burning, liming, urea application as well as carbon-containing fertilisers. Overall uncertainties result from uncertainties in the activity data and from uncertainties in the emission factors.

Manure management system distribution (MMS)

MMS distribution is based on the following surveys: (KONRAD 1995), TIHALO I (AMON et al. 2007) and TIHALO II (PÖLLINGER et al. 2018). Uncertainties are estimated with ± 10%.

Country specific MCF for liquid manure systems:

MCF values have a great impact on estimation of methane emissions from manure management. Default MCF values given in the 2006 IPCC GL are derived from a limited number of laboratory studies and theoretical considerations. Following the guidelines, the default values may have a large uncertainty for an individual country because they may not reflect the specific manure management conditions present within the country. For that reason it is highly necessary to measure MCF values under field conditions.

At the University of Natural Resources and Applied Life Sciences a three-year measurement campaign on emissions from manure stores financed by the Federal Ministry of Agriculture, Forestry, Environment, and Water Management and the Federal Ministry for Education, Science, and Culture was carried out (AMON et al. 2002a, 2006, 2007a). Published results have been integrated into the revised GHG inventory. The country specific MCFs reflect the agricultural practice and the climate conditions in Austria better than the default values. The uncertainty range for the country specific MCF is estimated to be ± 20% (AMON & HÖRTENHUBER 2010).

Activity data and emission factors

Uncertainties were derived by analysing official Austrian livestock numbers published in June and December each year. Comparing these two data sets the standard deviation was calculated. As a conservative approach the doubled standard deviation was taken, leading to an uncertainty for cattle of 1% and for swine of 4%.

Uncertainties of emission factors for CH_4 emissions of enteric fermentation were considered 20% for cattle and swine as these livestock categories are calculated by using a Tier 2 methodology (IPCC 2019) and 40% for all other animals calculated with Tier 1 methodology (IPCC 2006). This is consistent with more detailed knowledge for those animals that contribute more to the emissions. Uncertainties of emission factors for CH_4 from manure management were assessed at 20% for livestock categories calculated with Tier 2 methodology and country specific parameters (cattle and swine) and

30% for all other animal categories following IPCC 2006. An uncertainty of 100% was taken for direct N_2O emissions (IPCC 2006). Uncertainty of indirect N_2O emissions from manure management was treated like indirect N_2O emissions from agricultural soils, as described in detail below.

RYPDAL & WINIWARTER (2001) noted that the largest contributor to uncertainty for several existing GHG inventories is N_2O emissions from soils. Thus it is worthwhile to consider this source in some more detail – even if no real improvement of the situation should be expected at this time. While IPCC (2000) assumes two orders of magnitude as the uncertainty margin, re-evaluation of basically the same data leads to a considerable improvement of the situation to estimated 30%–300% of the best estimate, lognormal distribution (IPCC 2006). This range is closer but still higher compared to the one estimated by WINIWARTER & RYPDAL (2001), who assumed uncertainty in a triangular distribution between 50 and 200%.

The IPCC methodology (IPCC 2006) recommends separate treatment of direct and indirect emissions. Uncertainties of emission factors of indirect emissions are not significantly different from those of direct emissions, and the underlying processes (microbial nitrification/denitrification) are identical. Thus it was decided to treat the uncertainties of direct and indirect emissions as being correlated.

Table 179 presents uncertainties for emissions as well as for activity data and the EFs of the key categories of agriculture according to the error propagation method (Tier 1).

Table 179: Uncertainties of emissions and emission factors (key categories agriculture).

Categories		**CH_4 Emissions**	**N_2O Emissions**	**CO_2 Emissions**	**EF CH_4**	**EF N_2O**	**EF CO_2**
3.A.1	Cattle	+/-20.0%	–	–	+/-20%	–	–
3.B.1.1	Cattle	+/-20.0%	+/- 100.0%	–	+/-20%	+/-100%	–
3.D.a	Direct Soil Emissions	–	+/- 200.1%	–	–	+/-200%	–
3.D.b	Indirect Emissions	–	+/- 200.1%	–	–	+/-200%	–
	Activity Data						
Animal Population - Cattle				+/- 1%			
Animal Population - Swine				+/- 4%			
Animal Population – Sheep and Other				+/- 10%			
Area Data & Fertilizer Input (combined)				+/- 5%			

5.1.6 Recalculations

Update of activity data

3.A Enteric Fermentation, 3.B Manure Management, 3.D Agricultural Soils

Livestock data – poultry and deer

Updated livestock data for poultry (layers, broilers, turkeys and other poultry) and deer became available for the year 2020, based on the final results of the farm structure survey 2020 (STATISTIK AUSTRIA 2022). For 2016, activity data of the farm structure survey 2016 was used (STATISTIK AUSTRIA 2018). The numbers for the years 2017, 2018 and 2019 have been derived by interpolation.

Background data for feeding and nutrition of cattle

New values for the protein content of milk for the years 2019 and 2020 and for the fat content of milk for 2020 became available (AMA 2021). In addition, for the years 1996-2004 and 2014-2020 the data on distribution of cattle breeds were slightly updated. These improvements resulted in minor revisions of the values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ of dairy and suckling cows.

Biogas plants

Updated figures on biogas plants (E-CONTROL 2022b) resulted in slight revisions of CH_4 and N_2O with an impact in source categories *3.B Manure Management*, *3.D.a.2.a Animal manure applied to soils* and *3.D.a.2.c Other organic fertilizers applied to soils*.

3.A Enteric Fermentation (CH_4)

This category has been slightly revised due to updated activity and nutrition data (GE-intake, live-stock numbers of poultry and deer – see above).

The improvements resulted in updated emissions for the years 1996-2004 and 2014-2020 (+0.04 kt CH_4 for 2020).

3.D.a.4 Crop Residues (N_2O)

For 2020, sugar beet harvest amounts have been marginally revised resulting in lower N_2O amounts (-0.0005 kt N_2O for 2020).

3.D.a.5 Mineral Soils (N_2O)

Revisions of activity data (perennial cropland to annual cropland, for more information see chapter 6.3 on LULUCF) resulted in revised emissions for the entire time series (+0.001 kt N_2O for 2020).

Improvements of methodologies and emission factors

3.B Manure Management (CH_4, direct and indirect N_2O)

Methane and direct N_2O emissions have been revised for the years 1996-2004 and 2014-2020 (+0.001 kt CH_4 for 2020 and -0.001 kt N_2O for 2020), as a result of updated activity and nutrition data (see above).

Austria's agriculture model is based on the N-flow concept. Thus, revisions within Austria's air emission inventory affect calculation results in Austria's GHG inventory. In Austria's air emission inventory, the decreasing share of tied systems from 2017 onwards was taken into account for the first time. This improvement contributed to the increased emissions for indirect N_2O (+0.01 kt N_2O for 2020).

3.D Agricultural Soils (N_2O)

3.D.1.2.a Animal Manure Applied to Soils

Updates and improvements in the area of animal husbandry described above resulted in minor revisions of emissions from animal manure application (-0.01 kt N_2O for 2020).

3.D.1.3 Urine and dung deposited by Grazing Animals

Livestock related updates as already described before, resulted in revised N_2O emissions for the years 1996-2004 and 2014-2020 (-0.001 kt N_2O for 2020).

3.D.b Agricultural Soils (indirect soil emissions – N_2O)

Atmospheric deposition: the main reasons for revised emissions are the correction of a linkage error in the ammonia inventory and the adjusted activity data ($N_{excretion}$ values for cattle, livestock numbers poultry and deer, biogas). As a result, the indirect N_2O emissions from atmospheric deposition were revised downwards for the years 1991-2020 (-0.004 kt N_2O for 2020).

N leaching and run-off: updated AD (see above) are the reason for revised emissions for the entire time series (-0.001 kt N_2O for 2020).

Reallocation of emission sources

3.F Field burning

Following a recommendation of the NEC Review 2022, emissions from the burning of residual wood from vinicultures on open fields (formerly reported under *3.F.5 Other*) have been reallocated to category *5.C.2.1.b Incineration and Open Burning of Waste – Other*. This reallocation results in lower emissions of CH_4 and N_2O for the entire time series (-0.02 kt CH_4 and -0.0002 kt N_2O).

The whole time series of recalculations can bei found in Annex 8 to the NIR.

5.1.7 Completeness

Table 180 gives an overview of the IPCC categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated.

Table 180: Overview of sub-categories of agriculture: transformation into SNAP codes and status of estimation.

IPCC Category		SNAP		CO_2	CH_4	N_2O
3.A	**ENTERIC FERMENTATION**	**1004**	**ENTERIC FERMENTATION**	**NA**	✓	**NA**
3.A.1	Cattle	–	–	NA	✓	NA
3.A.1.a	Dairy Cattle	100401	Dairy cows	NA	✓	NA
3.A.1.b	Non-Dairy Cattle	100402	Other cattle	NA	✓	NA
3.A.2	Sheep	100403	Ovines	NA	✓	NA
3.A.3	Swine	100404	Fattening pigs	NA	✓	NA
3.A.4	Other Livestock			NA	✓	NA
	Buffalo	100414	Buffalos	NO	NO	NO
	Camels	100413	Camels	NO	NO	NO
	Deer	100415	Other	NA	✓	NA
	Goats	100407	Goats	NA	✓	NA
	Horses	100405	Horses	NA	✓	NA
	Mules and asses	100406	Mules and asses	IE[1)]	IE[1)]	IE[1)]
	Poultry	100408 /09/10	Laying hens, broilers, other poultry	NA	✓	NA
	Other (Rabbit, Reindeer, Ostrich, fur-bearing animals, Other)	100415	Other	NO	NO	NO

IPCC Category		SNAP		CO_2	CH_4	N_2O
3.B.	**MANURE MANAGEMENT**	**1005** **1009**	**MANURE MANAGEMENT REGARDING ORGANIC COMPOUNDS** **MANURE MANAGEMENT REGARDING NITROGEN COMPOUNDS**	**NA** **NA**	✓ **NA**	**NA** ✓
3.B.1	Cattle	–	–	NA	✓	✓
3.B.1.a	Dairy Cattle	100501	Dairy cows	NA	✓	✓
3.B.1.b	Non-Dairy Cattle	100502	Other cattle	NA	✓	✓
3.B.2	Sheep	100505	Ovines	NA	✓	✓
3.B.3	Swine	100503	Fattening pigs	NA	✓	✓
3.B.4	Other Livestock	–	–	NA	✓	✓
	Buffalo	100514	Buffalos	NO	NO	NO
	Camels	100513	Camels	NO	NO	NO
	Deer	100515	Deer	NA	✓	✓
	Goats	100511	Goats	NA	✓	✓
	Horses	100506	Horses	NA	✓	✓
	Mules and asses	100506	Mules and asses	IE[2)]	IE[2)]	IE[2)]
	Poultry	100507 /08/09	Laying hens, broilers, Other poultry (ducks, gooses,…)	NA	✓	✓
	Other (Rabbit, Reindeer, Ostrich, fur-bearing animals, Other)	100415	Other	NO	NO	NO
3.B.5	Indirect N_2O emissions			NO	NO	✓
3.C	**RICE CULTIVATION**	**100103** **100103**	**Rice Field (with fertilizers)** **Rice Field (without fertilizers)**	**NO**	**NO**	**NO**
3.D	**AGRICULTURAL SOILS**	**1001** **1002**	**Cultures with fertilizers** **Cultures without fertilizers**	**NA**	**NA**	✓
3.D.a	Direct N_2O emissions from managed soils	1001/1002	Cultures with and without fertilizers	NA	NA	✓
3.D.a.1	Inorganic N fertilizers	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2	Organic N fertilizers	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2.a	Animal manure applied to soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2.b	Sewage sludge applied to soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2.c	Other organic fertilizers applied to soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.3	Urine and dung deposited by grazing animals	1002	Cultures without fertilizers	NA	NA	✓
3.D.a.4	Crop residues	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.5	Mineralization/immobilization associated with loss/gain of soil organic matter	1002	Cultures without fertilizers	NA	NA	✓
3.D.a.6	Cultivation of organic soils (i.e. histosols)	1002	Cultures without fertilizers	NA	NA	✓
3.D.a.7	Other	–	–	NO	NO	NO
3.D.b	Indirect N_2O Emissions from managed soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.b.1	Atmospheric deposition	1001	Cultures with fertilizers	NA	NA	✓

IPCC Category		SNAP		CO_2	CH_4	N_2O
3.D.b.2	Nitrogen leaching and run-off	1001	Cultures with fertilizers	NA	NA	✓
3.E	**PRESCRIBED BURNING OF SAVANNAS**	**–**	**–**	**NO**	**NO**	**NO**
3.F	**FIELD BURNING OF AGRICULTURAL RESIDUES**	**1003**	**ON-FIELD BURNING OF STUBBLE, STRAW, …**	**NA**	✓	✓
3.F.1	Cereals	100301	Cereals	NA	✓	✓[2)]
3.F.2	Pulses	100302	Pulse	NO	NO	NO
3.F.3	Tubers and Roots	100303	Tuber and Root	NO	NO	NO
3.F.4	Sugar Cane	100304	Sugar Cane	NO	NO	NO
3.G	**Liming**	**1006**	**Use of pesticides and limestone**	✓	**NA**	**NA**
3.G.1	Limestone CaCO3	1006	Use of pesticides and limestone	✓	NA	NA
3.G.2	Dolomite CaMg(CO3)2	1006	Use of pesticides and limestone	✓	NA	NA
3.H	**Urea application**	**1006**	**Use of pesticides and limestone**	✓	**NA**	**NA**
3.I	Other carbon-containing fertilisers	1006	Use of pesticides and limestone	✓	NA	NA

[1)] *included in 3.A.4 Horses, SNAP 100406;* [2)]*included in 3.B.4 Horses, SNAP 100506*

[2)] *emissions reported for 1990-2020; for 2021 "not occurring"*

5.1.8 Planned Improvements

A new survey on animal husbandry and manure management systems ("TIHALO III" study) is planned for 2023/2024. Study results will be implemented in submission 2025.

5.2 Enteric fermentation (Category 3.A)

This chapter describes the estimation of CH_4 emissions from enteric fermentation. In 2021 87.1% of agricultural CH_4 emissions arose from this category.

5.2.1 Source Category Description

CH_4 emissions amounted to 180.5 kt in 1990 and have decreased by 17.1% to 149.7 kt in 2021. Almost all emissions of category 3.A (94.0% in 2021) are caused by cattle farming, thus CH_4 emissions from *Cattle (3.A.1)* are a key source. The contribution of *Dairy Cattle (3.A.1.1)* decreased from 54.2% in 1990 to 45.8% in 2021.

Table 181: Greenhouse gas emissions from enteric fermentation by sub-categories 1990–2021.

Year	**CH_4 emissions [kt] per Livestock Category**								
	3.A	**3.A.1.1**	**3.A.1.2**	**3.A.2**	**3.A.3**	**3.A.4.1**	**3.A.4.2**	**3.A.4.3**	**3.A.4.4**
	Total	**Dairy Cattle**	**Non-Dairy**	**Sheep**	**Swine**	**Other/ Poultry**	**Other/ Horses**	**Other/ Goats**	**Other/ Deer**
1990	180.52	97.88	75.47	2.48	3.13	0.19	0.89	0.19	0.30
1991	178.33	95.00	75.80	2.61	3.18	0.19	1.04	0.20	0.30
1992	170.83	91.50	71.92	2.50	3.12	0.18	1.11	0.20	0.30
1993	175.83	90.64	77.57	2.67	3.05	0.20	1.17	0.24	0.30
1994	175.44	89.10	78.67	2.74	3.00	0.19	1.20	0.25	0.30
1995	178.51	80.38	90.11	2.92	3.00	0.19	1.30	0.27	0.32
1996	175.41	79.68	87.64	3.05	2.96	0.17	1.32	0.27	0.33
1997	172.42	80.52	83.58	3.07	2.97	0.20	1.34	0.29	0.45
1998	171.41	84.59	78.63	2.89	3.08	0.19	1.36	0.27	0.40
1999	170.06	81.72	80.46	2.82	2.79	0.20	1.47	0.29	0.31
2000	167.56	73.23	86.66	2.71	2.71	0.16	1.49	0.28	0.32
2001	164.77	71.38	85.71	2.56	2.81	0.17	1.52	0.30	0.32
2002	161.50	70.64	83.39	2.43	2.71	0.17	1.54	0.29	0.33
2003	159.60	67.56	84.40	2.60	2.70	0.18	1.57	0.27	0.33
2004	159.42	65.80	86.03	2.62	2.57	0.18	1.62	0.28	0.34
2005	157.40	65.15	84.53	2.61	2.64	0.18	1.67	0.28	0.34
2006	156.17	64.65	83.89	2.50	2.62	0.18	1.72	0.27	0.35
2007	156.27	64.68	83.42	2.81	2.74	0.19	1.76	0.30	0.36
2008	155.51	65.50	82.09	2.67	2.56	0.19	1.81	0.31	0.37
2009	157.14	65.87	83.10	2.76	2.64	0.19	1.86	0.34	0.37
2010	156.52	65.98	82.18	2.87	2.63	0.20	1.91	0.36	0.38
2011	154.46	65.63	80.50	2.89	2.55	0.20	1.96	0.36	0.37
2012	153.14	65.80	78.96	2.92	2.53	0.21	2.01	0.37	0.35
2013	153.53	66.67	78.56	2.86	2.47	0.21	2.06	0.36	0.33
2014	154.15	67.91	77.99	2.79	2.44	0.22	2.11	0.35	0.33
2015	154.18	67.65	78.16	2.83	2.44	0.23	2.16	0.38	0.33
2016	154.55	68.99	76.99	3.03	2.40	0.24	2.16	0.41	0.33
2017	154.77	69.60	76.16	3.21	2.44	0.24	2.34	0.46	0.32
2018	152.73	68.91	74.80	3.25	2.41	0.25	2.34	0.46	0.32
2019	150.50	67.92	73.56	3.22	2.41	0.26	2.34	0.46	0.31
2020	149.36	68.42	71.99	3.15	2.43	0.27	2.34	0.46	0.31
2021	149.71	68.52	72.14	3.22	2.42	0.27	2.34	0.50	0.31
Share 2021	**100%**	**45.8%**	**48.2%**	**2.2%**	**1.6%**	**0.2%**	**1.6%**	**0.3%**	**0.2%**
1990–2021	**–17.1%**	**-30%**	**-4.4%**	**29.8%**	**-23%**	**42.9%**	**164.2%**	**169.4%**	**3.2%**

The overall reduction is caused by a decrease in total numbers of cattle and swine. However, in the case of dairy cows the reduction of animals is partly counterbalanced by an increase in emissions per animal (because of the increasing milk yield and the connected gross energy intake since 1990).

Following a recommendation of the centralized review 2008 CH_4 emissions from *Non-Dairy Cattle* are reported separately:

Table 182: Greenhouse gas emissions from non-dairy cattle (3.A.1.2) by sub-categories 1990–2021.

Year	CH₄ emissions [kt] of Non-Dairy Cattle (3.A.1.2) sub-categories					
	3.A.1.2 Total	Suckling Cows > 2 yr	Young Cattle < 1 yr	Breeding Heifers 1–2 yr	Fattening Heifers 1–2 yr	Other Cattle > 2 yr
1990	75.47	4.65	19.96	18.47	22.51	9.88
1991	75.80	5.68	19.35	18.30	22.23	10.24
1992	71.92	6.01	18.06	17.41	20.61	9.82
1993	77.57	6.93	18.33	18.61	23.19	10.52
1994	78.67	9.03	17.98	18.98	22.79	9.88
1995	90.11	21.23	17.66	19.13	21.94	10.16
1996	87.64	21.57	16.88	18.64	20.34	10.20
1997	83.58	19.47	16.14	18.60	18.67	10.70
1998	78.63	15.80	16.53	18.19	17.69	10.42
1999	80.46	18.19	16.45	18.23	17.06	10.52
2000	86.66	26.11	16.35	17.57	16.09	10.54
2001	85.71	26.79	16.38	17.20	15.60	9.75
2002	83.39	25.58	16.08	16.82	15.50	9.39
2003	84.40	25.54	16.10	16.26	15.73	10.78
2004	86.03	27.61	16.00	16.36	15.25	10.81
2005	84.53	28.55	15.50	16.26	14.97	9.25
2006	83.89	28.67	15.08	15.70	15.41	9.03
2007	83.42	28.75	14.68	14.91	16.33	8.75
2008	82.09	28.26	14.30	14.17	16.62	8.74
2009	83.10	28.11	13.92	13.90	17.96	9.21
2010	82.18	27.79	13.24	13.29	18.44	9.42
2011	80.50	27.40	13.04	13.09	17.72	9.26
2012	78.96	26.58	13.15	13.18	17.27	8.78
2013	78.56	25.34	13.14	13.65	17.67	8.76
2014	77.99	24.67	13.22	13.68	17.56	8.87
2015	78.16	24.12	13.08	13.96	17.82	9.18
2016	76.99	23.35	13.24	13.85	17.46	9.10
2017	76.16	22.30	13.08	13.73	18.11	8.94
2018	74.80	21.59	12.94	13.65	17.50	9.11
2019	73.56	21.05	12.61	13.31	17.76	8.83
2020	71.99	20.55	12.42	13.03	17.21	8.77
2021	72.14	20.01	12.70	13.11	17.64	8.70
Share 2021	**100%**	**28%**	**18%**	**18%**	**24%**	**12%**
1990–2021	**-4.4%**	**330.6%**	**-36.4%**	**-29.1%**	**-21.7%**	**-12.0%**

The rise in suckling cow numbers (see Table 183) nearly counterbalances the decreasing emission trend of all the other non-dairy cattle sub-categories. These sub-categories include both, female cattle and bulls.

5.2.2 Methodological Issues

The IPCC Tier 1 Method was applied for sheep, goats, horses and 'other animals'. For *Cattle* and *Swine* the more detailed Tier 2 method was applied. The IPCC Guidelines do not provide methodologies for the categories poultry and other.

The animal category "deer", reported under category *'other livestock' (3.A.4.4),* corresponds to furred game mainly including deer in Austria. No further data on the exact composition of this animal category is available. As the contribution to the overall emissions is very small, the default emission factor of sheep has been used because sheep is the most similar animal category to deer.

For the calculation of CH_4 emissions from poultry the emission factors (net energy ingested, methane conversion rate) applied by Switzerland have been chosen to be applied in the Austrian emission inventory as Tier 1. Agricultural practices in Switzerland are very similar to those in Austria: Both countries have a small structured agriculture due to similar alpine conditions and comparable traditions. In both countries high shares of farms (in Austria as well as in Switzerland about 57%) manage less than 20 ha. No IPCC default values are available.

Activity data

The Austrian official statistics (STATISTIK AUSTRIA 2022a) provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year[95].

Table 183 and Table 184 presents applied animal data. Background information is listed below:

From 1990 onwards: The continuous decline of dairy cattle numbers is connected with the increasing milk yield per cow: For the production of milk according to Austria's milk quota every year a smaller number of cows is needed.

1991: A minimum counting threshold for poultry was introduced. Farms with less than 11 poultry were not considered any more. However, the contribution of these small farms is negligible, both with respect to the total poultry number and to the trend.
The increase of the soliped population between 1990 and 1991 is caused by a better data collection from riding clubs and horse breeding farms.

1993: New characteristics for swine and cattle categories were introduced in accordance with Austria's entry into the European Economic Area and the EU guidelines for farm animal population categories. In 1993 part of the "Young cattle < 1 yr" category was included in the "Young cattle 1–2 yr" category. This shift is considered to be insignificant: no inconsistency in the emission trend of "Non-Dairy Cattle" category was recorded.
In the same year "Young swine < 50 kg" were shifted to "Fattening pigs > 50 kg" (before 1993 the limits were 6 months and not 50 kg which led to the shift) causing distinct inconsistencies in time series. Following a recommendation of the Centralized Review 2003, the age class split for swine categories of the years 1990–1992 was adjusted using the split from 1993.

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[95] For cattle livestock counts are also held in June, but seasonal changes are very small (between 0% and 2%). Livestock counts of sheep are only held in December (sheep is only a minor source for Austria and seasonal changes of the population are not considered relevant).

1993: For the first time other animals e.g. deer (but not wild living animals) were counted. Following the recommendations of the Centralized Review 2004, to ensure consistency and completeness animal number of 1993 was used for the years 1990 to 1992.

1995: The financial support of suckling cow husbandry increased significantly in 1995 when Austria became a Member State of the European Union. The husbandry of suckling cows is used for the production of veal and beef; the milk yield of the cow is only provided for the suckling calves. Especially in mountainous regions with unfavourable farming conditions, suckling cow husbandry allows an extensive and economic reasonable utilisation of the pastures. Suckling cow husbandry contributes to the conservation of the traditional Austrian alpine landscape.

1996–1998: The market situation affected a decrease in veal and beef production, resulting in a declining suckling cow husbandry. Farmers partly used their former suckling cows for milk production. Thus, dairy cow numbers slightly increased at this time. Reasons are manifold: Changing market prices, BSE epidemic in Europe and change of consumer behaviour, milk quota etc.

1998–2000; 2006–2008: increasing/decreasing swine numbers: The production of swine has a high elasticity to prices: Swine numbers are changing due to changing market prices very rapidly. Market prices change due to changes in consumer behaviour, saturation of swine production, epidemics etc.

Table 183: Domestic livestock population and its trend 1990–2021 (I).

Year	Population size [heads] * Livestock category						
	Dairy	Non-Dairy	Suckling Cows	Young Cattle < 1 yr	Breeding Heifers 1–2 yr	Fattening Heifers, Bulls, Oxen 1–2 yr	Other Cattle > 2 yr
1990	904 617	1 679 297	47 020	925 162	254 883	305 920	146 312
1991	876 000	1 658 266	57 333	893 732	252 923	301 903	151 769
1992	841 716	1 559 009	60 481	831 612	241 002	280 076	145 838
1993	828 147	1 505 740	69 316	705 547	257 939	314 982	157 956
1994	809 977	1 518 541	89 999	706 579	263 591	309 586	148 786
1995	706 494	1 619 331	210 479	691 454	266 108	298 244	153 046
1996	697 521	1 574 428	212 700	670 423	259 747	277 635	153 923
1997	699 811	1 498 129	191 106	630 853	259 494	254 986	161 690
1998	728 718	1 442 963	154 276	635 113	254 251	241 908	157 415
1999	697 903	1 454 908	176 680	630 586	255 244	233 039	159 359
2000	621 002	1 534 445	252 792	655 368	246 382	220 102	159 801
2001	597 981	1 520 473	257 734	658 930	241 556	214 156	148 097
2002	588 971	1 477 971	244 954	640 060	236 706	213 226	143 025
2003	557 877	1 494 156	243 103	641 640	229 150	216 971	163 292
2004	537 953	1 513 038	261 528	646 946	230 943	210 454	163 167
2005	534 417	1 476 263	270 465	628 426	229 874	206 429	141 069
2006	527 421	1 475 498	271 314	631 529	222 104	212 887	137 664
2007	524 500	1 475 696	271 327	634 089	211 044	226 014	133 222
2008	530 230	1 466 979	266 452	636 469	200 787	230 457	132 814
2009	532 976	1 493 284	264 547	643 441	196 476	249 486	139 334
2010	532 735	1 480 546	260 883	634 052	187 386	256 266	141 959

Year	Population size [heads] * Livestock category						
	Dairy	Non-Dairy	Suckling Cows	Young Cattle < 1 yr	Breeding Heifers 1–2 yr	Fattening Heifers, Bulls, Oxen 1–2 yr	Other Cattle > 2 yr
2011	527 393	1 449 134	256 831	623 364	184 160	245 770	139 009
2012	523 369	1 432 249	248 438	628 715	184 932	238 968	131 196
2013	529 560	1 428 722	236 655	626 970	191 002	243 546	130 549
2014	537 744	1 423 457	229 986	629 401	191 049	241 408	131 613
2015	534 098	1 423 512	224 348	624 483	194 493	244 588	135 600
2016	539 867	1 414 524	216 678	632 150	192 455	239 588	133 653
2017	543 421	1 400 055	207 007	623 517	190 364	248 227	130 940
2018	532 873	1 379 935	200 475	618 218	188 698	239 685	132 859
2019	524 068	1 355 452	195 480	605 322	183 402	243 023	128 225
2020	524 783	1 330 649	190 685	598 598	179 120	235 277	126 969
2021	526 461	1 343 639	185 692	611 007	180 083	240 992	125 865
Trend 90–21	**-41.8%**	**-20.0%**	**294.9%**	**-34.0%**	**-29.3%**	**-21.2%**	**-14.0%**

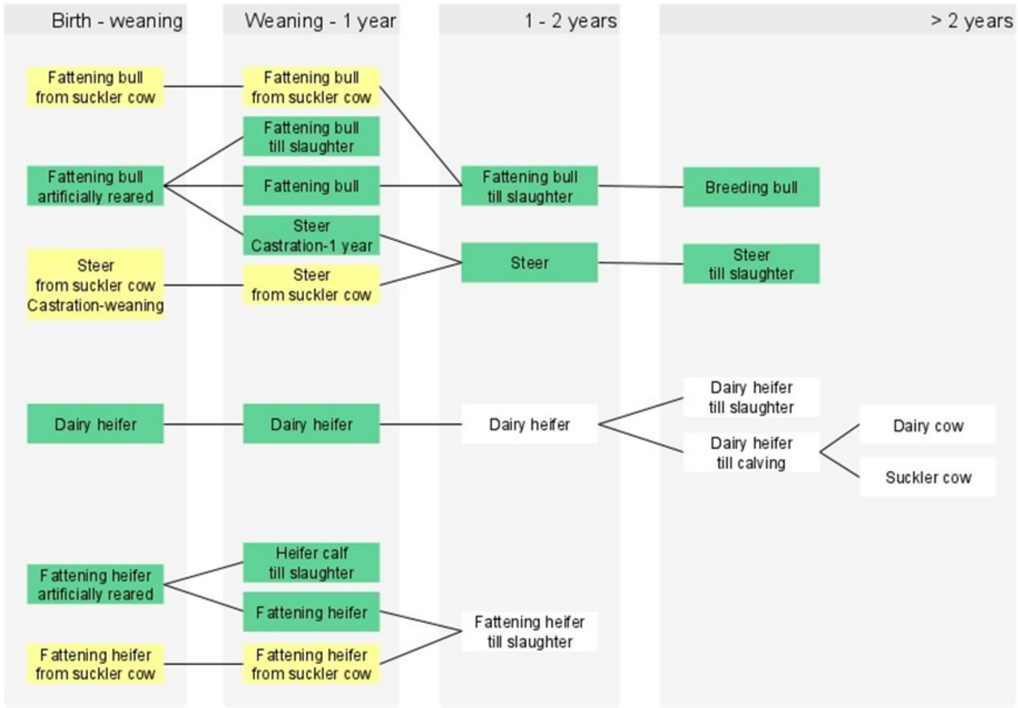
The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO AGR. STATISTICAL SYSTEM 2001). In the case of Austria, these data come from the national statistical system (Statistik Austria). However, there are inconsistencies between these two data sets. Analysis shows that there is often a time gap of one year between the two data sets. FAOSTAT data are seemingly based on the official Statistik Austria data but there is an annual attribution error. In the Austrian inventory Statistik Austria data is used, they are the best available.

Cattle numbers increased by 0.8 % in 2021 compared to the previous year (dairy cows: + 0.3 %; other cattle: + 1 %). According to the Green Report 2022 (BML 2022b) the larger animal production was driven in 2021 primarily by higher producer prices and restocking as well as higher milk prices.

Splitting of cattle categories for background calculations

In order to be able to take more precise feeding assumptions and energy requirement calculations into account, the livestock categories "cattle <1 year", "cattle 1-2 years, breeding animals", "cattle 1-2 years, fattening animals", "dairy cows", "suckling cows" and "other cattle > 2 years" were further subdivided. For this subdivision additional data from AgrarMarkt Austria (AMA) were used. However, the numbers of animals per superordinate category (see Table 183) based on (STATISTIK AUSTRIA 2022a) were not changed.

Figure 31: Allocation of the cattle numbers for determining energy requirements.



Source: Umweltbundesamt

Reallocation of swine categories

The number of pigs was reclassified to allow a more accurate calculation of energy requirements by dividing them into three categories: "breeding sows (including suckling piglets up to 8 kg live weight) and boars", "piglets 8 to 32 kg live weight" and "fattening pigs" (see Table 184).

Breeding sows and boars

The livestock numbers of category "breeding pigs over 50 kg", taken from livestock census data of Statistics Austria, also include gilts above 50 kg until first insemination, which make up approximately 19% of this category. In terms of feed intake and nutrient excretion they correspond more to category "fattening pigs" and have therefore been assigned to that category. Breeding boars, which comprise just about 2% of "breeding pigs (over 50 kg)" were calculated similarly as sows in terms of feed intake and excretions.

Piglets 8 to 32 kg

In the official Austrian livestock census, piglets between 8 and 32 kg live weight are divided into the categories "up to 20 kg" and "young pigs 20-50 kg". The number of piglets 8 to 32 kg used for emission calculations was determined on the basis of rearing days and body weight.

Fattening pigs

As the category "fattening pigs above 32 kg to the end of fattening" is not provided in the livestock census, it had to be derived from the categories "piglets 20-50 kg" and "pigs 50 kg to end of fattening". In addition, the category "gilts above 50 kg before first insemination" was added, since these were subtracted from the breeding sows category.

The total number of pigs according to Statistics Austria (STATISTIK AUSTRIA 2021a) exceeds the total number of pigs used in the inventory calculations as they do not consider litters <8kg. This can be explained by the emission factors of breeding sows which already take into account the emissions of suckling piglets up to 8 kg live weight. The Austrian swine numbers are presented in the following table:

Table 184: Domestic livestock population and its trend 1990–2021 (II).

Year	Livestock category – Population size [heads]*									
	Total Swine (including litter <8kg)**	**Total Swine (excluding litter <8kg)**	**Young & Fattening Pigs incl. gilts**	**Breeding Sows without replacement gilts**	**Young Swine 8-32 kg**	**litter <8kg[3)]**	**Sheep**	**Goats**	**Horses[1)]**	**Deer[2)]**
1990	3 687 981	3 470 006	2 002 846	374 956	1 092 204	217 975	309 912	37 343	49 200	37 100
1991	3 637 980	3 517 698	2 030 373	380 110	1 107 215	120 282	326 100	40 923	57 803	37 259
1992	3 719 600	3 440 509	1 985 820	371 769	1 082 919	279 091	312 000	39 400	61 400	37 418
1993	3 819 798	3 352 984	1 935 482	362 017	1 055 485	466 814	333 835	47 276	64 924	37 577
1994	3 728 991	3 277 124	1 892 105	359 098	1 025 920	451 867	342 144	49 749	66 748	37 736
1995	3 706 185	3 262 871	1 878 195	368 616	1 016 060	443 314	365 250	54 228	72 491	40 323
1996	3 663 747	3 217 898	1 831 533	365 000	1 021 365	445 849	380 861	54 471	73 234	41 526
1997	3 679 876	3 234 647	1 848 408	359 760	1 026 479	445 229	383 655	58 340	74 170	56 244
1998	3 810 310	3 357 927	1 960 585	352 722	1 044 620	452 383	360 812	54 244	75 347	50 365
1999	3 433 029	3 029 381	1 774 617	317 690	937 073	403 648	352 277	57 993	81 566	39 086
2000	3 347 931	2 948 771	1 723 098	307 020	918 653	399 160	339 238	56 105	82 943	39 612
2001	3 440 405	3 033 701	1 785 146	317 320	931 235	406 704	320 467	59 452	84 319	40 138
2002	3 304 650	2 922 646	1 711 744	306 522	904 380	382 004	304 364	57 842	85 696	40 664
2003	3 244 866	2 877 585	1 723 988	303 926	849 671	367 281	325 495	54 607	87 072	41 190
2004	3 125 361	2 754 732	1 625 238	288 288	841 206	370 629	327 163	55 523	89 816	42 102
2005	3 169 541	2 812 822	1 694 649	287 570	830 604	356 719	325 728	55 100	92 560	43 014
2006	3 139 438	2 774 835	1 659 535	288 522	826 778	364 603	312 375	53 108	95 304	43 926
2007	3 286 292	2 913 744	1 761 475	288 248	864 022	372 548	351 329	60 487	98 048	44 839
2008	3 064 231	2 716 737	1 629 226	270 714	816 797	347 494	333 181	62 490	100 792	45 751
2009	3 136 967	2 781 641	1 699 735	266 571	815 336	355 326	344 709	68 188	103 536	46 663
2010	3 134 156	2 776 522	1 696 999	261 410	818 113	357 634	358 415	71 768	106 280	47 575
2011	3 004 907	2 669 093	1 643 448	249 725	775 920	335 814	361 183	72 358	109 024	45 654
2012	2 983 158	2 646 917	1 635 956	239 999	770 962	336 241	364 645	73 212	111 768	43 733
2013	2 895 841	2 575 599	1 594 771	231 750	749 078	320 242	357 440	72 068	114 512	41 812
2014	2 868 191	2 544 151	1 577 174	224 983	741 994	324 040	349 087	70 705	117 256	41 600
2015	2 845 451	2 525 795	1 572 529	225 158	728 108	319 656	353 710	76 620	120 000	41 388
2016	2 792 803	2 483 812	1 549 287	218 773	715 751	308 991	378 381	82 735	120 000	41 176
2017	2 820 082	2 507 701	1 570 251	221 197	716 252	312 381	401 480	91 134	130 000	40 457
2018	2 776 574	2 471 234	1 562 976	210 675	697 584	305 340	406 336	91 536	130 000	39 738
2019	2 773 225	2 468 737	1 557 498	211 058	700 181	304 488	402 658	92 504	130 000	39 018
2020	2 806 461	2 495 809	1 571 571	208 364	715 874	310 652	393 764	92 758	130 000	38 299
2021	2 785 587	2 479 172	1 568 407	205 556	705 209	306 415	402 345	100 601	130 000	38 299
Trend 90–21	**-24.5%**	**-28.6%**	**-21.7%**	**-45.2%**	**-34.5%**	**+40.6%**	**29.8%**	**169.4%**	**164.2%**	**3.2%**

** from 1990 to 1992 adjusted age class split for swine as recommended in the centralized review (October 2003)*

*** total number of Swine according to (STATISTIK AUSTRIA 2022a) and published in (BML 2022b)*

****furred game, mainly deer.*

[1)] for the years 2000–2002 and 2004–2014: interpolated values

[2)] for the years 1991–1993, 2000-2002, 2004–2009, 2011–2012, 2014-2015 and 2017-2019: interpolated values

[3)] not applied because already considered in the emission factors of breeding sows

Goat and sheep numbers increased in 2021 compared to 2020. For swine a decrease in livestock numbers could be observed in 2021.

Horse numbers for 2015, 2016, 2017, 2018, 2019, 2020 and 2021 are provided by the Ministry of Agriculture and are published in (BML 2022b, p. 53). Horse numbers used for the years before 2004 are based on livestock accountings and are assessed to be representative for Austria. Data for the years 2004 to 2014 were derived by interpolation.

Table 185: Domestic livestock population and its trend 1990–2021 (III).

Year	Livestock category – Population size [heads]*					
	Total Poultry	**Chicken***	**Laying hens***	**Broilers***	**Turkeys****	**Other Poultry****
1990	13 820 961	13 139 151	8 392 369	4 746 782	524 616	157 194
1991	14 397 143	13 478 820	8 340 068	5 138 752	759 307	159 016
1992	13 683 900	12 872 100	7 853 673	5 018 427	671 215	140 585
1993	14 508 473	13 588 850	8 307 661	5 281 189	793 431	126 192
1994	14 178 834	13 265 572	8 288 140	4 977 432	781 643	131 619
1995	13 959 316	13 157 078	7 899 011	5 258 067	679 477	122 761
1996	12 979 954	12 215 194	7 387 086	4 828 108	642 541	122 219
1997	14 760 355	13 949 648	7 894 150	6 055 498	693 010	117 697
1998	14 306 846	13 539 693	7 193 505	6 346 188	645 262	121 891
1999	14 498 170	13 797 829	6 786 341	7 011 488	585 806	114 535
2000	11 786 670	11 077 343	6 555 815	4 521 528	588 522	120 805
2001	12 571 528	11 905 111	6 974 146	4 930 965	547 232	119 185
2002	12 571 528	11 905 111	6 974 146	4 930 965	547 232	119 185
2003	13 027 145	12 354 358	6 525 623	5 828 735	550 071	122 716
2004	13 258 183	12 577 852	6 602 159	5 975 692	559 463	120 869
2005	13 489 222	12 801 345	6 678 696	6 122 650	568 854	119 022
2006	13 720 260	13 024 839	6 755 232	6 269 607	578 246	117 175
2007	13 951 298	13 248 332	6 831 768	6 416 564	587 638	115 328
2008	14 182 336	13 471 826	6 908 304	6 563 521	597 030	113 481
2009	14 413 375	13 695 319	6 984 841	6 710 479	606 421	111 634
2010	14 644 413	13 918 813	7 061 377	6 857 436	615 813	109 787
2011	15 020 126	14 305 565	7 373 407	6 932 158	610 708	103 853
2012	15 395 838	14 692 317	7 685 438	7 006 879	605 602	97 919
2013	15 771 551	15 079 069	7 997 468	7 081 601	600 497	91 985
2014	16 334 620	15 634 432	8 356 808	7 277 624	597 071	103 117
2015	16 897 690	16 189 796	8 716 148	7 473 648	593 645	114 249
2016	17 460 759	16 745 159	9 075 488	7 669 671	590 219	125 381
2017	18 033 026	17 309 548	9 190 513	8 119 035	584 503	138 975
2018	18 605 292	17 873 937	9 305 538	8 568 399	578 787	152 569
2019	19 177 559	18 438 326	9 420 563	9 017 763	573 070	166 162
2020	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
2021	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
Trend 90–21	**42.9%**	**44.6%**	**13.6%**	**99.4%**	**8.1%**	**14.4%**

* *interpolated values for the years 2004-2009, 2011-2012, 2014-2015 and 2017-2019*

** *value for 1999 is not available – value derived from the average share of previous and following 5 years of total other poultry; interpolated values for the years 2004-2009, 2011-2012, 2014-2015 and 2017-2019*

Animal numbers of Poultry and Other (furred game) are not included in the livestock counts held in December each year but gathered within Austria's farm structure surveys carried out as complete surveys every 10 years. The latest farm structure survey was carried out in 2020. New livestock data for poultry (layers, broilers, turkeys and other poultry) as well as for deer was included on the basis of the final results of the 2020 survey (STATISTIK AUSTRIA 2022b).

5.2.2.1 Cattle (3.A.1)

Key Source: Yes (CH_4)

CH_4 emissions from enteric fermentation – cattle (sum of dairy and non-dairy cattle) are a key source due to the contribution to total greenhouse gas emissions in Austria and also due to its contribution to the total inventory's trend. In the year 2021, emissions from enteric fermentation – cattle contributed 5.1% to total greenhouse gas emissions in Austria.

CH_4 emissions were calculated using the IPCC Tier 2 methodology. In submission 2022 new study results of the research project "MiNutE" (HÖRTENHUBER et. al. 2022b, HÖRTENHUBER et. al. 2023) carried out by the University of Natural Resources and Life Sciences, Vienna, have been implemented. Within the framework of this country specific study refined calculations for cattle and swine were elaborated establishing a dynamic use of national parameters on the basis of latest available science. Activity data were obtained from national statistics and are presented in Table 183 and Table 184.

Emission factors

Country specific emission factors were used. They were calculated from the specific gross energy intake and the methane conversion factor (2019 Refinement to the 2006 IPCC GL, Equation 10.21).

$$EF = [GE * (Y_m/100) * 365\ days)/55.65]$$

EF = emission factor, kg CH_4 head^{-1} yr^{-1} *GE= gross energy intake, MJ head^{-1} day^{-1}*
Y_m = Methane conversion factor, per cent of gross energy in feed converted to methane
The factor 55.56 (MJ/kg CH_4) is the energy content of methane

Table 186: Methane conversion factors (Y_m) 1990-2021 for cattle categories in Austria.

Year	Methane conversion factor (Y_m)					
	Dairy cows	Suckling cows	Breeding heifers 1-2 years	Fattening heifers 1-2 years	Cattle <1 year	Cattle >2 years
1990	6.50	6.50	6.30	6.30	4.34	6.30
1991	6.49	6.50	6.30	6.30	4.34	6.30
1992	6.49	6.50	6.30	6.30	4.34	6.30
1993	6.48	6.50	6.30	6.30	4.80	6.30
1994	6.47	6.50	6.30	6.30	4.73	6.30
1995	6.47	6.50	6.30	6.30	4.68	6.30
1996	6.46	6.50	6.30	6.30	4.63	6.30
1997	6.45	6.50	6.30	6.30	4.69	6.30
1998	6.44	6.50	6.30	6.30	4.75	6.30
1999	6.44	6.50	6.30	6.30	4.75	6.30
2000	6.43	6.50	6.30	6.30	4.58	6.30
2001	6.42	6.50	6.30	6.30	4.55	6.30
2002	6.42	6.50	6.30	6.30	4.57	6.30
2003	6.41	6.50	6.30	6.30	4.55	6.30

Year	Methane conversion factor (Y_m)					
	Dairy cows	Suckling cows	Breeding heifers 1-2 years	Fattening heifers 1-2 years	Cattle <1 year	Cattle >2 years
2004	6.40	6.50	6.30	6.30	4.50	6.30
2005	6.40	6.50	6.30	6.30	4.49	6.30
2006	6.39	6.50	6.30	6.30	4.40	6.30
2007	6.38	6.50	6.30	6.30	4.31	6.30
2008	6.38	6.50	6.30	6.30	4.23	6.30
2009	6.37	6.50	6.30	6.30	4.11	6.30
2010	6.36	6.50	6.30	6.30	4.00	6.30
2011	6.36	6.50	6.30	6.30	3.99	6.30
2012	6.35	6.50	6.30	6.30	3.98	6.30
2013	6.34	6.50	6.30	6.30	3.98	6.30
2014	6.33	6.50	6.30	6.30	3.97	6.30
2015	6.33	6.50	6.30	6.30	3.95	6.30
2016	6.32	6.50	6.30	6.30	3.93	6.30
2017	6.31	6.50	6.30	6.30	3.92	6.30
2018	6.31	6.50	6.30	6.30	3.90	6.30
2019	6.30	6.50	6.30	6.30	3.87	6.30
2020	6.30	6.50	6.30	6.30	3.84	6.30
2021	6.30	6.50	6.30	6.30	3.85	6.30

As explained in Chapter 5.2.2, the feeding assumptions and energy demand calculations were developed on the basis of a very detailed analysis of the Austrian livestock population (see Figure 31). These detailed considerations elaborated in (HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) made it necessary to proceed on the basis of the latest available scientific literature. For emission calculation Austria therefore uses the most updated information on methane conversion factors (Y_m) provided in the 2019 Refinement to the 2006 IPCC GL, Table 10.12.

Methane conversion factor (Y_m) dairy cows

For 2021, a methane conversion factor for "medium producing cows" of 6.3 was applied based on the annual milk yield of 7 249 kg and feed digestibility of 71.6% of Austrian dairy cows. For 1990, a methane conversion factor for low producing cows of 6.5 was taken based on the annual milk yield of 3 791 kg of Austrian dairy cows and considerations on feed digestibility.

The average methane conversion factor for all the other non-dairy cattle categories resulted in a value of 5.21 for 2021.

Methane conversion factor (Y_m) suckling cows

A methane conversion factor for "low producing cows" of 6.5 was applied. Despite higher feed digestibility of the average feed ration of Austrian suckler cows, suckling cows can be counted as low producing cows due to their low milk yield.

Methane conversion factor (Y_m) breeding and fattening cattle

A methane conversion factor of 0 was applied for unweaned calves fed mainly with milk. For all other categories of breeding and fattening cattle, a methane conversion factor of 6.3 was taken. This value is recommended for cattle feed rations consisting of more than 75% high quality forage, mixed rations and for a feed digestibility of 62-71%. Although the average feed digestibility of breeding and fattening cattle in Austria is higher, the proportion of high-quality basic feed is mostly 75% or higher.

For the Gross Energy Intake country specific values were applied. The estimation was made separately for all cattle categories.

Gross energy intake of dairy cows (3.A.1.a):

In previous submissions the Austrian specific values for dairy cows were derived from (GRUBER & STEINWIDDER 1996, PÖTSCH 2005 and GRUBER & PÖTSCH 2006). Calculations on gross energy intake used since submission 2022 were elaborated within a country-specific study on animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023).

Gross energy intake of dairy cattle is calculated using equation 10.16 taken from the 2019 Refinement to the 2006 IPCC GL, which is derived based on the summed net energy requirements and the energy availability characteristics of the feed.

The following information has been used for feed intake estimates:

Body mass

Data on body mass form the basis for the calculation of the maintenance net energy. The body mass of the most common breeds Fleckvieh, Braunvieh and Holstein for the years from 2016 onwards were derived from the Efficient Cow project (EGGER-DANNER et al. 2016). In this project, body mass was assessed as part of the dairy performance tests. Data from cows in or after their first lactation were used. The cows' weight was evaluated repeatedly (46 896 weight assessments in total) and increases with rising milk yield.

Animal husbandry

The parameters of animal husbandry are used to calculate the net energy for activity. This depends on how much time the animals spend in the barn, on the pasture or on the mountain pasture. The proportion of grazed cows was derived from country specific studies "TIHALO I and II" and weighted with the average number of grazing hours per day and the number of grazing days per year (AMON et al. 2007; PÖLLINGER et al. 2018). For the proportion of dairy cows on pasture in 1990 an expert estimate by Alfred Pöllinger was used. Data for the years between (1990, 2005, 2017) were interpolated.

Milk yield

The milk yield and the fat content of the milk are needed for the calculation of net energy for lactation. The protein content of the milk is used in the calculation of N retention. Austrian dairy cattle show average milk yields from 3 791 kg/cow (1990) to 7 249 kg/cow (2021). The time series of average milk yields per dairy cow was taken from national statistics and are presented in Table 188. Data on the average fat content and protein content of milk were derived from information provided by AgrarMarkt Austria (AMA).

Gestation

The proportion of animals that experience gestation in a year is used to calculate the net energy for gestation. The percentage of gestating cows is calculated by dividing 365 days by the days between calvings. For the years 2007-2020, the days between two subsequent calvings was calculated per breed and weighted accordingly, based on the data of the annual breeding data reports

(RINDERZUCHT AUSTRIA 2022). For small-framed breeds, the calving interval of Grauvieh was used, for medium- and large-framed breeds the calving interval of Pinzgauer was used. In 2020, Fleckvieh cows had a calving interval of 391 days, Brown Swiss of 418 days, Holstein of 413 days, Grauvieh of 403 days and Pinzgauer of 399 days.

Feeding

The average crude protein content in dry matter and the proportion of crude ash in dry matter were derived from the Efficient Cow project (EGGER-DANNER et al. 2016) for the years 2016-2019. The value for 2002 is based on the mean value of two national studies (STEINWIDDER & GUGGENBERGER 2003; GRUBER & STEINWENDER 1992). The years in between were derived by interpolation. The average feed digestibility in Austria for dairy cows was estimated by nutrition expert Dr. Erich Pötsch (2005) based on model calculations from (GRUBER & STEINWIDDER 1996) on feed intake, performance and excretion. Feed digestibility is expressed as a percentage and adjusted to the level of the annual milk yield.

Table 187: Parameters for calculating GE intake for dairy cattle in Austria 1990-2021.

Year	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	digestibility of feed
	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}		%
1990	49.88	1.03	31.97	0.00	4.63	0.52	66.48
1991	49.89	0.99	32.45	0.00	4.63	0.52	66.56
1992	49.89	0.96	32.95	0.00	4.63	0.52	66.65
1993	49.89	0.92	33.93	0.00	4.63	0.52	66.78
1994	50.02	0.89	34.60	0.00	4.64	0.52	66.90
1995	50.14	0.86	39.25	0.00	4.65	0.52	67.70
1996	50.25	0.82	39.79	0.00	4.66	0.52	67.78
1997	50.36	0.79	40.84	0.00	4.67	0.52	67.95
1998	50.47	0.76	42.12	0.00	4.68	0.52	68.16
1999	50.58	0.72	43.41	0.00	4.68	0.52	68.36
2000	50.70	0.69	44.56	0.00	4.69	0.52	68.58
2001	50.81	0.66	46.37	0.00	4.70	0.53	68.85
2002	50.92	0.62	47.18	0.00	4.71	0.53	68.99
2003	51.03	0.59	48.66	0.00	4.72	0.53	69.21
2004	51.13	0.56	50.26	0.00	4.73	0.53	69.45
2005	51.22	0.52	49.91	0.00	4.73	0.53	69.43
2006	51.31	0.52	50.88	0.00	4.74	0.53	69.60
2007	51.41	0.52	51.82	0.00	4.75	0.53	69.74
2008	51.52	0.52	52.23	0.00	4.75	0.53	69.83
2009	51.63	0.51	52.30	0.00	4.76	0.53	69.85
2010	51.74	0.51	52.64	0.00	4.78	0.53	69.89
2011	51.82	0.50	53.60	0.00	4.78	0.53	70.08
2012	51.89	0.50	55.39	0.00	4.80	0.53	70.37
2013	52.00	0.49	55.68	0.00	4.81	0.53	70.43
2014	52.10	0.49	56.31	0.00	4.82	0.53	70.55
2015	52.18	0.49	56.78	0.00	4.86	0.53	70.60

Year	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	digestibility of feed
	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}		%
2016	52.28	0.48	58.41	0.00	4.86	0.53	70.87
2017	52.26	0.48	59.17	0.00	4.86	0.53	71.03
2018	52.24	0.48	61.23	0.00	4.86	0.53	71.38
2019	52.19	0.48	61.96	0.00	4.83	0.53	71.49
2020	52.18	0.48	63.04	0.00	4.82	0.53	71.65
2021	52.17	0.48	62.72	0.00	4.82	0.53	71.59

For dairy cattle there was a 24.1% increase of GE intake between 1990 and 2021 mainly due to an increase of the milk yield per dairy cow in this time (lactation performance). The resulting emission factor is presented in the following table:

Table 188: Annual milk yield, gross energy intake and CH_4 emission factors of dairy cattle 1990–2021.

Year	Average live body weight	Milk Yield	Gross Energy Intake	Emission Factor
	kg	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
1990	676	3 791	253.8	108.20
1991	676	3 848	254.6	108.44
1992	676	3 908	255.5	108.71
1993	676	3 997	257.5	109.45
1994	678	4 076	259.1	110.00
1995	681	4 619	268.3	113.78
1996	683	4 670	269.7	114.23
1997	685	4 787	271.9	115.06
1998	687	4 924	274.6	116.08
1999	689	5 062	277.3	117.10
2000	691	5 210	279.6	117.92
2001	693	5 394	283.3	119.36
2002	695	5 487	285.0	119.94
2003	697	5 638	288.0	121.10
2004	699	5 802	291.2	122.31
2005	700	5 783	290.6	121.92
2006	702	5 903	292.5	122.57
2007	704	5 997	294.6	123.31
2008	706	6 059	295.4	123.54
2009	708	6 068	295.8	123.58
2010	710	6 100	296.8	123.86
2011	711	6 227	298.6	124.44
2012	713	6 418	302.0	125.73
2013	715	6 460	302.7	125.89
2014	716	6 542	304.0	126.29
2015	718	6 579	305.2	126.66
2016	720	6 759	308.2	127.79

Year	Average live body weight	Milk Yield	Gross Energy Intake	Emission Factor
	kg	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
2017	719	6 865	309.3	128.08
2018	719	7 104	312.6	129.31
2019	718	7 179	313.7	129.61
2020	718	7 286	315.5	130.37
2021	718	7 249	315.0	130.14

[1)] *From 1995 onwards data have been revised by Statistik Austria.*

Up to the early 1990ies Austrian dairy husbandry was determined by traditional Austrian green feeding and traditional Austrian breeds. From the mid 1990ies onwards milk production has been intensified: diets with higher energy concentration were fed and the share of high yield breeds (e.g. Holstein Friesian) in dairy farming was increased. Anyhow, the traditional Austrian breed "Fleck-vieh" (about 700 kg live weight) still dominates the herd.

GE Gross energy intake of non-dairy cattle (3.A.1.b):

Suckling cows:

In the framework of the new study on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) the gross energy intake was calculated by applying equation 10.16 taken from the 2019 Refinement to the 2006 IPCC GL (IPCC 2019). The parameters for calculating GE intake for suckling cows are provided in Table 189.

Body mass

A comparison of the body mass of suckling cows and dairy cows showed that suckling cows have about 50 kg less body mass than dairy cows (GRUBER et al. 2001, 2015; HÄUSLER et al. 2015).

Animal husbandry

Similar to the dairy cows, the proportion of grazed suckling cows was derived from the TIHALO studies (AMON et al., 2007; PÖLLINGER et al., 2018) and from expert judgement (PÖLLINGER 2008) for the year 1990. The proportion of suckling cows was weighted with the grazing time and the grazing days per year. Data for the years between (1990, 2005, 2017) were interpolated.

Milk yield

The husbandry of suckling cows is used for the production of veal and beef. The milk yield of the cow is only provided for the suckling calves. A new born calve has around 40 kg and suckles until it weighs about 350 kg. As a rule of thumb under the national circumstances in Austria 10 kg milk are needed for 1 kg gain in weight for a calve.

The study „Mutterkuh und Ochsenhaltung 2003" in which 56 holdings in Styria, Lower Austria, Carinthia and Salzburg were investigated, reports daily rates of weight increases of 1 020 g (2002) and 1 060 g (2003). Calves were suckled about 300 days (GRABNER et al. 2004). An experiment based on measurements made from 1978 to 1987 (STEINWENDER & GOLD 1989) shows similar results: The daily increase of weight of young bulls was 1 225 g and of young cows 1 044 g.

Thus, for 1990 in the Austrian Greenhouse Gas Emission Inventory an average milk yield of 3 000 kg was applied (see Table 190).

In a study with Austrian suckling cows (Simmental) carried out from 2004 to 2008, the influence of duration of suckling period (180 days and 270 days) on milk yield and body weight of cows and weight gain of calves was determined (STEINWIDDER et al. 2006). Cows were fed with forage of low quality. Anyhow, the average milk yield per suckling period was on a high level: For 6 months of suckling an average milk yield of 2 245 kg, and for 9 month of suckling an average milk yield of 3 351 kg per cow has been measured (HÄUSLER 2009). The daily gains of the beef cattle (Simmental x Limousin steers and heifers) were 1.27 and 1.28 kg for the 180 or 270 days of suckling, respectively.

In consideration of the low forage quality identified in the study mentioned above, the suckling periods of up to 300 days and a calculated demand of 3 500 kg milk per calve, an average milk yield of 3 500kg has been assumed for the years from 2004 onwards. Values between 1990 and 2004 have been derived by interpolation (see Table 190).

Gestation

Information on the calving interval were derived from the 2012, 2014 and 2019 suckling cow and steer husbandry working group reports ("Arbeitskreisberichte" zu Mutterkühen und Ochsen).

Feeding

For the year 1990 a crude protein content of 11.9% was applied, which is the crude protein requirement for a milk yield of 3 000 kg milk per year according to (GRUBER & PÖTSCH 2006). Starting in 2004, a milk yield of 3 500 kg milk per year is assumed, for which a crude protein content of 12% is taken, corresponding to the feeding recommendation for suckler cows (STEINWIDDER 2003).

The percentage of crude ash in dry matter was derived from national studies (STEINWIDDER & GUGGENBERGER 2003; GRUBER & PÖTSCH 2006) and corresponds to the values used in previous inventories. Based on these studies, a crude ash content of 11% was adopted for milk yields up to 7 000 kg. A crude ash content of 11% in DM was therefore adopted for suckling cows from 1990 to 2020.

The average feed digestibility was assessed in an expert evaluation for dairy cows by (PÖTSCH 2005), based on model calculations taken fromn (GRUBER & STEINWIDDER 1996) on feed intake, performance and excretions. The values for dairy cattle were adopted adjusted to the level of annual milk yield for suckling cows.

Table 189: Parameters for calculating GE intake for suckling cows in Austria 1990-2021.

Year	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	digestibility of feed
	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}		%
1990	47.09	1.19	25.30	0.00	4.36	0.51	65.31
1991	47.10	1.21	25.60	0.00	4.36	0.52	65.36
1992	47.10	1.22	25.90	0.00	4.36	0.52	65.41
1993	47.10	1.24	26.37	0.00	4.35	0.52	65.47
1994	47.23	1.26	26.68	0.00	4.36	0.52	65.52
1995	47.36	1.28	27.01	0.00	4.37	0.52	65.57
1996	47.47	1.29	27.39	0.00	4.38	0.52	65.63
1997	47.58	1.31	27.73	0.00	4.39	0.52	65.68
1998	47.70	1.33	28.10	0.00	4.39	0.52	65.73

Year	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	digestibility of feed
	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}	MJ day^{-1}		%
1999	47.81	1.35	28.48	0.00	4.40	0.52	65.78
2000	47.93	1.37	28.72	0.00	4.41	0.52	65.84
2001	48.04	1.39	29.17	0.00	4.41	0.52	65.89
2002	48.15	1.46	29.48	0.00	4.42	0.52	65.94
2003	48.27	1.50	29.90	0.00	4.43	0.52	66.00
2004	48.37	1.49	30.32	0.00	4.43	0.52	66.05
2005	48.46	1.50	30.21	0.00	4.44	0.52	66.05
2006	48.55	1.53	30.17	0.00	4.44	0.52	66.05
2007	48.66	1.56	30.24	0.00	4.45	0.52	66.05
2008	48.77	1.61	30.17	0.00	4.46	0.52	66.05
2009	48.88	1.65	30.17	0.00	4.46	0.52	66.05
2010	48.99	1.70	30.21	0.00	4.47	0.52	66.05
2011	49.05	1.75	30.13	0.00	4.56	0.52	66.05
2012	49.12	1.80	30.21	0.00	4.61	0.52	66.05
2013	49.25	1.86	30.17	0.00	4.54	0.52	66.05
2014	49.34	1.90	30.13	0.00	4.57	0.52	66.05
2015	49.44	1.95	30.21	0.00	4.57	0.52	66.05
2016	49.54	2.00	30.24	0.00	4.57	0.52	66.05
2017	49.52	2.06	30.17	0.00	4.56	0.52	66.05
2018	49.51	2.10	30.17	0.00	4.55	0.52	66.05
2019	49.45	2.12	30.21	0.00	4.54	0.52	66.05
2020	49.44	2.12	30.28	0.00	4.53	0.52	66.05
2021	49.42	2.12	30.28	0.00	4.53	0.52	66.05

For suckling cows, net energy for maintenance accounts for the largest share of energy demand. In the following table it can be observed that the GE-intake increased over the time series which is largely influenced by rising net energy for maintenance and lactation.

Table 190: Annual milk yield, gross energy intake and CH_4 emission factors of suckling cows 1990–2021.

Year	Average live body weight	Milk Yield	Gross Energy Intake	Emission Factor
	kg	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
1990	626	3 000	231.81	98.83
1991	626	3 036	232.49	99.12
1992	626	3 071	233.16	99.40
1993	626	3 107	234.34	99.91
1994	628	3 143	235.42	100.37
1995	631	3 179	236.61	100.87
1996	633	3 214	237.85	101.40
1997	635	3 250	238.99	101.89
1998	637	3 286	240.24	102.42
1999	639	3 321	241.49	102.95

Year	Average live body weight	Milk Yield	Gross Energy Intake	Emission Factor
	kg	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
2000	641	3 357	242.31	103.30
2001	643	3 393	243.80	103.94
2002	645	3 429	244.99	104.44
2003	647	3 464	246.42	105.06
2004	649	3 500	247.64	105.57
2005	650	3 500	247.64	105.57
2006	652	3 500	247.88	105.68
2007	654	3 500	248.55	105.96
2008	656	3 500	248.81	106.08
2009	658	3 500	249.28	106.27
2010	660	3 500	249.87	106.52
2011	661	3 500	250.20	106.67
2012	663	3 500	250.92	106.97
2013	665	3 500	251.18	107.09
2014	666	3 500	251.56	107.25
2015	668	3 500	252.20	107.52
2016	670	3 500	252.76	107.76
2017	669	3 500	252.63	107.70
2018	669	3 500	252.65	107.71
2019	668	3 500	252.64	107.71
2020	668	3 500	252.81	107.78
2021	668	3 500	252.77	107.76

Other non-dairy cattle categories:

As for dairy and suckling cows, the gross energy intake for all other cattle categories were calculated using equation 10.16 taken from the 2019 Refinement to the 2006 IPCC GL. The other non-dairy cattle categories were further subdivided (see Figure 31) within the new study on feeding and nutrition in order to be able to take more precise feeding assumptions and energy requirement calculations. Detailed information on the parameters used for the calculations and the relevant country-specific background data on weight, growth, husbandry and feeding is extensively described for the different cattle categories in (HÖRTENHUBER et al. 2022a).

As a result of the updated information from the new study on animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) and the application of the 2019 IPCC Refinements, a dynamic time series could be generated. In previous submissions emissions from enteric fermentation of Non-Dairy Cattle were calculated with a constant gross energy intake for the whole time series.

In the following tables the GE intakes and the resulting CH_4 EF of the different other non-dairy cattle categories are indicated. For cattle < 1 year GE intake and EF are significant lower due to the unweaned calves fed mainly with milk. Dairy calves do not yet excrete relevant amounts of methane and, due to the methane conversion factor of YM = 0, have no influence on the calculation during the milk suckling and drinking phase.

Table 191: Gross energy intake of other cattle categories 1990–2021.

Year	Breeding heifers 1-2 years	Fattening heifers, bulls & oxen 1-2 years	Cattle <1 year	Cattle >2 years
		[MJ GE day^{-1}]		
1990	175.42	178.09	75.88	163.35
1991	175.13	178.17	76.08	163.32
1992	174.85	178.10	76.22	163.03
1993	174.56	178.21	82.49	161.16
1994	174.28	178.18	81.93	160.71
1995	174.00	178.00	83.20	160.60
1996	173.71	177.27	82.86	160.42
1997	173.43	177.16	83.24	160.22
1998	173.14	176.95	83.47	160.15
1999	172.86	177.15	83.79	159.82
2000	172.58	176.91	83.11	159.61
2001	172.29	176.26	83.31	159.38
2002	172.01	175.98	83.79	158.91
2003	171.72	175.40	84.07	159.69
2004	171.44	175.31	83.78	160.34
2005	171.16	175.49	83.73	158.62
2006	171.05	175.17	82.80	158.76
2007	170.94	174.86	81.96	158.97
2008	170.83	174.49	81.00	159.20
2009	171.24	174.25	80.20	159.92
2010	171.66	174.17	79.53	160.54
2011	172.07	174.45	79.96	161.17
2012	172.48	174.94	80.18	161.88
2013	172.90	175.58	80.34	162.44
2014	173.31	175.99	80.60	163.16
2015	173.72	176.28	80.87	163.86
2016	174.14	176.35	81.19	164.74
2017	174.55	176.58	81.57	165.32
2018	175.07	176.71	81.75	166.00
2019	175.59	176.89	82.05	166.60
2020	176.12	177.07	82.26	167.14
2021	176.12	177.12	82.25	167.19

The resulting emission factors are presented in the following table:

Table 192: CH_4 emission factors of other cattle categories 1990-2021.

Year	Breeding heifers 1-2 years	Fattening heifers, bulls & oxen 1-2 years	Cattle <1 year	Cattle >2 years
		[kg CH_4/head*yr]		
1990	72.48	73.59	21.58	67.50
1991	72.37	73.62	21.65	67.48
1992	72.25	73.59	21.72	67.37
1993	72.13	73.64	25.97	66.59

Year	Breeding heifers 1-2 years	Fattening heifers, bulls & oxen 1-2 years	Cattle <1 year	Cattle >2 years
		[kg CH_4/head*yr]		
1994	72.01	73.63	25.44	66.41
1995	71.90	73.55	25.54	66.36
1996	71.78	73.25	25.18	66.29
1997	71.66	73.21	25.59	66.20
1998	71.54	73.12	26.03	66.17
1999	71.43	73.20	26.09	66.04
2000	71.31	73.10	24.94	65.95
2001	71.19	72.83	24.85	65.86
2002	71.07	72.72	25.13	65.66
2003	70.96	72.48	25.09	65.99
2004	70.84	72.44	24.73	66.25
2005	70.72	72.51	24.67	65.54
2006	70.68	72.38	23.87	65.60
2007	70.63	72.25	23.15	65.69
2008	70.59	72.10	22.47	65.78
2009	70.76	72.00	21.63	66.08
2010	70.93	71.97	20.88	66.34
2011	71.10	72.08	20.92	66.60
2012	71.27	72.29	20.92	66.89
2013	71.44	72.55	20.96	67.12
2014	71.61	72.72	21.00	67.42
2015	71.78	72.84	20.95	67.71
2016	71.95	72.87	20.94	68.07
2017	72.12	72.96	20.97	68.31
2018	72.34	73.02	20.93	68.59
2019	72.56	73.09	20.84	68.84
2020	72.77	73.17	20.74	69.06
2021	72.77	73.19	20.78	69.08

5.2.2.2 Swine (3.A.3)

Key Source: No

Methane emissions from enteric fermentation – swine contributed 1.6% to total emissions from enteric fermentation in 2021.

Feeding assumptions and energy demand calculations were developed on a very detailed level elaborated in (HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023). Activity data are obtained from national statistics and are presented in Table 184.

Emission factors

Country specific emission factors were used, calculated from the specific gross energy intake in line with Equation 10.21 of IPCC 2019 and IPCC 2006.

$$EF = [GE * (Y_m/100) * 365\ days)/55.65]$$

EF = emission factor, kg CH_4 head^{-1} yr^{-1}
GE= gross energy intake, MJ head^{-1} day^{-1}
Y_m = Methane conversion factor, per cent of gross energy in feed converted to methane
The factor 55.56 (MJ/kg CH_4) is the energy content of methane

Methane Conversion factors taken from (DÄMMGEN et al. 2012) are indicated in Table 193.

Table 193: Methane conversion factors (Y_m) for swine

Swine category	**Methane conversion factor (Y_m)**
Breeding sows	0.71
Fattening pigs	0.46
Piglets 8 – 32 kg	0.44
Swine total	**0.48 (weighted average)**

Feed intake data was derived from the new country-specific study on animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023). Based on (PRILLER 2004) typical rations for Austrian pig farming were compiled in 2020 by national nutrition experts.

Detailed information on performance indicators, feed quantities and components of feed rations as well as ingredients of the feed components are described in (HÖRTENHUBER et al. 2022a).

Table 194: GE-intake and CH_4 emission factors of swine categories 1990-2021.

Year	**Breeding sows**		**Fattening pigs**		**Piglets 8 – 32 kg**	
	GE-intake	**EF**	**GE-intake**	**EF**	**GE-intake**	**EF**
	[MJ GE day^{-1}]	**[kg CH_4/head*yr]**	**[MJ GE day^{-1}]**	**[kg CH_4/head*yr]**	**[MJ GE day^{-1}]**	**[kg CH_4/head*yr]**
1990	43.7	2.04	10.9	1.00	1.9	0.33
1991	43.8	2.04	10.9	1.01	1.9	0.33
1992	43.9	2.04	10.9	1.01	1.9	0.33
1993	44.0	2.05	10.9	1.01	1.9	0.34
1994	44.1	2.05	10.9	1.01	1.9	0.34
1995	44.2	2.06	10.9	1.01	1.9	0.34
1996	44.3	2.06	10.9	1.01	1.9	0.34
1997	44.4	2.07	10.9	1.02	1.9	0.34
1998	44.5	2.07	10.9	1.02	1.9	0.34
1999	44.6	2.07	10.8	1.02	1.9	0.35
2000	44.6	2.08	10.8	1.02	1.9	0.35
2001	44.7	2.08	10.8	1.02	1.9	0.35
2002	44.8	2.09	10.8	1.02	1.9	0.35
2003	44.9	2.09	10.8	1.02	1.9	0.35
2004	45.0	2.10	10.8	1.03	1.9	0.35
2005	45.1	2.10	10.8	1.03	1.9	0.36
2006	45.6	2.12	10.8	1.03	1.9	0.35
2007	46.0	2.14	10.8	1.03	1.9	0.35
2008	46.4	2.16	10.8	1.04	1.9	0.35
2009	46.9	2.18	10.9	1.04	1.9	0.35
2010	47.3	2.20	10.9	1.04	1.9	0.35

Year	Breeding sows		Fattening pigs		Piglets 8 – 32 kg	
	GE-intake	EF	GE-intake	EF	GE-intake	EF
	[MJ GE day^{-1}]	[kg CH_4/head*yr]	[MJ GE day^{-1}]	[kg CH_4/head*yr]	[MJ GE day^{-1}]	[kg CH_4/head*yr]
2011	47.7	2.22	10.9	1.05	1.9	0.35
2012	48.1	2.24	10.9	1.05	1.9	0.35
2013	48.6	2.26	10.9	1.05	1.9	0.35
2014	49.0	2.28	11.0	1.06	1.9	0.35
2015	49.4	2.30	11.0	1.06	1.9	0.35
2016	49.9	2.32	11.0	1.06	1.8	0.34
2017	50.3	2.34	11.0	1.07	1.8	0.34
2018	50.7	2.36	11.0	1.07	1.8	0.34
2019	51.2	2.38	11.1	1.07	1.8	0.34
2020	51.2	2.38	11.1	1.07	1.8	0.34
2021	51.2	2.38	11.1	1.07	1.8	0.34

5.2.2.3 Sheep (3.A.2), and Other livestock (3.A.4: Poultry, Horses, Goats and Deer)

Key Source: No

As presented in Table 181, CH_4 emissions from sheep, and other livestock (poultry, horses, goats and deer) are only minor emission sources of enteric fermentation in Austria. Together they contributed 4.4% to total emissions from this category in 2021. The most important sub-category is sheep, with a contribution of 2.2%, followed by horses (1.6%), goats (0.3%), poultry as well as deer with each about 0.2% (figures are also presented in Table 181).

The IPCC Tier 1 methodology and default emission factors have been used (see Table 195):

Table 195: IPCC Default Emission Factors for Categories estimated by Tier 1.

IPCC Category	Emission Factor* (Developed Countries) [kg CH_4/head*yr]	IPCC Category	Emission Factor* (Developed Countries) [kg CH_4/head*yr]
3.A.2 Sheep (+ Deer)	8.0	3.A.4.2 Horses	18.0
3.A.4.3 Goats	5.0		

** Source: IPCC 2006 Guidelines, Table 10.10, p.10.28*

Deer:

The deer category is including roe deer, red deer, fallow deer and to some extent wild boars. As no further data on the exact composition of this animal category is available and the contribution to the overall emissions is very small, a simple conservative approach has been chosen: emissions from deer were estimated applying the default emission factor of sheep, which is the most similar animal category to deer.

Poultry:

The IPCC Guidelines do not provide specific methodologies for the estimation of emissions from poultry. For the calculation of emissions from poultry the Swiss values (Gross Energy Intake (GE), Methane Conversion Rate (Y_m), conversion factor metabolisable energy to gross energy) were used as Tier 1.

Y_m:	0.16%
Conversion factor:	0.7
GE:	1.80 MJ/head/yr

Swiss data on energy intake (see Swiss NIR 2021, FOEN 2021) are taken from (SBV 2020 based on the same method from SBV 2007). The Y_m value is based on an in vivo trial with broilers (HADORN & WENK 1996). Activity data were obtained from national statistics and are presented in Table 185.

Agricultural practices in Switzerland are very similar to those in Austria: Both countries have a small structured agriculture due to similar alpine conditions and comparable traditions. In both countries high shares of farms (in Austria as well as in Switzerland about 57%) manage less than 20 ha.

5.2.3 Category-specific QA/QC

In category 3.A.1 the following source specific QA/QC procedures have been carried out:

- ✓ Gross energy intake data elaborated by scientific experts from the Agricultural Research and Education Centre (AREC) Raumberg-Gumpenstein, derived from peer reviewed sources;
- ✓ External review by Austrian agricultural experts (stakeholder meeting "inventory talks" 2010);
- ✓ Audit of data supplier: milk yield data (Statistik Austria), livestock data;
- ✓ Differences to default values checked, explained and documented;
- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources (e.g. crop residues, energy crops performed in 2015)
- ✓ External review of the revised agricultural model according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting "inventory talks" 2014.
- ✓ External review of the revised agricultural model (AMON & HÖRTENHUBER 2019) according to the new data on the agricultural practice (PÖLLINGER et al. 2018) by Austrian agricultural experts: stakeholder meeting "inventory talks" 2018.
- ✓ External review of the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) based on the research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) by Austrian agricultural experts.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.2.4 Uncertainties

Uncertainties are presented in Table 179.

5.2.5 Recalculations

Update of activity data

Livestock data – poultry and deer

Updated livestock data for poultry (layers, broilers, turkeys and other poultry) and deer became available for the year 2020, based on the final results of the farm structure survey 2020 (STATISTIK AUSTRIA 2022). For 2016, activity data of the farm structure survey 2016 was used (STATISTIK AUSTRIA 2018). The numbers for the years 2017, 2018 and 2019 have been derived by interpolation.

Background data for feeding and nutrition of cattle

New values for the protein content of milk for the years 2019 and 2020 and for the fat content of milk for 2020 became available (AMA 2021). In addition, for the years 1996-2004 and 2014-2020 the data on distribution of cattle breeds were slightly updated. These improvements resulted in minor revisions of the values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ of dairy and suckling cows.

The improvements resulted in updated emissions for the years 1996-2004 and 2014-2020 (+0.04 kt CH_4 for 2020).

5.3 Manure management (Category 3.B)

This chapter describes the estimation of CH_4 and N_2O emissions from animal manure. In 2021 12.9% of the agricultural CH_4 emissions and 20.9% of the agricultural N_2O emissions were caused by this category.

5.3.1 Source Category Description

CH_4 and N_2O emissions from manure management are presented in the following tables:

Table 196: CH_4 emissions from manure management 1990–2021.

Year	CH₄ emissions from manure management [kt]								
	Livestock categories								
	3.B Total	3.B.1.1 Dairy Cattle	3.B.1.2 Non-Dairy	3.B.2 Sheep	3.B.3 Swine	3.B.4.1 Other/ Poultry	3.B.4.2 Other/ Horses	3.B.4.3 Other/ Goats	3.B.4.4 Other/ Deer
1990	22.58	10.24	6.45	0.10	5.28	0.35	0.14	0.01	0.01
1991	22.38	9.92	6.48	0.10	5.32	0.38	0.16	0.01	0.01
1992	21.49	9.54	6.15	0.10	5.16	0.35	0.17	0.01	0.01
1993	21.71	9.42	6.61	0.10	4.99	0.38	0.18	0.01	0.01
1994	21.48	9.23	6.71	0.10	4.85	0.38	0.19	0.01	0.01
1995	21.36	8.14	7.71	0.11	4.80	0.36	0.20	0.01	0.01
1996	20.92	8.06	7.51	0.12	4.68	0.34	0.21	0.01	0.01
1997	20.62	8.10	7.13	0.12	4.66	0.37	0.21	0.01	0.01
1998	20.66	8.46	6.69	0.11	4.80	0.35	0.21	0.01	0.01
1999	19.96	8.13	6.83	0.11	4.30	0.34	0.23	0.01	0.01
2000	19.40	7.23	7.37	0.10	4.14	0.30	0.23	0.01	0.01

Year	CH₄ emissions from manure management [kt]								
	Livestock categories								
	3.B Total	3.B.1.1 Dairy Cattle	3.B.1.2 Non-Dairy	3.B.2 Sheep	3.B.3 Swine	3.B.4.1 Other/ Poultry	3.B.4.2 Other/ Horses	3.B.4.3 Other/ Goats	3.B.4.4 Other/ Deer
2001	19.19	6.99	7.29	0.10	4.23	0.32	0.24	0.02	0.01
2002	18.68	6.89	7.09	0.09	4.03	0.32	0.24	0.01	0.01
2003	18.37	6.54	7.17	0.10	3.97	0.32	0.24	0.01	0.01
2004	18.05	6.33	7.29	0.10	3.74	0.32	0.25	0.01	0.01
2005	17.93	6.27	7.15	0.10	3.80	0.33	0.26	0.01	0.01
2006	18.23	6.42	7.37	0.10	3.73	0.33	0.27	0.01	0.01
2007	18.84	6.62	7.59	0.11	3.88	0.34	0.28	0.02	0.01
2008	18.91	6.89	7.69	0.10	3.58	0.34	0.28	0.02	0.01
2009	19.58	7.13	8.03	0.11	3.65	0.35	0.29	0.02	0.01
2010	19.90	7.33	8.17	0.11	3.60	0.35	0.30	0.02	0.01
2011	20.28	7.62	8.38	0.11	3.48	0.36	0.31	0.02	0.01
2012	20.54	7.81	8.48	0.11	3.42	0.37	0.31	0.02	0.01
2013	21.00	8.14	8.71	0.11	3.31	0.38	0.32	0.02	0.01
2014	21.53	8.51	8.92	0.11	3.24	0.39	0.33	0.02	0.01
2015	22.02	8.71	9.22	0.11	3.20	0.41	0.34	0.02	0.01
2016	22.40	9.02	9.33	0.12	3.15	0.42	0.34	0.02	0.01
2017	22.96	9.32	9.53	0.12	3.17	0.43	0.37	0.02	0.01
2018	22.57	9.12	9.37	0.12	3.12	0.44	0.37	0.02	0.01
2019	22.29	8.97	9.24	0.12	3.11	0.44	0.37	0.02	0.01
2020	22.16	8.99	9.06	0.12	3.14	0.45	0.37	0.02	0.01
2021	22.24	9.02	9.12	0.12	3.12	0.45	0.37	0.03	0.01
Share 2021	**100%**	**40.6%**	**41.0%**	**0.6%**	**14.0%**	**1.6%**	**0.6%**	**0.0%**	**0.0%**
1990–2021	**–1.5%**	**-11.9%**	**41.3%**	**29.8%**	**-41.0%**	**28.3%**	**164.2%**	**169.4%**	**3.2%**

From 1990 to 2021 CH_4 emissions from manure management decreased by 1.5% to 22.24 kt.

Table 197: Direct N_2O emissions from manure management per livestock category 1990–2021.

Year	Direct N₂O emissions from manure management [kt]								
	Livestock categories								
	Direct Total	3.B.1.1 Dairy	3.B.1.2 Non-Dairy	3.B.2 Sheep	3.B.3 Swine	3.B.4.1 Other/ Poultry	3.B.4.2 Other/ Horses	3.B.4.3 Other/ Goats	3.B.4.4 Other/ Deer
1990	1.533	0.544	0.565	0.021	0.372	0.012	0.015	0.003	0.001
1991	1.520	0.528	0.563	0.022	0.373	0.013	0.017	0.004	0.001
1992	1.456	0.507	0.532	0.021	0.361	0.012	0.018	0.004	0.001
1993	1.444	0.500	0.537	0.022	0.347	0.013	0.020	0.004	0.001
1994	1.434	0.491	0.546	0.023	0.336	0.013	0.020	0.005	0.001
1995	1.448	0.433	0.619	0.024	0.331	0.012	0.022	0.005	0.001
1996	1.418	0.429	0.604	0.025	0.321	0.011	0.022	0.005	0.001
1997	1.390	0.432	0.572	0.026	0.318	0.013	0.022	0.005	0.001
1998	1.384	0.452	0.540	0.024	0.327	0.012	0.023	0.005	0.001
1999	1.342	0.434	0.552	0.024	0.290	0.012	0.025	0.005	0.001

Year	Direct N_2O emissions from manure management [kt]								
	Livestock categories								
	Direct	3.B.1.1	3.B.1.2	3.B.2	3.B.3	3.B.4.1	3.B.4.2	3.B.4.3	3.B.4.4
	Total	Dairy	Non-Dairy	Sheep	Swine	Other/ Poultry	Other/ Horses	Other/ Goats	Other/ Deer
2000	1.329	0.388	0.599	0.023	0.278	0.010	0.025	0.005	0.001
2001	1.317	0.375	0.595	0.021	0.283	0.011	0.025	0.005	0.001
2002	1.280	0.371	0.578	0.020	0.268	0.011	0.026	0.005	0.001
2003	1.270	0.356	0.586	0.022	0.263	0.011	0.026	0.005	0.001
2004	1.257	0.349	0.598	0.022	0.245	0.011	0.027	0.005	0.001
2005	1.247	0.346	0.587	0.022	0.248	0.011	0.028	0.005	0.001
2006	1.250	0.346	0.594	0.021	0.244	0.011	0.029	0.005	0.001
2007	1.274	0.348	0.601	0.024	0.255	0.011	0.030	0.006	0.001
2008	1.261	0.354	0.602	0.022	0.234	0.011	0.030	0.006	0.001
2009	1.292	0.359	0.621	0.023	0.239	0.012	0.031	0.006	0.001
2010	1.297	0.362	0.624	0.024	0.236	0.012	0.032	0.007	0.001
2011	1.302	0.367	0.625	0.024	0.233	0.012	0.033	0.007	0.001
2012	1.308	0.374	0.627	0.024	0.229	0.012	0.034	0.007	0.001
2013	1.319	0.384	0.634	0.024	0.222	0.013	0.034	0.007	0.001
2014	1.337	0.398	0.642	0.023	0.218	0.013	0.035	0.006	0.001
2015	1.356	0.404	0.655	0.024	0.216	0.014	0.036	0.007	0.001
2016	1.372	0.416	0.657	0.025	0.215	0.014	0.036	0.008	0.001
2017	1.398	0.428	0.664	0.027	0.217	0.014	0.039	0.008	0.001
2018	1.378	0.422	0.653	0.027	0.213	0.015	0.039	0.008	0.001
2019	1.363	0.416	0.643	0.027	0.213	0.015	0.039	0.008	0.001
2020	1.355	0.418	0.632	0.026	0.215	0.016	0.039	0.008	0.001
2021	1.361	0.419	0.637	0.027	0.213	0.016	0.039	0.009	0.001
Share 2021	**100%**	**30.8%**	**46.8%**	**2.0%**	**15.7%**	**1.2%**	**2.9%**	**0.7%**	**0.1%**
1990–2021	**–11.2%**	**-23.0%**	**12.8%**	**29.8%**	**-42.6%**	**27.1%**	**164.2%**	**169.4%**	**3.2%**

From 1990 to 2021 the direct N_2O emissions from manure management decreased by 11.2% to 1.36 kt. Emissions of cattle dominate the trend. The reduction of dairy cow numbers is partly counterbalanced by an increase in emissions per animal (because of the increasing gross energy intake, milk production and N excretion of dairy cattle since 1990).

Table 198: Direct, indirect and total N_2O Emissions from manure management 1990–2021.

Year	N_2O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
1990	1.920	1.533	0.387	NO
1991	1.916	1.520	0.396	NO
1992	1.840	1.456	0.384	NO
1993	1.831	1.444	0.388	NO
1994	1.822	1.434	0.388	NO
1995	1.840	1.448	0.392	NO
1996	1.804	1.418	0.386	NO

Year	N_2O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
1997	1.778	1.390	0.388	NO
1998	1.776	1.384	0.392	NO
1999	1.724	1.342	0.381	NO
2000	1.702	1.329	0.373	NO
2001	1.693	1.317	0.376	NO
2002	1.650	1.280	0.370	NO
2003	1.642	1.270	0.372	NO
2004	1.628	1.257	0.371	NO
2005	1.621	1.247	0.373	NO
2006	1.625	1.250	0.374	NO
2007	1.658	1.274	0.384	NO
2008	1.641	1.261	0.380	NO
2009	1.682	1.292	0.390	NO
2010	1.690	1.297	0.393	NO
2011	1.692	1.302	0.390	NO
2012	1.700	1.308	0.392	NO
2013	1.712	1.319	0.394	NO
2014	1.734	1.337	0.398	NO
2015	1.758	1.356	0.402	NO
2016	1.778	1.372	0.406	NO
2017	1.811	1.398	0.413	NO
2018	1.789	1.378	0.412	NO
2019	1.774	1.363	0.412	NO
2020	1.769	1.355	0.414	NO
2021	1.779	1.361	0.418	NO
Share 2021	**100.0%**	**76.5%**	**23.5%**	**NO**
1990–2021	**-7.3%**	**-11.2%**	**7.9%**	**-**

Total N_2O emissions (direct and indirect) from sector *3.B Manure Management* decreased by 7.3% between 1990 and 2021. The share of direct N_2O emissions in total N_2O emissions from sector *3.B* is 76.5% and 23.5% of indirect N_2O emissions in 2021.

Higher volatilization losses due to increased cattle husbandry in loose housing systems are responsible for the increase of indirect N_2O emissions from atmospheric deposition compared to 1990.

5.3.2 Methodological Issues

For the estimation of CH_4 emissions from manure management, cattle (identified as key category) and swine, the IPPC-Tier 2 methodology and country specific parameters were used. In submission 2019 the CH_4 emission estimates for the other livestock categories have been improved by moving from the Tier 1 to the Tier 2 methodology using country-specific MMS distributions and IPCC default parameters.

Within the inventory update carried out for submission 2010 the following improvements were made:

- implementation of more accurate data on manure management system distribution gathered through an Austrian survey (AMON et al. 2007);
- improved consideration of the amount of slurry stored under cool and under warm conditions;
- new country specific emission factors for slurry storage;
- introduction of deep litter systems with best available emission factors.

Inventory revision 2015 (AMON & HÖRTENHUBER 2014) concentrated on implementing the IPCC 2006 Guidelines.

In 2018 another revision of the agricultural model has been carried out (AMON & HÖRTENHUBER 2019) by implementing the new input data on agricultural practices in Austria from the research project "Surveys on manure management from agricultural livestock farming in Austria (TIHALO II) (PÖLLINGER et al. 2018)" and by improving the N flow according to the EMEP/EEA GB 2016. Although the biggest revisions were recorded in Austria's ammonia inventory, there were some inventory updates with significant impacts to Austria's GHG inventory:

- Increased share of liquid systems (cattle)
- Introduction of the system 'deep litter < 1 month'
- Improved calculations for the non-key animals sheep, goats and poultry

In submission 2020 Austria's agricultural N-flow model was further improved by implementing the EMEP/EEA Guidebook 2019.

In submission 2022 updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}), taken from a new research project on country-specific animal feeding and nutrition (MiNutE study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) have been included into the inventory.

Manure Management Systems (MMS)

MMS data used in the national inventory is based on the following national surveys on agricultural practices (KONRAD 1995, AMON et al. 2007 and PÖLLINGER et al. 2018). The research project 'Animal husbandry and manure management systems in Austria (TIHALO I)' (AMON et al. 2007) has been carried out as a comprehensive survey on the agricultural practices in Austria. Within this project, the Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU) closely co-operated with the Swiss College of Agriculture, the Austrian Chamber of Agriculture, the Umweltbundesamt, the Agricultural Research and Education Centre Raumberg-Gumpenstein and the Statistics Austria. The statistical sampling plan (5 000 Austrian farms, return rate of 39%) was set up with the assistance of the Statistics Austria to guarantee the selection of a representative sample.

As a result of TIHALO I, for the year 2005 updated representative data on animal husbandry and manure management systems all over Austria was available. For the year 1990 MMS data based on (KONRAD 1995) was used. In this study data on existing Austrian conditions were derived from a research survey carried out on 720 randomly-chosen agricultural enterprises in the years 1989–1992.

In 2017 the TIHALO I study has been followed-up by a new research project (TIHALO II) (PÖLLINGER et al. 2018). For this project, as for the previous one, a comprehensive survey on the agricultural practices in Austria has been carried out. 5 000 questionnaires were sent to the farmers and a return rate of 37% could be achieved. Compared to the first TIHALO study, the questionnaire for the farmers was additionally available as an online version, which was used by more than 50% of the participants. The current study was conducted by the Agricultural Research and Education Centre Raumberg-Gumpenstein as lead, but in close cooperation with the Austrian Chamber of Agriculture, the Federal Institute of Agricultural Economics, the Federal Ministry for Sustainability and Tourism[96] and the Umweltbundesamt. So, for 2017 new information on livestock feeding, management systems and practices as well as application techniques in Austria became available.

For the creation of a plausible time series the MMS distribution of 1990 (based on KONRAD 1995) partly had to be adopted. Changes to the year 1990 were derived from the TIHALO I and TIHALO II study results and expert opinion (DI Alfred Pöllinger, Agricultural Research and Education Centre Raumberg-Gumpenstein) carried out in (AMON & HÖRTENHUBER 2019). MMS data from 2006–2016 were derived by linear extrapolation. Taking into account the existing provisions of animal welfare, adjustments were necessary for the years after 2017. Trend extrapolation resulted in increased shares of loose housing systems and decreased shares of tied systems. However, the overall shares of liquid and solid systems based on (PÖLLINGER et al. 2018) remained unchanged.

Information on anaerobic digestion is based on data published by the Austrian Energy Regulator (E-CONTROL 2008-2022). 1990 data are based on (AMON 2002).

For the livestock categories sheep, poultry, horses, goats and deer country specific MMS data has been applied. Data are based on the TIHALO II results (PÖLLINGER et al. 2018) and expert judgement (PÖLLINGER 2018), carried out in (AMON & HÖRTENHUBER 2019). Except for chicken, the MMS distribution of these animal categories has been kept constant over the entire time series.

Austria's MMS data are provided in Table 199 and Table 200.

Table 199: Manure Management System distribution in Austria 2021.

Livestock category	Liquid/ Slurry	Solid Storage	Pasture/ Range/ Paddock	Composting	Anaerobic Digestion	Other Systems
	[%]	[%]	[%]	[%]	[%]	[%]
Dairy cattle	54.0	29.1	3.7	1.9	2.3	9.0
Non-dairy cattle	33.7	21.8	7.8	1.6	2.3	32.9
Suckling cows	27.5	26.4	17.8	2.1	2.3	23.9
Cattle < 1 year	20.4	17.3	6.2	1.3	2.3	52.5
Breeding heifers 1–2 years	40.1	23.9	4.0	1.6	2.3	28.2
Fattening heifers, bulls and oxen 1–2 years	51.4	17.4	3.4	1.2	2.3	24.2
Other cattle > 2 years	40.0	30.0	7.4	1.8	2.3	18.5
Sheep	0.0	65.0	35.0	0.0	0.0	0.0
Goats	0.0	94.4	5.6	0.0	0.0	0.0
Horses	0.0	80.0	20.0	0.0	0.0	0.0
Swine (Total)	88.3	5.1	0.0	0.4	0.5	5.8

[96] From 2020 onwards „The Federal Ministry for Agriculture, Regions and Tourism"

Livestock category	Liquid/ Slurry	Solid Storage	Pasture/ Range/ Paddock	Composting	Anaerobic Digestion	Other Systems
	[%]	[%]	[%]	[%]	[%]	[%]
Breeding sows	81.1	12.1	0.0	0.7	0.5	5.7
Young and fattening pigs	89.7	3.7	0.0	0.3	0.5	5.9
Chicken	0.0	96.6	3.0	0.0	0.4	0.0
Layers	0.0	95.6	4.0	0.0	0.4	0.0
Broilers	0.0	99.3	0.3	0.0	0.4	0.0
Other poultry	0.0	99.8	0.2	0.0	0.0	0.0
Turkeys	0.0	99.8	0.2	0.0	0.0	0.0
Other Poultry	0.0	99.8	0.2	0.0	0.0	0.0
Deer	0.0	20.0	80.0	0.0	0.0	0.0

Table 200: Other systems 2021 in detail.

Livestock category	Yard	Deep Litter < 1 month	Deep Litter > 1 month	Aerobic Treatment
	[%]	[%]	[%]	[%]
Dairy cattle	5.0	1.7	1.7	0.7
Non-dairy cattle	3.2	10.6	18.6	0.4
Suckling cows	6.5	8.6	8.6	0.2
Cattle < 1 year	1.8	15.1	35.4	0.3
Breeding heifers 1–2 years	5.6	9.0	13.1	0.5
Fattening heifers, bulls and oxen 1–2 years	0.7	9.0	13.8	0.7
Other cattle > 2 years	2.6	7.2	8.3	0.3
Sheep	0.0	0.0	0.0	0.0
Goats	0.0	0.0	0.0	0.0
Horses	0.0	0.0	0.0	0.0
Swine (Total)	0.8	1.7	2.3	1.0
Breeding sows	1.0	1.6	2.4	0.7
Young and fattening pigs	0.8	1.7	2.3	1.1
Chicken	0.0	0.0	0.0	0.0
Layers	0.0	0.0	0.0	0.0
Broilers	0.0	0.0	0.0	0.0
Other poultry	0.0	0.0	0.0	0.0
Turkeys	0.0	0.0	0.0	0.0
Other Poultry	0.0	0.0	0.0	0.0
Deer	0.0	0.0	0.0	0.0

Small farms more frequently use solid manure systems, whereas large farms make more use of slurry systems. The time series on MMS shows for cattle a decreasing share of solid systems, pasture and composting but increasing shares of liquid systems, anaerobic digestion and 'other systems'. Deep litter dominates the other system category for non-dairy cattle and swine. Young and fattening pigs as well as breeding sows are increasingly held on liquid systems, whereas in the young and fattening pig category a stronger trend to liquid systems was identified. The rearing of sheep, goats, horses and deer is of minor importance in Austria. In general, these livestock categories are pastured and their housings are based on solid systems (straw).

Influence of application time on stored liquid slurry

Cattle

The evaluation of the TIHALO questionnaires (Amon et al. 2007) produced the following results: 32% of the slurry is applied in spring, 42% in summer and 25% in autumn (n=933 farms, projected by Statistik Austria to representative Austrian conditions). Following data on the storage of slurry were derived:

On average are

- in spring 55% of the stores' capacity filled,
- in summer 45% of the stores' capacity filled,
- in autumn 37.5% of the stores' capacity filled,
- in winter 62.5% of the stores' capacity filled.

Swine

The evaluation of the TIHALO questionnaires (Amon et al. 2007) produced the following results: 57% of the slurry is applied in spring, 27% in summer and 16% in autumn (n=628 farms, projected by Statistik Austria to representative Austrian conditions). Following data on the storage of slurry were derived:

On average are:

- in spring 43% of the stores' capacity filled,
- in summer 41% of the stores' capacity filled,
- in autumn 50% of the stores' capacity filled,
- in winter 75% of the stores' capacity filled.

Emission measurements under field conditions showed, that an increase in methane emissions during slurry storage was only observed during the summer season. The following table presents the slurry stored in cold and warm season per animal category as used in the national inventory.

Table 201: Liquid slurry – percentage storage in cold and warm season for 2021.

Livestock category	Liquid slurry storage	
	warm season [%]	**cold season [%]**
Dairy cattle	21.6	78.4
Suckling cows	17.3	82.7
Cattle < 1 year	20.9	79.1
Breeding heifers 1–2 years	21.5	78.5
Fattening heifers, bulls and oxen 1–2 years	21.6	78.4
Non-dairy cattle > 2 years	20.6	79.4
Breeding sows	19.6	80.4
Young and fattening pigs	19.6	80.4

Derivation of manure digested in biogas plants

In the current submission the calculation of the amounts and proportions of digested manure (VS_{ex} and N_{ex}) was restructured together with the calculation of N from plant-based substrates. The same or comparable data sources were used as in previous submissions.

Data basis for the estimation are published numbers of biogas plants under contract for electricity supply, annual energy amounts (kWh) produced from Austrian biogas plants and the energy-related distribution of the substrates used. Below additional information on the derivation of manure digested in biogas plants is provided as recommended in the ARR 2013, para 49.

Biogas plant numbers have been obtained from (AMON et al 2002) for the years 1990 to 2000 and from the annual reports of the Austrian Energy Regulator E-Control for the years from 2005 onwards. Plant numbers between the years 2000 and 2005 have been derived by interpolation.

Energy amounts (kWh) from animal manure were also taken from the annual reports of E-Control. As before 2007 the energy shares of animal manures were not reported, those of the year 2007 have been used backwards to the year 1990. The total annual mass of manure used as substrates was calculated from the total annual energy amounts from manure with factors for kWh per t of substrate (cattle slurry and solid manure, pig slurry and solid manure, chicken manure) and by using default values of (AGENCY FOR RENEWABLE RESOURCES 2021).

The following default values have been used: 1 m^3 methane = 9.97 kWh energy, 1 density methane = 0.72 kg/m^3, CHP electric efficiency = 28 to 47 %. For the latter value, not a simple average value between the minimum and the maximum of the range was used, but a weighted average, which evaluates the minimum value two thirds and the maximum value one third. Thus, a better agreement with alternative and previously used values on kWh per t substrate could be determined. For this purpose, values from (LFL BAYERN 2021) were taken to calculate the amount of bioas-CH_4 per t substrate. IPCC default B_0 values were applied

Table 202 Characteristic values for the calculation of the VS_{ex} amounts and substrate amounts in biogas plants

	cattle slurry	cattle solid	pig slurry	pig solid	chicken manure
kg VSex per kg CH_4	12.92	12.92	5.53	5.53	6.85
kg CH_4 per t fresh matter (FM) manure input	14.21	49.50	12.24	44.58	32.19

Table 203: Numbers of biogas plants and amounts of digested manure 1990–2021.

Year	Biogas plant	Energy amounts from animal manure	Annually digested manure	VSexcretion anaerobically digested
	[number]	[kWh /yr]	[t DM/yr]	[t /yr]
1990	5	458 707	3 764	615
1991	7	642 190	5 270	861
1992	8	733 932	6 023	984
1993	11	1 009 156	8 282	1 352
1994	32	2 935 728	24 093	3 934
1995	38	3 486 177	28 610	4 672
1996	43	3 944 884	32 374	5 286
1997	57	5 229 265	42 915	7 008
1998	70	6 421 905	52 702	8 606
1999	100	9 174 150	75 289	12 294
2000	120	11 008 980	90 347	14 753
2001	142	13 045 641	107 061	17 482
2002	164	15 082 302	123 775	20 212

Year	Biogas plant	Energy amounts from animal manure	Annually digested manure	VSexcretion anaerobically digested
	[number]	[kWh /yr]	[t DM/yr]	[t /yr]
2003	187	17 118 963	140 490	22 941
2004	209	19 155 624	157 204	25 670
2005	231	21 192 286	173 918	28 400
2006	253	23 210 599	190 482	31 104
2007	294	26 972 000	221 350	36 145
2008	293	34 825 202	303 882	48 819
2009	291	40 509 656	372 173	59 087
2010	289	45 962 844	441 240	69 427
2011	288	28 639 327	232 831	42 290
2012	291	29 640 442	242 322	43 628
2013	293	30 658 365	252 004	44 993
2014	289	31 693 096	261 877	46 385
2015	291	32 082 582	266 911	46 087
2016	287	34 130 324	250 290	58 844
2017	288	32 215 830	238 378	55 165
2018	288	33 509 640	245 082	59 340
2019	283	26 947 680	188 089	52 528
2020	280	27 384 000	191 134	53 379
2021	272	26 059 200	181 887	50 796

Table 203 shows increasing biogas plant numbers along with rising amounts of digested amounts of manure. However, since 2018 plant numbers and digested amoungs are decreasing.

Activity data

(Statistik Austria 2022) provides national data of annual livestock numbers on a very detailed level (see Table 183, Table 184, Table 185). These data are basis for the estimation.

5.3.2.1 Estimation of CH_4 Emissions

CH_4 emissions of cattle and swine are estimated with the Tier 2 approach. This method requires detailed information on animal characteristics and on the manner in which the manure is managed. The following formula has been used (2006 IPCC GL, Equation 10.23):

$$EF_T = (VS_{(T)} * 365) * [B_{0(T)} * 0.67\ kg\ m^{-3} * \Sigma_{S,k}\ MCF_{S,k}/100 * MS_{(T,S,k)}]$$

$EF_{(T)}$ = *annual CH_4 emission factor for livestock category T, kg CH_4 animal^{-1}yr^{-1}*

$VS_{(T)}$ = *daily volatile solid excreted for livestock category T, kg dry matter animal^{-1}yr^{-1}*

$B_{0(T)}$ = *maximum methane producing capacity for manure produced by livestock category T, m^3 CH_4 kg^{-1} of VS excreted*

0,67 = *conversion factor of m^3 CH_4 to kilograms CH_4*

$MCF_{(S,k)}$ = *methane conversion factors for each manure management system S by climate region k, %*

$MS_{(T,S,k)}$ = *fraction of livestock category T`s manure handled using manure systems S in climate region k, dimensionless*

Methane conversion factors (MCF)

The default MCF values for 'cool climate regions' presented in the IPCC 2006 GL (Table 10.17) were used for the following systems:

- Pasture, Range, Paddock (MCF: 1%),
- Solid Storage (MCF: 2%),
- Anaerobic digester (MCF: 2%),
- Composting (MCF: 0.5%),
- Aerobic Treatment (MCF: 0.0%),
- Yard: the MCF of Pasture, Range, Paddock was applied (MCF: 1%).

According to the guidelines, cool climates have an average temperature below 15 °C. The average temperature in Austria varies from 8.4 °C in Klagenfurt to 10.5 °C in Vienna (ZAMG, Jahrbuch 2004).

Country specific MCF for anaerobic digesters

In Austria, safety regulations for the building and operation of agricultural biogas plants are rather strict. Investment costs for the building of the biogas plants are only granted, if the farmer proofs that the strict safety regulations have been followed. The safety regulations have been developed and documented in the frame of the EU-ALTENER standard for the building and operation of agricultural biogas plants. The safety regulations do not suggest that there is a significant probability for substantial CH_4 losses through leakage.

Anyhow, there is no national study available that estimates CH_4 leakage losses from Austrian biogas plants. A study worked out in Germany (FNR 2010) shows that CH_4 losses of biogas plants are about 1–2% of the gas produced under cold climate conditions.

In response to a question raised by the ERT during the Centralized Review 2011, the estimations now consider methane losses from anaerobic digesters. Following the results of the study mentioned above and national expert judgment (AMON T. 2011) the methane conversion factor (MCF) for anaerobic digesters was increased from 0% to 2%, resulting in higher CH_4 emissions.

Country specific MCF for liquid systems of cattle and swine

IPCC encourages measurements of emissions from manure management under field conditions in order to improve the basis of emission estimates. The Division of Agricultural Engineering (DAE) at the University of Natural Resources and Applied Life Sciences (BOKU) has carried out a three-year measurement campaign on emissions from manure stores financed by the Federal Ministry of Agriculture, Forestry, Environment, and Water Management and the Federal Ministry for Education, Science, and Culture. Emission rates have now been published in peer reviewed publications (AMON et al. 2002a, 2006, 2007a). They can therefore be used for calculating MCF values for liquid manure systems.

Table 204: Country specific MCFs for liquid systems (AMON et al. 2006, AMON et al. 2007a).

Animal Category	cold season [%]	warm season [%]
Cattle	0.97	37.22
Swine	3.27	3.87

The country specific MCFs have been applied to the amounts of liquid manure storage under cold and warm climate conditions (see Table 204). The extensive emission measurements under field conditions showed, that an increase in methane emissions during slurry storage was only observed during the summer season. The low temperature in all other seasons in Austria reduces methane formation significantly during slurry storage. Emission measurements were carried out in one of the warmest Austrian region and therefore may tend to overestimate MCF values. The following table presents average values for liquid systems for the years 1990 and 2021.

Table 205: Average MCFs for liquid systems 1990 and 2021.

Animal Category	**1990 [%]**	**2021 [%]**
Dairy Cattle	8.7	8.8
Other Cattle	8.7	8.4
Swine	3.4	3.4

The following table presents the average MCFs for other systems for the years 1990 and 2021.

Table 206: Average MCFs for other systems 1990 and 2021.

Animal Category	**1990 [%]**	**2021 [%]**
Dairy Cattle	6.2	4.6
Other Cattle	9.4	10.3
Swine	11.6	10.6

In submission 2010 deep litter systems were introduced to the Austrian MMS distribution (AMON et al. 2007). Based on new survey data (PÖLLINGER et al. 2018) a differentiation into deep litter < 1 month and deep litter > 1 month has been implemented into inventory submission 2019.

For deep litter systems < 1 month the default MCF value of 3% for the system *cattle and swine deep bedding < 1 month* was taken (2006 IPCC GL ,Table 10.17).

In Austria manure from deep litter systems > 1 month is usually removed twice a year – in spring and in autumn. The bedding is continuously added, there is no mixing**.** Austrian measurements showed that CH_4 emissions from farmyard manure were always lower than CH_4 emissions from liquid manure. In the IPCC Guidelines the default MCF for deep litter systems equals the default MCF for liquid systems. Hence, for Austria the chosen MCF of 17% (IPCC 2006) is a conservative estimate.

The big share of deep litter in the other system category is responsible for the high MCF values of other cattle and swine. However, compared to the submissions before, in submission 2019 the average MCF of other systems decreased due to the split of the deep litter systems into deep litter < 1 month and deep litter > 1 month.

MCF used for yards

In yards aerobic processes are predominant, the dung dries after excretion. Thus, seen from the microbiological point of view, conditions for methane production from dung excreted on yards are unfavourable: CH_4 is only formed under anaerobic and wet conditions. The creation of methane in yards is best reflected in the 2006 IPCC MCF of 1%.

Maximum methane producing capacity (B_{0i})

The IPCC default values were used (Annex 10A.2, Tables 10A-4 through 10A-9, IPCC 2006 Guidelines).

5.3.2.1.1 Cattle (3.B.1.1 – CH_4 and 3.B.2.1 – N_2O)

Key Source: Yes (CH_4, N_2O)

Austrian specific values for cattle are calculated dependent on annual milk yields (dairy and suckling cows), growth, activity and maintenance information as well as corresponding feed intake data (gross energy intake, feed digestibility, ash content, see chapter 5.2.2.1 and Table 207).

In submission 2022 feed intake assumptions were updated within the framework of the new country specific study on animal feeding and nutrition (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023). Calculation of VS excretion rates follows equation 10.24 provided in (IPCC 2019)

$$VS = [GE * (1 - DE\%/100) + (UE * GE)] * [(1 - ASH)/18.45]$$

VS = volatile solid excretion per day on a dry-organic matter basis, kg VS day^{-1}
GE = gross energy intake, MJ day^{-1}
DE% = digestibility of the feed in percent (e.g. 60 percent)
*(UE * GE) = urinary energy expressed as fraction of GE. The default value of 0.04GE has been taken.*
ASH = ash content of manure calculated as a fraction of the dry matter feed intake
18.45 = conversion factor for dietary GE per kg of dry matter (MJ kg-1).

Volatile solid (VS) excretion – dairy cattle

The following table provides the parameters used for determining the VS excretion of dairy cattle. VS excretion rates increased over the time series. Information on GE intake, feed digestibility and ash content are described in chapter 5.2.2.1.

Table 207: Feed intake and VS excretion of Austrian dairy cattle for the period 1990-2021

Year	GE intake [MJ day^{-1}]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day^{-1}]
1990	253.8	66.48	8.83	4.71
1991	254.6	66.56	8.83	4.71
1992	255.5	66.65	8.83	4.72
1993	257.5	66.78	8.83	4.74
1994	259.1	66.90	8.83	4.75
1995	268.3	67.70	8.83	4.81
1996	269.7	67.78	8.83	4.83
1997	271.9	67.95	8.83	4.84
1998	274.6	68.16	8.83	4.86
1999	277.3	68.36	8.83	4.88
2000	279.6	68.58	8.83	4.89
2001	283.3	68.85	8.83	4.92
2002	285.0	68.99	8.83	4.93
2003	288.0	69.21	8.82	4.95
2004	291.2	69.45	8.82	4.97
2005	290.6	69.43	8.82	4.97

Year	GE intake [MJ day-1]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day-1]
2006	292.5	69.60	8.82	4.97
2007	294.6	69.74	8.82	4.99
2008	295.4	69.83	8.82	4.99
2009	295.8	69.85	8.82	4.99
2010	296.8	69.89	8.82	5.00
2011	298.6	70.08	8.82	5.00
2012	302.0	70.37	8.81	5.02
2013	302.7	70.43	8.81	5.02
2014	304.0	70.55	8.81	5.03
2015	305.2	70.60	8.81	5.04
2016	308.2	70.87	8.81	5.05
2017	309.3	71.03	8.81	5.04
2018	312.6	71.38	8.81	5.04
2019	313.7	71.49	8.81	5.04
2020	315.5	71.65	8.81	5.04
2021	315.0	71.59	8.81	5.04

Volatile solid (VS) excretion – suckling cows

In the current submission VS excretion rates of suckling cows have been updated according to (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023). The VS excretion are now higher compared to previous submissions due to higher demand for gross energy caused by increasing body mass and milk yields. In the table below the feed intake parameters relevant for VS excretion are provided. Further information on GE intake, feed digestibility and ash content are included in chapter 5.2.2.1.

Table 208: Feed intake and VS excretion of Austrian suckling cows for the period 1990–2021.

Year	GE intake [MJ day-1]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day-1]
1990	231.81	65.31	11.00	4.33
1991	232.49	65.36	11.00	4.33
1992	233.16	65.41	11.00	4.34
1993	234.34	65.47	11.00	4.36
1994	235.42	65.52	11.00	4.37
1995	236.61	65.57	11.00	4.39
1996	237.85	65.63	11.00	4.40
1997	238.99	65.68	11.00	4.42
1998	240.24	65.73	11.00	4.43
1999	241.49	65.78	11.00	4.45
2000	242.31	65.84	11.00	4.46
2001	243.80	65.89	11.00	4.48
2002	244.99	65.94	11.00	4.50
2003	246.42	66.00	11.00	4.52
2004	247.64	66.05	11.00	4.53
2005	247.64	66.05	11.00	4.53
2006	247.88	66.05	11.00	4.54
2007	248.55	66.05	11.00	4.55

Year	GE intake [MJ day^{-1}]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day^{-1}]
2008	248.81	66.05	11.00	4.56
2009	249.28	66.05	11.00	4.56
2010	249.87	66.05	11.00	4.57
2011	250.20	66.05	11.00	4.58
2012	250.92	66.05	11.00	4.59
2013	251.18	66.05	11.00	4.60
2014	251.56	66.05	11.00	4.61
2015	252.20	66.05	11.00	4.62
2016	252.76	66.05	11.00	4.63
2017	252.63	66.05	11.00	4.62
2018	252.65	66.05	11.00	4.63
2019	252.64	66.05	11.00	4.63
2020	252.81	66.05	11.00	4.63
2021	252.77	66.05	11.00	4.63

Volatile solid (VS) excretion – other non-dairy cattle

As for dairy and suckling cows Austrian specific values on VS excretion for all other non-dairy cattle categories were calculated in (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023) by applying Equation 10.24 provided in (IPCC 2019).

Instead of calculations based on a constant gross energy intake as in previous submissions, dynamic VS excretion rates could be determined (see Table 209).

The data used for the calculation of VS excretion of the livestock categories *Non-Dairy Cattle* (GE intake, ash content, digestibility) is described in detail in (HÖRTENHUBER et al. 2022a). As indicated in chapter 5.2.2 (see Figure 31), the other cattle categories had to be further subdivided in order to calculate at the required level of detail.

Table 209: VS excretion of Austrian other cattle categories for the period 1990–2021.

Year	Breeding heifers 1-2 years [kg VS day^{-1}]	Fattening heifers 1-2 years [kg VS day^{-1}]	cattle <1 year [kg VS day^{-1}]	cattle >2 year [kg VS day^{-1}]
1990	3.32	2.73	0.88	3.21
1991	3.32	2.73	0.88	3.21
1992	3.31	2.73	0.88	3.21
1993	3.31	2.73	1.03	3.22
1994	3.30	2.73	1.02	3.22
1995	3.30	2.73	1.05	3.22
1996	3.29	2.73	1.04	3.22
1997	3.28	2.73	1.05	3.22
1998	3.28	2.73	1.06	3.22
1999	3.27	2.73	1.07	3.22
2000	3.27	2.73	1.05	3.22
2001	3.26	2.73	1.06	3.23
2002	3.26	2.73	1.07	3.23
2003	3.25	2.73	1.07	3.22

Year	Breeding heifers 1-2 years [kg VS day-1]	Fattening heifers 1-2 years [kg VS day-1]	cattle <1 year [kg VS day-1]	cattle >2 year [kg VS day-1]
2004	3.25	2.73	1.07	3.21
2005	3.24	2.73	1.07	3.23
2006	3.24	2.73	1.04	3.22
2007	3.24	2.74	1.02	3.21
2008	3.24	2.74	1.00	3.21
2009	3.24	2.75	0.98	3.21
2010	3.25	2.76	0.96	3.21
2011	3.26	2.76	0.97	3.23
2012	3.27	2.77	0.97	3.24
2013	3.27	2.77	0.97	3.25
2014	3.28	2.78	0.98	3.26
2015	3.29	2.78	0.98	3.27
2016	3.30	2.79	0.99	3.28
2017	3.31	2.80	1.00	3.29
2018	3.32	2.80	1.00	3.30
2019	3.33	2.80	1.00	3.30
2020	3.34	2.81	1.01	3.31
2021	3.34	2.81	1.01	3.31

5.3.2.1.2 Swine (3.B.1.3)

Key Source: No

Volatile solid (VS) excretion – swine

In the previous inventories measured values for VS excretion according to (SCHECHTNER 1991) were used and kept constant for the whole time series. In the present inventory updated country-specific VS excretion rates could be determined based on diets taken from (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023) and calculated according to equation 10.24 provided in (IPCC 2019). Information on energy intake, ash content and digestibility is described in (HÖRTENHUBER et al. 2022a). In the following table the VS excretion rates for the swine categories are indicated.

Table 210: VS excretion from Austrian swine for the period 1990-2021

Year	Breeding sows [kg VS day-1]	Young & fattening pigs [kg VS day-1]	Young swine 8-32 kg [kg VS day-1]
1990	0.59	0.38	0.14
1991	0.59	0.38	0.14
1992	0.60	0.38	0.14
1993	0.60	0.38	0.14
1994	0.60	0.38	0.14
1995	0.60	0.38	0.14
1996	0.60	0.38	0.14
1997	0.60	0.38	0.14
1998	0.61	0.38	0.14
1999	0.61	0.38	0.14
2000	0.61	0.38	0.14
2001	0.61	0.38	0.15

Year	Breeding sows [kg VS day^{-1}]	Young & fattening pigs [kg VS day^{-1}]	Young swine 8-32 kg [kg VS day^{-1}]
2002	0.61	0.38	0.15
2003	0.61	0.38	0.15
2004	0.61	0.38	0.15
2005	0.62	0.39	0.15
2006	0.62	0.38	0.15
2007	0.62	0.38	0.15
2008	0.63	0.38	0.14
2009	0.63	0.38	0.14
2010	0.64	0.38	0.14
2011	0.64	0.38	0.14
2012	0.64	0.38	0.14
2013	0.65	0.37	0.14
2014	0.65	0.37	0.14
2015	0.66	0.37	0.13
2016	0.66	0.37	0.13
2017	0.66	0.37	0.13
2018	0.67	0.37	0.13
2019	0.67	0.37	0.13
2020	0.67	0.37	0.13
2021	0.67	0.37	0.13

Piglets (< 8 kg) were not taken into account because the emission factors for breeding sows already take into account the emissions of suckling piglets up to 8 kg live weight.

5.3.2.1.3 Sheep (3.B.2) and Other livestock (3.B.4: Poultry, Horses, Goats, Deer)

Key Source: No

CH_4 emissions of sheep, poultry, horses, goats and deer are estimated with the Tier 2 approach (equation 10.23 of the 2006 IPCC GL).

For VS excretion, B_0 and MCF the 2006 IPCC default values were taken. Information on management systems is indicated in Table 199.

Table 211: IPCC default values used for CH_4 calculation of sheep and other livestock in Austria.

Livestock category	Volatile Solids (VS) excretion [kg $animal^{-1}$ day^{-1}]	CH_4 producing potential – B_0 [m^2 CH_4 kg^{-1} VS]
Sheep	0.40	0.19
Goats	0.30	0.18
Horses	2.13	0.30
Layers	0.02	0.39
Broilers	0.01	0.36
Turkeys	0.07	0.36
Other Poultry (ducks, geese,..)	0.02	0.36

Data source: IPCC 2006, Table 10A-9

The Austrian inventory does not distinguish between horses and mules and asses. Mules and asses are included in the horse category (3.B.4.2) and are only of very little importance in Austria. Thus, CH_4 emissions from the manure of horses were estimated with the default values of horses.

The deer category (3.B.4.4) is including roe deer, red deer, fallow deer and to some extent wild boars. As no further data on the exact composition of this animal category is available and the contribution to the overall emissions is very small, a simple conservative approach has been chosen: except for the MMS data, for which a country-specific distribution has been used, the default values of sheep were applied, because sheep is the most similar animal category to deer (which dominates this category).

5.3.2.1.4 Estimation of direct N_2O Emissions from manure management

Key Source: 3.B.1

Following the guidelines, all direct and indirect emissions of N_2O occurring before the manure is applied to soils (during the storage and treatment of manure or otherwise used for feed, fuel or construction purposes) are reported under manure management.

For the estimation of direct N_2O emissions from manure management systems Austria uses a Tier 2 approach. The IPCC methodology for estimating N_2O emissions from manure management entails multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems (see formulas below).

N excretion per animal waste management system:

$$Nex_{(S)} = \sum_{(T)}[N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}]$$

$Nex_{(S)}$ = N excretion in manure management system S [kg yr^{-1}]
$N_{(T)}$ = number of animals of type T in the country
$Nex_{(T)}$ = N excretion of animals of type T in the country [kg N $animal^{-1}$ yr^{-1}]
$MS_{(T,S)}$ = fraction of $Nex_{(T)}$ that is managed in manure management system S for animals of type T in the country
T = type of animal category

Direct N_2O emission per animal waste management system:

$$N_2O_{(S)} = \sum[Nex_{(S)} \times EF_{3(S)}] * (44/28)$$

$N_2O_{(S)}$ = direct N_2O emissions from manure management system S in the country [kg N_2O yr^{-1}]
$Nex_{(S)}$ = N excretion in manure management system S [kg yr^{-1}]
$EF_{3(S)}$ = N_2O-N emission factor for manure management system S [kg N_2O-N per kg of Nex in $MS_{(S)}$]

Manure Management System (MMS)

The manure management system distribution data applied to estimate N_2O emissions from *Manure Management* is the same as used for the estimation of CH_4 emissions from *Manure Management* (see Table 200).

N excretion

In previous years country specific N excretion values were based on (GRUBER & PÖTSCH 2006, PÖTSCH et al. 2005, STEINWIDDER & GUGGENBERGER 2003, UNTERARBEITSGRUPPE N-ADHOC 2004 and ZAR 2004) and Richtlinien Sachgerechter Düngung (BMLFUW 2017). However, the feeding of cattle and swine has changed in the last two decades. Therefore, a new research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b, HÖRTENHUBER et. al. 2023) has been carried out by the University of Natural Ressources and Life Sciences, Vienna. As a result, updated and representative values for energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) are available. New data have been included into the inventory of submission 2022.

Within the framework of this country specific study, the necessary information was compiled and derived from official statistical data, international and national technical literature, representative data from producer associations (e.g. ZAR, project "Efficient Cow" EGGER-DANNER et al. 2018), feed analyses and feed calculations of the project partner and the feed company Fixkraft (fixkraft.at, based on the feeding strategies of their customers). The results were supplemented and revised with information from experts, e.g. feeding advisors from the chambers of agriculture, working group advisors and additional data surveys on farms.

The extensive results of the MiNutE Study made it possible to calculate national excretion values at a much more detailed level based on the latest available scientific literature (IPCC 2019).

Cattle

The annual N excretion rates were calculated with Equation 10.31A (IPCC 2019), which can be estimated as the difference between the total nitrogen taken in by the animal and the total nitrogen retained for growth and milk production.

$$Nex_{(T)} = (N_{intake(T)} - N_{retention(T)}) * 365$$

$Nex_{(T)}$	*= annual N excretion rates, kg N animal-1 yr-1*
$N_{intake(T)}$	*= the daily N intake per head of animal of species/category T, kg N animal-1 day-1*
$N_{retention(T)}$	*= amount of daily N intake by head of animal of species / category T, that is retained by animal of species/category T, kg N animal-1 day-1,*
365	*= Number of days in a year*

The same dietary assumptions have been used as for modelling methane emissions from CRF sector *3.A Enteric Fermentation* (see chapter 5.2).

N intake rates are determined by applying equation 10.32 (IPCC 2019) based on the gross energy intake and crude protein in dry matter. The energy demand of cattle has been also calculated by applying the 2019 Refinement to the 2006 IPCC GL, taking into account body mass and weight gain performance, husbandry, milk yield, gestation and feeding parameters. Crude protein in dry matter was calculated using data from different national studies (EGGER-DANNER et al. 2016, STEINWIDDER AND HÄUSLER 2004, STEINWIDDER AND GUGGENBERGER 2003, STEINWENDER 1992) and is detailed documented in (HÖRTENHUBER et al. 2022a).

N retention rates are calculated by applying equation 10.33 of the 2019 Refinement to the 2006 IPCC GL. For dairy and suckling cows the respective milk yields and protein in milk is taken into account. Milk yields are presented in Table 212. For dairy cows the milk yield is provided annually by Statistics Austria, published in (BML 2000–2022). For suckler cows an annual milk yield of 3 000 kg for 1990 and of 3 500 kg for the years from 2004 onwards was determinded (HÄUSLER 2009). Data on the average fat content and protein content of milk from dairy cows for the years 1991-2020 were derived from information provided by AgrarMarkt Austria (AMA). Due to missing data for the year 1990, the value of 1991 was adopted. For 2021 the value of 2020 was taken as proxy. Similar to dairy cows, the AMA data on the average fat and protein content of delivered has been used as the measured milk fat content of cows of beef breeds does not differ significantly to those of dairy cows according to (SCHOLZ et al. 2001). For the other cattle categories the average daily weight gain and net energy for growth are the parameters needed. The average daily weight gain was determined on the basis of national studies, detailed described in (HÖRTENHUBER et al. 2022a). Net energy for growth has been calculated by applying equation 10.15 (IPCC 2019).

Table 212: Austria specific N excretion values of dairy and suckling cows for the period 1990–2021.

Year	Dairy cows		Suckling cows	
	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]
1990	3 791	91.05	3 000	72.18
1991	3 848	91.13	3 036	72.30
1992	3 908	91.03	3 071	72.29
1993	3 997	91.13	3 107	72.36
1994	4 076	91.54	3 143	72.73
1995	4 619	92.44	3 179	72.85
1996	4 670	92.62	3 214	73.09
1997	4 787	93.05	3 250	73.44
1998	4 924	93.44	3 286	73.73
1999	5 062	93.65	3 321	73.91
2000	5 210	93.92	3 357	74.14
2001	5 394	94.24	3 393	74.36
2002	5 487	94.55	3 429	74.73
2003	5 638	95.88	3 464	75.14
2004	5 802	97.19	3 500	75.41
2005	5 783	97.00	3 500	75.46
2006	5 903	98.02	3 500	75.67
2007	5 997	98.67	3 500	75.76
2008	6 059	99.15	3 500	75.91
2009	6 068	99.53	3 500	76.20
2010	6 100	99.88	3 500	76.37
2011	6 227	100.57	3 500	76.44
2012	6 418	102.15	3 500	76.71
2013	6 460	102.38	3 500	76.76
2014	6 542	103.08	3 500	76.95
2015	6 579	103.65	3 500	77.20
2016	6 759	104.88	3 500	77.30
2017	6 865	105.13	3 500	77.25
2018	7 104	106.04	3 500	77.20
2019	7 179	106.27	3 500	77.15
2020	7 286	106.78	3 500	77.16
2021	7 249	106.60	3 500	77.14

[1)] *From 1995 onwards data have been revised by Statistik Austria, which led to significant higher milk yield data of Austrian dairy cows.*

Table 213: Austria specific N excretion values of other cattle for the period 1990-2021

Year	**Nitrogen excretion [kg/animal*yr]**			
	breeding heifers 1-2 years	**fattening heifers & bulls & oxen 1-2 years**	**cattle <1 year**	**cattle >2 year**
1990	60.67	58.53	30.53	63.75
1991	60.56	58.57	30.63	63.72
1992	60.46	58.56	30.70	63.68
1993	60.35	58.57	31.78	63.47
1994	60.24	58.57	31.88	63.43
1995	60.14	58.46	33.18	63.40
1996	60.03	58.24	33.24	63.29
1997	59.93	58.23	33.14	63.25
1998	59.82	58.10	32.81	63.16
1999	59.72	58.17	33.08	63.19
2000	59.61	58.14	33.74	63.10
2001	59.50	57.86	33.97	63.04
2002	59.40	57.75	34.07	62.87
2003	59.29	57.50	34.37	63.00
2004	59.19	57.41	34.51	62.99
2005	59.08	57.51	34.53	62.75
2006	59.04	57.64	34.51	62.62
2007	59.00	57.73	34.49	62.50
2008	58.96	57.82	34.33	62.37
2009	59.10	57.83	34.34	62.42
2010	59.24	57.93	34.38	62.46
2011	59.38	58.00	34.56	62.66
2012	59.52	58.17	34.57	62.90
2013	59.66	58.37	34.47	63.12
2014	59.79	58.48	34.45	63.34
2015	59.93	58.57	34.55	63.54
2016	60.07	58.62	34.64	63.75
2017	60.21	58.66	34.73	63.90
2018	60.39	58.63	34.76	64.02
2019	60.57	58.68	34.93	64.16
2020	60.75	58.83	35.00	64.33
2021	60.75	58.82	34.94	64.32

Swine

Annual N excretion rates of the categories breeding pigs (sows and boars), piglets 8-32 kg, and fattening pigs were calculated using equation 10.31A provided in the 2019 Refinement to the IPCC 2006 GL.

N intake rates for swine are estimated with equation 10.32A taking into account dry matter intake per day during a specific growth stage and the crude protein in dry matter for growth stage.

Following the 2019 Refinement to the IPCC 2006 Guidelines, the N retention rates vary among different swine categories. So, for breeding sows equation 10.33A, for piglets equation 10.33B and for fattening pigs equation 10.33C have been applied.

Information on performance indicators (daily gain of weight, average slaughter weights, etc.), feed quantities (energy requirements, crude protein content per kg feed, information N-reduced feeding etc.) and components of feed rations is summarized in (HÖRTENHUBER et al. 2022a).

Table 214: Austria specific N excretion values of swine for the period 1990-2021

Year	**Nitrogen excretion [kg/animal*yr]**		
	breeding sows plus litter	**fattening pigs**	**piglets 8-32 kg**
1990	23.2	14.8	3.7
1991	23.2	14.8	3.7
1992	23.1	14.7	3.7
1993	23.1	14.7	3.7
1994	23.0	14.7	3.7
1995	22.9	14.6	3.7
1996	22.9	14.6	3.7
1997	22.8	14.6	3.7
1998	22.7	14.5	3.8
1999	22.7	14.5	3.8
2000	22.6	14.5	3.8
2001	22.5	14.4	3.8
2002	22.5	14.4	3.8
2003	22.4	14.3	3.8
2004	22.3	14.3	3.8
2005	22.3	14.3	3.8
2006	22.3	14.2	3.8
2007	22.3	14.1	3.7
2008	22.3	14.0	3.7
2009	22.3	13.9	3.7
2010	22.3	13.8	3.6
2011	22.3	13.7	3.6
2012	22.3	13.6	3.6
2013	22.3	13.5	3.5
2014	22.3	13.4	3.5
2015	22.2	13.3	3.5
2016	22.2	13.2	3.5
2017	22.2	13.1	3.4
2018	22.2	13.0	3.4
2019	22.1	12.9	3.4
2020	22.1	12.9	3.4
2021	22.1	12.9	3.4

Other livestock

Sheep and goats: life weight, daily gain of weight, degree of pregnancy or lactating, feeding rations.

Poultry: feeding ration, duration of keeping, nitrogen uptake, nitrogen efficiency.

Horses: feeding ration per horse category, weight of horses.

Table 215: Austria specific N excretion values of non-key livestock categories.

Livestock category	Nitrogen excretion [kg/animal*yr]
Sheep	13.1
Goats	12.3
Horses	47.9
Layers	0.73
Broilers	0.28
Turkeys	1.18
Other poultry	0.48
Other animals/furred game[1)]	13.1

[1)] N-ex value of sheep applied

Livestock numbers per category can be found in Table 183, Table 184 and Table 185. Data on manure management system distribution is presented in Table 199 and Table 200.

Emission factors

N_2O emission factors of the 2006 IPCC Guidelines have been used for all MMS.

Emission factors applied in the Austrian inventory are listed in the following table.

Table 216: Emission factors for N_2O from manure management.

Animal Waste Management System	Emission factor [kg N_2O-N per kg N excreted]	Reference
Liquid/Slurry	~0.005*	IPCC 2006, Table 10.21
Solid Storage	0.005	IPCC 2006, Table 10.21
Pasture/Range/Paddock (cattle, poultry and pigs)	0.020	IPCC 2006, Table 11.1
Pasture/Range/Paddock (sheep, goats, horses and deer)	0.010	IPCC 2006, Table 11.1
Composting	0.006	IPCC 2006, Table 10.21
Aerobic Treatment	0.005	IPCC 2006, Table 10.21
Anaerobic Digester	0.0	IPCC 2006, Table 10.21
Deep Litter	0.010	IPCC 2006, Table 10.21
Poultry manure (with/without litter)	0.001	IPCC 2006, Table 10.21

* *The average N_2O emission factor of liquid slurry was calculated from the proportion of untreated slurry without national crust (zero emissions following IPCC, 2006) and the proportion which is aerated, covered, or with natural crust (EF of 0.005 following IPCC, 2006).*

Yard

In the IPCC guidelines no emission factor for yard is available. It is assumed, that the storage of the yard manure equals the average manure management systems distribution in Austria (see Table 199 and Table 200). Thus, the implied N_2O emission factor of all systems (except pasture) has been used.

Scientific background for this approach:

N_2O emissions result from the interaction of manure N with organic carbon that is present in soils and in straw. This explains the higher IPCC N_2O EFs of pasture, solid systems or composting compared to liquid slurry EF or the EF of slurry from anaerobic digesters. The presence of organic carbon favours N_2O formation. Applying the N_2O EF of pasture or solid systems for N_2O emissions from yards would result in an overestimation of N_2O emissions, as there is neither soil-C nor straw-C in the yard.

Manure excreted in yards regularly (daily) enters the storage; urine is continuously discharged to the storage. Keeping the high uncertainties of N_2O emissions in mind, the weighted implied N_2O EFs of all systems (except pasture) per animal category are a conservative approach that tends to overestimate yard emissions, as these values include high shares of solid storage systems.

Table 217: N_2O emission factors used for the calculation of N_2O from yards 1990–2021.

Year	Dairy	Non-Dairy	Swine
		[kg N_2O-N per kg N excreted]	
1990	0.004	0.004	0.005
1991	0.004	0.004	0.005
1992	0.004	0.004	0.005
1993	0.004	0.004	0.005
1994	0.004	0.004	0.005
1995	0.004	0.004	0.004
1996	0.004	0.004	0.004
1997	0.004	0.004	0.004
1998	0.004	0.004	0.004
1999	0.004	0.004	0.004
2000	0.004	0.004	0.004
2001	0.004	0.004	0.004
2002	0.004	0.004	0.004
2003	0.004	0.004	0.004
2004	0.004	0.004	0.004
2005	0.004	0.004	0.004
2006	0.004	0.004	0.004
2007	0.004	0.004	0.004
2008	0.004	0.004	0.004
2009	0.004	0.004	0.004
2010	0.004	0.004	0.004
2011	0.004	0.004	0.004
2012	0.004	0.004	0.005
2013	0.004	0.004	0.005
2014	0.004	0.005	0.005
2015	0.004	0.005	0.005
2016	0.005	0.005	0.005
2017	0.005	0.005	0.005
2018	0.005	0.005	0.005
2019	0.005	0.005	0.005
2020	0.005	0.005	0.005
2021	0.005	0.005	0.005

For the calculation of the losses of gaseous N species (NH_3-N, NO_x-N, N_2) the mass-flow procedure pursuant to EMEP/EEA methodologies (EEA 2019) has been applied. A brief description of methodologies and emission factors applied in the Austrian NH_3 and NO_x inventory under the NEC Directive as well as the UNECE/LRTAP convention is provided in chapter 5.4.2.1.

5.3.2.1.5 Estimation of indirect N_2O emissions from manure management

Key Source: Yes (Tier 2)

Following the 2006 IPCC guidelines, indirect N_2O emissions from atmospheric deposition result from volatile nitrogen losses primarily occurring in the forms of ammonia and nitric oxide. Nitrogen losses begin at the point of excretion and continue through on-site management in storage and treatment systems. Further nitrogen can be lost through run-off and leaching into soils from the solid storage of manure at outdoor areas.

Indirect N_2O emissions through N-leaching and run-off from manure storage

Relevant information concerning Austria's animal housings and manure storage systems was derived from national publications, recommendations and regulations, i.e. from ÖKL (Österreichisches Kuratorium für Landtechnik und Landentwicklung), from the Austrian Institute of Construction Engineering (OIB) and on regional regulations of the federal states of Lower Austria (Niederösterreich) and Salzburg.

According to ÖKL-Merkblatt 24 (ÖKL 2011), a watertight construction of animal housings and manure storage systems is generally required. Water tightness has to be certificated for funding administrations. Furthermore, the tightness of the constructions is required in construction laws of the federal states and the Austrian Institute of Construction Engineering (OIB) (section 3.4.2 in OIB Guideline 3) (OIB 2011).

The OIB Guideline 3[97] is directly implemented in the laws of all federal states' in Austria except for Salzburg and Lower Austria. Lower Austria and Salzburg implemented comparable laws, which ensure the closeness of animal housing and storage constructions. A demand on tightness can also be derived from Austrian laws concerning groundwater protection (§ 30) and according to environmental protection regulations of the federal states (KREUZHUBER 2013).

Considering the legal background in Austria, leaching from sector manure management does not occur in Austria and is thus reported as "not occurring".

Indirect N_2O emissions through volatilization losses from manure management

Following the 2006 IPCC GL, indirect N_2O emissions due to volatilization of N from manure management were calculated using Tier 2 methodology. Austria considers a detailed flow of nitrogen throughout the animal housing and manure management systems.

The indirect N_2O emissions from volatilization of N in forms of NH_3 and NO_x are estimated following equation 10.26 (IPCC 2006) multiplied with the default IPCC emission factor presented in the IPCC 2006 GL in Table 11.3, which is 0.01 kg N_2O-N (kg NH_3-N+NO_x-N volatilised).

[97] http://www.oib.or.at/

$$N_{volatilisation\text{-}MMS} = \sum_S[\sum_T[(N_{(T)} * Nex_{(T)} * MS_{(T,S)} * (Frac_{GasMS}/100)_{(T,S)}]] * EF$$

$N_{(T)}$ = *number of head of livestock species/category T*

$Nex_{(T)}$ = *annual average N excretion per head of species/category T, expressed in kg N*

$MS_{(T,S)}$ = *fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure system S*

$Frac_{GasMS}$ = *percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NO_x in the manure management system S,%*

The country specific value of $Frac_{GasMS}$ includes the following N losses calculated within the Austrian N-flow model:

- NH_3-N losses from housing, storage, yard
- NO_x-N losses from manure management

Table 218: NH_3-N and NO_x-N volatilisation losses of manure management systems 1990 to 2021.

Year	N losses from manure management systems	$Frac_{GASMS}$	Year	N losses from manure management systems	$Frac_{GASMS}$
	[t N/yr]	(N_{losses}/Nex)		[t N/yr]	(N_{losses}/Nex)
1990	24 629	0.13	2006	23 827	0.14
1991	25 202	0.13	2007	24 441	0.14
1992	24 445	0.13	2008	24 178	0.14
1993	24 669	0.13	2009	24 819	0.15
1994	24 666	0.13	2010	25 004	0.15
1995	24 924	0.13	2011	24 850	0.15
1996	24 578	0.13	2012	24 939	0.15
1997	24 715	0.14	2013	25 046	0.15
1998	24 925	0.14	2014	25 296	0.15
1999	24 273	0.14	2015	25 573	0.15
2000	23 751	0.14	2016	25 829	0.15
2001	23 946	0.14	2017	26 260	0.16
2002	23 531	0.14	2018	26 204	0.16
2003	23 687	0.14	2019	26 187	0.16
2004	23 591	0.14	2020	26 328	0.16
2005	23 742	0.14	2021	26 582	0.16

5.3.3 Category-specific QA/QC

In the categories *3.B.1* (cattle) and *3.B.3* (swine) the following source specific QA/QC procedures have been carried out:

- ✓ VS and N excretion data elaborated by national experts (Agricultural Research and Education Centre Raumberg-Gumpenstein, University of Natural Resources and Applied Life Sciences), derived from peer reviewed sources;
- ✓ Surveys on MMS conducted by scientific experts;
- ✓ Country specific MCF derived from peer reviewed studies;
- ✓ Differences to default values explained and documented;
- ✓ Rationale for selecting MCFs and EFs explained and documented;

- ✓ Audit of data supplier: milk yield data (Statistik Austria), livestock data;
- ✓ External review by Austrian agricultural experts (stakeholder meetings "inventory talks" 2010),
- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources (e.g. crop residues, energy crops performed in 2015)
- ✓ External review of the revised agricultural model according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting "inventory talks" 2014.
- ✓ External review of the revised agricultural model (AMON & HÖRTENHUBER 2019) according to the new data on the agricultural practice (PÖLLINGER et al. 2018) by Austrian agricultural experts: stakeholder meeting "inventory talks" 2018.
- ✓ External review of the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) based on the research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) by Austrian agricultural experts.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.3.4 Uncertainties

Uncertainties are presented in Table 179.

5.3.5 Recalculations

Update of activity data

Please refer to chapter 5.1.6

Improvements of methodologies and emission factors

Methane and direct N_2O emissions have been revised for the years 1996-2004 and 2014-2020 (+0.001 kt CH_4 for 2020 and -0.001 kt N_2O for 2020), as a result of updated activity and nutrition data.

Austria's agriculture model is based on the N-flow concept. Thus, revisions within Austria's air emission inventory affect calculation results in Austria's GHG inventory. In Austria's air emission inventory, the decreasing share of tied systems from 2017 onwards was taken into account for the first time. This improvement contributed to the increased emissions for indirect N_2O (+0.01 kt N_2O for 2020).

5.4 Agricultural soils (Category 3.D)

5.4.1 Source Category Description

N_2O emissions from the source categories *3.D.a direct soil emissions* and 3*.D.b indirect soil emissions* are key categories.

In 2021 79.1% of total N_2O emissions from agriculture (57.2% of total Austrian N_2O emissions) originated from agricultural soils, the rest stemmed from manure management.

Emissions from this category (N_2O) contributed 2.3% (1 785.82 kt CO_2 equivalents) to Austria's total greenhouse gas emissions in the year 2021. This is 24.7% of all GHG emissions from the sector agriculture.

The trend of N_2O emissions from this category is decreasing: in 2021 emissions were 15.6% below 1990 levels.

Table 219 presents N_2O emissions of agricultural soils by sub-category as well as their trends and their share in total N_2O emissions.

Table 219: N_2O emissions from agricultural soils, 1990–2021.

	N_2O emissions [kt]													
Year	3.D Total	3.D.a Direct Soil Emissions	Inorganic N-Fertilisers	Organic N- Fertiliser	Animal manure applied to soils	Sewage sludge applied to soils	Other organic fertilizers applied to soils	Urine and dung deposited by grazing	Crop Residues	Mineralization	Organic Soils	3.D.b Indirect Soil Emissions	Athm. Deposition	Nitrogen Leaching and run-off
1990	7.99	6.70	2.20	2.60	2.58	0.02	0.00	0.56	1.18	0.00	0.17	1.29	0.57	0.71
1991	7.91	6.63	2.19	2.58	2.56	0.02	0.00	0.53	1.15	0.00	0.17	1.27	0.57	0.71
1992	7.56	6.34	2.16	2.48	2.46	0.02	0.00	0.49	1.04	0.00	0.17	1.22	0.54	0.68
1993	7.43	6.22	2.05	2.49	2.46	0.03	0.01	0.48	1.03	0.00	0.17	1.20	0.54	0.66
1994	7.38	6.19	1.98	2.49	2.45	0.02	0.01	0.47	1.08	0.00	0.17	1.19	0.53	0.66
1995	7.40	6.21	2.00	2.49	2.45	0.03	0.02	0.46	1.08	0.00	0.17	1.19	0.53	0.66
1996	7.31	6.14	1.99	2.45	2.41	0.03	0.02	0.44	1.08	0.00	0.17	1.18	0.52	0.66
1997	7.43	6.25	2.02	2.42	2.38	0.03	0.02	0.43	1.21	0.00	0.17	1.18	0.51	0.67
1998	7.43	6.25	2.04	2.43	2.38	0.03	0.02	0.40	1.21	0.00	0.17	1.18	0.51	0.67
1999	7.26	6.10	1.94	2.37	2.31	0.03	0.03	0.38	1.24	0.00	0.17	1.15	0.50	0.66
2000	7.05	5.93	1.89	2.34	2.27	0.03	0.03	0.37	1.15	0.00	0.17	1.12	0.48	0.64
2001	7.05	5.94	1.88	2.33	2.26	0.03	0.04	0.35	1.22	0.00	0.17	1.11	0.48	0.64
2002	7.02	5.91	1.92	2.28	2.21	0.02	0.05	0.33	1.22	0.00	0.17	1.10	0.47	0.64
2003	6.69	5.62	1.74	2.27	2.20	0.02	0.05	0.31	1.12	0.00	0.17	1.07	0.46	0.60
2004	6.63	5.58	1.53	2.26	2.18	0.02	0.05	0.30	1.31	0.00	0.17	1.05	0.45	0.60
2005	6.59	5.54	1.58	2.25	2.17	0.02	0.06	0.29	1.26	0.00	0.17	1.05	0.45	0.60
2006	6.55	5.50	1.60	2.24	2.15	0.02	0.06	0.29	1.20	0.00	0.17	1.05	0.46	0.59
2007	6.60	5.54	1.63	2.27	2.17	0.02	0.07	0.29	1.18	0.00	0.17	1.06	0.47	0.60
2008	7.01	5.90	1.87	2.23	2.13	0.02	0.07	0.29	1.33	0.00	0.17	1.11	0.47	0.64
2009	6.81	5.72	1.73	2.27	2.17	0.02	0.08	0.30	1.25	0.00	0.17	1.09	0.48	0.62
2010	6.37	5.33	1.39	2.26	2.15	0.03	0.08	0.30	1.21	0.00	0.17	1.04	0.47	0.57
2011	6.78	5.70	1.63	2.24	2.13	0.03	0.08	0.30	1.36	0.00	0.17	1.08	0.47	0.61
2012	6.66	5.58	1.69	2.22	2.11	0.03	0.09	0.30	1.20	0.00	0.17	1.08	0.47	0.60
2013	6.58	5.51	1.65	2.21	2.10	0.02	0.09	0.30	1.17	0.00	0.17	1.07	0.47	0.59

N₂O emissions [kt]														
Year	**3.D Total**	**3.D.a Direct Soil Emissions**	**Inorganic N-Fertilisers**	**Organic N- Fertiliser**	Animal manure applied to soils	Sewage sludge applied to soils	Other organic fertilizers applied to soils	**Urine and dung deposited by grazing**	**Crop Residues**	**Mineralization**	**Organic Soils**	**3.D.b Indirect Soil Emissions**	**Athm. Deposition**	**Nitrogen Leaching and run-off**
2014	6.92	5.81	1.76	2.22	2.11	0.02	0.09	0.31	1.36	0.00	0.17	1.11	0.48	0.63
2015	6.91	5.79	1.90	2.23	2.11	0.03	0.09	0.31	1.19	0.00	0.17	1.12	0.49	0.62
2016	7.21	6.05	1.99	2.24	2.11	0.03	0.09	0.31	1.35	0.01	0.17	1.16	0.50	0.65
2017	6.93	5.80	1.89	2.24	2.12	0.03	0.09	0.31	1.19	0.01	0.17	1.13	0.50	0.63
2018	6.77	5.66	1.81	2.21	2.09	0.03	0.09	0.31	1.16	0.01	0.17	1.10	0.49	0.61
2019	6.65	5.57	1.66	2.18	2.07	0.03	0.09	0.30	1.26	0.01	0.17	1.07	0.47	0.60
2020	6.71	5.63	1.68	2.17	2.05	0.03	0.09	0.30	1.30	0.01	0.17	1.08	0.47	0.61
2021	6.74	5.66	1.75	2.17	2.06	0.03	0.09	0.30	1.26	0.01	0.17	1.08	0.47	0.61
Share 2021	**100%**	**84.0%**	**26.0%**	**32.4%**	**30.7%**	**0.4%**	**1.3%**	**4.5%**	**18.8%**	**0.2%**	**2.5%**	**16.1%**	**7.0%**	**9.1%**
1990–2021	**–15.6%**	**–15.6%**	**-20.6%**	**-16.4%**	**-20.1%**	**51.7%**	**4 577.8%**	**-46.2%**	**7.2%**	**211.4%**	**0.0%**	**-16.0%**	**–17.9%**	**–14.4%**

5.4.2 Methodological Issues

Austria uses IPCC Tier 1 and country specific methodologies for the calculation of N_2O emissions from agricultural soils. In response to recommendations of the ERT (ARR 2013, para 51 and 52) additional descriptions of the Austrian N-flow model have been included since NIR 2014 (see Annex 3.2).

Table 220: N_2O emission factors for agricultural soils.

Category	Emission Factor [kg N_2O-N/kg N]	Source
3.D.1 Direct N_2O Emissions from Managed Soils		
1. Inorganic N fertilizers 2. Organic N fertilizers a. Animal manure applied to soils b. Sewage sludge applied to soils c. Other organic fertilizers applied to soils (energy crops from biogas plants, compost)	0.01	IPCC 2006 (Table 11.1)
3. Urine and dung deposited by grazing animals (cattle, pigs, poultry)	0.02	IPCC 2006 (Table 11.1)
3. Urine and dung deposited by grazing animals (other animals)	0.01	IPCC 2006 (Table 11.1)
4. Crop residues	0.01	IPCC 2006 (Table 11.1)
5. Mineralization/immobilization associated with C-losses	0.01	IPCC 2006 (Table 11.1)
6. Cultivation of organic soils	8.2 [kg N_2O-N/ha]	IPCC 2013 Wetland Supplement (Table 2.5)
3.D.b Indirect N_2O Emissions from managed soils		
1. Atmospheric deposition	0.01	IPCC 2006 GL (Table 11.3)
2. Nitrogen leaching (and run-off)	0.0075	IPCC 2006 GL (Table 11.3)

Activity Data

Data for necessary input parameters (activity data) were taken from the following sources:

Table 221: Data sources for nitrogen input to agricultural soils.

Category	Activity Data Sources
3.D.a Direct soil emissions	
Inorganic N fertilizers (mineral fertilizers)	Total mineral fertilizer consumption (including urea): National data provided by Agrarmarkt Austria (AMA) and published annually in the official national reports "Grüne Berichte" (BML 2022b)[1].
Animal manure applied to soils	Calculations within source category 3.B
Sewage sludge applied to soils	Water Quality Report 2000 (PHILIPPITSCH et al. 2001), Report on sewage sludge (UMWELTBUNDESAMT 1997), Austrian report on water pollution control (BMLFUW 2002), Data deliveries from Austria's federal provinces (UMWELTBUNDESAMT 2011a, 2013, 2014a, 2015, 2016a, 2017, 2018, 2019a, 2020, 2021, 2022b)
Other organic fertilizers applied to soils	Energy crops from biogas plants: Ökostromberichte 2008, 2011, 2013, 2017, 2018 & 2019; raw material balances for 2007, 2009, 2011, 2014, 2015, 2016, 2017 & 2018 (E-CONTROL 2008, 2011, 2013, 2017, 2018, 2019, 2020, 2021 & 2022) Compost application: AD elaborated from treated amounts in composting plants (chapter waste, Table 310) and application paths worked out by (UMWELTBUNDESAMT 2015)
Urine and dung deposited by grazing animals	Calculations within source category 3.B
Crop residues	Harvest amounts of agricultural crops (BML 2022b)
Mineralization/immobilization associated with C-losses	C losses reported in sub category *4.B.1.3 'Perennial converted to annual'* (see chapter LULUCF)
Cultivation of organic soils	Organic soils area is estimated on the basis of soil inventory data
3.D.b Indirect soil emissions	
Atmospheric deposition	Amount of manure left for spreading calculated within source category 3.B. Mineral fertilizer data obtained from (BML 2022b)[1]
Nitrogen leaching (and run-off)	see above (synthetic fertilizers, animal waste, sewage sludge)

[1] *Agrarmarkt Austria Marketing (https://www.ama.at) is Austria's entity preparing the national mineral fertilizer statistics annually published in (BML 2022b) (www.gruenerbericht.at and www.agraroekonomik.at)*

Mineral fertilizer application

Austria's official national mineral fertilizer statistics (total amounts, including urea) is compiled by Agrarmarkt Austria, AMA, and annually published by the Austrian Federal Ministry of Agriculture, Forestry, Regions and Water Management in its official reports (BML 2022b).

The S & A report 2004 noticed high inter-annual variations in N_2O emissions of sector *3.D.1.a Inorganic N-fertilizers*. These variations are caused by the effect of storage: Sales data are changing very rapidly due to changing market prices. Additionally, the fertilizer tax intensified this effect at the beginning of the 1990ies. However, not the whole amount purchased is applied in the year of purchase. Considering this effect, Austria uses the arithmetic average of each two years as activity data. For reasons of transparency, the time series of fertilizer sales data, presented in Table 222, includes the year 1989 as starting point as Austria uses the average mean of sold fertilizers of the years 1989 and 1990 as activity data for 1990.

In the in-country review 2007 it was recommended to consider revising the time series by determining actual fertilizer use in accordance with the IPCC good practice guidance. However, investigations showed that data on the actual fertilizer use are not available in Austria. Therefore it has been decided to continue to use the official fertilizer sales data as input data for the emission inventory. The UNFCCC centralized review 2008 considered the use of fertilizer sales data as an appropriate alternative (ARR 2008, para 50). Austria's approach is fully in line with the 2006 IPCC Guidelines, *Chapter 11.2.1.3 – Choice of activity data*, which states that annual fertiliser consumption data may be collected from official country statistics, often recorded as fertiliser sales and/or as domestic production and imports. In 2016 the UNFCCC centralized review confirmed the Austrian approach (ARR 2016, para A.6).

Time series for fertilizer consumption is presented in Table 222. For detailed information on different types of mineral fertilizers used in Austria, please refer to "Austria's Informative Inventory Report 2023 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants" (UMWELTBUNDESAMT 2023b).

Table 222: Mineral fertilizer N consumption in Austria 1990–2021 and arithmetic average of each two years.

Year	Annual Nutrient Sales Data [t N/yr]	Weighted Nutrient Consumption [t N/yr]	Year	Annual Nutrient Sales Data [t N/yr]	Weighted Nutrient Consumption [t N/yr]
1989	140 916				
1990	139 042	139 979	2006	103 700	101 700
1991	140 030	139 536	2007	103 300	103 500
1992	134 811	137 421	2008	134 400	118 850
1993	125 581	130 196	2009	86 300	110 350
1994	126 736	126 159	2010	90 629	88 465
1995	128 000	127 368	2011	116 751	103 690
1996	125 300	126 650	2012	97 721	107 236
1997	131 800	128 550	2013	112 005	104 863
1998	127 500	129 650	2014	111 615	111 810
1999	119 500	123 500	2015	130 252	120 934
2000	121 600	120 550	2016	122 623	126 438
2001	117 100	119 350	2017	117 704	120 163
2002	127 600	122 350	2018	113 136	115 420
2003	94 400	111 000	2019	98 234	105 685
2004	100 800	97 600	2020	115 676	106 955
2005	99 700	100 250	2021	106 483	111 080

Data source: AMA data (Agrarmarkt Austria, www.ama.at) published in the "Green Reports" of the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML, https://www.bml.gv.at/): https://gruenerbericht.at/cm4/

Legume cropping areas

The yearly numbers of the legume cropping areas were taken from official statistics (BML 2022b) and (Statistik Austria 1990–2022).

Table 223: Cropped area legume production and others, 1990–2021.

	Areas [ha]						
Year	**peas**	**soja beans**	**horse/field beans**	**clover hey, lucerne, ...**	**Other forage renewed annually***	**Meadows ploughed every four years****	**Cover crops*****
1990	40 619	9 271	13 131	57 875	3 650	39 233	3 000
1991	36 218	14 733	14 377	65 467	4 885	51 561	3 000
1992	43 706	52 795	14 014	64 379	6 119	47 078	3 000
1993	44 028	54 064	1 064	68 124	4 423	30 801	3 000
1994	38 839	46 632	10 081	72 388	4 710	32 820	3 000
1995	19 133	13 669	6 886	71 024	4 928	40 586	73 379
1996	30 782	13 315	4 574	72 052	2 060	44 007	146 759
1997	50 913	15 217	2 783	75 976	2 585	47 972	220 138
1998	58 637	20 031	2 043	76 245	2 879	51 603	293 517
1999	46 007	18 541	2 333	75 028	3 340	51 608	366 897
2000	41 114	15 537	2 952	74 266	4 087	56 794	437 276
2001	38 567	16 336	2 789	72 196	6 105	64 988	438 563
2002	41 605	13 995	3 415	75 429	7 040	69 106	465 974
2003	42 097	15 463	3 465	78 813	7 631	72 804	490 694
2004	39 320	17 864	2 835	83 349	8 094	74 429	482 052
2005	36 037	21 429	3 549	88 974	9 185	76 501	475 938
2006	32 652	25 013	4 555	97 549	10 287	72 591	496 833
2007	28 111	20 183	4 479	101 861	12 796	61 678	331 742
2008	22 306	18 419	3 695	98 966	14 355	57 668	309 338
2009	15 168	25 321	2 819	101 073	15 559	58 310	312 181
2010	13 562	34 378	4 344	106 080	16 525	59 169	300 969
2011	11 715	38 123	6 028	104 800	17 162	58 534	303 121
2012	10 704	37 126	6 852	104 808	18 046	56 794	301 810
2013	7 248	42 027	6 194	101 861	17 326	60 087	285 509
2014	6 863	43 832	7 862	102 369	18 203	59 899	269 812
2015	7 274	56 895	10 780	100 364	18 592	57 503	276 689
2016	7 733	49 791	10 823	96 672	18 266	52 117	275 547
2017	6 721	64 467	10 296	94 209	17 477	50 029	268 515
2018	6 917	67 624	7 645	96 098	20 445	52 431	278 946
2019	5 333	69 207	5 713	101 671	22 785	53 098	269 682
2020	5 616	68 424	5 492	104 449	24 559	50 440	261 238
2021	5 652	76 430	6 188	100 351	22 390	50 602	250 557

* *value for 1991 is interpolated as no data is available*

** *(BML 2022b), 1991–1994 and 1996 (STATSTIK AUSTRIA 1990–2014)*

*** *greening variants A+B+C+D until 2014. From 2015 onwards a new funding period started (BML 2022b). Only small amounts before 1995.*

Harvest Data

Harvest data and data of the cultivated area were taken from (BML 2022b) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT UND BERGBAUERNFRAGEN 2022) and are presented in Table 224 and Table 225.

Table 224: Harvest Data I, 1990–2021.

	Harvest [1 000 t]									
Year	**corn**	**wheat**	**rye**	**barley**	**oats**	**maize (corn)**	**Other* cereals**	**potato**	**sugar beet**	**fodder beet**
1990	5 290	1 404	396	1 521	244	1 620	104	794	2 494	171
1991	5 045	1 375	350	1 427	226	1 571	95	790	2 522	173
1992	4 323	1 325	278	1 342	185	1 118	74	738	2 605	119
1993	4 206	1 018	292	1 100	191	1 524	82	886	2 994	129
1994	4 436	1 255	319	1 184	172	1 421	85	594	2 561	103
1995	4 452	1 301	314	1 065	162	1 474	136	724	2 886	85
1996	4 493	1 240	156	1 083	153	1 736	126	769	3 131	62
1997	5 009	1 352	207	1 258	197	1 842	153	677	3 012	59
1998	4 771	1 342	236	1 212	164	1 646	171	647	3 314	72
1999	4 806	1 416	218	1 153	152	1 700	167	712	3 217	70
2000	4 490	1 313	183	855	118	1 852	171	695	2 634	47
2001	4 827	1 508	214	1 012	128	1 771	194	695	2 773	43
2002	4 745	1 434	171	861	117	1 956	206	684	3 043	40
2003	4 246	1 191	133	882	129	1 708	203	560	2 485	33
2004	5 295	1 719	213	1 007	139	1 945	272	693	2 902	33
2005	4 880	1 453	164	880	128	2 021	234	763	3 084	17
2006	4 440	1 396	94	914	131	1 746	158	655	2 493	22
2007	4 732	1 399	189	811	99	1 995	239	669	2 656	15
2008	5 714	1 690	219	968	108	2 449	282	757	3 091	14
2009	5 105	1 523	184	835	109	2 169	285	722	3 083	13
2010	4 776	1 518	161	778	98	1 956	265	672	3 132	11
2011	5 669	1 782	202	859	110	2 453	263	816	3 456	12
2012	4 839	1 275	205	662	93	2 351	252	665	3 114	10
2013	4 545	1 598	235	734	87	1 639	252	604	3 466	8
2014	5 658	1 804	233	846	106	2 334	335	751	4 244	11
2015	4 784	1 726	171	840	96	1 638	312	536	2 853	7
2016	5 642	1 970	188	860	95	2 180	349	767	3 534	8
2017	4 813	1 437	129	782	77	2 076	313	653	2 994	8
2018	4 747	1 371	177	695	75	2 130	299	698	2 150	6
2019	5 363	1 605	201	833	78	2 299	348	751	1 965	5
2020	5 595	1 660	219	870	84	2 412	350	886	2 092	6
2021	5 226	1 529	152	738	89	2 435	284	770	3 017	5

** mixed grain, triticale*

Table 225: Harvest Data II, 1990–2021.

	Harvest [1 000 t]								
Year	**silo-green maize**	**clover-hey**	**rape**	**Sun-flower**	**soja bean**	**horse-/fodder bean**	**peas**	**vegeta-bles**	**oil pumkin**
1990	4 289	457	102	57	18	41	145	273	3
1991	4 252	463	128	72	37	37	133	277	4
1992	3 523	336	126	79	81	31	137	227	4
1993	4 220	445	125	104	103	29	107	230	3
1994	4 152	531	217	92	105	27	134	246	3

	Harvest [1 000 t]								
Year	**silo-green maize**	**clover-hey**	**rape**	**Sun-flower**	**soja bean**	**horse-/fodder bean**	**peas**	**vegeta-bles**	**oil pumkin**
1995	3 996	549	268	61	31	17	60	302	5
1996	3 918	560	121	44	27	10	93	297	8
1997	3 940	616	129	44	34	6	162	349	8
1998	3 865	649	128	57	51	5	178	313	11
1999	3 729	643	193	64	50	6	140	399	6
2000	3 531	493	125	55	33	7	97	361	6
2001	3 035	508	147	51	34	7	112	391	7
2002	3 285	552	129	58	35	9	96	406	9
2003	3 026	418	78	71	39	9	93	376	10
2004	3 374	562	121	78	45	8	122	414	5
2005	3 600	705	104	81	61	10	90	384	8
2006	3 546	737	137	85	65	12	90	392	11
2007	3 741	622	145	60	53	11	57	402	12
2008	3 949	650	175	80	54	8	45	426	8
2009	3 789	648	171	71	71	7	35	449	8
2010	3 557	682	171	66	95	11	31	457	15
2011	4 006	631	180	74	109	18	36	557	16
2012	4 003	588	149	53	104	16	15	471	13
2013	4 199	547	197	51	83	14	18	464	10
2014	4 072	630	198	58	118	21	17	555	11
2015	3 807	484	112	38	136	25	19	442	19
2016	4 172	636	142	60	153	28	19	473	30
2017	3 697	514	117	51	193	23	15	452	15
2018	3 777	488	121	60	184	16	17	427	15
2019	3 954	519	107	64	215	13	13	460	16
2020	4 277	607	100	56	203	14	13	483	23
2021	4 006	564	86	74	235	16	13	501	26

Table 226: Cultivation Area I, 1990–2021.

	Area [ha]								
Year	**wheat**	**rye**	**barley**	**oats**	**maize (corn)**	**Other* cereals**	**potato**	**sugar beet**	**fodder beet**
1990	278 226	93 041	292 424	61 956	198 073	24 717	31 760	49 758	3 845
1991	271 068	85 070	296 905	61 053	185 302	24 045	33 421	51 430	3 783
1992	245 728	69 114	274 972	54 695	172 557	20 637	33 036	53 846	2 952
1993	240 971	73 701	265 348	52 869	169 935	22 212	31 090	53 398	2 836
1994	240 961	77 021	252 746	49 357	179 465	21 853	29 738	52 019	2 241
1995	255 910	76 826	229 099	40 778	173 352	31 705	27 036	51 643	1 759
1996	247 602	51 222	259 648	41 609	201 342	30 643	26 335	53 082	1 203
1997	259 832	57 807	260 641	46 083	188 311	33 389	23 476	51 569	1 166
1998	264 405	59 282	265 622	40 514	171 239	36 271	22 854	49 598	1 322
1999	260 579	55 901	243 886	35 503	177 077	34 860	23 180	46 472	1 275
2000	293 806	52 473	223 762	32 981	187 802	37 224	23 737	42 836	1 036
2001	287 777	51 219	217 473	31 449	194 904	39 817	23 123	44 705	923

Area [ha]									
Year	wheat	rye	barley	oats	maize (corn)	Other* cereals	potato	sugar beet	fodder beet
2002	288 764	47 145	200 948	32 103	195 922	46 139	22 523	44 464	817
2003	272 001	40 003	212 308	34 387	196 409	50 189	21 122	43 223	732
2004	290 174	45 664	191 333	30 284	201 451	51 787	21 925	44 737	692
2005	288 960	42 847	191 740	30 218	189 637	48 108	22 186	44 690	296
2006	284 577	26 924	206 443	35 151	181 196	37 369	21 920	39 401	400
2007	292 976	46 702	193 331	31 125	193 419	47 132	22 675	42 270	260
2008	296 775	53 171	185 857	26 571	216 354	53 926	22 800	43 032	238
2009	309 034	48 528	181 525	27 600	200 276	58 352	22 222	43 860	214
2010	302 852	45 699	168 891	26 576	201 137	56 997	21 973	44 841	193
2011	304 334	45 943	153 286	25 029	217 100	53 613	22 851	46 580	179
2012	308 179	48 525	150 576	24 815	219 702	51 392	21 782	49 263	170
2013	297 286	56 108	142 574	23 165	201 917	52 221	21 128	50 849	168
2014	304 645	48 241	145 825	23 297	216 316	58 347	21 384	50 604	169
2015	302 965	39 563	151 769	23 501	188 728	59 934	20 368	45 436	134
2016	315 088	37 312	140 425	22 512	195 252	60 360	21 221	43 497	133
2017	295 029	34 476	138 903	23 245	209 476	60 872	22 991	42 684	131
2018	292 654	40 725	139 270	21 452	209 903	61 700	23 755	31 246	116
2019	277 291	43 679	137 242	20 596	220 690	64 190	23 969	27 878	107
2020	277 912	42 735	134 801	20 135	212 596	60 274	24 260	26 319	100
2021	277 447	32 869	123 624	24 360	218 198	54 102	22 562	37 852	89

** mixed grain, triticale*

Table 227: Cultivation Area II, 1990–2021.

Area [ha]									
Year	silo- green maize	clover-hey	rape	Sun-flower	soja bean	horse-/fodder bean	peas	vegeta-bles	oil pumkin
1990	107 134	54 225	40 844	23 336	9 271	13 131	40 619	8 390	9 000
1991	106 694	58 204	45 552	23 930	15 162	13 334	36 218	8 403	9 000
1992	101 106	58 260	49 919	30 905	52 795	14 014	43 706	7 914	7 977
1993	101 113	63 701	59 090	35 740	55 473	10 640	44 028	7 246	6 260
1994	93 874	67 678	71 402	39 294	46 632	10 081	38 839	7 548	6 346
1995	90 682	66 096	89 246	28 550	13 669	6 886	19 133	8 482	8 957
1996	85 359	69 992	64 904	18 983	13 315	4 574	30 782	8 300	12 533
1997	84 464	73 380	54 897	19 954	15 217	2 783	50 913	8 377	13 995
1998	79 338	73 366	52 086	22 096	20 031	2 043	58 637	7 916	13 097
1999	76 485	71 688	65 768	24 249	18 541	2 333	46 007	8 317	12 004
2000	73 960	70 179	51 762	22 336	15 537	2 952	41 114	8 173	10 376
2001	72 254	66 091	56 098	20 329	16 336	2 789	38 567	8 173	11 540
2002	73 685	68 389	55 383	21 381	13 995	3 415	41 605	8 258	13 974
2003	72 309	71 181	44 035	25 748	15 463	3 465	42 097	8 348	15 450
2004	75 614	75 255	35 284	28 988	17 864	2 835	39 320	8 431	12 502
2005	76 987	79 789	35 251	30 179	21 429	3 549	36 037	8 042	16 271
2006	78 655	87 263	42 582	34 621	25 013	4 555	32 652	8 691	18 151
2007	80 331	89 066	48 509	26 446	20 183	4 479	28 111	9 627	17 888

	Area [ha]								
Year	silo- green maize	clover-hey	rape	Sun-flower	soja bean	horse-/fodder bean	peas	vegeta-bles	oil pumkin
2008	81 078	84 611	56 056	26 787	18 419	3 695	22 306	10 321	16 299
2009	80 336	85 515	56 933	25 870	25 321	2 819	15 168	9 481	19 685
2010	81 239	89 555	53 803	25 411	34 378	4 344	13 562	9 112	26 464
2011	81 444	87 638	53 636	26 049	38 123	6 028	11 715	10 024	26 119
2012	82 375	86 762	55 821	23 362	37 126	6 852	10 704	8 800	22 741
2013	110 818	84 535	58 557	21 808	42 027	6 194	7 248	9 523	17 884
2014	83 464	84 166	52 816	20 540	43 832	7 862	6 863	9 710	22 382
2015	91 989	81 772	37 529	19 061	56 895	10 780	7 274	9 455	31 816
2016	84 643	78 406	39 662	18 189	49 791	10 823	7 733	10 143	38 928
2017	82 188	76 732	40 502	22 018	64 467	10 296	6 721	10 282	22 397
2018	83 349	75 653	40 504	21 504	67 624	7 645	6 917	10 152	23 241
2019	85 684	78 886	35 966	21 245	69 207	5 713	5 333	10 463	25 220
2020	86 792	79 889	31 827	23 828	68 424	5 492	5 616	10 259	35 438
2021	84 557	77 960	28 273	24 678	76 430	6 188	5 652	10 247	39 131

Sewage sludge application on fields

In the frame of the reporting obligation under the Urban Wastewater Directive (91/271/EEC) the annual amount of sewage sludge as ton dry substance per year (t DS/a) is collected by the authorities of the Austrian Provincial Governments. After quality assessment and aggregation the data are reported once a year to the national authorities.

Table 228: Amount of sewage sludge (dry matter) produced in Austria, 1990–2021.

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied sewage sludge N [t N]
1990	161 936	31 507	19.5	1 232
1991	161 936	31 507	19.5	1 232
1992	200 000	30 000	15.0	1 170
1993	300 000	45 000	15.0	1 755
1994	350 000	38 500	11.0	1 502
1995	390 500	42 400	10.9	1 654
1996	390 500	42 955	11.0	1 675
1997	390 500	42 955	11.0	1 675
1998	392 909	43 220	11.0	1 686
1999	392 909	43 220	11.0	1 686
2000	392 909	43 220	11.0	1 686
2001	398 800	41 600	10.4	1 622
2002	322 096	36 065	11.2	1 407
2003	315 130	39 186	12.4	1 528
2004	294 942	35 357	12.0	1 379
2005	290 110	35 541	12.3	1 386
2006	241 364	39 369	16.3	1 535
2007	245 202	40 713	16.6	1 588
2008	248 169	39 247	15.8	1 531
2009	252 181	39 945	15.8	1 558

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied sewage sludge N [t N]
2010	262 805	44 354	16.9	1 730
2011	265 962	43 796	16.5	1 708
2012	266 949	41 487	15.5	1 618
2013	238 273	38 231	16.0	1 491
2014	239 044	39 626	16.6	1 545
2015	234 880	46 861	20.0	1 828
2016	237 982	48 314	20.3	1 884
2017	236 180	47 549	20.1	1 854
2018	234 481	48 170	20.5	1 879
2019	233 499	49 676	21.3	1 937
2020	228 009	48 357	21.2	1 886
2021	193 623	47 909	24.7	1 868

Amounts of agriculturally applied sewage sludge were obtained from: Water Quality Report 2000 (PHILIPPITSCH et al. 2001), Report on sewage sludge (UMWELTBUNDESAMT 1997), Austrian report on water pollution control (BMLFUW 2002), and submissions from Austria's federal provinces to the Umweltbundesamt (UMWELTBUNDESAMT 2011a, 2013, 2014a, 2015, 2016a, 2017, 2018, 2019a, 2020, 2021, 2022b).

Application of compost on fields

Total amounts of compost (composting plants and home composting) were taken from Table 310 (chapter waste). Based on (BUCHGRABER et al. 2003 and EGLE et al. 2014) a share of 45% of the compost from composting plants is applied in sector agriculture. The dry matter content of 40% for compost is derived from (RÖMPP 1996–1999).

Table 229: Amount of compost (dry matter) produced in Austria, 1990–2021.

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
1990	83 561	4 303	5.1	60
1991	90 673	7 053	7.8	99
1992	119 341	12 304	10.3	172
1993	163 281	27 577	16.9	386
1994	205 698	39 915	19.4	559
1995	230 215	49 597	21.5	694
1996	246 700	55 575	22.5	778
1997	248 815	52 335	21.0	733
1998	260 179	54 397	20.9	762
1999	271 131	56 104	20.7	785
2000	293 394	62 568	21.3	876
2001	307 189	69 031	22.5	966
2002	321 267	75 023	23.4	1 050
2003	329 523	78 427	23.8	1 098
2004	336 106	80 949	24.1	1 133
2005	337 811	81 236	24.0	1 137
2006	332 860	78 641	23.6	1 101
2007	335 456	79 575	23.7	1 114

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
2008	343 002	82 744	24.1	1 158
2009	355 000	87 971	24.8	1 232
2010	366 861	93 140	25.4	1 304
2011	383 990	100 612	26.2	1 409
2012	408 881	111 488	27.3	1 561
2013	395 643	105 092	26.6	1 471
2014	406 344	109 334	26.9	1 531
2015	403 880	107 489	26.6	1 505
2016	427 051	116 967	27.4	1 638
2017	428 747	117 254	27.3	1 642
2018	426 617	116 502	27.3	1 631
2019	440 388	121 782	27.7	1 705
2020	445 348	123 677	27.8	1 731
2021	458 589	129 337	28.2	1 811

5.4.2.1 Direct soil emissions (3.D.a)

Key Source: Yes (N_2O)

Direct soil emissions are the most important sub-category of *3.D Agricultural Soils*. 84 % (5.66 kt in 2021) of N_2O emissions from agricultural soils arise from this sub-category (see Table 219).

N_2O emissions from the following sources were estimated:

- Inorganic N fertilizers (mineral fertilizers and urea)
- Organic N fertilizers
  - Animal manure applied to soils,
  - Sewage sludge applied to soils
  - Other organic fertilizers applied to soils
- Urine and dung deposited by grazing animals
- Incorporation of *crop residues* after harvest
- Mineralization/immobilization associated with loss/gain of soil organic matter
- Cultivation of organic soils (i.e. histosols)

Following IPCC 2006, N_2O is calculated from overall N additions to soils without subtraction of the amounts that volatilize as NH_3-N and NO_x-N during and after application as it had to be done according to the 1996 IPCC GL.

Direct N_2O emissions from manure applied to soils were calculated using a country specific methodology based on the N-flow approach. N_2O emissions from all other sources were calculated using the 2006 IPCC Tier 1 methodology. Calculation methods are described in the following subchapters. The conversion from N_2O-N to N_2O emissions is performed by multiplication with (44/28).

5.4.2.1.1 Nitrogen input through application of inorganic (mineral) N fertilizers

The method applied for calculation of direct N_2O emissions is IPCC Tier 1 (IPCC 2006, Equation 11.1).

$$N_2O\text{-}N_{\text{N inputs}} = F_{SN} * EF_1$$

N_2O-$N_{N\ inputs}$ = *annual direct N_2O-N emissions produced from managed soil, kg N_2O-N yr^{-1}*
F_{SN} = *annual amount of synthetic fertilizer N (mineral and urea) applied to soils, kg N yr^{-1} – (see Table 222)*
EF_1 = *emission factor for N_2O emissions from N inputs, kg N_2O-N (kg N input)$^{-1}$ (IPCC 2006, table 11.1)*

5.4.2.1.2 N input from organic N fertilizers to cropland and grassland

Organic N fertilizers (F_{ON}) include the following N-inputs to soils (IPCC 2006, equation 11.3):

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

- Nitrogen input through the application of animal manure to soils, excluding grazing (F_{AM})
- Nitrogen input through the application of sewage sludge to soils (F_{SEW})
- Nitrogen input through the application of compost to soils (F_{COMP})
- Nitrogen inputs through other organic amendments (F_{OOA}) used as fertiliser (in Austria energy crops from biogas plants applied to soils).

Nitrogen input from animal manure applied to soils

A country specific methodology based on the N-flow approach was used. According to the IPCC method, nitrogen from manure that is used as a biofuel should be subtracted, but this is irrelevant for Austria because in Austria manure is not used as a biofuel at all.

Nitrogen left for spreading

After storage, manure is applied to agricultural soils. Manure application is connected with NH_3-N, NO_x-N, N_2O-N and N_2 losses that depend on the amount of manure N. With regard to a comprehensive treatment of the nitrogen budged, Austria established a link between the ammonia and nitrous oxide emissions inventory. This procedure enables the use of country specific data, which is more accurate than the use of the default values for $Frac_{GasMS}$ provided in the 2006 IPCC GL, table 10.23.

From total N excretion by Austrian livestock, the following losses were subtracted:

- N excreted during grazing,
- NH_3-N losses from the housings and yards,
- NH_3-N losses from manure storages,
- NH_3-N losses from biogas plants,
- NO_x-N losses from manure management,
- N_2O-N losses from manure management,
- N_2 losses from manure storages.

The remaining N is applied to agricultural soils.

Table 230: Animal manure left for spreading on agricultural soils per livestock category 1990–2021 (I).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	**dairy cattle**	**suckling cows**	**all other cattle**	**breeding sows & litter**	**young & fattening pigs**
1990	164 035	64 656	2 627	55 468	6 930	26 554
1991	162 906	62 898	3 197	54 859	7 003	26 909
1992	156 449	60 594	3 360	51 603	6 828	26 308
1993	156 470	59 903	3 841	52 165	6 627	25 628
1994	155 865	59 067	4 993	51 892	6 546	24 998
1995	155 870	52 220	11 654	52 049	6 697	24 789
1996	153 063	51 841	11 772	50 317	6 608	24 244
1997	151 219	52 447	10 587	48 529	6 488	24 425
1998	151 451	55 035	8 547	47 484	6 337	25 747
1999	147 266	53 021	9 773	47 323	5 678	23 214
2000	144 743	47 484	13 972	47 446	5 463	22 520
2001	143 790	46 040	14 229	46 654	5 622	23 229
2002	140 542	45 660	13 536	45 740	5 405	22 253
2003	139 786	44 010	13 452	46 844	5 335	22 178
2004	138 654	43 171	14 466	46 916	5 034	20 967
2005	137 925	42 956	14 910	45 173	5 000	21 680
2006	136 987	42 810	14 899	44 927	5 019	21 096
2007	138 203	42 828	14 816	44 760	5 014	22 163
2008	135 811	43 478	14 467	44 280	4 686	20 245
2009	137 782	43 848	14 310	45 365	4 604	20 777
2010	137 102	43 952	14 035	45 021	4 500	20 500
2011	135 327	43 794	13 771	44 099	4 361	19 984
2012	134 383	44 116	13 281	43 535	4 189	19 718
2013	133 942	44 717	12 578	43 874	4 040	19 039
2014	134 157	45 695	12 176	43 830	3 917	18 661
2015	134 183	45 615	11 843	44 215	3 915	18 407
2016	134 472	46 639	11 336	43 813	3 857	18 279
2017	134 887	47 037	10 763	43 767	3 901	18 365
2018	132 999	46 426	10 374	43 188	3 716	18 121
2019	131 433	45 658	10 083	42 614	3 748	18 087
2020	130 767	45 844	9 807	41 852	3 700	18 275
2021	130 998	45 816	9 528	42 390	3 651	18 216

Table 231: Animal manure left for spreading on agricultural soils per livestock category 1990–2021 (II).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	**poultry**	**sheep**	**goats**	**horses/solipeds**	**deer**
1990	164 035	4 667	1 699	287	1 085	63
1991	162 906	4 601	1 788	314	1 275	63
1992	156 449	4 326	1 711	303	1 354	63
1993	156 470	4 617	1 830	363	1 432	63
1994	155 865	4 575	1 876	382	1 472	64

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	poultry	sheep	goats	horses/solipeds	deer
1995	155 870	4 376	2 002	417	1 598	68
1996	153 063	4 090	2 088	418	1 615	70
1997	151 219	4 462	2 103	448	1 635	95
1998	151 451	4 159	1 978	417	1 661	85
1999	147 266	4 015	1 931	445	1 799	66
2000	144 743	3 672	1 860	431	1 829	67
2001	143 790	3 876	1 757	457	1 859	68
2002	140 542	3 878	1 669	444	1 890	69
2003	139 786	3 773	1 784	419	1 920	69
2004	138 654	3 829	1 794	426	1 980	71
2005	137 925	3 884	1 786	423	2 041	73
2006	136 987	3 939	1 713	408	2 102	74
2007	138 203	3 994	1 926	465	2 162	76
2008	135 811	4 049	1 827	480	2 223	77
2009	137 782	4 103	1 890	524	2 283	79
2010	137 102	4 154	1 965	551	2 344	80
2011	135 327	4 300	1 980	556	2 404	77
2012	134 383	4 443	1 999	562	2 465	74
2013	133 942	4 586	1 960	554	2 525	71
2014	134 157	4 764	1 914	543	2 586	70
2015	134 183	4 944	1 939	589	2 646	70
2016	134 472	5 122	2 074	636	2 646	69
2017	134 887	5 219	2 201	700	2 867	68
2018	132 999	5 310	2 228	703	2 867	67
2019	131 433	5 393	2 208	711	2 867	66
2020	130 767	5 488	2 159	713	2 867	65
2021	130 998	5 488	2 206	773	2 867	65

A more detailed description of the methods applied for the calculation of NH_3 and NO_x emissions is given in the report "Austria's Informative Report 2023 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants" (UMWELTBUNDESAMT 2023b)[98]. Following a recommendation of the in-country review 2007, more information on the calculation of volatilization ratios has been included to the NIR (see below).

NH_3 emissions from cattle and swine are estimated using a country specific methodology following the N-flow approach. NH_3 emissions from sheep, goats, horses, poultry and deer are estimated using the EMEP/EEA Tier 2 methodology (EEA 2019).

[98] https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

NH_3 emissions from housing (cattle and swine)

Table 232 provides the NH_3-N emission factors used in the calculation of NH_3 emissions from animal housing (DÖHLER et al 2001). For cattle they differentiate between loose housing and tied housing systems, which is relevant for Austria.

Table 232: Emission factors for NH_3 emissions from animal housing.

Manure management system	kg NH_3-N (kg N excreted)$^{-1}$
Cattle, tied systems, liquid slurry system	0.040
Cattle, tied systems, solid storage system	0.039
Cattle, loose houses, liquid slurry system	0.118
Cattle, loose houses, solid storage system	0.118
Young & Fattening pigs, liquid slurry system	0.150
Young & Fattening pigs, solid storage system	15% of total N + 30% of the remaining TAN
Sows plus litter, liquid slurry system	0.167
Sows plus litter, solid storage system	0.167

In submission 2019 the grooved floor system for cattle and the partly slatted floor systems for swine was implemented to the Austrian ammonia inventory (AMON & HÖRTENHUBER 2019). Specific abatement factors from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE 2015) were used.

NH_3 emissions from manure storage

NH_3 emissions from storage are estimated from the amount of N left in the manure when the manure enters the storage. This amount of N is calculated as following:

From total N excretion the N excreted during grazing and the NH_3-N losses from housing (see above) are subtracted. The remaining N enters the store.

Cattle and swine

Table 233 provides NH_3 emission factors for the storage of cattle and swine manures (EIDGENÖSSISCHE FORSCHUNGSANSTALT 1997).

Table 233: NH_3 emission factors for manure storage.

Manure storage system	kg NH_3-N (kg TAN)$^{-1}$
Cattle, liquid slurry system	0.15
Cattle, solid storage system	0.30
Pigs, liquid slurry system	0.12
Pigs, solid storage system	0.30

TAN content in excreta

The detailed method makes use of the total NH_3 nitrogen (TAN) when calculating emissions. TAN content for Austrian cattle and swine manure is given in SCHECHTNER 1991.

Table 234: TAN content for Austrian cattle and swine manure (SCHECHTNER 1991).

Manure	TAN content for Austria [%]	Manure	TAN content for Austria [%]
cattle – solid storage system	15.0	pig – solid storage system	15.0
cattle – liquid slurry system	50.0	pig – liquid slurry system	65.0

Austria's ammonia inventory additionally uses specific abatement factors to emission factors for a range of manure treatment options taken from the Swiss ammonia inventory model 'DYNAMO' (MENZI et al. 2003, REIDY et al. 2007, REIDY & MENZI 2005). These abatement factors are fully consistent with the abatement factors provided in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (UNECE 2015). For further information please refer to "Austria's Informative Inventory Report 2023" (UMWELTBUNDESAMT 2023b).

Sheep, goats, horses, poultry and deer

The EMEP/EEA Tier 2 methodology was applied. Tier 2 uses a mass flow approach based on the concept of a flow of TAN through the manure management system (EEA 2019). Table 235 presents the default EMEP/EEA Tier 2 NH_3-N emission factors and associated parameters used in the calculations for Austria's non-key livestock categories (EEA 2019, Table 3.9). Information on MMS is provided in Table 199; country specific N excretion values are presented in Table 235.

Table 235: Default Tier 2 NH_3-N EF and associated parameters for the Tier 2 methodology.

NFR	Livestock category	proportion of TAN	EF housing	EF storage	EF spreading
3.B.2	Sheep	0.50	0.22	0.32	0.90
3.B.4.d	Goats	0.50	0.22	0.28	0.90
3.B.4.e	Horses (mules, asses)	0.60	0.22	0.35	0.90
3.B.4.g.i	Laying hens	0.70	0.20	0.08	0.45
3.B.4.g.ii	Broilers	0.70	0.21	0.30	0.38
3.B.4.g.iii	Turkeys	0.70	0.35	0.24	0.54
3.B.4.g.iv	Other poultry	0.70	0.38(*)	0.21(*)	0.50(*)
3.B.4.h	Other animals(**)	0.50	0.22	0.32	0.90

*) *EF = weighted mean of ducks & geese for 2021*

**) *In Austria furred game, mainly deer, dominates the livestock category 'other animals'. As sheep is the most similar livestock category to deer, for 'other animals' the NH_3 emission factors of sheep have been used.*

In submission 2019 for layers and broilers the management system "manure belt with covered storage" was implemented into Austria´s ammonia inventory (AMON & HÖRTENHUBER 2019) using specific abatement factors from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE 2015).

NO_x emissions from manure management

NO_x-N-losses from manure management were calculated according to the Tier 2 methodology as outlined in the EMEP/EEA Emission Inventory Guidebook 2019 (EEA 2019). The calculations make use of the mass-flow approach based on the concept of a flow of TAN through the manure management system.

Emission factors for slurry and solid NO are taken from the EMEP/EEA GB 2019 chapter 3.B, Table 3.10.

For cattle and swine national TAN contents were taken from (SCHECHTNER 1991, see Table 234). Default TAN values according to the EMEP/EEA GB 2019, Table 3.9, are applied for sheep, goats, horses, poultry and deer. Detailed information is included in "Austria's Informative Inventory Report 2023" (UMWELTBUNDESAMT 2023b).

N_2 emissions from manure management

In submission 2019 for the first time N_2 losses have been considered in Austria's N flow model (AMON & HÖRTENHUBER 2019). For both, slurry and litter-based manures, the default N_2 emission factors from Table 3.10 (EEA 2019) were used. For further information, please refer to "Austria's Informative Inventory Report 2023" (UMWELTBUNDESAMT 2023b).

NH_3-N and NO_x-N volatilisation losses associated with manure application

Volatilisation losses following the application of organic N fertilizers on soils are basis for the estimation of indirect N_2O emissions from atmospheric deposition. NH_3-N and NO_x-N emission factors used in Austria's Air Emission Inventory are briefly described in chapter indirect N_2O emissions from soils/ deposition (5.4.2.2).

Nitrogen input through sewage sludge application

N_2O emissions

The method applied for the calculation of N_2O emissions is IPCC Tier 1 with a default emission factor of 1.0% N_2O-N per kg N input to agricultural soils.

In Austria fertilisation by sewage sludge is very small. In 2021 N_2O emissions from sewage sludge contributed only 0.4% of N_2O emissions from category 3.D Agricultural Soils.

N content data of sewage sludge was obtained from (UMWELTBUNDESAMT 1997). The study contains sewage sludge analyses carried out by the Umweltbundesamt. Digested sludge samples from 17 municipal sewage sludge treatment plants taken in winter 1994/1995 were investigated with regard to more than one hundred inorganic, organic and biological parameters in order to get an idea of the quality of municipal sewage sludge. Following this study a mean value of 3.9% N in dry matter was taken.

In 2007 the N-content value of sewage sludge was re-examined. The comparison with national studies (ZESSNER, M. 1999) and (ÖWAV-Regelblatt Nr. 17 – Landwirtschaftliche Verwertung von Klärschlamm 2004 – www.oewav.at) approved the value of 3.9% N/dm.

The amount of nitrogen input from agriculturally applied sewage sludge was calculated according to the following formula:

$$F_{Sslu} = Sslu_N * Sslu_{agric}$$

F_{Sslu} = *Annual nitrogen input to soils by agriculturally applied sewage sludge [t N]*

$Sslu_N$ = *Nitrogen content in dry matter [%] – 3.9%*

$Sslu_{agric}$ = *Annual amount of sewage sludge agriculturally applied [t/t] (see Table 228)*

The annual agricultural consumption of sewage sludge is presented in Table 228.

Other organic fertilizers applied to soils (energy crops from biogas plants and compost)

This sub-category includes the N inputs from energy crops applied to soils as fertilizer after the digestion process in biogas plants and the N inputs from the application of compost to agriculture soils.

Activity data

Energy crops

The calculation of N from anaerobically digested energy crops (digestates) was done on the basis of raw material and energy balances reported by E-Control (E-CONTROL 2008, 2011, 2013, 2017, 2018, 2019, 2020, 2021 & 2022). N content of digested energy crops was derived from specific literature (RESCH et al. 2006; LANDESBETRIEB LANDWIRTSCHAFT HESSEN 2013; SÜD-TREBER GMBH 2021). Amounts of digested manure N are calculated in sector manure management.

Compost

Activity data for agricultural compost application was derived by expert judgement by Umweltbundesamt (2015) on the basis of treated amounts and application pathways (BUCHGRABER et al. 2003) and (EGLE et al. 2014). Based on (LANDWEHR 2000; KRANERT & LANDWEHR 2010; RÖMPP 1996–1999) and (BRUNSTERMANN 2007) an organic mass loss of 50% during the composting process has been applied. For compost a dry matter content of 40% (RÖMPP 1996–1999) was used. The N-content of dry matter of 1.4% was derived from (AMLINGER et al. 2005).

Table 236: N from biogas slurry and compost 1990–2021.

Year	Digestates (livestock manures) [kg N year^{-1}]	Digestates (veg. part) [kg N year^{-1}]	N from compost [kg N year^{-1}]
1990	43 081	55 953	60 236
1991	59 865	78 334	98 742
1992	68 212	89 524	172 251
1993	92 336	123 096	386 072
1994	268 357	358 096	558 816
1995	316 882	425 239	694 352
1996	357 164	481 192	778 047
1997	472 028	637 859	732 696
1998	579 414	783 335	761 553
1999	825 808	1 119 050	785 463
2000	988 928	1 342 861	875 945
2001	1 172 639	1 591 290	966 428
2002	1 352 982	1 839 719	1 050 323
2003	1 540 528	2 088 148	1 097 984
2004	1 721 393	2 336 577	1 133 292
2005	1 901 444	2 585 007	1 137 307
2006	2 087 432	2 831 198	1 100 971
2007	2 429 006	3 290 008	1 114 044
2008	3 232 879	3 598 664	1 158 411
2009	3 878 366	3 598 883	1 231 597
2010	4 517 999	3 542 337	1 303 964
2011	2 723 292	3 967 113	1 408 564
2012	2 825 664	3 982 333	1 560 827

Year	Digestates (livestock manures) [kg N year^{-1}]	Digestates (veg. part) [kg N year^{-1}]	N from compost [kg N year^{-1}]
2013	2 919 051	3 997 529	1 471 292
2014	3 017 376	4 012 634	1 530 673
2015	3 023 619	4 124 919	1 504 839
2016	3 629 561	4 291 965	1 637 533
2017	3 414 975	4 330 692	1 641 556
2018	3 640 926	4 071 751	1 631 028
2019	3 126 519	3 747 936	1 704 948
2020	3 184 092	3 808 620	1 731 477
2021	3 033 340	3 624 365	1 810 716

Methodology

IPCC Tier 1 methodology and the default emission factor of 1.0% N_2O-N per kg N input to agricultural soils were used.

5.4.2.1.3 Urine and dung deposited by grazing animals

Key Source: No

Following the IPCC Guidelines, N_2O emissions resulting from nitrogen input through excretions of grazing animals (directly dropped onto the soil) are calculated under *Manure Management* but reported under *Agricultural Soils*.

$$N_2O\text{-}N_{PRP} = F_{PRP} * EF_{3\ PRP}$$

N_2O-N $_{PRP}$ = annual direct N_2O-N emissions from urine and dung inputs to grazed land, kg N_2O-N yr^{-1}.

F $_{PRP}$ = annual amount of urine and dung nitrogen deposited on soils during grazing [t N] – see Table 237

$EF_{3\ PRP}$ = default emission factors for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals [t N_2O-N/t N], – 0.02 for cattle and swine and 0.01 for sheep, goats, horses and other animals (IPCC GUIDELINES 2006 – table 11.1).

Table 237: Nitrogen excreted during grazing on pasture, range and paddock (N_{exPRP}) 1990–2021.

Year	N excretion grazing [t]	Year	N excretion grazing [t]
1990	18 864	2006	10 644
1991	18 201	2007	10 882
1992	16 922	2008	10 861
1993	16 679	2009	11 095
1994	16 184	2010	11 234
1995	16 135	2011	11 259
1996	15 545	2012	11 276
1997	15 079	2013	11 252
1998	14 162	2014	11 311
1999	13 563	2015	11 418
2000	13 219	2016	11 571
2001	12 507	2017	11 724
2002	11 748	2018	11 608
2003	11 364	2019	11 441

Year	N excretion grazing [t]	Year	N excretion grazing [t]
2004	11 119	2020	11 304
2005	10 637	2021	11 316

5.4.2.1.4 Nitrogen input from incorporation of crop residues

Austria uses the IPCC 2006 Tier 1 methodology for emission calculation.

Additionally to the residues from harvest crops (including legume crops) the following N amounts returned to soils are included:

- N from meadows ("seeded pastures") ploughed every four years
- N from other forage crops on arable land renewed annually
- N from cover crops

According the IPCC 2006 GL biological nitrogen fixation has been removed as a direct source of N_2O due to the lack of evidence of significant emissions arising from the fixation process itself.

N from meadows ploughed every four years („Wechselwiesen")

Specific seeded pastures have to be ploughed every few years and followed by another crop to formally remain the status "arable land". Following Austrian experts these kind of meadows are ploughed (and covered by another crop) every four years (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c). Activity data on seeded pastures („Wechselwiesen") were taken from the Green Reports (BML 2022b). The average N content of residues was derived on the basis of the assumption that 25% of plants are legume forages and 75% are non-legume forages (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c). Average dry matter net yield per hectare (7 000 kg dm for common management) was taken from BUCHGRABER & GINDL (2004).

N from other forage crops on arable land renewed annually

Activity data on other forage crop area renewed annually was taken from the Green Reports (BML 2022b).

The average N content of residues was derived on the basis of the assumption that 25% of plants are legume forages and 75% are non-legume forages (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c). Average dry matter net yield per hectare (7 000 kg dm for common management) was taken from BUCHGRABER & GINDL (2004).

N from crop residues of cover crops

N input amount (20 kg N/ha) from mineralising residues of cover crops was obtained from the „Richtlinien für die sachgerechte Düngung" (Austrian fertilizer recommendations) (BMLFUW 2017). Activity data (areas with cover crops) were taken from Austria's Green Reports (BML 2022b).

Methodology

Austria applies the 2006 IPCC Tier 1 methodology, equation 11.7A. For emission calculation the default emission factor of 1.0% N_2O-N per kg N input to agricultural soils is used.

Applied parameters are presented in Table 238.

Table 238: Input factors used for estimation of N added to soils from crop residues (IPCC 2006, Table 11.2).

	Slope	Intercept	N content of above-ground residues (N_{AG})	Ratio of below-ground residues to above-ground biomass (R_{BG-BIO})	N content of below-ground residues (N_{BG})	dry matter fraction of harvested product*	$Frac_{Renew}$
Wheat**	1.09	0.88	0.006	0.22	0.009	0.86	1.0
Rye	1.09	0.88	0.005	0.22	0.011	0.86	1.0
Barley	0.98	0.59	0.007	0.22	0.014	0.86	1.0
Oats	0.91	0.89	0.007	0.25	0.008	0.86	1.0
Other cereals***	1.09	0.88	0.006	0.22	0.009	0.86	1.0
Maize (corn)	1.03	0.61	0.006	0.22	0.007	0.86	1.0
Potato	0.1	1.06	0.019	0.20	0.014	0.22	1.0
Sugarbeet	0.1	1.06	0.019	0.20	0.014	0.22	1.0
Fodderbeet	0.1	1.06	0.019	0.2	0.014	0.20	1.0
Maize (silo)	1.03	0.61	0.006	0.22	0.007	0.32	1.0
Clover-hay	0.29	0	0.027	0.40	0.019	0.86	0.48
Rape	1.13	0.85	0.008	0.19	0.008	0.91	1.0
Sunflower	1.13	0.85	0.008	0.19	0.008	0.91	1.0
Sojabean	0.93	1.35	0.008	0.19	0.008	0.88	1.0
Fodderbean	1.13	0.85	0.008	0.19	0.008	0.88	1.0
Peas	1.13	0.85	0.008	0.19	0.008	0.86	1.0
Vegetables	1.07	1.54	0.016	0.20	0.014	0.20	1.0
Oil pumpkin	1.07	1.54	0.016	0.20	0.014	0.92	1.0
Other forages	0.30	0	0.018	0.505	0.0145	1.00	1.0
Meadows ploughed every four years	0.30	0	0.018	0.505	0.0145	1.00	0.25

* *Country specific values are taken from (Umweltbundesamt 1998) and (STATISTIK AUSTRIA 2015) for grains, maize, potato, sugar beet, silo maize, rape, sunflower, soja bean, fodder bean, peas and oil pumpkin.*

***IPCC defaults for "grains" chosen, as IPCC default values for wheat are not appropriate for Austria.*

****Mixed grain, mainly triticale. IPCC defaults for "grains" chosen.*

$Frac_{Renew}$: For most of the crops the total area is renewed annually ($Frac_{Renew}$ = 1).

In the case of clover hay a $Frac_{Renew}$ of 0.48 is used. This factor has been determined by analysing INVEKOS data for the period 2007 to 2013 based on the mean cultivation time without ploughing. Within this investigation for individual parcels with cultures of clover, clover-grass, and lucerne (alfalfa) the development over time was observed. Data analyses resulted in a cultivation time of 2.1 years (weighted mean).

Meadows are ploughed every four years resulting in a $Frac_{Renew}$ factor of 0.25 (see above).

Activity data

Harvest data were taken from (BML 2022b) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT UND BERGBAUERNFRAGEN 2022) and are presented in Table 224: and Table 225. Legume cropping areas were available from official statistics (BML 2022b) and (STATISTIK AUSTRIA 1990–2022) and can be found in Table 223.

5.4.2.1.5 Mineralization/immobilization associated with loss/gain of soil organic matter

In Austria N_2O emissions from this source category are occurring only in a very small scale.

Methodology

N_2O emissions from mineralisation due to management changes on 'cropland remaining cropland' are calculated using equation 11.8 from the 2006 IPCC guidelines and the IPCC default emission factor of 0.01 kg N_2O-N/kg N. For the C:N ratio the default value of 10 has been used.

Activity data

The annual losses of soil carbon (tons of C) are taken as reported under *4.B.1 sub category 'Perennial converted to annual'* (see chapter 6.3.4.1.3).

5.4.2.1.6 Cultivation of organic soils (i.e. histosols)

According to Austria's soil inventories organic soils are not occurring in cropland in Austria. They can be found only in the grassland category.

Methodology

The emissions from organic soils were estimated according to the IPCC (2013) Wetlands Supplement which provides updated default emission factors for drained organic soils. The IPCC default emission factor for temperate nutrient rich deeply drained grassland of 8.2 kg N_2O-N/ha (Table 2.5 of IPCC 2013 Wetland Supplement) has been applied.

The associated N_2O emissions are reported in sector Agriculture under CRF source category *3.D.6 Cultivation of organic soils (i.e. histosols)* in line with the IPCC Reporting Guidelines.

Activity data

The area of organic grassland soils was estimated with data of the soil inventories of the Federal Provinces of Austria which are compiled in the Austrian Soil Information System – BORIS – (http://www.borisdaten.at**)**. The carbon content from the upper soil horizon (weighted mean for 0–30 cm) was calculated out of 200 grassland sites. Sites with more than 17% C_{org} (NESTROY et al. 2000) were selected as "organic soils" and their area was extrapolated to the complete Austrian grassland area.

The estimation resulted in a total area of 12 954 ha organic grassland soils which was applied for the whole time series. Emission calculation with the default emission factor for drained grassland soils resulted in constant emissions from drained organic grassland soils across the time series.

5.4.2.2 Indirect soil emissions (3.D.b)

Key Source: Yes (N_2O)

According to the IPCC definition, indirect N_2O emissions are caused by atmospheric deposition of nitrogen onto soils and by nitrogen leaching and runoff from soils.

Indirect N_2O emissions through atmospheric nitrogen deposition

A country specific methodology was used. Detailed calculations of volatilisation losses follow the N-flow approach and result in country specific values of $Frac_{GASF}$ and $Frac_{GASM}$.

Emissions were calculated following equation 11.9 provided in the IPCC 2006 GL

$$N_2O_{(ATD)}\text{-}N = [(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})] * EF_4$$

$N_2O_{(ATD)}$-N	*= annual amount of N_2O-N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O-N*
F_{SN}	*= annual amount of synthetic fertilizer N applied to soils [t N] (see Table 222)*
$Frac_{GASF}$	*= Fraction of synthetic fertilizer N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$*
F_{ON}	*= annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}*
F_{PRP}	*= annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}*
$Frac_{GASM}$	*= Fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied or deposited)$^{-1}$*
EF_4	*= emission factor for N_2O emissions from N volatilisation and re-deposition on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilised) (2006 IPCC GUIDELINES, Table 11.3)*

Country specific volatilisation fraction of synthetic N fertilizers ($Frac_{GASF}$) includes:

- NH_3-N and NO_x-N losses from urea and non-urea N fertilizers

Country specific volatilisation fraction of organic N fertilizers and N deposited by grazing animals ($Frac_{GASM}$) includes:

- NH_3-N and NO_x-N losses from animal manure applied to agricultural soils
- NH_3-N and NO_x-N losses from dung and urine deposited by grazing animals
- NH_3-N and NO_x-N losses from sewage sludge applied to agricultural soils
- NH_3-N and NO_x-N losses from biogas digestates applied to agricultural soils
- NH_3-N and NO_x-N losses from compost applied to agricultural soils

Table 239: NH_3-N and NO_x-N volatilisation losses from synthetic fertilizers and organic N fertilizers (including grazing) 1990 to 2021.

Year	N losses mineral fertilizer (incl. urea)	$Frac_{GASF}$	N losses from applied organic N fertilizer materials and grazing	$Frac_{GASM}$
	[t N/yr]	(N_{losses}/N_{FERT})	[t N/yr]	($N_{losses}/N_{FON+FPRP}$)
1990	6 826	0.05	29 592	0.16
1991	6 805	0.05	29 331	0.16
1992	6 583	0.05	28 012	0.16
1993	6 105	0.05	28 170	0.16
1994	5 943	0.05	27 911	0.16
1995	6 045	0.05	27 659	0.16
1996	5 992	0.05	27 034	0.16
1997	6 086	0.05	26 666	0.16
1998	6 185	0.05	26 499	0.16
1999	6 013	0.05	25 767	0.16
2000	5 791	0.05	25 068	0.15
2001	5 575	0.05	24 728	0.15

Year	N losses mineral fertilizer (incl. urea)	$Frac_{GASF}$	N losses from applied organic N fertilizer materials and grazing	$Frac_{GASM}$
	[t N/yr]	(N_{losses}/N_{FERT})	[t N/yr]	($N_{losses}/N_{FON+FPRP}$)
2002	5 670	0.05	24 095	0.15
2003	5 485	0.05	23 897	0.15
2004	5 227	0.05	23 637	0.15
2005	5 338	0.05	23 400	0.15
2006	5 550	0.05	23 423	0.15
2007	5 762	0.06	23 833	0.15
2008	6 090	0.05	23 709	0.15
2009	6 160	0.06	24 218	0.16
2010	5 388	0.06	24 334	0.16
2011	5 722	0.06	24 186	0.16
2012	6 002	0.06	24 186	0.16
2013	5 907	0.06	24 277	0.16
2014	6 319	0.06	24 495	0.16
2015	6 617	0.05	24 706	0.16
2016	7 021	0.06	24 955	0.16
2017	6 782	0.06	25 238	0.16
2018	6 264	0.05	24 910	0.16
2019	5 581	0.05	24 590	0.16
2020	5 489	0.05	24 456	0.16
2021	5 565	0.05	24 324	0.16

Following a recommendation of the in-country review 2007, additional background information on the calculation of volatilization ratios has been included to the NIR (see below).

A detailed description of the method applied for NH_3 and NO_x is given in the report 'Austria's Informative Inventory Report 2023 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants' (UMWELTBUNDESAMT 2023b).

NH_3-N and NO_x-N volatilization losses from mineral fertilizer application

With regard to a comprehensive treatment of the nitrogen budget, Austria established a link between the ammonia and nitrous oxide emissions inventory. This procedure enables the use of country specific data, which is more accurate than the use of the default value for $Frac_{GASF}$.

NH_3 and NO_x emissions from sector *3 Agriculture* are estimated according to the EMEP/EEA 2019 Guidebook (EEA 2019).

NH_3 emissions from synthetic fertilizers are estimated using a country specific methodology which requires detailed information on urea fertilizer application. The EMEP/EEA GB 2019 provides specific NH_3 emission factors for different types of synthetic fertilizers and for different climatic conditions (EEA 2019, table 3.2). According to IPCC 2006, Austria belongs to Group III '*temperate and cool temperate countries*' with largely acidic soils. 65% of Austria´s soils are classified as normal (pH<7) and 35% as high (pH>=7) based on Austrian Soil Information System – BORIS – (http://www.borisdaten.at).

For more detailed information, please refer to 'Austria's Informative Inventory Report 2023 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants' (UMWELTBUNDESAMT 2023b).

For the calculation of NO_x-N losses the Tier 1 methodology according to the EMEP/EEA GB 2019 is applied. Emissions of NO_x are calculated as a fixed percentage of total fertilizer nitrogen applied to soil. For all mineral fertilizer types the default emission factor of 4% is used (0.04 kg NO per kg applied fertilizer-N).

NH_3-N volatilization losses occurring during manure application

NH_3 emission factors for spreading of slurry and farmyard manure (expressed as share of TAN) following (REIDY et al. 2007) have been applied:

Table 240: Emission factors for NH_3 emissions from animal waste application.

Application technique	kg NH_3-N (kg TAN)$^{-1}$
spreading solid manure cattle	0.79
spreading solid manure pigs	0.81
broadcast spreading liquid manure cattle	0.50
broadcast spreading liquid manure pigs	0.25

Austria's ammonia inventory considers various techniques used for manure application in Austria (AMON & HÖRTENHUBER 2019). Specific abatement factors were obtained from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE 2015). For more information please refer to Austria's Informative Inventory Report 2023 (UMWELTBUNDESAMT 2023b).

NO_x-N emissions from animal manure applied to soils

The Tier 1 methodology according to the EMEP/EEA GB 2019, chapter 3.D, is applied. The default emission factor of 0.04 kg NO per kg of organic fertilizer-N spread on agricultural soils is used, which has been taken from table 3.1 (EEA 2019).

NH_3-N and NO_x-N volatilization losses from sewage sludge application

For the calculation of NH_3-N losses the EMEP/EEA default emission factor for sewage sludge of 0.13 kg NH_3/kg fertilizer N was applied (EEA 2019).

NO_x emissions were estimated according to the EMEP/EEA GB 2019 (EEA 2019, Annex 2) using the default Tier 1 EF of NO for sewage sludge (0.04 kg NO_2/kg sewage sludge N).

NH_3-N and NO_x-N volatilization losses from biogas slurry application (energy crops)

For the calculation of NH_3-N losses from energy crops applied to soils as fertilizer after the digestion process (biogas slurry), the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.08 kg NH_3 per kg N applied was applied (EEA 2019, Table 3.1).

NO_x-N losses were estimated with the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.04 kg NO per kg waste N applied (EEA 2019, Table 3.1).

NH_3-N and NO_x-N volatilization losses from compost application

NH_3-N losses from compost applied to soils as fertilizer were calculated with the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.08 kg NH_3 per kg N applied (EEA 2019, Table 3.1).

NO_x-N losses were estimated with the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.04 kg NO per kg N applied (EEA 2019, Table 3.1).

Indirect N_2O emissions from nitrogen leaching and run-off

A country-specific methodology based on the N-flow approach and country specific losses by leaching and runoff was used.

Results of a country specific study (EDER et al. 2015) determine a value of 15.154% for the fraction of leaching losses from nitrogen additions to Austria's managed soils. The peer reviewed study used 22 lysimeters, covering a wide range of soils, climatic conditions and management practices in Austria, to evaluate nitrogen losses through leaching and to calculate an Austria-specific value of FraCLEACH.

The emission calculation follows the following formula (equation 11.10, IPCC 2006 GL):

$$E\text{-}N_2O_{LL} = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) * Frac_{LEACH} * EF_5$$

$E\text{-}N_2O_{LL}$	*= N_2O emissions from leaching losses, expressed as N_2O-N [t N]*
F_{SN}	*= Annual amount of nitrogen in synthetic fertilizers (mineral and urea) applied on soils [kg N] (seeTable 222)*
F_{ON}	*= Annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils [kg N]*
F_{PRP}	*= Annual amount of urine and dung N produced by grazing animals and directly dropped on agricultural soils during grazing [kg N]*
F_{CR}	*= amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually [kg N]*
F_{SOM}	*= Annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management [kg N] → not occurring in Austria [NO]*
$Frac_{LEACH}$	*= Fraction of all N added to/mineralised in managed soils that is lost through leaching and run off (country specific value of 0.15154 following EDER et al. 2015)*
EF_5	*= Emission factor for N_2O from N leaching and runoff, kg, N_2O-N (0.0075 [kg/kg] following 2006 IPCC GL ,Table 11.3)*

5.4.3 Category-specific QA/QC

In the categories 3.D the following source specific QA/QC procedures have been carried out:

- ✓ NH_3-N, NO_x-N and N_2 losses calculated in compliance to the obligations under EU NEC Directive and UNECE/LRTAP Convention;
- ✓ Methods and emission factors reviewed by the EAGER[99] network;
- ✓ Plausibility of CRF N-fractions checked;
- ✓ Differences to IPCC default values explained and documented;
- ✓ External review by Austrian agricultural experts (stakeholder meeting "inventory talks" 2010);

[99] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources (e.g. crop residues, energy crops performed in 2015)
- ✓ External review of the revised agriculture inventory according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting "inventory talks" 2014
- ✓ External review of the revised agricultural model (AMON & HÖRTENHUBER 2019) according to the new data on agricultural practice (PÖLLINGER et al. 2018) by Austrian agricultural experts: stakeholder meeting "inventory talks" 2018.
- ✓ External review of the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) based on the research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER) by Austrian agricultural experts.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.4.4 Uncertainties

Uncertainties are presented in Table 179.

5.4.5 Recalculations

Update of activity data

Please refer to chapter 5.1.6.

Improvements of methodologies and emission factors

3.D.1.2.a Animal Manure Applied to Soils

Updates and improvements in the area of animal husbandry resulted in minor revisions of emissions from animal manure application (-0.01 kt N_2O for 2020).

3.D.1.3 Urine and dung deposited by Grazing Animals

Livestock related updates resulted in revised N_2O emissions for the years 1996-2004 and 2014-2020 (-0.001 kt N_2O for 2020).

3.D.b Agricultural Soils (indirect soil emissions – N_2O)

Atmospheric deposition: the main reasons for revised emissions are the correction of a linkage error in the ammonia inventory and the adjusted activity data ($N_{excretion}$ values for cattle, livestock numbers poultry and deer, biogas). As a result, the indirect N_2O emissions from atmospheric deposition were revised downwards for the years 1991-2020 (-0.004 kt N_2O for 2020).

N leaching and run-off: updated AD are the reason for revised emissions for the entire time series (-0.001 kt N_2O for 2020).

The whole time series of recalculations is included in Annex 8 to the NIR.

5.5 Field burning of agricultural residues (Category 3.F)

5.5.1 Source Category Description

This category comprises burning straw from cereals and residual wood of vinicultures on open fields in Austria.

Burning agricultural residues on open fields in Austria is legally restricted by provincial law and since 1993 additionally by federal law and is only occasionally permitted on a very small scale. Therefore the contribution of emissions from field burning of agricultural waste to the total emissions is very low.

In the year 2021 no emissions occurred in this category for the first time ("not occurring"). CH_4 and N_2O emissions for the years from 1990 to 2021 are presented in Table 241.

Table 241: Emissions from field burning (3.F) 1990–2021.

Year	CH_4 [kt]	N_2O [kt]	Year	CH_4 [kt]	N_2O [kt]
1990	0.03	0.001	2007	0.03	0.001
1991	0.03	0.001	2008	0.02	0.001
1992	0.03	0.001	2009	0.02	0.001
1993	0.03	0.001	2010	0.02	0.001
1994	0.03	0.001	2011	0.01	0.000
1995	0.03	0.001	2012	0.01	0.000
1996	0.03	0.001	2013	0.01	0.000
1997	0.03	0.001	2014	0.01	0.000
1998	0.03	0.001	2015	0.01	0.000
1999	0.03	0.001	2016	0.01	0.000
2000	0.03	0.001	2017	0.00	0.000
2001	0.03	0.001	2018	0.00	0.000
2002	0.03	0.001	2019	0.00	0.000
2003	0.03	0.001	2020	0.00	0.000
2004	0.05	0.001	2021	NO	NO
2005	0.03	0.001	**Trend 1990–2021**	**–100%**	**–100%**
2006	0.02	0.001	**Share in Agriculture 2021**	**0%**	**0%**

5.5.2 Methodological issues

5.5.2.1 Cereals (3.F.1)

Following a recommendation of the Centralized Review 2003 the IPCC method with default emission factors was applied. In response to questions raised during the UNFCCC centralized review 2010, the estimate has been improved by providing a breakdown of the emissions on a crop by crop basis.

In submission 2016 the calculation has been updated according to the 2006 IPCC GL, equation 2.27. Default emission factors were applied, taken from (IPCC 2006, Table 2.5); default combustion factors from the 2006 IPCC GL, Table 2.6, were used. Dry matter fractions were taken from (STATISTIK

AUSTRIA 2015). IPCC default residue/crop product ratios as used in source category *3.D.a.4 crop residues* (see also chapter on N from crop residues 0) were applied. Parameters are presented in the following table:

Table 242: Input parameters used to estimate emissions from field burning of cereals.

	Combustion factor [%]	**Dry matter fraction [t/t]**	**Residue/Crop product (ExF) [t/t]**
Wheat	0.90	0.86	1.28
Barley	0.90	0.86	1.09
Oats	0.90	0.86	1.19
Rye	0.90	0.86	1.31
Other cereals*	0.90	0.86	1.29

**mixed grain, triticale*

According to the Austrian Chamber of Agriculture (AUSTRIAN CHAMBER OF AGRICULTURE 2022), no field burning occurred in Austria in 2021 ("NO"). In the last years the areas burnt were decreasing steadily, in the previous year 2020 only 5 ha were burnt. For 1990 an average value of 2 500 ha was indicated for Austria's main cultivation regions (PRESIDENTIAL CONFERENCE OF AUSTRIAN AGRICULTURAL CHAMBERS 2004). The extrapolation to Austria's total cereal production area resulted in a value of 2 630 ha.

5.5.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.5.4 Recalculations

Following a recommendation of the NEC Review 2022, emissions from the burning of residual wood from vinicultures on open fields (formerly reported under *3.F.5 Other*) have been reallocated to category *5.C.2.1.b Incineration and Open Burning of Waste – Other*. This reallocation results in lower emissions of CH_4 and N_2O for the entire time series (-0.02 kt CH_4 and -0.0002 kt N_2O).

5.6 Liming (Category 3.G)

Key Source: No

5.6.1 Source Category Description

The application of lime to agricultural soils is a source of CO_2 emissions. It is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g. calcic limestone ($CaCO_3$), or dolomite

($CaMg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3$-), which evolves into CO_2 and water (H_2O) (IPCC 2006).

Table 243: CO_2 emissions from Liming (3.G) 1990–2021.

Year	Limestone [kt]	Dolomite [kt]	Year	Limestone [kt]	Dolomite [kt]
1990	36.79	8.87	2008	59.53	12.09
1991	35.64	8.59	2009	60.39	11.75
1992	36.79	8.87	2010	57.27	11.34
1993	34.26	8.26	2011	63.61	13.54
1994	29.67	7.15	2012	65.68	15.16
1995	28.75	6.93	2013	60.48	14.85
1996	25.76	6.21	2014	61.02	14.12
1997	32.19	7.76	2015	68.20	15.23
1998	33.11	7.98	2016	68.22	15.57
1999	29.44	7.10	2017	69.62	16.40
2000	33.69	8.91	2018	78.03	18.48
2001	37.85	10.01	2019	80.78	18.62
2002	40.68	9.90	2020	80.56	18.38
2003	40.29	10.12	2021	80.75	18.35
2004	40.18	10.29	**Share in 3.G 2021**	**80.6%**	**19.4%**
2005	44.25	9.38	**Trend 1990–2021**	**119.5%**	**106.9%**
2006	48.67	9.41	**Trend 2020–2021**	**0.2%**	**-0.2%**
2007	51.25	10.64			

5.6.2 Methodological issues

In response to a question raised during the ESD review 2019 regarding the reporting of 'NO' for emissions from dolomite application, Austria carried out an investigation on that issue. As a result, Austria improved its calculations and reports CO_2 emissions from the use of dolomite from submission 2020 onwards.

Activity data

Since submission 2020 new activity data on the amounts of both, limestone and dolomite, have become available. New data are based on specific information from Austria's biggest trading company and on sales data. In previous submissions application amounts of limestone were estimated on the basis of annual area data (ha) and assumptions on limestone application.

Table 244: Application of limestone and dolomite in Austria (arithmetic average of each two years)

Year	Liming [tons $year^{-1}$]		
	Limestone	Dolomite	Total
1990	83 623	18 612	102 235
1991	81 010	18 030	99 040
1992	83 623	18 612	102 235
1993	77 874	17 332	95 206
1994	67 421	15 006	82 427
1995	65 330	14 540	79 871

Year	Liming [tons year^{-1}]		
	Limestone	Dolomite	Total
1996	58 536	13 028	71 564
1997	73 170	16 285	89 455
1998	75 261	16 750	92 011
1999	66 898	14 889	81 788
2000	76 560	18 701	95 261
2001	86 014	21 002	107 015
2002	92 462	20 774	113 235
2003	91 570	21 230	112 800
2004	91 315	21 591	112 905
2005	100 557	19 673	120 230
2006	110 615	19 735	130 350
2007	116 470	22 330	138 800
2008	135 285	25 365	160 650
2009	137 260	24 640	161 900
2010	130 155	23 795	153 950
2011	144 578	28 398	172 975
2012	149 268	31 808	181 075
2013	137 463	31 163	168 625
2014	138 679	29 631	168 310
2015	155 005	31 945	186 950
2016	155 053	32 673	187 725
2017	158 235	34 415	192 650
2018	177 336	38 760	216 095
2019	183 581	39 065	222 645
2020	183 085	38 565	221 651
2021	183 532	38 504	222 036

Total application amounts for Austria provided in Table 244 are derived from annual sales data of Austria's biggest trade company for carbonate liming materials (www.bodenkalk.at) and expert judgement on domestic production and market (Wolfgang Gfrerer, Bodenkalk company). Provided annual amounts of calcic limestone and dolomite are considered to be representative for Austria.

Not the whole amount purchased is applied in the year of purchase. Considering this effect, Austria uses the arithmetic average of each two years as activity data. This approach has been chosen in consistency with the approach used in the estimation of N_2O emissions from mineral fertiliser application (see chapter 5.4.2).

Methodology

The Tier 1 methodology following equation 11.12 (IPCC 2006) for calculating the CO_2 emissions has been applied.

$$CO_2\text{–}C\ Emission = (M_{Limestone} \cdot EF_{Limestone}) + (M_{Dolomite} \cdot EF_{Dolomite})$$

CO_2–C Emission = *annual C emissions from lime application, tonnes C yr^{-1}*

M = *annual amount of calcic limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$), tonnes yr^{-1}*

EF = *emission factor, tonne of C (tonne of limestone)$^{-1}$.*

Emission Factors

The IPCC default emission factors for limestone (0.12) and dolomite (0.13) have been applied.

5.6.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.6.4 Recalculations

No recalculations have been carried out.

5.6.5 Planned Improvements

No improvements are planned.

5.7 Urea Application (Category 3.H)

Key Source: No

5.7.1 Source category description

CO_2 is lost by adding urea to soils during fertilisation. Urea ($CO(NH_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. The formed bicarbonate evolves into CO_2 and water, similar to the soil reaction during addition of lime (IPCC 2006 GL).

Table 245: Emissions from Urea Application (3.H) 1990–2021.

Year	CO_2 emissions [kt]	Year	CO_2 emissions [kt]
1990	9.60	2007	27.72
1991	11.58	2008	26.18
1992	13.62	2009	31.43
1993	15.57	2010	28.85
1994	17.91	2011	27.47
1995	19.79	2012	30.63
1996	19.37	2013	30.28
1997	20.17	2014	34.04
1998	21.45	2015	34.90
1999	21.57	2016	39.26
2000	19.36	2017	38.30
2001	16.46	2018	32.03

Year	CO_2 emissions [kt]	Year	CO_2 emissions [kt]
2002	16.77	2019	26.77
2003	19.10	2020	24.54
2004	21.15	2021	23.12
2005	21.89	**Trend 1990–2021**	**140.9%**
2006	24.88	**Share in Agriculture 2021**	**15.5%**

5.7.2 Methodological issues

For the CO_2-C emissions from urea usage, the IPCC 2006 Tier 1 methodology is applied using equation 11.13. The amount of urea used is multiplied with an emission factor. The default emission factor of 0.20 for urea, which is equivalent to the carbon content of urea on an atomic weight basis (20% for $CO(NH_2)_2$), is applied.

$$CO_2{-}C\ Emission = M \cdot EF$$

CO_2–C Emission = annual C emissions from urea application, tonnes C yr-1

M = annual amount of urea fertilisation, tonnes urea yr-1

EF = emission factor, tonne of C (tonne of urea)-1

Activity Data

The activity data taken for the amount of urea used in agriculture are the same as used for the calculation of N containing emissions (see Table 222). It comprises non-stabilized and stabilized urea quantities.

Table 246: Urea used in agriculture

Year	Weighted Urea Consumption [t N/yr]	Urea used in agriculture [t UREA/yr]	Year	Weighted Urea Consumption [t N/yr]	Urea used in agriculture [t UREA/yr]
1990	6 107	13 085	2006	15 832	33 926
1991	7 366	15 784	2007	17 637	37 793
1992	8 667	18 572	2008	16 658	35 695
1993	9 911	21 238	2009	19 999	42 855
1994	11 400	24 429	2010	18 357	39 335
1995	12 592	26 983	2011	17 481	37 460
1996	12 325	26 411	2012	19 489	41 763
1997	12 838	27 509	2013	19 266	41 285
1998	13 649	29 248	2014	21 662	46 418
1999	13 725	29 410	2015	22 212	47 597
2000	12 320	26 400	2016	24 983	53 535
2001	10 472	22 440	2017	24 375	52 232
2002	10 675	22 874	2018	20 380	43 671
2003	12 154	26 045	2019	17 035	36 503
2004	13 457	28 837	2020	15 616	33 462
2005	13 932	29 855	2021	14 712	31 526

RWA: Raiffeisen Ware Austria, sales company

5.7.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.7.4 Recalculations

No recalculations have been carried out.

5.7.5 Planned Improvements

No improvements are planned.

5.8 Other carbon-containing fertilizers (Category 3.I)

Key Source: No

In response to a question raised during the ESD Review 2020, Austria estimated CO_2 emissions from calcium ammonium nitrate (CAN) in the current submission for the first time.

5.8.1 Source category description

CAN (calcium ammonium nitrate) fertilizers include limestone or dolomite and therefore emit CO_2 when applied to soils.

Table 247: Emissions from Other carbon-containing fertilizers (3.I) 1990–2021.

Year	CO_2 emissions [kt]	Year	CO_2 emissions [kt]
1990	30.66	2007	20.31
1991	30.82	2008	26.88
1992	31.02	2009	22.52
1993	29.76	2010	14.89
1994	28.53	2011	21.37
1995	28.76	2012	22.20
1996	28.81	2013	21.60
1997	29.58	2014	23.59
1998	29.93	2015	27.15
1999	27.74	2016	28.55
2000	27.37	2017	26.38
2001	27.86	2018	26.30
2002	29.17	2019	24.61
2003	24.43	2020	25.47
2004	18.95	2021	27.06
2005	20.03	**Trend 1990–2021**	**–11.7%**
2006	20.08	**Share in Agriculture 2021**	**18.1%**

5.8.2 Methodological issues

Activity Data

CAN fertilizer data is fully consistent with AD amounts used in source category 3.D.1.1 Inorganic N fertilizers and corresponds to the fertiliser type specific AD used in the Tier 2 calculations within Austria's ammonia inventory under the LRTAP Convention and NEC Directive (UMWELTBUNDESAMT 2023b). In consistency with the calculations under source category 3.D.1.1 the arithmetic average of each two years was used as activity data.

Methodology

CAN traded in Austria contains 27% nitrogen. From this share the composition can be derived considering the molar weights of the two components (Ammoniumnitrate NH_4NO_3 and limestone or dolomite). This results in a share of 23 weight% of limestone (or dolomite, respectively).

Table 248: Amounts of calcium ammonium nitrate in Austria 1990-2021

Year	Calcium ammonium nitrate (CAN) [t N]	Calcium ammonium nitrate (CAN) [t]	Limestone (or dolomite) contained in CAN [t]
1990	79 024	292 680	66 898
1991	79 434	294 198	67 245
1992	79 956	296 133	67 688
1993	76 704	284 087	64 934
1994	73 520	272 294	62 239
1995	74 114	274 495	62 742
1996	74 259	275 032	62 864
1997	76 242	282 378	64 544
1998	77 126	285 653	65 292
1999	71 497	264 803	60 526
2000	70 547	261 286	59 723
2001	71 791	265 893	60 776
2002	75 184	278 461	63 648
2003	62 950	233 150	53 291
2004	48 843	180 901	41 349
2005	51 614	191 164	43 695
2006	51 760	191 705	43 818
2007	52 351	193 894	44 319
2008	69 276	256 580	58 647
2009	58 031	214 929	49 127
2010	38 384	142 162	32 494
2011	55 080	204 001	46 629
2012	57 214	211 904	48 435
2013	55 660	206 148	47 120
2014	60 808	225 213	51 477
2015	69 977	259 174	59 240
2016	73 583	272 528	62 292
2017	67 977	251 768	57 547
2018	67 774	251 015	57 375
2019	63 431	234 930	53 698

Year	Calcium ammonium nitrate (CAN)	Calcium ammonium nitrate (CAN)	Limestone (or dolomite) contained in CAN
	[t N]	**[t]**	**[t]**
2020	65 632	243 081	55 561
2021	69 745	258 317	59 044

Finally, the Tier 1 methodology following equation 11.12 (IPCC 2006) for calculating the CO_2 emissions from lime application has been applied.

$$CO_2\text{–C Emission} = (M_{Limestone} \cdot EF_{Limestone}) + (M_{Dolomite} \cdot EF_{Dolomite})$$

CO_2–C Emission = *annual C emissions from lime application, tonnes C yr^{-1}*
M = *annual amount of calcic limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$), tonnes yr^{-1}*
EF = *emission factor, tonne of C (tonne of limestone)$^{-1}$.*

According to information of producers and importers both lime and dolomite containing CAN is applied in Austria. Therefore, the arithmetic average of limestone and dolomite has been applied. This approach was accepted by the TERT (EEA 2020).

In the current submission, Austria checked its import statistics in order to validate its assumptions on limestone and dolomite contents. The investigations confirmed the current approach using the arithmetic mean of limestone and dolomite.

5.8.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.8.4 Recalculations

No recalculations have been carried out.

5.8.5 Planned Improvements

No improvements are planned.

6 LULUCF (CRF SECTOR 4)

6.1 Sector Overview

This category comprises GHG emissions and removals arising from land use, land use change and forestry (LULUCF). Table 249 presents the total and category emissions and removals from this sector.

Table 249: Emissions and removals (+/-) from Sector 4 LULUCF by category and gas - kt CO_2, CH_4 and N_2O.

Year	Greenhouse gas emissions/removals [kt CO_2]								[kt CH_4]	[kt N_2O]
	4 Total	A Forest land	B Crop land	C Grass land	D Wet lands [1]	E Settle ments[1]	F Other land[1]	G Harvested Wood Products	Total CH_4	Total N_2O (direct and indirect)
1990	-12 347	-11 078	171	685	47	448	502	-3 122	0.97	0.42
1991	-19 344	-19 110	165	680	47	460	511	-2 098	0.96	0.44
1992	-9 670	-9 716	159	676	47	483	521	-1 840	0.96	0.45
1993	-17 213	-17 453	152	671	47	505	531	-1 667	0.96	0.47
1994	-9 822	-9 148	157	672	47	523	532	-2 604	0.96	0.47
1995	-19 920	-18 865	127	468	34	473	413	-2 569	0.95	0.46
1996	-19 003	-17 540	99	470	39	483	410	-2 964	0.95	0.45
1997	-22 823	-21 609	71	473	39	482	407	-2 686	0.95	0.44
1998	-19 397	-18 250	49	476	39	481	403	-2 595	0.96	0.44
1999	-20 619	-20 098	13	476	40	489	404	-1 943	0.95	0.44
2000	-14 428	-13 928	-30	476	40	498	406	-1 889	0.96	0.44
2001	-29 571	-28 197	-107	476	40	511	407	-2 701	0.95	0.44
2002	-13 330	-11 348	-127	731	52	629	369	-3 635	0.97	0.45
2003	-15 448	-12 889	-127	727	52	643	370	-4 223	0.97	0.45
2004	-22 571	-20 778	-139	728	52	652	362	-3 448	0.95	0.45
2005	-18 565	-16 768	-131	728	52	662	353	-3 461	0.95	0.45
2006	-9 220	-7 075	-128	727	42	672	345	-3 803	0.96	0.45
2007	-5 830	-2 401	-145	723	44	658	337	-5 045	0.95	0.46
2008	-12 523	-9 465	-101	713	56	700	328	-4 755	0.96	0.47
2009	-8 200	-8 742	-140	540	85	687	496	-1 126	0.96	0.47
2010	-19 910	-19 097	-139	533	86	663	495	-2 452	0.96	0.47
2011	-15 510	-14 426	-143	528	90	633	494	-2 687	0.96	0.47
2012	-5 917	-5 459	-152	526	86	643	493	-2 055	0.96	0.46
2013	-6 391	-6 852	-136	525	118	599	492	-1 138	0.96	0.46
2014	-7 758	-7 982	-107	523	88	601	491	-1 372	0.96	0.45
2015	-6 710	-7 056	-44	517	75	558	494	-1 254	0.96	0.45
2016	-7 139	-7 646	9	491	94	554	497	-1 137	0.95	0.45
2017	-3 396	-3 344	59	469	84	555	500	-1 719	0.95	0.45
2018	4 776	5 056	87	453	83	563	503	-1 969	0.96	0.45
2019	1 989	1 753	117	448	76	549	507	-1 462	0.96	0.44
2020	-5 364	-6 954	167	443	76	516	510	-122	0.96	0.43

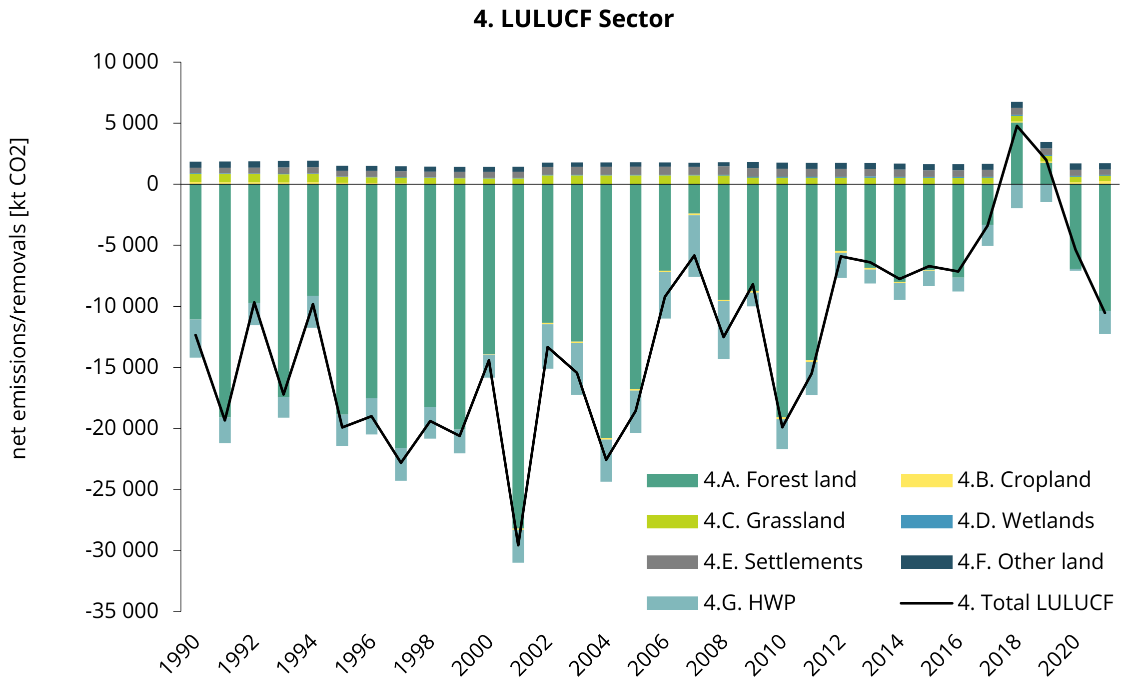
Year	Greenhouse gas emissions/removals [kt CO_2]								[kt CH_4]	[kt N_2O]
	4 Total	A Forest land	B Crop land	C Grass land	D Wet lands [1)]	E Settle ments[1)]	F Other land[1)]	G Harvested Wood Products	Total CH_4	Total N_2O (direct and indirect)
2021	-10 541	-10 375	259	434	76	441	514	-1 889	0.97	0.42
1990–2021	**-15%**	**-6%**	**51%**	**-37%**	**60%**	**-2%**	**2%**	**-39%**	**0%**	**-1%**

[1)] *Only land use conversions are reported*

Table 249 shows that land use, land use change and forestry is generally a net sink in Austria. For the years after 2002 a significant increase in biomass drain from Forest land causes a clear decrease in the net sink of the biomass pool of the subcategory "Forest land remaining forest land (*4.A.1*) with subsequent impacts on the annual total GHG balance of the LULUCF sector.

The most important category is Forest land, in particular its subcategory Forest land remaining forest land which is generally a net sink for CO_2. Forest land essentially dictates the level and trend in LULUCF total emissions/removals. For example, the net LULUCF emissions in 2018 and 2019 were driven by the respective net emissions from this category. Harvested wood products represent the second most important category, contributing consistent, and at times substantial, removals of CO_2. Between 2000 and 2015, the cropland category constituted a net sink of CO_2 and total GHGs (in CO_2 equivalent); however, since 2016 this category has been estimated as a small yet increasing net source of emissions. The other subcategories are consistent sources of GHG emissions.

Figure 32: Emissions and removals (+/-) from Sector 4 LULUCF by sub-categories [kt CO_2]



Source: Umweltbundesamt

6.1.1 Emission Trends

In 2021, net CO_2 removals from the sector LULUCF amounted to 10 541 kt CO_2, while CH_4 (0.97 kt CH_4) and N_2O (0.42 kt N_2O) emissions together amounted to 139 kt in CO_2 equivalent. Therefore, the net GHG balance of the sector in 2021 amounted to -10 402 kt in CO_2 equivalent, which corresponds to a net sink that offset 13% of national total GHG emissions (without LULUCF) in 2021 compared to 15% in the base year.

The most important category is Forest land (4.A) with net removals of 10 359 kt CO_2 equivalent in 2021 (including indirect emissions). Harvested Wood Products (HWP, 4.G) is the second largest sink category and contributed removals of 1 889 kt CO_2 equivalent. Total net emissions arising from the other categories amounted to 1 835 kt CO_2 equivalent in 2021 (including indirect emissions).

The net carbon stock changes in forest biomass (subcategory 4.A.1) demonstrate considerable interannual variation and thus have a major impact on the overall results in sector 4. Figures for annual growth and for annual harvest of forest biomass differ significantly year by year due to annual variations in influencing factors like weather conditions, timber demand and prices and occurrance of windthrow and other disturbance events (e.g. low increment in 2003, 2013, 2015, 2018 and 2019; very high harvest rates in 2007 and 2008). The dynamics in forest biomass gains and losses explain high annual variations, as well as the overall declining sink strength of the Forest land category and the LULUCF sector. In addition to the aforementioned year-to-year variations, it should also be noted that annual increment has generally decreased over the time series, while harvest rates on the other hand have been increasing. Finally, changes in forest soil carbon stocks (particularly in subcategory *4.A.1*) also vary substantially between years due to dynamics in weather (and harvest residues) that affect inputs to the soil C pool, as well as rates of soil decomposition. Indeed variations in the forest soil C pool have a substantial influence on the LULUCF sector as a whole. For example, low increments and relatively high harvest rates in 2018 and 2019 coincided with substantial net C losses from the forest soil pool, leading to substantial net CO_2 emissions from the Forest land category and the LULUCF sector.

In order to be consistent with the IPCC 2006 Guidelines for LULUCF, the area of all LUC categories in the land use transition matrix is reported in the conversion status for 20 years. After these 20 years they are accounted in the land remaining land categories.

6.1.2 Key Categories

The overall key category analysis is presented in Chapter 1.5. Key categories within this sector are shown in Table 250.

Table 250: Key categories of sector LULUCF (T1).

IPCC Category	Source Categories	Key Categories	
		GHG	**KS-Assessment***
4.A.1	Forest land remaining forest land	CO_2	LA
4.A.2	Land converted to forest land	CO_2	LA; TA
4.C.1	Grassland remaining grassland	CO_2	LA
4.C.2	Land converted to grassland	CO_2	LA 1990
4.E.2	Land converted to settlements	CO_2	LA
4.F.2	Land converted to other land	CO_2	LA

IPCC Category	Source Categories	Key Categories	
		GHG	KS-Assessment*
4.G	HWP	CO_2	LA; TA

LA = Level Assessment (if not further specified – for the years 1990 and 2021)

TA = Trend Assessment 1990–2021

6.1.3 Methodology

The methodologies for estimating emissions/removals from LULUCF are described in detail in the subchapters 6.1 to 6.8. However, due to the NFI as the source of data for LUC to and from forests, the methodology for calculating emissions/removals due to land use changes from Forest land (which are subcategories of *4.B – 4.F*) are included in the methodological description of emissions/removals due to Land converted to forest land. The next two subchapters nonetheless give a sector overview on the methods used for estimating the LULUCF emissions/removals.

6.1.3.1 Activity data

For the complete time series from 1990 to 2021 on areas remaining in a land use category and areas affected by LUC since 1970, activity data had to be compiled from data from different surveys. Austria reports LUC areas with a transition period of 20 years, starting 20 years before 1990.

The main characteristics of the applied area compilation technique are as follows:

- Consistency with respect to the Austrian area (use of subcategory "Other land")
- Consistency within and across years in subcategories
- Hierarchical treatment of data sources:

1st hierarchy: Systematically measured statistics are considered to have highest reliability (e.g. NFI forest area),

2nd hierarchy: Land use statistics based on land register and land use surveys for EU-funding are given higher hierarchy than other estimates for land use (agricultural areas),

3rd hierarchy: Estimates for land use based on specific information are given higher priority than mere estimates on likelihood basis (e.g. bogs in *4.D*),

4th hierarchy: Estimates on likelihood basis are given higher priority than data gaps (e.g. no LUC from wetland to cropland),

5th hierarchy: Data gaps (*4.F* "Other land").

The forest area and land use change areas from and to forests are based on data from the National Forest Inventory (NFI). The Austrian NFI uses a geographically fixed grid system, so the NFI results are geographically specific. For each mean year of an inventory period, data on the total forest area are provided, with annual area data between two consecutive inventories calculated by linear interpolation. The land use changes from and to forests are based on area measurements of such activities at the NFI grid points.

Data for the total cropland area are available from Statistik Austria based on FSS (Farm Structure Surveys) (ÖSTAT, 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014, 2018, 2022) and IACS (Integrated Administration and Control System) data (STATISTIK AUSTRIA 1990–2022). Based on the Austrian farm structure surveys, Statistik Austria also provides data for the total grassland area. For the years between these surveys grassland area data were derived by linear interpolation. However, in preparation for this submission a time-consistency issue in these data was identified, whereby grasslands that are not managed for agriculture, but nonetheless retain their status as managed grasslands, are not included these total area statistics. Corrections of these data within the data processing routines that ensure consistency in the land use change matrices has thus been applied (see 6.4.2). Estimates on the land use changes between cropland and grassland were derived from the data of the geographically specific Integrated Administrative Control System (IACS, see also 6.3.2).

Bogs/fens are protected areas in most Austrian provinces and are thus considered as areas which have not been subject to change since 1990. The changes in the annual water body area were derived from geographically specific data of the Real Estate Database. Due to data discontinuities data were interpolated between 1971–1981, 1981–1995 and 1995–2005. Since 2005 annual data are reported.

Based on the regional information of the Real Estate Database, also geographically specific data for the settlement area are provided annually since 2006. As the database was previously updated irregularly, pre-2006 settlement areas were interpolated. The increases of settlement area derived mainly from conversion from grassland and cropland sites.

The area of other land is reported in accordance to the IPCC-2006 GL. Other land is therefore understood to be the difference between the sum of areas of all LU categories except "Other Land" and the official total area of Austria. This calculation helps to avoid double counting or area omissions. The LUC areas from forest land to other land are based on the NFIs.

By expert judgement certain land use changes were considered not to occur in Austria:

- Wetlands, settlements or other land converted to cropland or grassland – the total area of cropland and grassland is decreasing, whereas the areas of settlement and wetland increase over the time period (see Table 251). Furthermore, from an economical and practical point of view any re-conversion of settlements and wetlands to cropland or grassland are considered as very unlikely. Other land is not suited for cropland and grassland use.
- Cropland or settlements converted to wetlands – it is assumed that LUC to water bodies occur close to existing water bodies, which are mainly from grasslands
- Wetlands converted to settlements

All this information was merged and based on annual land use changes, a matrix for a LUC transition period over 20 years starting 20 years before 1990 was established. The remaining area was then calculated as the difference between the total area of a land use category and the land use changes to each category. Further details on the methodologies of area information are given in each land use chapter. As different sources of land use and land use change data have been used, it is important to note that adjustment of certain official area statistics was required to ensure that the annual land use change matrices match up between years. These adjustments were implemented as a response to a recommendation raised during the 2020 ESD Review (EEA 2020) and are described in the respective land use category chapters.

The digital cadastral data base of Austria allows an assessment of the area of the category "other land". If the areas for "other land" were taken from this database (instead calculating the "other land" area as the difference between the area sum of all land categories except other land and the area of total Austria) the resulting sum of areas of all land use categories would be each year 1 to 2% lower than the real area of total Austria. From that small difference we assume that the used statistics (though different databases for all land uses) give an accurate picture of how the total Austrian area is distributed between the land use categories over time.

Table 251 presents land use data and data for land use changes for the years 1990 and 2021 for the total area of Austria as used for the calculations.

Table 251: Land use and LUC data for Austria for the years 1990 and 2021.

Area in ha	1990	2021	Diff 1990-2021
4.A Forest land – total area	**3 892 518**	**4 019 562**	**127 044**
1 Forest land remaining forest land – total area	3 632 699	3 888 319	255 620
1.1.a Forest land remaining forest land: coniferous	2 431 959	2 446 355	14 396
1.1.b Forest land remaining forest land: deciduous	737 406	1 006 023	268 617
1.1.c Forest land remaining forest land: forest not in yield	463 333	435 940	-27 393
2. Land converted to forest land	259 819	131 243	-128 576
2.1 Cropland converted to forest land	30 962	11 676	-19 287
2.2 Grassland converted to forest land	144 197	59 785	-84 412
2.3 Wetland converted to forest land	12 534	8 995	-3 539
2.4 Settlement converted to forest land	17 122	8 683	-8 439
2.5 Other Land converted to forest land	55 004	42 105	-12 899
4.B Cropland – total area	**1 500 824**	**1 390 513**	**-110 311**
1. Cropland remaining cropland	1 469 195	1 336 637	-132 558
1.a Annual remaining annual	1 366 824	1 259 244	-107 580
1.b Perennial remaining perennial	81 883	55 804	-26 079
1.c Perennial converted to annual	7 244	9 853	2 608
1.d Annual converted to perennial	13 243	11 737	-1 506
2. Land converted to cropland	31 630	53 876	22 247
2.1 Forest Land converted to cropland	4 125	2 785	-1 341
2.2 Grassland converted to cropland	27 504	51 091	23 587
2.2.a Grassland converted to annual cropland	26 947	49 710	22 763
2.2.b Grassland converted to perennial cropland	557	1 382	825
2.3 Wetland Land converted to cropland	NO	NO	NO
2.4 Settlement converted to cropland	NO	NO	NO
2.5 Other Land converted to cropland	NO	NO	NO
4.C Grassland – total area	**1 713 483**	**1 510 464**	**-203 019**
1. Grassland remaining grassland	1 655 668	1 409 379	-246 289
2. Land converted to grassland	57 814	101 084	43 270
2.1 Forest land converted to grassland	32 467	35 303	2 835
2.2 Cropland converted to grassland	25 347	65 782	40 435
2.2.a annual cropland converted to grassland	25 090	64 551	39 461
2.2.b perennial cropland converted to grassland	257	1 231	974

Area in ha	1990	2021	Diff 1990-2021
2.3 Wetland land converted to grassland	NO	NO	NO
2.4 Settlement converted to grassland	NO	NO	NO
2.5 Other land converted to grassland	NO	NO	NO
4.D Wetlands – total area	**132 616**	**154 371**	**21 754**
1. Wetlands remaining wetlands	127 105	130 165	3 059
2. Land converted to wetlands	5 511	24 206	18 695
2.1 Forest land converted to wetlands	1 706	3 677	1 971
2.2 Cropland converted to wetlands	NO	NO	NO
2.3 Grassland converted to wetlands	3 804	20 529	16 724
2.4 Settlement converted to wetlands	NO	NO	NO
2.5 Other land converted to wetlands	NO	NO	NO
4. E Settlements – total area	**380 055**	**580 486**	**200 431**
1. Settlements remaining settlements	230 483	446 208	215 725
2. Land converted to settlements	149 572	134 278	-15 294
2.1 Forest land converted to settlements	9 792	11 551	1 759
2.2 Cropland converted to settlements	95 550	57 779	-37 771
2.3 Grassland converted to settlements	44 230	64 948	20 717
2.4 Wetlands converted to settlements	NO	NO	NO
2.5 Other land converted to settlements	NO	NO	NO
4. F Other land – total area	**767 504**	**731 604**	**-35 900**
1. Other land remaining other land	749 370	713 133	-36 237
2. Land converted to other land	18 134	18 472	337
2.1 Forest land converted to other land	18 134	18 472	337
2.2 Cropland converted to other land	NO	NO	NO
2.3 Grassland converted to other land	NO	NO	NO
2.4 Wetlands converted to other land	NO	NO	NO
2.5 Settlement converted to other land	NO	NO	NO
Total area	**8 387 000**	**8 387 000**	

6.1.3.2 Definition of C-pools

As recommended by the ERT during the ICR 2013 a detailed description of the C-pools as used in the GHG-reporting of Austria is given in the table below.

Table 252: Definitions of C-pools.

Pools		Description
Living biomass	Above ground biomass	Forest land: All living biomass (DBH > 5cm) above the soil including stem, stump, branches, seeds, bark and foliage (foliage only of evergreen trees). At ARD sites and LUC from and to forests all forest biomass (shrubs, forest understory) with a DBH > 0 cm to 5 cm is also taken under consideration.

Pools		Description
		Other subcategories: All living biomass is taken under consideration
	Below ground biomass	All living biomass of live roots with a diameter > 2 mm.
Dead organic matter	Dead wood	All non-living woody biomass not contained in the litter or soil, standing on the ground, without dead roots, as they are already considered as part of the litter or soil.
	Litter	All non-living biomass lying dead in various states of decomposition above the mineral or organic soil.
Soils	Soil organic matter	All organic matter in mineral and organic soils (including peat) to a soil depth of 50 cm (forests, LUC from and to forests) or to a soil depth of 30 cm (all other land uses and LUC).

6.1.3.3 Emission factors

The calculations of the emissions follow the methods described in the IPCC 2006 GL, with an almost complete use of higher tier methods and carbon stock change-/emission factors derived from national data. Austria is consistently closing gaps in national input data for relevant subcategories with surveys and studies. The most important national statistics and data sources for the used emission factors are the Austrian national forest inventory, agricultural statistics, studies on cropland and grassland biomass, as well as studies on the cropland soil organic carbon content and the results of the country-wide soil surveys. Furthermore, specific national studies are available to come up with carbon stock change-/emission factors for the categories "settlements" and "other land".

6.1.4 Quality Assurance and Quality Control (QA/QC)

The calculations of the data for category 4 are embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 1.2.3).

Important elements of QA/QC:

- ✓ Are the correct values used (check for transcription errors …)?
- ✓ Check of plausibility of input data (time-series, order of magnitude …)
- ✓ Is the data set complete for the whole time series?
- ✓ Check of calculation units. ..
- ✓ Check of plausibility of results (time-series, order of magnitude …)
- ✓ Correct transformation/transcription into CRF
- ✓ Where possible data is checked with data from other sources
- ✓ order of magnitude checks …
- ✓ Are all references clearly made?
- ✓ Are all assumptions documented?

Specific elements of QA/QC for LULUCF:

The input data estimates and results are checked as follows. The results of these checks are described in the QA/QC documentation:

1) Bottom-up check

1.1) Input data

1.1.1) Check for the plausibility of the activity data and their trend

Step 1: Documentation of the most important reasons for changes and non-changes of activity data

Step 2: Check and documentation if these changes or non-changes of activity data fit to trends of underlying conditions

Step 3: If step 1 and 2 do not allow any explanation further check of the used statistics and their estimates (see 1.2) and/or communication with the data providers

1.1.2) Check for plausibility of the emission factors as well as the related input data and their trends

Step 1: Documentation of the most important reasons for changes and non-changes of emission factors

Step 2: Check and documentation if these changes or non-changes of emission factors fit to trends of underlying conditions

Step 3: If step 1 and 2 do not allow any explanation further check of the used statistics and their estimates (see 1.2) and/or communication with the data providers

1.1.3) Check of input data for completeness

1.2) Estimations

1.2.1) Check of the correctness of all equations in the estimate files

1.2.2) Check of the correctness of all interim results

1.3) Check of the plausibility of the results and their trends related to point 1.1 and documentation of the plausibility of changes and non-changes on basis of point 1.1

1.4) Check of the correctness of all data and results transfer

2) Top-down check

2.1) Check the consistency between sum of land use areas and the total official area for Austria.

2.2) Comparison of the used activity data with those from other statistics. Documentation of the results of these comparisons and documentation of the reasons for the choice of statistics when data deviate more than 5% compared to other statistics

2.3) Comparison of the used emission factors and underlying input data with those of other data sources (e.g. from literature results in NIRs of other comparable regions and IPCC default values). Documentation of the results of these comparisons. Further check according to points 1.1 and 1.2 as well as check on the suitability of the used input data in case of implausible differences. Documentation of this further check.

6.1.5 Uncertainty Assessment

The uncertainty in the LULUCF GHG balance is estimated by using the @Risk-Software, which runs Monte-Carlo-simulations of spreadsheet GHG emission calculations. For that purpose, the uncertainties of all activity data, emission factors and input parameters for emission factors were defined. For each subcategory a bottom-up analysis of the uncertainties of the estimated emission/removal figures for the subcategory was carried out. All pools and gases were included in this analysis. Correlations between the parameters were taken into consideration during the simulations. To calculate uncertainties the emission calculation procedures were repeated with 10 000 to 100 000 iteration steps, with uncertainty expressed as the 95% confidence interval (standard deviation of the multiple simulation outputs multiplied by 2), which is in line with IPCC 2006 GL. This procedure was applied to each LULUCF subcategory and for the total LULUCF sector emissions/removals. For this submission an updated uncertainty analysis was carried out on basis of improved emission factors and uncertainties for the soil carbon pool.

The average uncertainty of the total LULUCF sector emissions/removals across the years is ±5 148 kt CO_2. This represents on average ±48% of the total LULUCF emissions/removals.

The biomass and soil carbon changes of *4.A.1* have in most years the highest impact on the total emissions/removals of the LULUCF sector. As a consequence, the uncertainty of these emissions/removals (around 40% for the forest biomass pool and 57 % for the forest soil pool) also have a significant impact on the uncertainty of the total emissions/removals of the LULUCF sector.

All other subcategories contribute to a clearly smaller extent to the results and, hence, uncertainty of the LULUCF totals, despite their partly very high relative uncertainties (in%) in their respective total emissions/removals.

Regarding the high uncertainty of the LULUCF sector it is important to understand that the LULUCF sector is the only one where the total emissions/removals of the sector are the result of both additions and subtractions (biomass gains minus biomass losses and net emissions minus net removals from the subcategories and their respective pools). This is – following the rules of error propagation – one of the main reasons why the relative uncertainties of LULUCF are higher than in other sectors. Furthermore, the relative uncertainty depends significantly on the level of the net emission/removal – the closer the net result is to zero the higher is the relative uncertainty. So, even the use of country specific and sophisticated methods may result in typically high relative LULUCF uncertainty figures. Another issue is the use of higher tiers in LULUCF which does not necessarily reduce the uncertainty of the figures. For instance, a Tier 1 approach assumes the soil C stock does not change, and thus associated uncertainties in estimating soil C stock changes are also not considered. So, despite the large potential errors of not including this important C stock, the calculated uncertainties would be lower.

6.1.6 Recalculations

The GHG balance of the LULUCF sector has been substantially revised since the last submission in 2022. Due to methodological changes and particularly the availability of new data from the NFI, the time series of annual total GHG emissions/removals from LULUCF vary from the previously submission by -15 971 to +8 073 kt CO_2e per year. Methodological changes and impacts on emissions/removals at the category level are detailed below.

The whole time series of recalculations is included in Annex 8 to the NIR.

4.A Forest land

The final results of the NFI 2016/21 were made available for the preparation of the GHG inventory reported in this 2023 submission. This led to substantial recalculations in the Forest land category, causing changes in annual net emissions/removals ranging from -16 477 to 7 513 kt CO_2e over the whole time series.

The new NFI data led to recalculations in the biomass and deadwood pools of the category 4.A.1 Forest land remaing forest land (*forest in yield*), due to the new data on biomass increment and drain, dead wood stock change, C-content, mass ratios of stems, branches and roots and tree species distribution affecting the years since 2009. Furthermore, for *forest not in yield* which represent ca. 15% of the Austrian forest area, but for which emissions/removals were previously not estimated under 4.A.1, changes in the biomass and deadwood pools for 1990-2021 have been estimated and reported based on sampling in the 2007/09 and 2016/21 NFIs and model simulations over the whole time series.

For the soil (and litter) pool of 4.A.1, estimates of soil carbon stock changes over the whole series have been substantially revised based on new simulations with the Yasso20 model (see chapter 6.2.4.1.3 for details). In comparison to the previous submissions, the soil pool is estimated on average as a net sink over the time series. Furthermore, in contrast to previously reported negative stock change that was constant over the time, the new simulations have been conducted with dynamic annual drivers resulting in substantial annual variations ranging from annual soil carbon losses in some years to net soil carbon gains in others.

For the category 4.A.2 Land converted to forest land the whole time series has been revised. This is due to the new LUC data from NFI 2016/21 affecting the respective land-use changes to Forest land since 2009. Furthermore, updates to the country-specific growth and drain rates as well as dead wood stock change on areas with LUC from and to forest that were first assessed in the ARD NFI 2011/13 and were subsequently reevaluated in the NFI 2016/21 leading to updates in these stock change factors. In addition, the way these growth and harvest rates are implemented in the calculation has been improved (see chapter 6.2.4.2.1 for details).

4.B Cropland

The method to estimate land-use changes between Grassland and Cropland based on IACS/LPIS data was further improved for the 2023 submission. In addition, the LUC areas from Forest land to Cropland since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to cropland for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions/removals of the Cropland category: The annual emissions/removals differ from the last submission in 2022 by -250 to -109 kt CO_2e per year.

4.C Grassland

The total Grassland area was adjusted for grasslands, which are no more agriculturally managed and as a consequence no more tracked by the IACS system, but nonetheless do not lose their status as Managed grassland. Furthermore, the method to estimate land-use changes between Grassland and Cropland based on IACS/LPIS data was further improved for the 2023 submission. In addition, the LUC areas from Forest land to Grassland since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Grassland for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the Grassland category: The annual emissions are in the range of 25 to 190 kt CO_2e per year higher compared to the last submission in 2022.

4.D Wetland

The LUC areas from Forest land to Wetland since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Wetland for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the Wetland category: The annual emissions are in the range of 3.6 to 16.9 kt CO_2e per year higher compared to the last submission in 2022.

4.E Settlements

In this submission, the hierarchy in which the respective LU and LUC data sources are ranked in terms of accuracy was adjusted. Due consistency issues identified in the statistics on total Grassland area, the BEV statistics on total settlement area are now considered more reliable than the statistics on total Grassland area data. Therefore, BEV statistics on total Settlement area are used over the whole time series, rather than extrapolating backwards from the latest year area using the repective LUCs to and from Settlements. Furthermore, in this submission the method to estimate land-use changes between Grassland and Cropland were based on IACS/LPIS data was revised. To ensure area consistency in the LUC matrices, the changes in these LUC areas also had an impact on the LUC areas from Cropland and Grassland to Settlements. Finally, the LUC areas from Forest land to Settlements since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Settlements for the whole time series were changed on the basis of the new NFI 2016/21 results. For Settlements, the above improvements led to annual category emissions that are 58 to 418 kt CO_2e higher compared to the last submission in 2022.

4.F Other land

The correction of the total Grassland area statistics, as well as the improved estimates of LUC between Grassland and Cropland, removed the residual in the Grassland area balance that was previously assigned as Grassland conversion to Other land. Consequently, in contrast to the previous submission, Grassland conversions to Other land are considered to be not occurring. In addition, the LUC areas from Forest land to Other land since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Other land for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the Other land category, with annual emissions deviating from the last submission in 2022 by -163 to +273 kt CO_2e.

4.G HWPs

The HWP production figures for the year 2020 were updated in the most recent JFSQ statistics. Consequently, the removal figures for this year had to be updated accordingly. The recalculations in the HWP category led to 2020 removals that are 51 kt CO_2e lower than previously reported.

6.1.7 Completeness

Table 253 gives an overview of the new IPCC categories included in this chapter and the corresponding sub-divisions for which the calculations are made. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions/removals from this subcategory have been estimated; for LULUCF CO_2 emissions/removals are estimated.

Table 253: IPCC categories according to the IPCC 2006 Guidelines.

IPCC categories[100]/ Sub division for calculation	**Description**	**Status for CO_2**	**Other GHG**
4 A	Forest land	✓	
4.A.1	Forest land remaining forest land	✓	
Coniferous	*Increase, decrease, net change in biomass carbon stock*	✓	
Deciduous	*Increase, decrease, net change in biomass carbon stock*	✓	
Forest not in yield	*Net change in biomass carbon stock*	✓	
	Net carbon stock change in dead organic matter	✓	
	Net carbon stock change in soils	✓1)	
4.A.2	Land converted to forest land	✓	
4.A.2.1	Cropland converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	
4.A.2.2	Grassland converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	✓ N_2O
4.A.2.3	Wetlands converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	
4.A.2.4	Settlements converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	
4.A.2.5	Other land converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	
4.B	Cropland	✓	
4.B.1	Cropland remaining cropland	✓	
Annual remaining annual	*Carbon stock change in living biomass*	✓	
Annual remaining annual	*Carbon stock change in soils*	✓	
Perennial remaining perennial	*Carbon stock change in living biomass*	✓	
Perennial remaining perennial	*Carbon stock change in soils*	✓	
Annual converted to perennial	*Carbon stock change in living biomass*	✓	
Annual converted to perennial	*Carbon stock change in soils*	✓	
Perennial converted to annual	*Carbon stock change in living biomass*	✓	
Perennial converted to annual	*Carbon stock change in soils*	✓	
4.B.2	Land converted to cropland	✓	
4.B.2.1	Forest land converted to cropland	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	✓ N_2O
4.B.2.2	Grassland converted to cropland	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soils	✓	✓ N_2O
4.B.2.3	Wetland converted to cropland	NO	
4.B.2.4	Settlements converted to cropland	NO	
4.B.2.5	Other land converted to cropland	NO	

[100] IPCC categories – applied according to the 2006 IPCC 2006 Guidelines for National Greenhouse Gas Inventories

IPCC categories[100]/ Sub division for calculation	**Description**	**Status for CO_2**	**Other GHG**
4.C	Grassland	✓	
4.C.1	Grassland remaining grassland	✓	
	Carbon stock change in soils	✓	✓ CH_4
4.C.2	Land converted to grassland	✓	
4.C.2.1	Forest land converted to grassland	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	
4.C.2.2	Cropland converted to grassland	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.C.2.3	Wetland converted to grassland	NO	
4.C.2.4	Settlements converted to grassland	NO	
4.C.2.5	Other land converted to grassland	NO	
4.D	Wetlands	✓	
4.D.1	Wetlands remaining wetlands	NE/NO	
4.D.2.1	Forest land converted to wetlands	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.D.2.2	Cropland converted to wetlands	NO	
4.D.2.3	Grassland converted to wetlands	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.D.2.4	Settlements converted to wetlands	NO	
4.D.2.5	Other land converted to wetlands	NO	
4.E	Settlements		
4.E.1	Settlements remaining settlements	NE	
4.E.2.1	Forest land converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.E.2.2	Cropland converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.E.2.3	Grassland converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.E.2.4	Wetlands converted to settlements	NO	
4.E.2.5	Other land converted to settlements	NO	
4.F	Other Land		
4.F.1	Other land remaining other land	NE	
4.F.2.1	Forest land converted to other land	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.F.2.2	Cropland converted to other land	NO	
4.F.2.3	Grassland converted to other land	NO	
4.F.2.4	Wetlands converted to other land	NO	
4.F.2.5	Settlements converted to other land	NO	
4.G	Harvested wood products		

IPCC categories[100]/ Sub division for calculation	Description	Status for CO_2	Other GHG
4.G.1	Solid wood	✓	
4.G.1.1	Sawn wood	✓	
4.G.1.2	Wood panels	✓	
4.G.2	Paper and paper board	✓	
4(I)	Direct nitrous oxides emissions from nitrogen inputs to managed soil	NO	
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NO/NA	
4(III)	Direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	NO	✓ N_2O
4(III)B.2	Land converted to cropland		
4(III)B.2.1	Forest land converted to cropland	✓	✓ N_2O
4(III)B.2.2	Grassland converted to cropland	✓	✓ N_2O
4(IV)	Indirect nitrous oxide emissions from managed soils	NO	✓ N_2O
4(V) 4 A 1 BiomassBurn_contr.	Biomass burning: controlled: Forest land remaining forest land	NO	NO
4(V) 4 A 1 BiomassBurn_wildfires	Biomass burning: Wildfires: Forest land remaining forest land	IE[2)]	✓ N_2O ✓ CH_4
4(V) 4 B 1 BiomassBurn_controlled	Biomass burning: controlled: residues of perennial cropland	IE[3)]	IE[4)] N_2O, CH_4
4(V) 4 D 1 BiomassBurn_wildfires	4.D.1 Biomass Burning: Wildfires: Wetlands remaining Wetlands	✓	✓ N_2O ✓ CH_4
4(G)	C stock changes in Harvested Wood Products	✓	

[1)] *CO_2 emissions/removals from changes in soil carbon stock of 4.A.1. are estimated for coniferous and deciduous forests. For forest not in yield, the soil carbon pool is assumed to be in equilibrium (notation key NA).*

[2)] *CO_2 emissions caused by wildfires (CRF Table 4(V)) are included in the category 4.A.1. Data on the area affected by wildfires are available for the years 1990 to 2021.*

[3)] *Included in the harvest of perennial cropland biomass*

[4)] *Included in Sector 5.C estimates – Incineration and Open Burning of Waste – Other*

6.1.8 Planned improvements

In the interest of improving LULUCF emissions estimates the used input parameters and applied methods are continuously re-evaluated. A number of potential future improvements have been identified, which will be considered for inclusion in future inventory submissions. These include:

- For soil organic carbon in grassland estimates based on possible management type assessment, country-specific SOC stock change rates are being investigated. A national ongoing research project on management measures appropriate to enhance or maintain SOC stocks in grassland soils will provide a sound base for estimating possibilities towards country-specific SOC stock change rates of Grassland remaining grassland.
- An analysis of existing urban tree data bases is ongoing in order to improve the estimates of CSC in biomass of the subcategory Settlements.

- As part of the ongoing evalulation and improvement of the national system for monitoring land use and land-use change, a current project is investigating spatially-explicit methods to improve the quantification of land-use changes to settlements and wetlands.
- A current national study is investigating the use of historic data sources and various maps for estimating the area of drained organic soils and is furthermore synthesising and evalulating possible soil emission factors for these areas.
- Two projects will begin this year with the aim of improving LULUCF methods in two specific areas:
  - Improved quantification of the total grassland area with spatially-explicit datasets.
  - Quantification of woody biomass on croplands and grasslands (e.g. single trees/tree groups, hedgerows etc) and development of respective carbon stock change factors

6.2 Forest land (Category 4.A)

6.2.1 Category description

In Austria, a total of 4.02 million ha (47.9%) is classified as forest land (BFW 2022). Since the first national forest inventory (NFI 1961–1970) there has been a steady increase in the total standing forest C stock in Austria. The sustaining of Austrian forests in the past has helped to maintain an important carbon stock in the Austrian landscape and avoid net CO_2 emissions to the atmosphere from the sector LULUCF. In 1990 the Austrian forests represented a carbon stock of 339 ± 42 Mt carbon from biomass and 463 ± 185 Mt carbon from soil, i.e. humus layer plus mineral soil to 50 cm depth. This total carbon stock represents approximately 40 times the Austrian CO_2 equivalent emissions of the greenhouse gases CO_2, CH_4 and N_2O in the year 1990 (UMWELTBUNDESAMT 2000a). Recently the Forest land category became, for the first time since reporting began, a net GHG source in single years, namely in 2018 and 2019. The net source values in these years are explained by high harvest rates due to natural disturbances, low increments due to weather conditions and net C losses from the soil pool.

Emission/Removal trends of forest land

In Austria, the area of forest land has been constantly increasing since 1990 (Figure 33). However, Land converted to forest land subcategories show a decreasing trend with the exception of Other land to forest land which is stagnating (Figure 34).

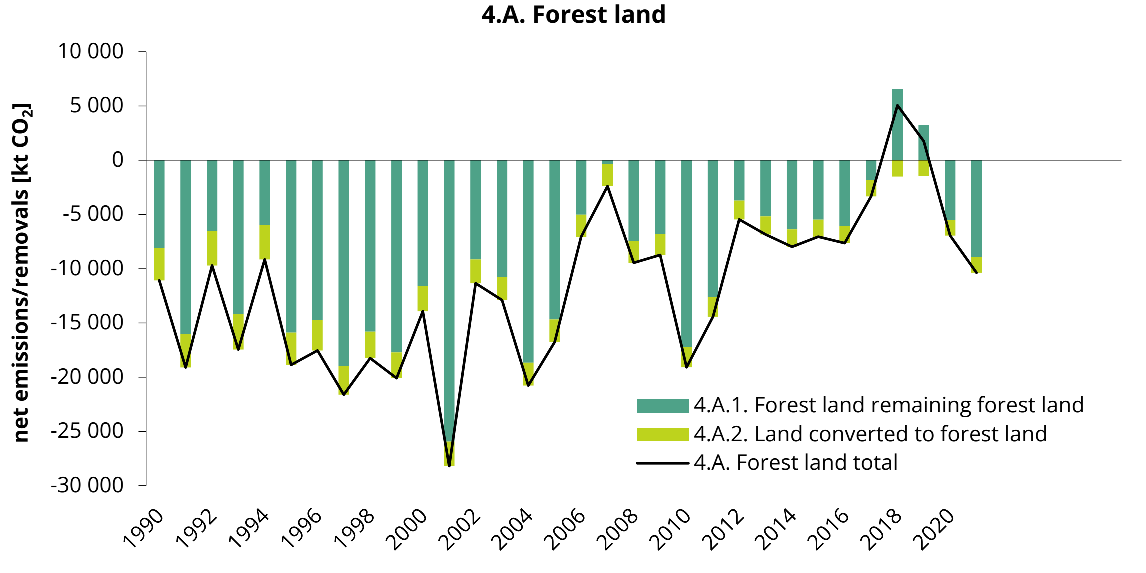
The annual net CO_2 results under sector *4.A* of the reported period 1990–2021 range from removals of -28 176 kt CO_2 to emissions of 5 073 kt CO_2 (mean: -11 755 kt CO_2). The most important subcategory is Forest land remaining forest land (*4.A.1*); however, land use changes to forests (*4.A.2*) and from forests (*4.B.2* to *4.F.2*) also contribute significantly to the net CO_2 balance of the LULUCF sector.

As already reported in previous submissions, changes in the Austrian forest biomass also resulted in a net carbon sink in the years before 1990. In the period 1961 to 1989 the mean annual net carbon sink amounted to 11 136 kt CO_2, with annual removals ranging from 4 324 kt CO_2 to 16 385 kt CO_2.

Between 1990 and 2021 the net carbon balance of the Forest land category ranged from being a carbon sink storing 33% of the total CO_2 equivalent emissions without LULUCF (CO_2, CH_4 and N_2O) to acting as a source and adding an additional 6% to national GHG emissions of the same year.

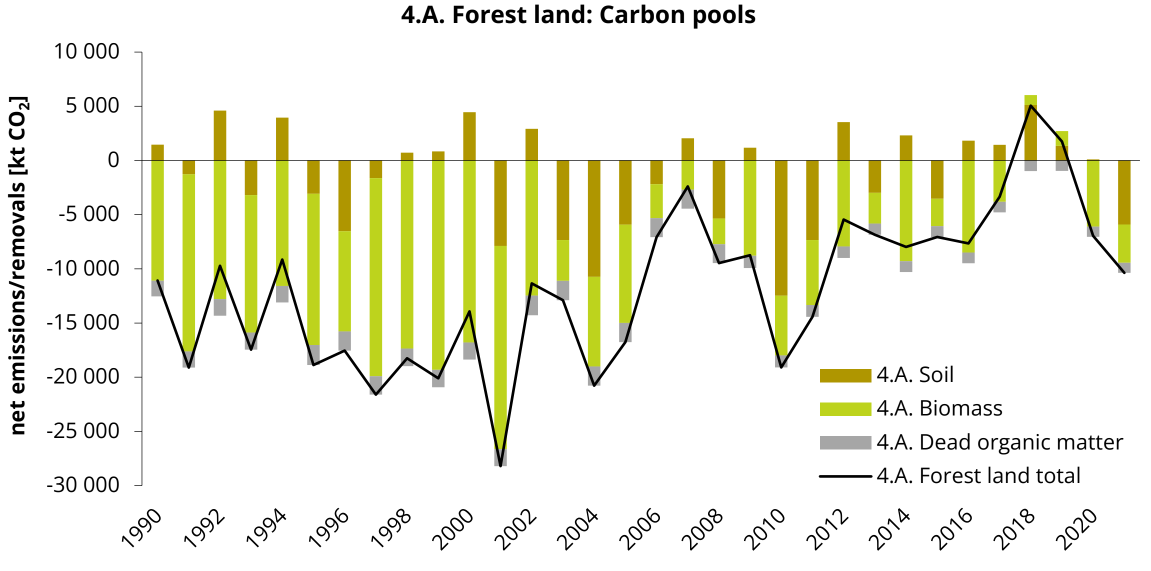
For the reported period 1990 to 2021 the total annual net CO_2 removals from land-use changes to forest range from about 1 437 kt CO_2 to 3 285 kt CO_2. The total annual emissions from land-use changes from forests (conversion of forest land) vary between 967 and 1 399 kt CO_2.

Figure 33: CO_2 removals/emissions (+/-) from IPCC Category 4.A Forest Land by forest land remaining forest land and land use change to forest land over 20 years from 1990–2021 [kt CO_2]



Source: Umweltbundesamt

Figure 34: CO_2 removals/emissions (+/-) from IPCC Category 4.A Forest Land by carbon pools from 1990–2021 [kt CO_2]



Source: Umweltbundesamt

Figure 35: Trend of total forest land and forest land remaining forest land.

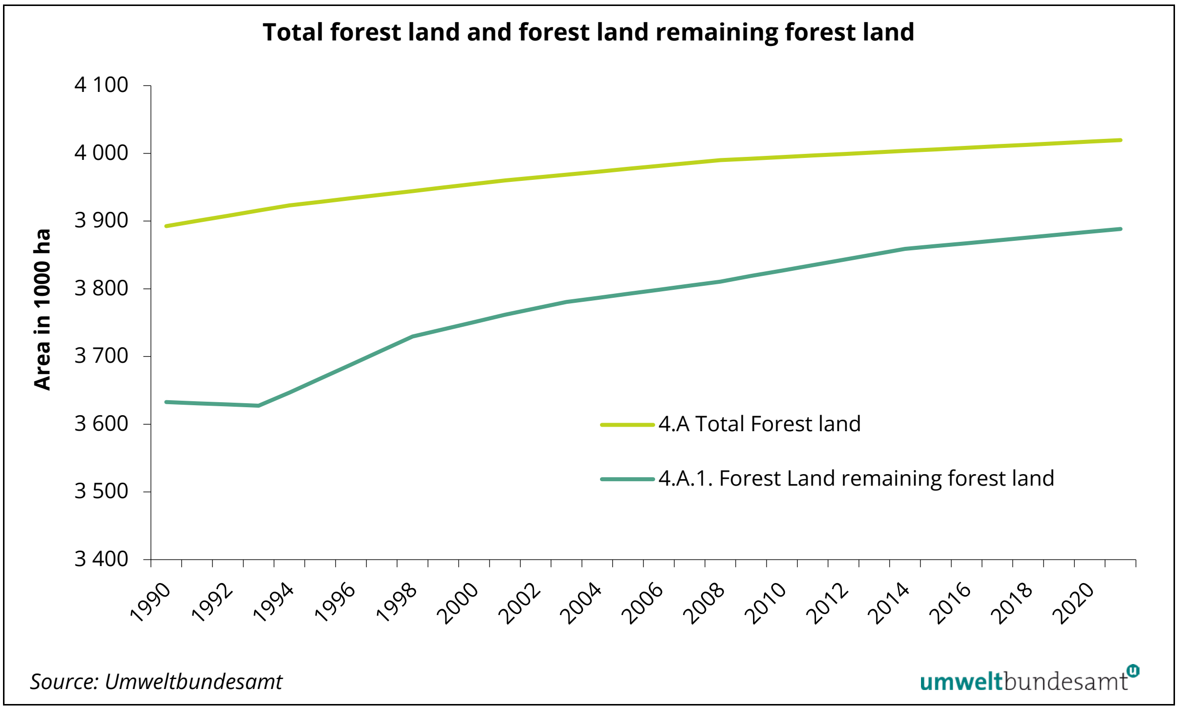
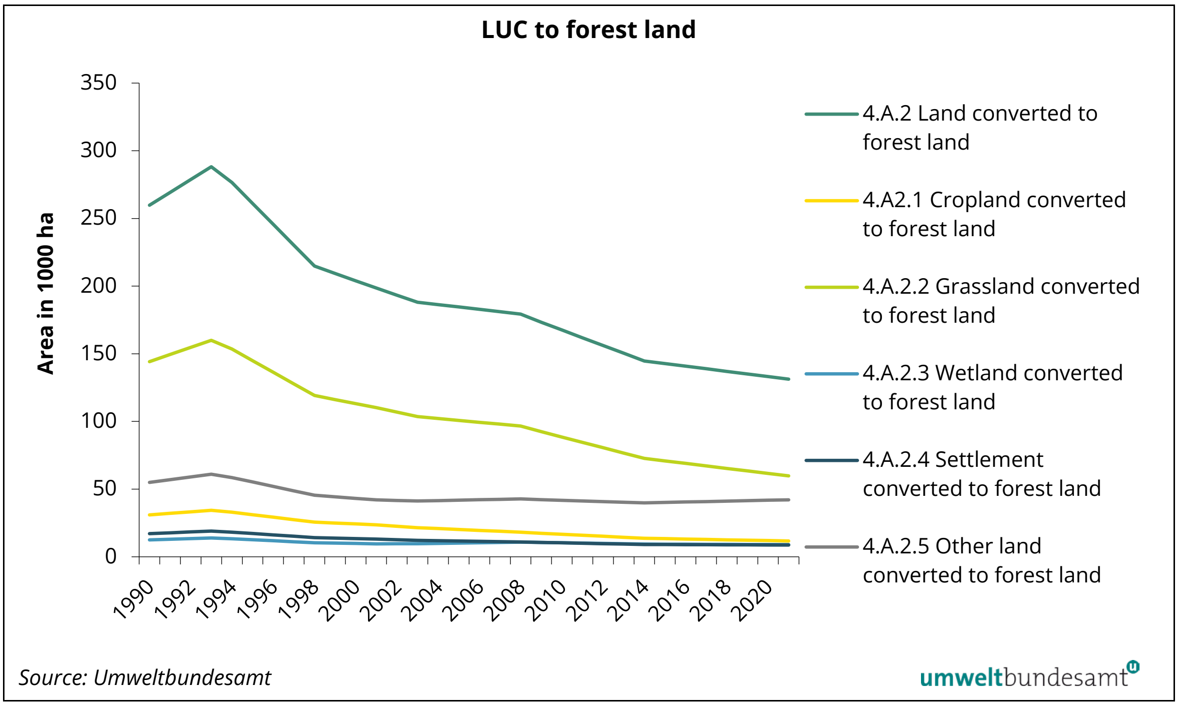


Figure 36: Trend of LUC to forest land (below) covering a conversion period of 20 years from 1990 to 2021 in 1 000 ha (Total forest land includes also forest out of yield).



The net carbon stock changes of the category *4.A* vary considerably between single years. The reason for this variation is that the figures for annual growth and for annual harvest differ significantly year by year due to variations of influencing factors on growth and harvest like weather conditions, timber demand and prices or wind throws and other natural disturbances. This leads to high yearly variations in these gross gains and losses and net changes in stocks. For example, large annual increases in the soil C pool combined with low harvest rates and high increment resulted in a strong sink of CO_2 in 2001. In contrast, very high harvest rates due to natural disturbances in e.g. 2007, 2018 and 2019 combined with net emissions out of the forest soil and low increment rates (in case of 2018 and 2019) due to the weather conditions lead to a weaker sink or even net emissions out of the Forest land category (e.g. 2018 and 2019). It should be noted that the above dyamics in the Forest land category (and the LULUCF sector as a whole), are driven mainly by the respective carbon stock changes in the subcategory 4.A.1 Forest land remaining forest land.

The variation within the net removals time trend for 4.A.2 Land converted to forest land is mainly due to the change of LUC areas and its composition of previous land use types across the time series.

Table 254: Total areas and land-use change areas of forest land (1990–2021) in kha – transition period of 20 years for LUC lands.

	4.A Total Forest land	4.A.1. Forest Land remaining forest land	4.A.2 Land converted to forest land	4.A2.1 Cropland converted to forest land	4.A.2.2 Grassland converted to forest land	4.A.2.3 Wetland converted to forest land	4.A.2.4 Settlement converted to forest land	4.A.2.5 Other land converted to forest land
1990	3 893	3 633	260	31	144	13	17	55
1991	3 900	3 631	269	32	149	13	18	57
1992	3 908	3 629	279	33	155	13	18	59
1993	3 916	3 627	288	34	160	14	19	61
1994	3 923	3 647	277	33	153	13	18	59
1995	3 928	3 667	261	31	145	13	17	55
1996	3 934	3 688	246	29	136	12	16	52
1997	3 939	3 709	230	27	128	11	15	49
1998	3 944	3 730	215	26	119	10	14	45
1999	3 950	3 740	209	25	116	10	14	44
2000	3 955	3 751	204	24	113	10	13	43
2001	3 960	3 762	199	24	110	10	13	42
2002	3 964	3 771	193	23	107	10	13	42
2003	3 969	3 781	188	22	104	10	12	41
2004	3 973	3 787	186	21	102	10	12	42
2005	3 977	3 793	185	20	101	10	12	42
2006	3 981	3 799	183	20	99	10	11	42
2007	3 986	3 805	181	19	98	11	11	42
2008	3 990	3 811	179	18	97	11	11	43
2009	3 992	3 819	173	17	92	11	11	42
2010	3 994	3 827	168	17	88	10	10	42
2011	3 997	3 835	162	16	85	10	10	41
2012	3 999	3 843	156	15	81	10	10	41
2013	4 001	3 851	150	14	77	10	9	40
2014	4 004	3 859	145	14	73	9	9	40
2015	4 006	3 863	143	13	71	9	9	40

	4.A Total Forest land	4.A.1. Forest Land remaining forest land	4.A.2 Land converted to forest land	4.A2.1 Cropland converted to forest land	4.A.2.2 Grassland converted to forest land	4.A.2.3 Wetland converted to forest land	4.A.2.4 Settlement converted to forest land	4.A.2.5 Other land converted to forest land
2016	4 008	3 867	141	13	69	9	9	40
2017	4 010	3 872	139	13	67	9	9	41
2018	4 013	3 876	137	13	65	9	9	41
2019	4 015	3 880	135	12	63	9	9	41
2020	4 017	3 884	133	12	62	9	9	42
2021	4 020	3 888	131	12	60	9	9	42

Table 255: CO_2 removals/emissions (+/-) from IPCC Category 4.A Forest Land from 1990–2021 kt CO_2 and CO_2 equiv.).

	4.A Total Forest land_CO_2	4.A.1. Forest land remaining Forest land_CO_2	4.A.2. Land converted to Forest land_CO_2	4.A.2.1 Cropland converted to Forest land_CO_2	4.A.2.2 Grassland converted to Forest land_CO_2	4.A.2.3 Wetlands converted to Forest land_CO_2	4.A.2.4 Settlements converted to Forest land_CO_2	4.A.2.5 Other Land converted to Forest land_CO_2	4(III)A2_N_2O emissions due to C losses in managed soils_N_2O in CO_2eq	4(IV)A2_N_2O emissions from N leaching and runoff_N_2O in CO_2eq	4(V)A1_Biomass burning wildfires_CO_2	4(V)A1_Biomass burning wildfires_CH_4 in CO_2eq	4(V)A1_Biomass burning wildfire_N_2O in CO_2eq
1990	-11 078	-8 122	-2 957	-412	-985	-88	-325	-1 146	27	3.050	IE	0.521	0.273
1991	-19 110	-16 043	-3 066	-427	-1 022	-92	-337	-1 189	28	3.161	IE	0.138	0.072
1992	-9 716	-6 540	-3 175	-442	-1 059	-95	-349	-1 231	29	3.272	IE	0.344	0.180
1993	-17 453	-14 168	-3 285	-457	-1 096	-98	-361	-1 273	30	3.383	IE	0.292	0.153
1994	-9 148	-5 998	-3 150	-439	-1 050	-94	-346	-1 221	29	3.246	IE	0.151	0.079
1995	-18 865	-15 891	-2 975	-414	-992	-89	-327	-1 153	27	3.065	IE	0.083	0.044
1996	-17 540	-14 742	-2 797	-390	-933	-84	-307	-1 084	25	2.884	IE	0.076	0.040
1997	-21 609	-18 989	-2 620	-365	-873	-78	-288	-1 016	24	2.702	IE	0.052	0.027
1998	-18 250	-15 807	-2 443	-340	-814	-73	-268	-947	22	2.521	IE	0.242	0.127
1999	-20 098	-17 716	-2 382	-332	-793	-71	-262	-924	22	2.458	IE	0.021	0.011
2000	-13 928	-11 608	-2 320	-323	-773	-69	-255	-900	21	2.394	IE	0.109	0.057
2001	-28 197	-25 937	-2 259	-315	-753	-68	-248	-876	21	2.331	IE	0.063	0.033
2002	-11 348	-9 151	-2 197	-300	-726	-68	-239	-863	20	2.310	IE	0.500	0.262
2003	-12 889	-10 756	-2 133	-285	-699	-68	-230	-850	20	2.289	IE	0.477	0.250
2004	-20 778	-18 668	-2 110	-276	-686	-70	-225	-853	20	2.309	IE	0.044	0.023
2005	-16 768	-14 683	-2 086	-267	-672	-72	-220	-855	20	2.329	IE	0.081	0.042
2006	-7 075	-5 013	-2 061	-258	-657	-73	-215	-857	21	2.349	IE	0.193	0.101
2007	-2 401	-364	-2 037	-249	-643	-75	-210	-860	21	2.369	IE	0.096	0.050
2008	-9 465	-7 452	-2 013	-240	-629	-76	-206	-862	21	2.390	IE	0.130	0.068
2009	-8 742	-6 801	-1 941	-228	-599	-75	-199	-840	20	2.319	IE	0.146	0.076
2010	-19 097	-17 223	-1 873	-218	-570	-73	-192	-820	20	2.252	IE	0.128	0.067
2011	-14 426	-12 620	-1 806	-207	-542	-72	-186	-800	19	2.185	IE	0.115	0.060
2012	-5 459	-3 720	-1 739	-196	-513	-71	-179	-780	19	2.118	IE	0.143	0.075
2013	-6 852	-5 180	-1 672	-185	-484	-69	-173	-760	18	2.052	IE	0.236	0.123
2014	-7 982	-6 378	-1 604	-174	-456	-68	-166	-741	17	1.985	IE	0.146	0.077
2015	-7 056	-5 476	-1 581	-169	-442	-68	-164	-738	17	1.963	IE	0.361	0.189

	4.A Total Forest land_CO_2	4.A.1. Forest land remaining Forest land_CO_2	4.A.2. Land converted to Forest land_CO_2	4.A.2.1 Cropland converted to Forest land_CO_2	4.A.2.2 Grassland converted to Forest land_CO_2	4.A.2.3 Wetlands converted to Forest land_CO_2	4.A.2.4 Settlements converted to Forest land_CO_2	4.A.2.5 Other Land converted to Forest land_CO_2	4(III)A2_N_2O emissions due to C losses in managed soils_N_2O in CO_2eq	4(IV)A2_N_2O emissions from N leaching and run-off_N_2O in CO_2eq	4(V)A1_Biomass burning wildfires_CO_2	4(V)A1_Biomass burning wildfires_CH_4 in CO_2eq	4(V)A1_Biomass burning wildfire_N_2O in CO_2eq
2016	-7 646	-6 089	-1 557	-164	-427	-68	-163	-734	17	1.941	IE	0.050	0.026
2017	-3 344	-1 810	-1 534	-160	-413	-68	-161	-731	17	1.919	IE	0.094	0.049
2018	5 056	6 566	-1 510	-155	-399	-68	-159	-728	17	1.896	IE	0.180	0.094
2019	1 753	3 239	-1 486	-150	-385	-68	-157	-725	16	1.874	IE	0.107	0.056
2020	-6 954	-5 493	-1 461	-145	-370	-68	-156	-722	16	1.852	IE	0.172	0.090
2021	-10 375	-8 938	-1 437	-141	-356	-68	-154	-719	16	1.830	IE	0.477	0.250

6.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The information on forest area is based on data of the Austrian National Forest Inventory (NFI – BFW 2022; GSCHWANTNER et al. 2010, SCHIELER et al. 1995; WINKLER 1997)). The NFI was carried out in the periods 1961–70. 1971–80, 1981–85, 1986–90. 1992–96, 2000–02, 2007–09 and 2016-21 covering the total forest area.

The NFI uses a permanently 4 x 4 km grid across all of Austria with four permanent sample plots of 300 m^2 size at each grid point. The NFI provides representative and systematically measured data for the total Austrian forest area and for all Austrian areas of LUCs from and to forests. This includes the areas of the complete category *4.A* and the areas of the subcategories *4.B.2.1*, *4.C.2.1*, *4.D.2.1*, *4.E.2.1* and *4.F.2.1*. The NFI grid covers the whole area of Austria and provides measured data on the total Austrian forest area with a statistical error of ±1.2% (see BFW 2022). Each grid point is terrestrially inspected during each NFI assessment for a potential af-/reforestation except grid points that are not suited to forest cover (e.g. grid points at glaciers or at permanent surface water bodies).

Due to its representativeness and coverage, the NFI data allow an unbiased reporting of the complete Austrian forest area and its change by LUCs from and to forests.

The NFI assessments related to the UNFCCC-reporting-period were carried out so far in the periods 1986/90, 1992/96, 2000/02, 2007/09, 2016/21. The forest areas measured for these periods were located in the mean year of the NFI measurement period and the areas for the other years were estimated by linear interpolation.

6.2.2.1 Methods used to derive annual data of FL remaining FL on the basis of the existing NFI datasets

The NFIs provide for each NFI period data on the area of productive forests and non-productive forests (forests not in yield) – those sum up to the total forest area in Austria and represent averages for the NFI assessment period.

By linear interpolation (area according to NFI is located in the mean year of NFI measurement period) annual figures for these areas are estimated. Furthermore, the NFIs provide information on the ratio of area covered by coniferous and deciduous trees.

The calculation of the annual data for **FL remaining FL** is then based on the following data (all based on NFI assessments), steps and considerations:

1. Total annual area of productive forests (forests in yield) is reduced by the area of LUC to productive FL over the previous 20 years (as sum of 20 years LUC transition period). For 1990: 3 169 kha. This is the sum of the figures of 1.1.a and 1.1.b in Table 251.
2. The result of step 1 is then split according to the area-distribution of coniferous and deciduous trees. e.g. for 1990: coniferous 2 432 kha + deciduous 737 kha = 3 169 kha (see Table 251 and CRF table).
3. LUC to forests not in yield also takes place and is assessed by the NFIs and after 20 years of transition period those areas are considered as FL remaining FL. Analogous to step 1, the total annual area of forests not in yield is reduced by the total area of LUC to forests not in yield. For 1990: 463 kha (see 1.1.c in Table 251).
4. Total forest land remaining forest land in CRF table is the sum of step 1 and 3 (For 1990 3 633 kha).

The result of step 4 and the total 20 year LUC to forest land sum up to the total forest area according to NFI (e.g. in 1990: 3 633 kha + 260 kha = 3 893 kha).

In previous submissions, the calculations of C-losses and C-gains for FL remaining FL considered only forest in yield. The NFI 2007/09 carried out for the first time an assessment of the standing stocks in the forests not in yield. The subsequent NFI 2016/21 carried out a re-assessment of these stocks, and these data (together with model simulations of net biomass and deadwood stock changes over the complete time series) became available in 2022. Therefore C-stock changes in forests not in yield are now included for the first time in the current submission.

6.2.2.2 Estimation of the annual LUC from and to FL and their splitting into the different subcategories

Total LUC areas to and from forests are available from the individual NFIs, whereby a division of these areas by the respective NFI assessment period leads to data for the annual LUCs. For years after the latest NFI, annual LUC areas calculated from the last inventory are assumed to occur in the subsequent years.

The specific shares of individual land use categories of these LUCs were assessed in the NFIs 2000/02 and 2007/09 and in the NFI 2016/21 (which cover the observation periods between the years of the NFI periods 1992/96 to 2000/02. 2000/02 to 2007/09 and 2007/09 to 2016/21). Due to a lack of data, relative distributions of the total LUC areas into the LUC sub-categories pre-1994 were assumed to be the same as those reported between NFI 1992/96 and 2000/02. In case a land use change has been observed at an inventory point of the NFIs, the type of the non-forest land was recorded. The various past/previous LU categories as assessed by the NFI were aggregated according to the IPCC 2006 Guidelines LU categories (Table 256).

In the years 2011 to 2013 a reduced ARD NFI was carried out only at all NFI plots which had land-use change activities to/from forests.With the ARD NFI 2011/13 also a thorough inspection of all land-use change areas to/from forests was carried out for the appropriateness of such a classification as land-use change areas. Areas previously accounted as land-use change areas due to:

- measurement or assessment errors,

- different classifications for unchanged plots by different NFI inspection teams in different NFIs,
- short time oscillations in activities below the legal time frames for accounting as afforestation or deforestation

could be identified and were deleted as land-use change areas to/from forests.

The latest full-scale NFI, carried out from 2016 to 2021, delivered more precise data on LUC to and from forest land than its reduced predecessor (ARD NFI 2011/13) because all grid points were sampled instead of only those where land use changes were expected. Therefore the new data replaces the results from ARD NFI 2011/13 entirely, including the assessment of biomass and dead wood stock changes on land-use change areas, which were resampled in the 2016/21 NFI with more accurate results on the biomass and deadwood stock changes on these areas. The new per ha data on drain, increment dead wood stock changes on land-use change areas serves as basis for the calculation of biomass and dead wood stock changes occurring through LUC from and to forest, which are applied across the whole time series.

Table 256: LU-classification systems (IPCC 2006 Guidelines and NFI 2000/02, 2007/09 and NFI 2016/21).

Land use categories in the IPCC 2006 GL	**LU classifications for LUC from and to forests according to the NFI (2000/02, 2007/09 and NFI 2016/21)**
Cropland	Annual cropland Perennial cropland Fallow, agricultural land
Grassland	Grassland (intensive. extensive use) Pastures (incl. slopes)
Wetlands	Water bodies Bogs, peatland Reed area
Settlements	Industry, mining Traffic area Landfills, dumps Urban, residential zone
Other land	Unmanaged alpine dwarf shrub heaths Scree Rock Others

Table 257: Land use changes to forest (% and ha) observed from 1990 to 2021 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and 2016/21; based on BFW 2022).

Categories of land use changes according to the IPCC 2006 GL	**1990 – NFI 1992/96**		**NFI 1992/96 – NFI 2000/02**		**NFI 2000/02 – NFI 2007/09**		**NFI 2007/09 – NFI 2016/21**	
	LUC to forest land (%)	**LUC to forest land [1 000 ha]**	**LUC to forest land (%)**	**LUC to forest land [1 000 ha]**	**LUC to forest land (%)**	**LUC to forest land [1 000 ha]**	**LUC to forest land (%)**	**LUC to forest land [1 000 ha]**
Cropland (4.A.2.1)	11.9	6.9	11.9	6.5	6.2	3.4	10.9	6.7
Grassland (4.A.2.2)	55.5	32.0	55.5	30.1	50.2	27.8	42.2	25.8
Wetlands (4.A.2.3)	4.8	2.8	4.8	2.6	8.7	4.8	5.5	3.4
Settlements (4.A.2.4)	6.6	3.8	6.6	3.6	5.0	2.8	7.8	4.8
Others (4.A.2.5)	21.2	12.2	21.2	11.5	29.9	16.6	33.7	20.6
Total	**100.0**	**57.7**	**100.0**	**54.3**	**100.0**	**55.4**	**100.0**	**61.2**

Table 258: Land use changes from forest (% and ha) observed from 1990 to 2021 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and 2016/21; based on BFW 2022).

Categories of land use changes according to the IPCC 2006 GL	1990 – NFI 1992/96		NFI 1992/96 – NFI 2000/02		NFI 2000/02 – NFI 2007/09		NFI 2007/09 – NFI 2016/21	
	LUC from forest land (%)	LUC from forest land [1000 ha]	LUC from forest land (%)	LUC from forest land [1000 ha]	LUC from forest land (%)	LUC from forest land [1000 ha]	LUC from forest land (%)	LUC from forest land [1000 ha]
Cropland (4.A.2.1)	6.2	1.2	6.2	1.1	6.1	1.6	2.7	1.0
Grassland (4.A.2.2)	49.0	9.5	49.0	8.5	56.7	14.5	45.0	16.8
Wetlands (4.A.2.3)	2.6	0.5	2.6	0.4	2.2	0.6	6.7	2.5
Settlements (4.A.2.4)	14.8	2.9	14.8	2.6	20.0	5.1	13.9	5.2
Others (4.A.2.5)	27.4	5.3	27.4	4.7	15.0	3.8	31.7	11.8
Total	**100.0**	**19.4**	**100.0**	**17.3**	**100.0**	**25.6**	**100.0**	**37.3**

As shown in Table 257 and Table 258 the land use changes to and from forests mainly appear to be from/to grassland sites (42–56% or 45–57%, respectively).

For the years 1994 back to 1970 it was assumed that the measured land use changes between two previous NFI periods show the same ratio of distribution between land use change subcategories as between the NFI periods 1992/96 to 2000/02. For the NFI periods 1986/90 and 1992/96 the total areas of LUC to forests and the total areas of LUC from forests are available, but no further distribution into the different LUC subcategories. So, the ratios of change areas from and to FL from/to individual land use categories according to NFI 2000/02 results could be applied directly to split the total LUC areas between NFIs 1986/90 and 1992/96 into the LUC categories. For the years from 1983 back to 1970 (NFIs before NFI 1986/90) only the net changes of the total forest area according to these older NFIs (1961/70. 1971/80. 1981/85) is available. These figures on the net forest area changes plus the information on LUC areas from/to forest according to the more recent NFIs were used to estimate the LUC areas from and to forests for these years: It was assumed that the detected net forest area changes between two NFI periods are based on the same ratio in LUC distribution (LUC to forests vs. LUC from forests) as between the more recent NFI periods. The ratio was always related to the total net increase or loss of forest area between two consecutive previous NFIs. The subsequent classification of the total LUC to/from forest between the LUC sub-categories again assumed the same distribution as between the NFI period 1992/96 to 2000/02. Thus, also for the years from 1983 back to 1970 annual LUC areas from and to forest could be estimated.

Land-use change areas are in the LUC subcategory for a transition period of 20 years starting 20 years before 1990. It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods. The reason for this is that the average annual LUC area within a NFI observation period can be assessed with sufficient accuracy but not the specific LUC area of single years of the observation period. Interpolations across NFI periods would thus be unsuitable. In contrast to earlier submissions, the calculation of emissions/removals from LUC from and to forest was changed this year because the new increment and drain data from land-use change sites was derived by observing the stock changes in biomass and dead wood that occurred over a period of 10 years. To accommodate this, LUC areas in transition have been split into two categories – short-term and long-term LUC – and multiplied with the respective average annual growth and harvest rates that were observed during the NFI 2016/21. As a consequence the stepwise changes in the emissions/removals from LUC to and from forest land seen in earlier submissions are smoothed over.

For the estimates of changes in litter and soil carbon stocks, the LUC area was further stratified according to five forest growth regions (Bohemian Massif, Inner Alps, Calcareous Alps, Foothills and Alpine ridge). The area information for these LUC is also based on the results of NFI 2000/02, NFI 2007/09 and NFI 2016/21. The results are finally summed up according to the areas of LUC as shown in Table 257 and Table 258. The specific carbon stocks for litter and soil for each forest growth region are shown in Table 269.

6.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The National Forest Inventory (NFI) of Austria is the main data provider for estimating the GHG balance of the Forest land category. Consequently, and for reasons of consistency, the applied forest definition for the reporting follows the definition used within the NFI. The selected parameters are:

- Minimum land area: 0.05 ha;
- Minimum crown cover: 30% (*in situ*. i.e. potential of the standing stock to reach this threshold);
- Minimum height: 2 m (*in situ*. i.e. potential of the standing stock to reach this threshold);
- Average width of forest area more than 10 m.

Permanently unstocked areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forest hauling systems, wood storage places, forest glades, forest roads) also represent forests. However, areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards, christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut are not accounted as forests but rather perennial cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not categorised as forests, but rather the land use category to which they belong (e.g shelter belts in cropland, woody plants in parks in settlements).

6.2.4 Methodological Issues

6.2.4.1 Forest Land remaining Forest Land (4.A.1)

6.2.4.1.1 Biomass

The country-specific method for estimating GHG emissions/removals from sector *4.A.1 Forest land remaining forest land* closely follows the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. The use of country specific conversion factors and biomass functions for tree branches, needles and below ground biomass provide more accurate and appropriate figures for Austrian forests. The main basis of the estimates are measured data for the forest area, stemwood volume increment and drain (harvest and other losses) of the growing stock (for both stemwood over bark with a diameter at breast height > 5 cm) according to the Austrian National Forest Inventory (NFI – (BFW 2022; BFW 2011a; GSCHWANTNER et al. 2010. SCHIELER et al. 1995; WINKLER 1997)). The NFI was carried out in the periods 1961–70, 1971–80, 1981–85, 1986–90, 1992–96, 2000–02, 2007–09 and 2016-21.

The NFI provides mean values for annual increment and drain between individual NFI observation periods. Each inter-inventory period spans the midpoint of one inventory to the midpoint of the next inventory e.g. 2001 to 2008 is the period between NFI 2000-02 and NFI 2007-09. However, rather than assume a constant average annual drain and a constant annual increment between inventory periods, relative indices[101] are used to distribute NFI drain and increment more realistically between the years based on national harvest statistics and relative increment indices based on tree ring analyses. For the period 2009-2020 the relative indices had not been applied to the drain in previous submissions, but for this report the time series was updated with the final results of the NFI 2016/21, which became available in 2022.

In addition to the NFI drain data, which are based on measurements in the forests, further harvest statistics exist (Table 259): the annually reported records of timber harvest (BMLRT 1964–2022) and the Austrian wood balance (BMK 2021). While it is assumed that the NFI provides more accurate figures on the total stemwood drain between inventories, the annually reported records of timber harvest are used to derive annual "relative harvest indices" for individual years (see below). For the corresponding inter-inventory period, the annual indices are calculated from proportional deviation of annual timber harvest values from their respective mean annual timber harvest for the inter-inventory (observation) period. The annual average drain from the NFI for the inter-inventory period is therefore adjusted by multiplying by the annual harvest index. In the same fashion, representative Austrian sets of tree ring cores (BFW 2022a, pers. comm.) are used to calculate the relative indices for distribute the average NFI increments over the years of the time series.

Table 259: Overview of the different harvest statistics in Austria.

Statistics	Characteristics/methodological approach	Units of drain or harvested wood
NFI – national forest inventories	Uses permanently marked grid (4x4 km) all over Austria, periodical investigation of sampling sites; measurements of increment and total stemwood drain (and other parameters) at permanent sampling plots in the forest.	m^3 total stemwood over bark
National annual records of timber harvest (HEM)	No measured data, annual reporting on wood disposal and wood going into self-consumption, declaration provided by forest authorities, wood from non-forest soils is not included; there is some underestimation of harvest in small-sized forest (private owners).	m^3 extracted stemwood under bark
National wood balance (HB)	No measured data, calculations based on NFI and HEM; includes also wood from non-forest areas and takes more possible and suspected domestic wood sources than HEM into account. available for specific years	m^3 extracted stemwood under bark

The above methods allow accurate estimates for individual years for the category *4.A.1* (Table 260). The figures for annual growth and for annual drain, and thus carbon stock changes, may differ significantly year by year and outliers exist (e.g. very low increment in 2003, 2013, 2015, 2018 and 2019; very high harvest rates in 2007 and 2008 due to natural disturbances). Several reasons influence the factors on growth and drain differences like weather conditions, timber demand and prices, and forest disturbances such as windthrows and bark beetle infestations. Such reasons for

[101] Values for the relative variation in the individual years of the time series

different growth and different drain in individual years explain the high annual variations in the CO_2 net removals by Austrian forests.

Note however that since 2020, constant average annual increment and preliminary annual drain values have been reported (extrapolation based on the latest NFI increment and drain). Once the next NFI data is available, the average annual increment and drain values from 2020 onwards will of course be replaced and adjusted by the respective relative indices.Table 260:Increment and drain in the Austrian forests on basis of NFIs and interpolated on basis of relative indices[102]. The bold and non-bold font indicate to which NFI observation period the average and annual increment and drain figures belong.

Year	Average annual increment according to NFI 1000 m³ o.b	annual increment interpolated on basis of indices 1000 m³ o.b.	average annual drain according to NFI 1000 m³ o.b	annual drain interpolated on basis of indices 1000 m³ o.b.
1985	**31416**	**32243**	**19846**	**19358**
1986		**30314**		**20201**
1987		**31416**		**19583**
1988		**31416**		**21275**
1989		30450		20265
1990		28513		23034
1991	27337	27241	19521	16849
1992		25448		17958
1993		25303		17969
1994		27067		21052
1995		**28976**		**18461**
1996		**26463**		**20071**
1997	**31255**	**33805**	**18797**	**19690**
1998		**32173**		**18766**
1999		**33968**		**18832**
2000		**30738**		**17752**
2001		**32663**		**18007**
2002		31343		21166
2003		26818		24317
2004		30055		23500
2005	30371	30748	25888	23483
2006		29361		27281
2007		31904		30395
2008		32367		31076
2009		**31046**		**24448**
2010		**29651**		**26059**
2011		**31522**		**27324**
2012		**32315**		**26338**
2013		**26955**		**25415**
2014	**29227**	**32251**	**26016**	**24975**
2015		**26924**		**25649**
2016		**30951**		**24499**
2017		**28192**		**25791**
2018		**26289**		**28049**
2019		**25401**		**27628**

[102] Please note that these increment and harvest rates do not represent those for "FL remaining FL", but those for "FL remaining FL" plus all subcategories of LUC from and to FL due to the Austrian-wide assessment of the NFIs.

Year	Average annual increment according to NFI 1000 m³ o.b	annual increment interpolated on basis of indices 1000 m³ o.b.	average annual drain according to NFI 1000 m³ o.b	annual drain interpolated on basis of indices 1000 m³ o.b.
2020		29227		24811
2021		29227		27221

Given the coverage of the NFI, increment and drain data from the NFI are the result of all possible reasons for biomass additions to- and losses from Austrian forests. This means that changes in the total standing forest stock due to land use changes, re-growth by forests, traditional (non-commercial) fuel wood consumption, forest land conversion, mortality, forest fires (wild-fires) and other damages are represented in the NFI increment and drain data.

In order to fulfil the requirements of the reporting format and to report on the category *4.A.1 Forest land remaining forest land*, estimates of emissions and removals from biomass with a DBH ≥ 5cm due to annual land use changes from and to forests are subtracted respectively from the total increment and drain of biomass according to the NFI. The approaches for calculating CO_2 emissions and removals related to land use changes are described in chapter 6.2.4.2. This steps thus provides with respective increment and drain in biomass of the Forest land remaining forest land area that are in yield.
For forests not in yield, biomass carbon stock changes were previously not estimated and reported under Forest land remaining forest land. For this 2023 submission, a method was developed to estimate net biomass stock changes back to 1990 based on the NFI 2016/21, which for the first time sampled the above-ground biomass and deadwood stocks in forests not in yield. The simulations were carried out by the Austrian Federal Research Centre for Forests. For each of these sampled plots, the trees were grouped into 12 species-DBH classes (4 species groups x 3 DBH classes). For each of these classes, parameters describing mortality and harvest were derived based on sampling of *minimally managed protective forests in yield* in the last five NFIs (NFI 1992/96 to 2016/21). In terms of growth, mortaility and harvest, this subsets of forests in yield were considered as very similar to forests not in yield. Based on these mortality and harvest rates for each of the species-DBH class, new trees are simulated to appear on the plots in each of the previous years back to 1989. The dimensions of the newly-appearing trees, were derived from at random from the sample trees in the respective species-DBH class. For past growth, rates of diameter and height growth were derived, again based on the sampling of *minimally managed protective forests in yield* in the last five NFIs. With these rates, the declining dimensions of the standing trees (trees sampled in the plots as well as trees that appear in previous years though the mortalility simulations) back in time were simulated. Based on the above gain and drain simulations, a time series of average per ha net biomass stock change (volume) of these forests was derived for the time series 1990-2021. Multiplication with respective wood densities, biomass expansion factors and carbon contents, and area of *Forest not in yield remaining forest not in yield* (all from the NFI) allowed conversion of the stock change units to kt C.

Wood densities

Shrinkage values, wood densities (absolute dry mass (dm)) and C contents for all tree species in Austria are used to convert the increment and drain of m³ stemwood over bark (o.b.) which is measured by the NFI into t carbon increment and t carbon drain of the stemwood o.b. The mean wood densities according to Table 261 represent aggregated values on basis of the species composition of increment and drain in Austria (see example in Table 262 for last two NFIs) and on country specific values for the shrinkage and wood densities for all individual tree species (Austrian Standard ÖNORM B3012). These conversion factors are calculated for each inventory period and separately for increment and drain respectively. Between the inventories they show only minor differences (< 1%) because the shares of the tree species change very slowly.

Further details on the approach and methodology are given in (UMWELTBUNDESAMT 2000a).

Table 261: Conversion factors for the stemwood o.b. of the Austrian forests; mean of several NFIs (UMWELTBUNDESAMT 2000a. updated).

Conversion factors	Coniferous	Deciduous
m^3 o.b. to t dm (stemwood)	0.38	0.54
t dm to t C (stemwood)	0.50	0.48

Table 262: Share of tree species in total stemwood increment and drain of the NFIs 2007/09 and 2016/21. (BFW 2022).

Tree species	% in total increment NFI 07/09	% in total drain t NFI 07/09	% in total increment NFI 16/21	% in total drain NFI 16/21
spruce	66.4	68.7	64.5	67.0
fir	4.2	4.0	4.0	4.0
larch	3.9	4.0	4.4	3.9
pine (pinus sylvestris)	4.0	6.3	4.5	6.6
pine (pinus nigra)	0.2	0.6	0.6	0.6
pinus cembra	0.2	0.1	0.2	0.1
weymouth pine (pinus strobus)	0.0	0.0	0.0	0.0
douglas fir	0.1	0.0	0.3	0.1
Total coniferous	**79**	**84**	**79**	**82**
beech (fagus sylvatica)	9.1	6.8	9.4	6.6
oak	2.2	2.2	2.4	1.6
hornbeam	0.8	0.5	0.9	0.8
ash	2.7	1.2	2.0	2.7
maple	1.4	0.7	1.8	0.7
elm	0.2	0.2	0.2	0.2
chestnut	0.2	0.2	0.1	0.2
robinia	0.3	0.3	0.3	0.4
sorbus, prunus	0.3	0.3	0.5	0.4
birch	0.7	0.9	0.7	0.8
alder	1.3	1.3	1.0	1.5
lime tree (Tilia)	0.4	0.2	0.4	0.2
poplar (Populus alba, Populus tremula)	0.5	0.5	0.6	0.6
poplar (Populus nigra. populus canadensis)	0.4	0.8	0.4	0.6
willow (Salix)	0.4	0.4	0.4	0.4
Total decidous	**21**	**16**	**21**	**18**
Total	**100**	**100**	**100**	**100**

Biomass functions (BF)

The increment and drain of the other tree compartments (branches, needles, roots) are estimated with the help of biomass functions (BF, Table 263:) and C contents for these tree compartments (coniferous: 0.47, deciduous: 0.48). The biomass functions were derived with the help of numerous single tree data from Austrian forest sites (see literature given below). Biomass functions as listed in Table 263: are applied to each single tree at the NFI plots of each NFI period to derive increment and drain of branches and roots of these trees. Only the evergreen biomass is estimated (leaves of deciduous trees become part of the soil C pool within one year).The compiled results for each tree species are further extrapolated to the total Austrian (productive) forest. These estimates are also carried out at the Austrian Federal Research Centre for Forests.

Table 263: Used biomass functions.

Tree species	Tree parts	Input parameter	Literature
Norway spruce (Douglas fir and other coniferous species than listed below)	Branches, needles	Dbh, height, crown ratio	(ECKMÜLLNER 2006)
Fir	Branches, needles	Dbh, crown ratio	(LEDERMANN & NEUMANN 2006)
Pine	Branches. needles	Dbh, height, crown ratio	(ECKMÜLLNER 2006)
Larch	Branches	Dbh, height, crown ratio	(RUBATSCHER et al. 2006)
Beech	Branches	Dbh, crown ratio	(LEDERMANN& NEUMANN 2006)
Oak	Branches	Dbh, crown ratio	(LEDERMANN& NEUMANN 2006)
Oak (coppice)	Branches	Dbh, crown ratio	(HOCHBICHLER et al. 2006)
Hornbeam	Branches	Dbh, crown ratio	(LEDERMANN& NEUMANN 2006)
Ash	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Other hardwood deciduous species	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Poplar	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Other weed tree species	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
All	Roots	Dbh, age	(WIRTH et al. 2004). (OFFENTHALER & HOCHBICHLER 2006)

On basis of the results of these biomass functions the average biomass expansion ratios according to Table 264 for total tree biomass/stemwood biomass were derived. The aggregated expansion factors in Table 264 are not used for the estimates but are provided as additional information for transparency reasons and to allow comparisons.

Table 264: Average expansion ratios total tree biomass/stemwood biomass for the Austrian forests for the period 1990–2008. Aggregated values derived from the single NFI tree data on basis of the applied biomass functions (based on BFW 2011b, pers. comm.).

Expansion ratio t dm stemwood → t dm whole tree (incl. also below ground biomass)	Coniferous	Deciduous
increment	1.62	1.63
drain	1.60	1.59

The resulting mean annual biomass increments and drain of the other tree biomass compartments (needles. branches. roots) for the individual NFI periods are converted to figures for single years in the same way as described above for stemwood (i.e. using the relative increment and harvest indices).

6.2.4.1.2 Dead wood

The estimates on C-stock changes in dead wood include only standing dead wood, because any falling dead tree (part) is accounted for as a C flux to litter/soil in the modeling of the litter/soil C stock changes (see chapter 6.2.4.1.3.). Since national data on the stock of dead wood are available from the NFI a Tier 3 method was applied.

Based on the data of the NFI the stock of dead wood (on average of all tree species) for the total forest area is 4.5 m^3 ha^{-1} for the inventory period 1992/96, 6.1 m^3 ha^{-1} for the inventory period 2000/02, 8.4 m^3 ha^{-1} for the inventory period 2007/09 and 9.7 m^3 for the inventory period 2016/21. Between the two periods 1986/90 to 1992/96 an increase of 10% of dead wood is estimated.

Based on the NFI 2016/21 stock changes in dead wood are available at land use change areas from and to forests with updated values, compared to when they were first measured in the ARD NFI 2011/13 (see chapter 6.2.4.2 – Dead wood). In order to fulfill the requirements of the reporting format and to report only the category *4.A.1 Forest land remaining forest land* without any double-counting, estimates of emissions and removals from C-stock changes of dead wood due to annual land use changes from and to forests are subtracted from the totals. For the calculation of the C-stock changes the conversion factors for stemwood as shown in Table 261 were used. These conversion factors do not include any estimates for roots and branches of the dead trees. The rationale is that dead roots are already part of the soil C pool and dead trees have usually only a negligible branch mass. It was assumed that the ratio between deciduous and coniferous dead wood is equal to the deciduous/coniferous ratio of the living trees.

The above methods describe how the deadwood stock changes for forests in yield under Forest land remaining forest land were derived. For forests not in yield, deadwood carbon stock changes were previously not estimated and not reported. For this 2023 submission, a method was developed to estimate net deadwood stock changes back to 1990 based on the NFI 2016/21, which for the first time sampled the above-ground biomass and deadwood stocks in forests not in yield. From the NFI 2016/21 sampling of these areas, the ratio between the deadwood stock and the standing biomass stock was derived and used as a coefficient by which the simulations of the annual standing biomass stock was multiplied. A time series of average per ha net deadwood stock change (volume) of these forests was derived for the time series 1990-2021. Multiplication with respective wood densities, expansion factors and carbon contents, and area of Forest not in yield remaining forest not in yield (all from the NFI) allowed conversion of the stock change units to kt C.

The results of the NFIs and simulations demonstrate an increase of dead wood in Austria. While not always a major contributor to the total C-balance of Forest land and the LULUCF, the associated annual net C-stock changes, which are equivalent to removals ranging between 257 kt CO_2 and 933 kt CO_2, are nonetheless significant.

6.2.4.1.3 Litter and soil

For the submission 2023, the dynamics of soil carbon in Forest land remaining forest land (forest in yield) were estimated with the simulation model Yasso20 (see FINNISH ENVIRONMENT INSTITUTE 2022 for details and references), a more advanced version of the previously used Yasso07 (FINNISH ENVIRONMENT INSTITUTE 2011). This model was selected because it can be parameterised using data from national forest and soil inventories and is thus well-suited for such country-level applications.

Yasso simulates the stock of soil carbon, changes in this stock and the release of carbon from soil on an annual basis. It needs estimates of aboveground and belowground flux of carbon to the soil, the chemical quality of the carbon input and basic data on climate (air temperature and precipitation) to run. The core of Yasso is a soil organic matter decomposition model. It is based on field measurements in a wide range of climatic conditions and has been applied in Nordic and Central European countries and to a pan-European data set.

The model simulation for Austria was based on data from two monitoring programs, the Austrian National Forest Inventory and the Austrian Forest Soil Survey. The Austrian NFI comprises 11 000 permanent sampling plots that are located on a regular grid. The soil monitoring network is part of this grid and comprises 529 sites. Soil sampling was repeated at 130 sites within the EU wide BioSoil project and these data were used to validate the model results. Furthermore, estimated aboveground and belowground litter inputs used to drive the model were previously validated against data from Austrian long-time monitoring sites. The Yasso simulations were carried out by the Austrian Federal Research Centre for Forests, the same institution responsible for the Austrian National Forest Inventory, the Austrian Forest Soil Survey and other forest monitoring activities.

Yasso20 model simulations of annual soil carbon stocks were made for each of the NFI plots that were considered as *Forest land remaining forest land* since NFI 1986/90 (ca. 8 700 plots). In previous submissions, the simulations were only conducted for a subset of forest plots from the soil monitoring network. The start of the time series of the simulations was set at 1985 after necessary spin-up simulations starting in 1961 to achieve a relative steady state in the SOC stocks that were on average similar mean measured forest soil carbon stocks (ca. 120 t C/ha). The annual aboveground and belowground flux of carbon to the soil and the chemical quality of the carbon input were estimated, at single-tree level, on the basis of the results of the Austrian NFIs (standing stock and drain at the plots) and with allometric functions for the conversion of stemwood to total tree biomass (see chapter 6.2.4.1.1). Any litterfall, dead roots input, any harvest residues input (e.g. needles, branches, pieces of stem, stump, roots) and *fallen* dead trees were estimated for the NFI plots and were included as C flux to the litter/soil in the Yasso simulations of the soil C stock changes. Therefore, the Yasso simulations also account for any flux of dead wood to the litter/soil (e.g. falling dead trees and branches, stumps and non-extracted tree parts after harvest). To avoid any double counting all these compartments are not accounted in the estimates of the dead wood stock pool, but only the changes in standing dead wood.

A further improvement in the soil C simulations was the use of monthly air temperature and annual precipitation data to drive the model, and the use of these annual variations in soil carbon stock changes in the inventory (rather than a stable average stock change over the time series). The needed meteorological time series for each simulated NFI plot were taken from a 1 km^2 resolution weather data set[103] provided by the Austrian weather service, *Zentralanstalt für Meteorologie und Geodynamik* (ZAMG).

The output of Yasso for each NFI plot is a yearly time series of the total litter/soil C pool and its changes, which is divided into the following pools: woody matter, non-woody matter and the acid-, water-, ethanol- and insoluble fractions. Yasso does not allow distinguishing between the C stock changes in the single litter and soil horizons and instead provides totals for the litter layer C plus the soil C pool. Therefore, the total litter and soil C stock changes of the subcategory 4.A.1 Forest land remaining forest land are reported under the mineral soil C pool changes in the CRFs.

[103] https://www.zamg.ac.at/cms/de/forschung/klima/klimatografien/spartacus

Note however that this removal/emission has to be finally adjusted for soil C stock losses due potential increases in non-stocked forest land (particularly forest roads).

Forest roads and other such non-stocked land for management purposes are accounted as forest land according to the Austrian and FAO forest definitions (see chapter 6.2.3). The Austrian NFIs provide detailed information on the area of forest roads and a further specific study on forest roads in Austria was used (WINKLER 2003). The estimates give an average area of approx. 700 ha per year that is converted from stocked forests to fortified macadam or gravel forest roads in the period covered by NFIs. According to WINKLER (2003), 50% of these fortified forest roads have vegetation (beside the wheel ruts) and the other half has no vegetation. For those without vegetation, 0 t C per ha and for those with vegetation 60 t C per ha was assumed as the respective equilibrium soil C stock (0–50 cm). Assuming an average soil C stock of 130 t C per ha of productive forest, a given yearly incease in forest road area is associated with a net soil C loss of 100 t C per ha over a 20 year transition period. This approach is completely consistent with the soil C stock discounting method according to the 2006 IPCC guidelines.

Finally, it should be reiterated that the above methods were applied to estimate 4.A.1 soil carbon stock changes in forests in yield. As part of the same national study dedicated to improving Yasso simulations of forest in yield, simulations were also made for forests not in yield. It should however be noted that the above-ground biomass of these areas have only been sampled in the previous two NFI cycles, introducing substantial uncertainty into the time series of required C inputs to the soil needed to drive the model. The simulations yielded substantial temporal variations in the annual soil carbon stock changes (-1 to +2.5 t C/ha/yr), but a clear tendency of annual C stock increases across the majority of the period since 1990. Furthermore, the simulated carbon stocks were considerably higher (ca. 161 t C ha) than average forest carbon stocks for forests in yield (ca. 120 t C ha). Considering the aforementioned factors and the lack of soil C measurements in the forsts not in yield to validate these simulated stocks and stock changes, it was considered inappropriate to use these simulations in the LULUCF GHG calculations. Therefore, the soil carbon stocks of forests not in yield under 4.A.1 are considered to be in equilibrium. According to the simulated soil C stock increases for these forests, this approach represents very likely an underestimate of the related forest land sink.

6.2.4.1.4 Biomass burning

The controlled burning of managed forest is not carried out in Austria. CO_2 emissions caused by biomass burning due to wildfires are included in category *4.A.1 Forest land remaining forest land*, as already reported in previous reports. Estimates of emissions from non-CO_2 gases from this category are reported. As a result of the update to the IPCC 2006 Guidelines, a new equation (2.27) following a Tier 1 method was applied.

$$L_{fire}\ (t\ GHG) = A * M_B * C_f * G_{ef} * 10^{-3}$$

A area burnt (ha)	*C_f combustion factor*
M_B mass of available fuel, t dm ha^{-1} (Table 2.4)	*G_{ef} emission factor, g kg^{-1} dm (Table 2.5)*

Data on the annual area affected by wildfires are available for the years 1990 to 2021 from the statistics of the Ministry responsible for forestry (BML) and range between 8 and 200 ha/year. According to the references in the IPCC 2006 Guidelines a mean value of 19.8 t ha^{-1} biomass consumption was applied. This represents the product of available biomass density on the land before combustion (M_B) and the combustion factor (C_f). The emission factors (G_{ef}) for N_2O and CH_4 were taken from table 2.5 of IPCC 2006 Guidelines.

However, due to the small area concerned, the amounts of N_2O and CH_4 emissions caused by wildfires are negligible, with annual sum N_2O and CH_4 emissions ranging between 0.031 and 0.79 kt CO_2 equivalents.

6.2.4.2 Land Use Changes to Forest Land (4.A.2)

The area of conversion status is followed for 20 years, thus all LUC since 1970 are taken into consideration for the emissions time series starting 1990.

6.2.4.2.1 Biomass

Based on the results of the NFI 2016/21 the experts of the Federal Research Centre for Forests provided detailed, measured values for increment and drain at the areas of LUC to and from forests (BFW, 2022), that replaced the previously used values in this category, which were based on the ARD NFI 2011/13. The data are available for coniferous and deciduous trees (diameter at breast height (dbh) ≥ 5cm) and for two age classes of the land-use change lands (long-term ARD areas, where the LUC occurred before the previous NFI period (i.e. before 2007/09) and short term ARD areas, where the LUC occurred after the previous NFI period (i.e. after 2007/09). For the forest biomass with a dbh < 5cm the stock changes were estimated. The detailed data for biomass increment and biomass drain, stock changes respectively are summarised in Table 265 and Table 266.

Table 265: Annual biomass increment and drain (DBH ≥ 5 cm) at ARD areas.

	Biomass increment DBH ≥ 5 cm. total tree biomass (t/ha/a)		Biomass drain DBH ≥ 5 cm. total tree biomass (t/ha/a)[104]	
	coniferous	deciduous	coniferous	deciduous
long term AR areas	2.11	1.67	0.38	1.19
short term AR areas	1.06	1.05	0.00	0.00
long term D areas	0.18	0.34	0.28	0.26
short term D areas	0.17	0.12	81.15	34.31

Table 266: Annual biomass stock change (DBH < 5 cm) at ARD areas.

	Biomass stock changes DBH < 5 cm (t/ha/a)			
	Above ground		Below ground	
	coniferous	deciduous	coniferous	deciduous
long term AR areas	-0.0027	0.0276	-0.0005	0.0030
short term AR areas	0.0053	0.0723	0.0007	0.0080
long term D areas	0.0017	-0.0048	0.0003	-0.0005
short term D areas	0.0002	0.0076	0.0000	0.0008

[104] Drain on short term D areas is shown as total observed biomass drain caused by deforestation (t/ha) instead of a yearly average over the duration of the assessment period, following the assumption that biomass is not lost continuously but instead within the year in which the deforestation takes place.

The biomass stock changes at the LUC lands to and from forests of the whole time series were calculated with these single values in Table 265 and Table 266.

Conversion factors (BF, C)

The detailed biomass assessment at the ARD areas between NFI 2007/09 and NFI 2016/21 allowed the application of the same biomass functions as used in sector 4.A.1. (see Biomass functions (BF**))** to derive biomass increment and biomass harvest of trees with a DBH ≥ 5cm. The stock changes of biomass < 5 cm is estimated based on counting between the last two NFI periods.

Table 267: C-conversion factors for forest biomass land use changes areas from and to forest land.

Conversion factors t dm to t C	increment		harvest	
	coniferous	deciduous	coniferous	deciduous
Above ground – stem	0.498	0.484	0.497	0.484
other tree compartments – branches. roots	0.473	0.481	0.473	0.480

Between 1990 and 2021 the average annual net C stock change in living biomass (DBH>0) per ha for areas with LUC to forests amounts to:

$$\Delta C_{BM} = 1.08 \text{ t C ha}^{-1} \text{ a}^{-1}$$

For areas with LUC from forests to other land uses the calculations lead to the following result of average annual net C stock change in living biomass (DBH>0cm) per ha and year for the time series 1990 to 2021:

$$\Delta C_{BM} = -2.66 \text{ t C ha}^{-1} \text{ a}^{-1}$$

In the year of LUC from forests to other land uses, the following average annual C stock drain in living biomass (DBH>5cm) per ha and year results:

$$\Delta C_{BM\ drain} = -56.17 \text{ t C ha}^{-1} \text{ a}^{-1}$$

An overview of the emissions/removals from land use changes to forests is given in Table 255.

6.2.4.2.2 Dead wood

Based on stock changes between the NFIs 2007/09 and 2016/21 the experts of the Federal Research Centre for Forests provided detailed, measured values for stock changes of standing dead wood at areas of LUC to and from forests across time. This includes also measurements of changes in dead wood stocks in the transition period which are already present at the LUC areas in the year of land-use change (BFW, 2022). The stock changes are listed in Table 268. As with living biomass, the change in dead wood biomass per ha is given for short- and long term LUC areas and is calculated over the 20 year transition period as described above.

Table 268: Annual stock changes of dead wood at ARD areas based on the NFI 2016/21 (BFW 2022).

	Stock changes – dead wood (t/ha/a)
long term AR areas	0.17
short term AR areas	0.05
long term D areas	-0.004
short term D areas	-1.22

6.2.4.2.3 Litter and soil

Soil and litter C stock changes were calculated for all land use change subcategories to and from forests. The soil C stock changes were stratified according to the specific soil C pools of different land use changes and additionally, according to five forest growth regions in Austria (Bohemian Massif, Inner Alps, Calcareous Alps, Foothills and Alpine ridge). To calculate the soil C stock changes due to LUC, a number of data sources were synthesized into a land-use soil C stock look-up table (Table 269). The table provides the estimates of C stocks in mineral soils (0–50 cm) and litter according to different land uses and forest. As the table shows, agricultural soil C stocks were calculated based on data from the Austrian Soil Information System (BORIS - see at references). Forest soil and litter C stocks are based on the results of the EU-wide Biosoil project (BFW 2009) which was carried out on 140 sites of the former forest soil survey (BFW 1992). For the remaining land use categories national estimates based on literature values or expert judgement were applied. The estimate and expert judgment of the soil C stocks in areas of settlements and traffic areas is based on the same approach as described in chapter 6.6.4.1.2. (In this chapter information about the assessment of the share of sealed area in settlements is provided). For the "other land uses" of other land (those which are not alpine shrub lands, rocks and stone slopes) we assume some C stock in soils, but due to the shallow depth of these soils only 30 t C ha^{-1}. Note that where the original data provide two or more stratified soil C stock values for a given LU category, weighted averages were calculated (weighted by the relative area of each stratum).

Table 269: Specific C-stocks (t C ha^{-1}) for litter and soil (0–50 cm) stratified according to five forest growth regions in Austria.

IPCC LU categories	National LU categories	Forest growth regions					Source
		Bohemian Massif	Inner alps	Calcareous alps	Foothills	Alpine Ridge	
		t C ha^{-1} (0–50 cm)					
Forest – litter	Forest	40	24	24	19	26	BFW 2009
Forest – mineral soil	Forest	88	91	109	77	117	BFW 2009
Cropland	Cropland	56	90	80	65	90	Umweltbundesamt – see[105] below
	Vineyards	58	58	58	58	58	Gerzabek et al. 2005
	Orchards/garden land	78	78	78	78	78	Gerzabek et al. 2005
Grassland	grassland intensive use	75	95	100	79	94	Umweltbundesamt– see footnote [105] below
	grassland extensive use	132	130	120	139	139	Umweltbundesamt– see footnote [105] below

[105] The values for forests, cropland and grassland represent regional averages which are based on Austrian soil inventories for forests (BFW 2009) and for agricultural land (AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 1988–1996, AMT DER TIROLER LANDESREGIERUNG 1988, AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG 1993, AMT DER SALZBURGER LANDESREGIERUNG 1993, AMT DER NIEDERÖSTERREICHISCHEN LANDEREGIERUNG 1994, AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG 1996, AMT DER KÄRNTNER LANDESREGIERUNG 1999, Compiled in the Austrian Soil Information System BORIS). The data have been stratified according to the Austrian forest growth regions.

IPCC LU categories	National LU categories	Forest growth regions					Source
		Bohemian Massif	Inner alps	Calcareous alps	Foothills	Alpine Ridge	
		t C ha^{-1} (0–50 cm)					
Wetlands	Surface waters and reed beds:	0	0	0	0	0	expert judgement
Settlements	Settlements and traffic area	54	54	54	54	54	Umweltbundesamt– see footnote [105] below and chapter 6.6.4.1.2
	Industrial and mining areas. dumps	30	30	30	30	30	Umweltbundesamt– see footnote [105] below and chapter 6.6.4.1.2
Other land	Alpine shrub lands	119	119	119	119	119	Körner et al. 1993
	Rocks and stone slopes:	0	0	0	0	0	expert judgement
	Other land uses	30	30	30	30	30	expert judgement

For the LUC calculations, the average soil C stocks for each land-use category were furthermore weighted by the respective relative area contributions to LUC to forests and LUC from forests. The NFIs 2000/02, 2007/09 and 2016/21 specify the LUC areas from and to forests over a broader range of LUC categories than the existing six major IPCC land use categories (see Table 269). LUC areas are reported for additional LU substrata for each forest growth region. Consequently, for each land use change category from and to forest area weighted mean values of soil C-stocks for each subcategory and growth region were calculated for each NFI period. (NFI 1992/96 to 200/02, NFI 2000/02 to 2007/09 and NFI 2007/09 to NFI 2016/21). Given the variation in relative contributions of the strata to LUC to forests and LUC from forests, and variation between the inventory periods, the C stocks for each LU category differ between the respective look-up tables (Table 270, Table 271 and Table 272).

Table 270: Area weighted mean values for carbon stocks in mineral soils (0–50 cm) of land use change areas from and to forest land between the NFI periods 1992/96 and 2000/02 and previous NFIs.

	C-stocks (t ha^{-1}) in soils (0–50 cm)[1]									
Land use categories (IPCC –GPG)	LUC to forest (forest growth regions)					LUC from forest (forest growth regions)				
	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge
Forest	88	91	109	77	117	88	91	109	77	117
Cropland	56	90	77	65	73	56	-	71	65	90
Grassland	77	123	117	85	125	75	116	115	88	128
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	34	54	54	41	40	54	54	54	38	48
Other land	30	53	21	27	51	30	73	40	30	25

[1] - no LUC from/to forest could be observed in these regions

Table 271: Area weighted mean values for carbon stocks in mineral soils (0–50 cm) of land use change areas from and to forest land between the NFI periods 2000/02 and 2007/09.

	C-stocks (t ha-1) in soils (0–50 cm)[1]									
Land use categories (IPCC –GPG)	**LUC to forest (forest growth regions)**					**LUC from forest (forest growth regions)**				
	Bohemian Massif	**Inner alps**	**Calc. alps**	**Foot-hills**	**Alpine Ridge**	**Bohemian Massif**	**Inner alps**	**Calc. alps**	**Foot-hills**	**Alpine Ridge**
Forest	88	91	109	77	117	88	91	109	77	117
Cropland	57	90	78	65	81	56	-	-	68	88
Grassland	91	128	117	87	130	75	128	114	124	128
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	45	-	54	34	38	35	54	47	41	48
Other land	39	46	49	30	49	-	53	22	13	41

[1] - no LUC from/to forest could be observed in these regions

Table 272: Area weighted mean values for carbon stocks in mineral soils (0–50 cm) of land use change areas from and to forest land between the NFI period 2007/09 and the NFI period 2016/21.

	C-stocks (t ha-1) in soils (0–50 cm)[1]									
Land use categories (IPCC –GPG)	**LUC to forest (forest growth regions)**					**LUC from forest (forest growth regions)**				
	Bohemian Massif	**Inner alps**	**Calc. alps**	**Foot-hills**	**Alpine Ridge**	**Bohemian Massif**	**Inner alps**	**Calc. alps**	**Foot-hills**	**Alpine Ridge**
Forest	88	91	109	77	117	88	91	109	77	117
Cropland	60	-	74	66	72	56	-	-	67	-
Grassland	87	128	115	93	128	75	124	114	109	125
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	42	54	53	50	48	41	43	47	43	48
Other land	119	67	52	86	71	-	59	29	47	66

[1] - no LUC from/to forest could be observed in these regions

The estimates of the soil C stock changes for LUC areas from and to forests were split into litter (humus layer, see Table 269) and mineral soil (see Table 270, Table 271 and Table 272) and follow the equations below. The changes are estimated annually on a regional basis (forest growth region) and summed up for each LUC subcategory in the CFR tables. Based on the to and from forest LUC area data, which are stratified between the forest growth areas in the NFI, soil C stock changes were calculated by applying the corresponding values from the tables to the equations below. For the years up to 2001, the mineral soil C stocks from Table 270 were applied; between 2002 and 2008, Table 271; and from 2009 onwards, Table 272.

Annual carbon stock changes in soils at LUC areas from and to forest land

$$\Delta SOC = A*(SOC_O - SOC_{O-T})/20$$

ΔSOC = average annual carbon stock change in soils (t C a^{-1}) over the LUC transition period of 20 years

A = conversion area from or to forest land for a transition period of 20 years

SOC_O = carbon stock in soils after conversion, respectively (e.g mineral forest soils in the Calcareous Alps →109 t C ha^{-1}, see Table 271)

SOC_{O-T} = carbon stock in soils before conversion, respectively (e.g. area weighted mean value of soil C stocks from grassland converted to forest land in the Calcareous Alps: 117 t C ha^{-1}, see Table 271).

Annual carbon stock changes in litter at LUC areas from and to forest land:

$$\Delta C_{LT} = A * (C_{LTo} - C_{LTo-t})/T$$

ΔC_{LT} = average annual carbon stock change in litter (t C a^{-1})

A = annual area of land converted from forests, respectively the annual area of land converted to forests following a transition period of 20 years.

C_{LTo} = carbon stock in litter after conversion, (e.g. 24 t C ha^{-1} for Calcareous Alps, see Table 269)

C_{LTo-t} = carbon stock in litter before conversion, respectively

T = transition period for the litter carbon stock changes (1 year for LUC areas from forest. 20 years for LUC areas to forest)

There is however one important exception to the above method. In response to review findings the estimates of the emissions/removals in the mineral soils of LUC categories with wetlands were revised. In submissions before 2014 wetlands (flooded land) were assumed to have a soil C stock of 0 t C ha^{-1}. Using the IPCC approach of calculating the C stock change between a period of 20 years led to unrealistic annual C stock gains (WL to FL) or losses (FL to WL) in mineral soils for lands with such LUC. Due to a lack of information in literature no C-stock changes in mineral soil are assumed for LUC between forest land and wetland. The changes WL to FL are higher than those of FL to WL, and FL can be expected to have higher C stocks in soil. Therefore, this approach represents a conservative estimate.

Estimates for the soil C stock changes of and between the other land use categories than forests are based on a soil depth of 0–30 cm (see chapters 6.3.1, 6.4.4.2, 6.5.4.2, 6.6.4.1, 6.7.4.1).

6.2.4.2.4 Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Increases in available N due to soil C losses from human induced land use changes enhance the mineralisation of soil organic N and therefore cause N_2O emissions. Since the 2016 submission, these emissions have been calculated for grassland converted to forest land because of related C losses in mineral soils. To estimate the associated N_2O emissions the tier 2 method as provided in the IPCC 2006 GL is applied:

$$N_2O\text{-}N = F_{SOM} * EF_1 \text{ (Eq.11.1)}$$

$$N_2O\text{-}N = F_{SOM} * (1 - Frac_{LEACH}) * EF_1 \text{ (Eq.11.1)}$$

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.1) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by the country specific C/N ratio of grassland soils (12, source: see footnote[105]) and multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 Guidelines. Then the result was converted from the amount of annual direct N_2O-N to N_2O emissions.

6.2.4.2.5 Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from mineralized soil nitrogen, indirect N_2O emissions occur due to the mineralized N which is leached from the soil . The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11:

$$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5 \text{ (eq.11.10)}$$

Where

…N_2O-N	*= annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils, kg yr^{-1}*
… F_{SOM}	*= the net annual amount of N mineralized in mineral soil associated with loss of soil C from soil organic matter as a result of changes in land use or management kg N yr^{-1}*
… $Frac_{LEACH}$	*= fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff kg N per kg of N additions*

$Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER, 2015) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.2.5 Uncertainty Assessment

The Austrian Federal Research Centre for Forests carried out an in-depth re-assessment of the uncertainty of the biomass C stock changes in Austrian Forests calculated from the NFI (BFW 2010, internal report). A ±40% uncertainty was estimated for the average annual net change in the biomass C stock in the NFI period 2000/02.

It is important to note that due to the design of the NFI the total change in the forest biomass stock also includes the biomass changes caused by LUC to and from forests. So, this ±40% uncertainty is valid for the total biomass changes at "forest land rem. forest land" plus lands of the subcategories with LUC to forests. As a consequence, the estimates of the overall uncertainty of sector 4 were carried out with the total net biomass changes at all forest lands and with the related uncertainty of this total net change.

The stock of dead wood is assessed within the NFI and with the same methods as living biomass. Therefore, we assume that the figures of the dead wood stock change have the same uncertainty as those of living tree biomass (±40%).

For this 2023 submission an improved estimate for the forest soil carbon stock changes on basis of an improved method and model was carried out for the whole time series (see chapter 6.2.4.1.3). For validation purposes, model simulations were conducted on a subset of 123 plots for which soil carbon stocks were measured in 1989 and 2009. The simulated and measured mean soil C stock changes did not differ significantly from one another. However, the comparsion showed the spatial variation (standard deviation) of the measured soil carbon stock changes was ca. 3.5 times higher than that of the simulations. This was considered in the uncertainty estimation. For each year of the time series of ca. 8600 plot simulations an average carbon stock change was calculated, together with a respective standard deviation. Based on the above comparison with measured soil carbon stock changes, this standard deviation was increased by a factor of 3.5. For each year, a standard error was calculated (from the increased standard deviation), which was subsequently used to estimate respective 95% confidence intervals. Over the time series an average uncertainty ±57 % was derived, representing a substantial decrease in the soil carbon stock change uncertainties that were previously reported.

The uncertainty of the forest area in yield was estimated with ±2%. In addition, the uncertainties of the estimates of the litter/soil C stock changes due to forest road construction (about 10% of the total emissions of the litter/soil pool of 5.A.1) have the following uncertainties associated with the input data: Annual area of forest road construction: ±100% until 1994, ±60% after 1994; soil C stock of the forest road: triangle distribution with 10, 30 and 60 t C ha^{-1}.

For the LUC lands to and from forests the following uncertainties of the input parameters were used. Table 273 shows the uncertainties for the areas of the subcategories with LUC to and from forests:

Table 273: Uncertainties of LUC areas to and from forests.

	before NFI 1985/90[1]	**since NFI 1985/90**[1]
Annual LUC area CL to FL or FL to CL	±200%	±80%
Annual LUC area GL to FL or FL to GL	±200%	±10%
Annual LUC area WL to FL or FL to WL	±200%	±120%
Annual LUC area SL to FL or FL to SL	±200%	±80%
Annual LUC area OL to FL or FL to OL	±200%	±80%
Annual LUC area to or from FL	±200%	±10%

[1] *Distributions were truncated at 0, because negative areas are not possible*

The uncertainty of the LUC areas to and from forest reflects the statistical design of the NFI. The different uncertainties between the time series reflect the fact that since NFI 1981/85 a fixed grid system has been installed which allows a separate assessment of both, gains and losses of forest land. The NFIs before could only detect the net changes of the forest area between the NFI periods. The differences in the uncertainties of single subcategories reflect the different size of the LUC areas of these subcategories – the constant absolute uncertainty in estimated LUC in ha results in an increasing relative uncertainty the smaller the respective LUC is.

For the litter/soil C stocks of all LUC areas the uncertainties according to Table 274 were used for the estimate of the uncertainties of soil C stock changes. These uncertainties are based on the results of the Austrian soil inventories (forest. cropland. grassland), on the information of the related literature according to Table 269 (other land) or on expert judgment based on information from related studies. For data based on soil inventories, two-times the standard error of mean was taken as the uncertainty estimate instead of twice the standard deviation as in previous submissions.

Table 274: Uncertainties of the litter/soil C stocks in the forest growth regions according to Table 269.

<table>
<tr><th rowspan="3">IPCC LU categories</th><th rowspan="3">National LU categories</th><th colspan="5">Forest growth regions</th><th rowspan="3">Austria</th></tr>
<tr><th>Bohemian Massif</th><th>Inner alps</th><th>Calcareous alps</th><th>Foot-hills</th><th>Alpine Ridge</th></tr>
<tr><th colspan="5">%</th></tr>
<tr><td>Forest – litter</td><td>Forest</td><td>±29</td><td>±34</td><td>±29</td><td>±29</td><td>±16</td><td>±13</td></tr>
<tr><td>Forest – mineral soil</td><td>Forest</td><td>±30</td><td>±18</td><td>±14</td><td>±26</td><td>±13</td><td>±8</td></tr>
<tr><td rowspan="2">Cropland</td><td>Annual cropland. fallows</td><td>±4</td><td>±20</td><td>±18</td><td>±3</td><td>±12</td><td>±2</td></tr>
<tr><td>Vineyards. Orchards/garden land</td><td>±3</td><td>±25</td><td>±20</td><td>±2</td><td>±15</td><td>±2</td></tr>
<tr><td rowspan="2">Grassland</td><td>grassland intensive use</td><td>±7</td><td>±8</td><td>±5</td><td>±4</td><td>±4</td><td>±3</td></tr>
<tr><td>grassland extensive use</td><td>±5</td><td>±7</td><td>±10</td><td>±21</td><td>±9</td><td>±5</td></tr>
<tr><td>Settlements</td><td>Settlements and traffic area</td><td colspan="6">Triangle distribution 10–54–75 t C ha^{-1}</td></tr>
</table>

IPCC LU categories	National LU categories	Forest growth regions					Austria
		Bohemian Massif	Inner alps	Calcareous alps	Foot-hills	Alpine Ridge	
		%					
	Industrial and mining areas. dumps	Triangle distribution 5–30-50 t C ha^{-1}					
Other land	Alpine shrub lands	Triangle distribution 15–119–567 t C ha^{-1}					
	Rocks and stone slopes:	Uniform distribution 0–13 t C ha^{-1}					
	Other land uses	Uniform distribution 0–70 t C ha^{-1}					

The uncertainties for the N_2O emission factors from soil due to land-use changes can be seen in Table 284, chapter 6.3.5.

For the forest fire estimates default uncertainties for the biomass consumption and emission factors according to the IPCC 2006 GL were used.

Monte-Carlo simulations based on the above uncertainties and distribution assumptions gave an average uncertainty of the total emissions/removals of the complete forest land category of ±4 696 kt CO_2 across the years. This represents on average an uncertainty of ±45%.

As expected from the high share of the forest land category in the total Austrian area and in the total LULUCF removals, the uncertainty of the total emissions/removals of the forest land category has the highest impact on the total uncertainty of the LULUCF sector removals.

6.2.6 Category-specific QA/QC

The NFI is based on a very comprehensive quality assurance system which allows the exact identification of sample points in the field, guarantees the repeated measurement of the right trees (permanent marked grid) and flags up implausible figures for individual parameters during the measurements on site and any missing trees compared to the period before (further details are given in HAUK & SCHADAUER (2009) and SCHIELER & HAUK (2001).

The calculation of the data for category *4.A* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see chapter 6.1.4).

6.2.7 Recalculations

The final results of the NFI 2016/21 were made available for the preparation of the GHG inventory reported in this 2023 submission. This led to substantial recalculations in the Forest land category, causing changes in annual net emissions/removals ranging from -16 477 to 7 513 kt CO_2e over the whole time series.

The new NFI data led to recalculations in the biomass and deadwood pools of the category 4.A.1 Forest land remaing forest land (*forest in yield*), due to the new data on biomass increment and drain, dead wood stock change, C-content, mass ratios of stems, branches and roots and tree species distribution affecting the years since 2009. Furthermore, for *forest not in yield* which represent ca. 15% of the Austrian forest area, but for which emissions/removals were previously not estimated under 4.A.1, changes in the biomass and deadwood pools for 1990-2021 have been estimated and reported based on sampling in the 2007/09 and 2016/21 NFIs and model simulations over the whole time series.

For the soil (and litter) pool of 4.A.1, estimates of soil carbon stock changes over the whole series have been substantially revised based on new simulations with the Yasso20 model. (see chapter 6.2.4.1.3 for details). In comparison to the previous submissions, the soil pool is estimated on average as a net sink over the time series. Furthermore, in contrast to previously reported negative stock change that was constant over the time, the new simulations have been conducted with dynamic annual drivers resulting in substantial annual variations ranging from annual soil carbon losses in some years to net soil carbon gains in others.

For the category 4.A.2 Land converted to forest land the whole time series has been revised. This is due to the new LUC data from NFI 2016/21 affecting the respective land-use changes to Forest land since 2009. Furthermore, updates to the country-specific growth and drain rates as well as dead wood stock change on areas with LUC from and to forest that were first assessed in the ARD NFI 2011/13 and were subsequently reevaluated in the NFI 2016/21 leading to updates in these stock change factors. In addition, the way these growth and harvest rates are implemented in the calculation has been improved (see chapter 6.2.4.2.1 for details).

6.2.8 Planned improvements

See Chapter 6.1.8.

6.3 Cropland (Category 4.B)

6.3.1 Category description

In Category *4.B* emissions and removals from Cropland remaining cropland and Land converted to cropland are reported. The calculations were made for all individual years from 1990 to 2021. Some management practices (e.g. slash and burn etc.) and some LUC subcategories (categories *4.B.2.3*, *4.B.2.4*, *4.B.2.5*) do not occur in Austria. Organic soils occur only in the Grassland category in Austria. Dead wood and litter do not occur in cropland.

Emissions/removals were estimated for the subcategories and related sources/sinks as shown in Table 275.

Table 275: Sources (or sinks) considered for cropland.

Category/source or sink
4.B Cropland – total
4.B.1 Cropland remaining cropland
- carbon stock change in biomass of "perennial cropland remaining perennial cropland" and carbon stock changes in biomass due to LUC between annual and perennial cropland

Category/source or sink
- soil carbon stock changes due to management changes in "annual cropland remaining annual cropland" and "perennial cropland remaining perennial cropland" and due to LUC between annual and perennial cropland
- CO_2 emissions due to biomass burning of agricultural residues
4.B.2 Land converted to cropland
4.B.2.1 Forest land converted to cropland
- carbon stock change in biomass due to LUC from forest land to cropland
- carbon stock change in DOM[106] due to LUC from forest land to cropland
- carbon stock change in SOM[107] due to LUC from forest land to cropland
- N_2O emissions from soils due to LUC from forest land to cropland
- N_2O emissions from soils due to N leaching and runoff
4.B.2.2 Grassland converted to cropland
- carbon stock change in biomass due to LUC from grassland to cropland
- carbon stock change in SOM due to LUC from grassland to cropland
- N_2O emissions from soils due to LUC from grassland to cropland
- N_2O emissions from soils due to N leaching and runoff

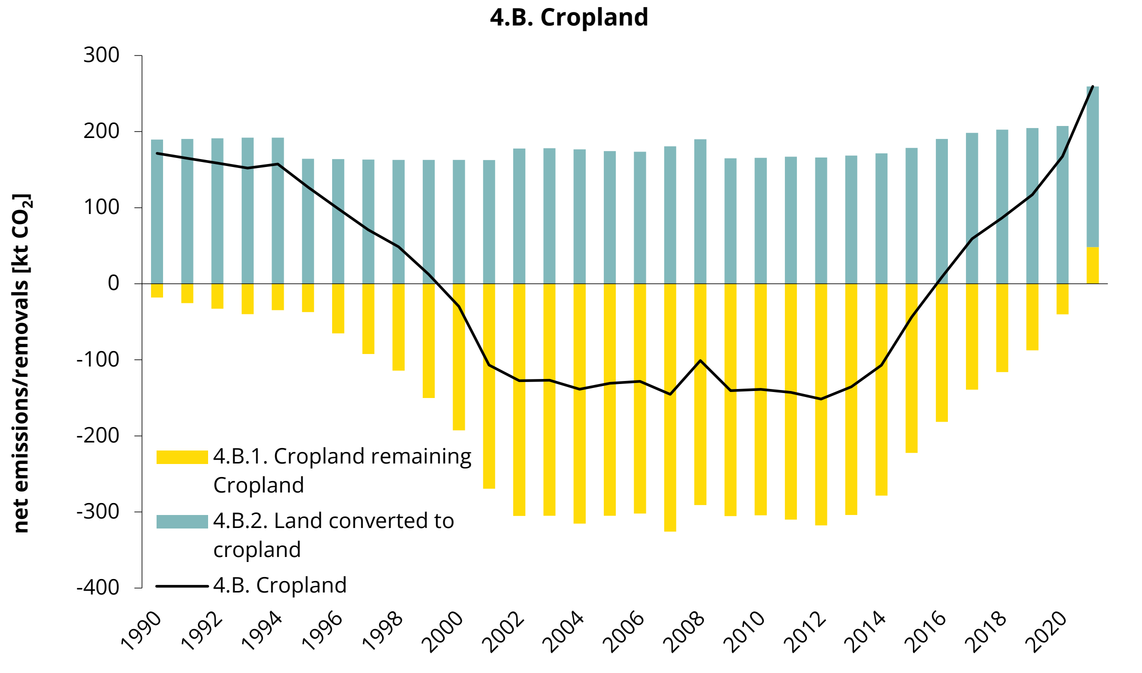
In 2021 1.40 million ha were identified as cropland including annual and perennial crops (STATISTIK AUSTRIA 2018, 2021a, 2021b, 2022a). The total Cropland area in Austria has been decreasing over the reported time series.

The total emissions and removals of Cropland range between -152 and 259 Gg CO_2, with emissions reported during the 90s, removals since 2000, and again emissions since 2016 (Table 276). The CO_2 emissions during the 90s were mainly caused by the soil C loss caused by conversion from Grassland to annual cropland and from Forest land to cropland. The net CO_2 removals between 2000 and 2015 are largely due to the increase of soil organic carbon in Cropland remaining cropland, due to specific management measures implemented by the Austrian agri-environmental program ÖPUL. This program was introduced in 1995, when Austria joined the EU. The removals turned into net CO_2 emissions from this subcategory in 2016, with emissions increasing since then. The reason is that increases in soil carbon stocks as a consequence of ÖPUL measures (which were mainly responsible for these net removals in past years) are starting to level off due to the reaching of the new equilibrium soil carbon stocks.

[106] DOM = Dead Organic Matter

[107] SOM = Soil Organic Matter

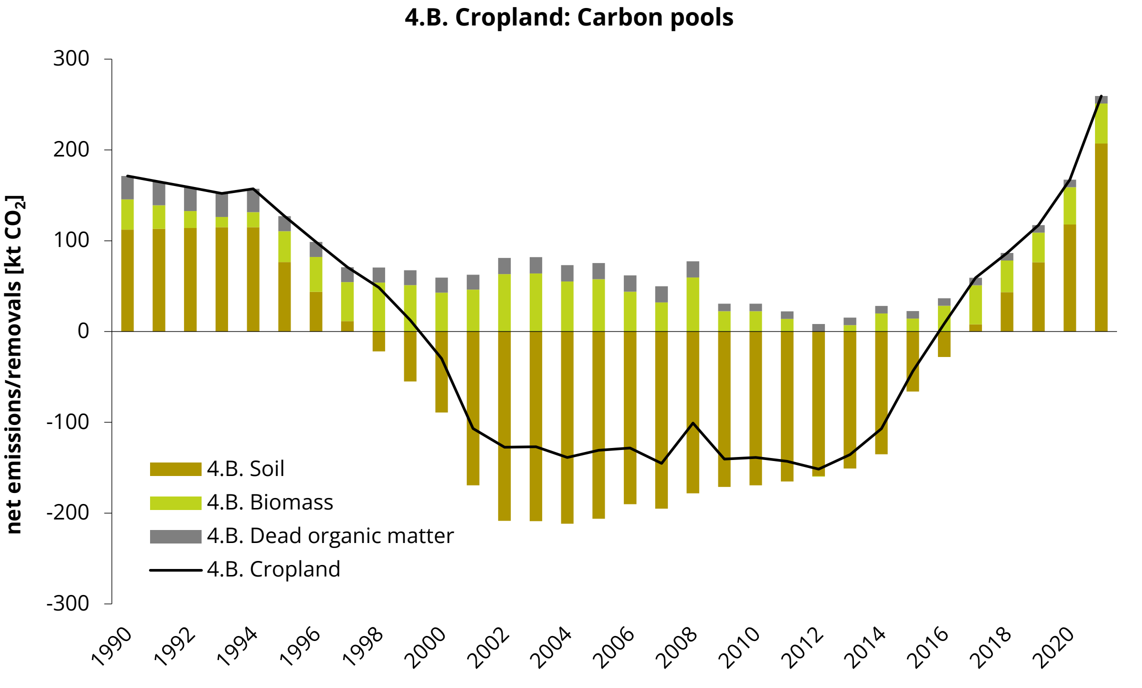
Figure 37: Emissions /removals (+/-) from cropland (1990–2021) by cropland remaining cropland and land use change to cropland in kt CO_2



Source: Umweltbundesamt

In 2021 the total land use change area to cropland was 53 876 ha (over a transition period of 20 years). The total annual emissions of Land converted to cropland over 1990–2021 range from 162 kt CO_2 to 211 kt CO_2 (Table 277).

Figure 38: Emissions /removals (+/-) from cropland (1990–2021) by carbon pools in kt CO_2



Source: Umweltbundesamt

Table 276: Total areas and land-use change areas of cropland (1990–2021) in ha – transition period of 20 years for LUC lands.

	4.B Total cropland	4.B.1.Cropland remaining cropland-total	a. annual remaining annual & perennial remaining perenial	b. annual cropland converted to perennial cropland	c. perennial cropland converted to annual cropland	4.B. 2. Land converted to cropland	2.1 Forest Land converted to cropland	2.2 Grassland Land converted to cropland - total	a. Grassland converted to annual cropland	b. Grassland converted to perennial cropland	2.3 Wetland converted to Cropland	2.4 Settlement converted to cropland	2.5 Other Land converted to cropland
1990	1 500 824	1 469 195	1 448 707	13 243	7 244	31 630	4 125	27 504	26 947	557	NO	NO	NO
1991	1 499 680	1 467 868	1 447 409	13 225	7 234	31 812	4 346	27 466	26 909	556	NO	NO	NO
1992	1 498 535	1 466 542	1 446 111	13 206	7 224	31 993	4 567	27 427	26 871	555	NO	NO	NO
1993	1 497 391	1 465 216	1 444 815	13 187	7 214	32 175	4 787	27 388	26 833	555	NO	NO	NO
1994	1 495 296	1 463 156	1 442 785	13 168	7 203	32 140	4 792	27 347	26 793	554	NO	NO	NO
1995	1 493 201	1 461 186	1 440 846	13 147	7 192	32 015	4 710	27 305	26 752	553	NO	NO	NO
1996	1 487 853	1 455 967	1 435 662	13 125	7 180	31 886	4 628	27 258	26 706	552	NO	NO	NO
1997	1 482 505	1 450 753	1 430 487	13 100	7 166	31 752	4 546	27 206	26 655	551	NO	NO	NO
1998	1 479 191	1 447 576	1 427 351	13 074	7 152	31 615	4 463	27 152	26 602	550	NO	NO	NO
1999	1 475 877	1 444 298	1 424 115	13 046	7 137	31 579	4 483	27 095	26 547	549	NO	NO	NO
2000	1 473 875	1 442 335	1 422 196	13 018	7 121	31 540	4 504	27 037	26 489	547	NO	NO	NO
2001	1 471 874	1 440 370	1 420 272	12 991	7 107	31 504	4 524	26 981	26 434	546	NO	NO	NO
2002	1 469 872	1 438 333	1 418 275	12 965	7 093	31 539	4 612	26 927	26 382	545	NO	NO	NO
2003	1 467 871	1 436 097	1 415 687	13 209	7 200	31 774	4 699	27 074	26 503	571	NO	NO	NO
2004	1 465 979	1 434 725	1 414 502	13 043	7 180	31 254	4 581	26 673	26 116	557	NO	NO	NO
2005	1 464 088	1 432 840	1 412 888	12 897	7 055	31 248	4 463	26 785	26 242	542	NO	NO	NO
2006	1 462 064	1 429 178	1 409 262	12 668	7 248	32 887	4 345	28 542	28 027	515	NO	NO	NO
2007	1 460 041	1 424 244	1 403 187	12 805	8 252	35 796	4 226	31 570	31 016	554	NO	NO	NO
2008	1 453 427	1 414 621	1 393 792	12 762	8 067	38 806	4 108	34 698	34 132	566	NO	NO	NO
2009	1 446 814	1 407 631	1 386 728	12 558	8 345	39 182	3 939	35 244	34 639	605	NO	NO	NO
2010	1 440 524	1 401 241	1 380 371	12 407	8 462	39 284	3 792	35 492	34 862	630	NO	NO	NO
2011	1 438 296	1 398 878	1 378 346	12 089	8 442	39 418	3 644	35 774	35 053	721	NO	NO	NO
2012	1 436 068	1 395 877	1 375 687	11 753	8 437	40 190	3 497	36 693	35 934	759	NO	NO	NO
2013	1 433 839	1 392 959	1 373 160	11 411	8 388	40 880	3 350	37 530	36 733	798	NO	NO	NO
2014	1 427 616	1 385 448	1 365 556	11 472	8 420	42 168	3 202	38 966	38 091	874	NO	NO	NO
2015	1 421 392	1 375 605	1 354 824	11 845	8 936	45 787	3 143	42 645	41 590	1 055	NO	NO	NO
2016	1 415 330	1 366 921	1 345 528	12 198	9 196	48 409	3 083	45 325	44 134	1 192	NO	NO	NO
2017	1 409 456	1 359 417	1 337 687	12 529	9 201	50 038	3 023	47 015	45 729	1 287	NO	NO	NO
2018	1 403 582	1 352 830	1 331 175	12 411	9 244	50 752	2 964	47 788	46 463	1 325	NO	NO	NO
2019	1 397 708	1 346 016	1 324 349	12 245	9 422	51 692	2 904	48 788	47 433	1 355	NO	NO	NO
2020	1 391 834	1 339 051	1 317 461	11 972	9 618	52 784	2 844	49 939	48 571	1 369	NO	NO	NO
2021	1 390 513	1 336 637	1 315 047	11 737	9 853	53 876	2 785	51 091	49 710	1 382	NO	NO	NO

Table 277: Emissions /removals (+/-) from cropland (1990–2021) in kt CO_2 and N_2O emissions in kt CO_2eq; other land use changes are not occurring.

	4 B Total Cropland_CO_2	4 B 1 Cropland remaining Cropland_CO_2	a. Annual remaining annual and perennial remaining perennial cropland_CO_2	b. Annual cropland converted to perennial cropland_CO_2	c. Perennial cropland converted to annual cropland_CO_2	4 B 2 Land converted to cropland_CO_2	2.1 Forest land converted to cropland _CO_2	2.2 Grassland converted to cropland_CO_2	2.2.a Grassland converted to annual cropland _CO_2	2.2.b Grassland converted to perennial cropland_CO_2	4(III)B2_N_2O emissions due to C losses in managed soils_N_2O in CO_2eq	4(IV)A2_N_2O emissions from N leaching and runoff_N_2O in CO_2eq
1990	171.38	-18.16	-12.36	-14.34	8.54	189.54	94.12	95.43	94.09	1.34	10.66	1.21
1991	164.96	-25.45	-19.68	-14.30	8.53	190.41	95.12	95.29	93.95	1.34	10.71	1.22
1992	158.52	-32.74	-27.00	-14.26	8.51	191.27	96.12	95.15	93.81	1.34	10.76	1.22
1993	152.09	-40.03	-34.32	-14.22	8.50	192.12	97.11	95.01	93.67	1.34	10.81	1.23
1994	157.27	-34.78	-29.09	-14.18	8.49	192.06	97.19	94.86	93.53	1.34	10.79	1.23
1995	126.98	-37.21	-31.53	-14.15	8.48	164.19	69.47	94.72	93.38	1.33	10.76	1.22
1996	98.61	-65.13	-59.44	-14.16	8.46	163.74	69.18	94.56	93.23	1.33	10.72	1.22
1997	70.89	-92.38	-86.67	-14.16	8.45	163.27	68.89	94.39	93.06	1.33	10.67	1.21
1998	48.51	-114.29	-108.60	-14.12	8.43	162.79	68.60	94.20	92.87	1.33	10.63	1.21
1999	12.50	-150.25	-144.58	-14.08	8.41	162.76	68.76	94.00	92.67	1.32	10.62	1.21
2000	-29.86	-192.56	-186.91	-14.04	8.39	162.70	68.91	93.79	92.47	1.32	10.60	1.21
2001	-106.77	-269.42	-263.80	-14.00	8.38	162.65	69.05	93.59	92.27	1.32	10.59	1.20
2002	-127.38	-305.16	-299.55	-13.96	8.36	177.78	84.37	93.41	92.09	1.32	10.57	1.20
2003	-126.86	-305.06	-305.30	-8.00	8.24	178.19	84.35	93.84	91.93	1.91	10.62	1.21
2004	-138.63	-315.36	-306.19	-17.66	8.49	176.73	83.33	93.40	92.34	1.05	10.42	1.18
2005	-130.76	-305.04	-296.70	-16.90	8.55	174.28	82.27	92.01	90.98	1.03	10.40	1.18
2006	-128.39	-301.91	-291.58	-18.46	8.13	173.52	81.20	92.32	91.61	0.71	10.95	1.24
2007	-145.23	-325.79	-323.63	-9.85	7.69	180.57	80.13	100.43	98.28	2.16	11.93	1.36
2008	-100.85	-290.80	-286.57	-14.21	9.99	189.94	79.06	110.88	109.26	1.62	12.96	1.47
2009	-140.41	-305.30	-296.92	-17.74	9.36	164.89	42.21	122.68	120.47	2.22	13.08	1.49
2010	-138.73	-304.35	-298.07	-16.13	9.85	165.61	41.33	124.28	122.31	1.97	13.11	1.49
2011	-142.88	-309.93	-300.57	-19.48	10.12	167.05	40.46	126.59	123.12	3.47	13.14	1.49
2012	-151.55	-317.48	-308.41	-19.16	10.08	165.93	39.62	126.31	123.89	2.42	13.40	1.52
2013	-135.52	-303.89	-295.46	-18.54	10.11	168.37	38.79	129.58	127.11	2.47	13.64	1.55
2014	-106.95	-278.39	-279.54	-8.83	9.98	171.43	37.95	133.48	130.09	3.39	14.07	1.60
2015	-43.69	-222.29	-229.85	-2.06	9.61	178.60	37.54	141.06	135.27	5.79	15.30	1.74
2016	8.69	-181.55	-188.63	-3.42	10.50	190.24	37.13	153.12	148.03	5.08	16.18	1.84
2017	59.13	-139.20	-145.50	-4.74	11.05	198.33	36.72	161.62	157.29	4.33	16.73	1.90
2018	86.56	-116.02	-111.54	-15.50	11.02	202.58	36.30	166.28	163.07	3.21	16.96	1.93
2019	117.12	-87.55	-82.21	-16.31	10.97	204.68	35.82	168.86	165.79	3.07	17.28	1.96
2020	167.32	-40.12	-32.97	-18.33	11.18	207.43	35.33	172.10	169.37	2.74	17.64	2.01
2021	259.37	48.23	53.72	-16.89	11.40	211.14	34.84	176.30	173.54	2.75	18.01	2.05

6.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The data for total Cropland areas were taken from national statistics (STATISTIK AUSTRIA 2021a, STATISTIK AUSTRIA 2021b, STATISTIK AUSTRIA 2018, STATISTIK AUSTRIA 2022). The area of Cropland remaining cropland represents the total Cropland area minus Land converted to cropland.

Since 1990 the cropland area statistics of „Statistik Austria" has been used for the activity data. These data are based on the Farm Structure Survey (FSS). In the years when the full FSS was conducted (1990, 1995, 1999, 2010 and 2020) these data were taken (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013, 2022a). In some intermediate years random sample Farm Structure Surveys were carried out (1993, 1997, 2003, 2005, 2007, 2013 and 2016 – sources: ÖSTAT 1994, 1998, STATISTIK AUSTRIA 2005, 2006, 2008, 2014, 2018). Since joining the EU in 1995, Austria is committed to run the IACS data base, which in contrast to FSS is updated yearly, but includes only Cropland area (and Grassland area) of farms that receive support under the CAP (which, however, is almost all cropland area in Austria, see below). It covers detailed information on various Cropland subcategories. For some crops (vegetable, flowers and floriculture) the activity data from IACS is complemented by STATISTIK AUSTRIA data and expert judgments (e.g. by experts of the chambers of agriculture).

For the total annual cropland area the data from the FSS differ from the IACS data. In most years the area taken from the FSS database is larger, because a greater number of farms is included in FSS compared to IACS. The annual cropland area in the intermediate years between the FSS updates, has been interpolated in response to an ESD 2020 review finding (EEA 2020) with regards to interannual land use area consistency in land use change matrices. Also, since the 2022 submission the annual total cropland area is simply interpolated (linear) for the non-FSS years and over certain intermediate random sample FSS years (e.g. 2003 and 2005), for which time series consistency issues were identified. Only for the year 2021 - after the full FSS survey year in 2020 - we extrapolate using the 2021 IACS data that are adjusted by a factor based on the 2020 comparison of the FSS and IACS total annual cropland areas.

Data for perennial cropland area (viticulture, orchards, house gardens, Christmas trees and perennial energy crops) were taken from full and random sample FSS as well; intermediate years were interpolated.

In the orchards time series there are two discontinuities which led to substantial area changes:

- Between 1968 and 1969 there was a sharp increase in the orchard area, probably caused by the inclusion of extensive orchards area for the first time.
- Between 1982 and 1983 there was a considerable decrease in the orchard area probably due to the changed delimitation: the threshold for the minimum unit was raised from 0.5 to 1 ha. In addition, from 1983 on, municipalities were no longer obliged to report small areas and unproductive agricultural areas, which were reported before under the orchards category.

For time series consistency, the area for orchards was extrapolated backwards until 1960.

In the time series for house gardens two sharp changes occurred:

- Between 1982 and 1983: this is probably due to the changed delimitation: the threshold for the minimum unit was raised from 0.5 to 1 ha. In addition, from 1983 on municipalities were no longer obliged to report small areas and unproductive agricultural areas, which were reported before under the house gardens category.

- Between 1994 and 1995: This might be a result of the new Common Agricultural Policy (CAP) of the EU, because house gardens are no longer supported under this policy, and it is likely that these areas were then reported under cropland or grassland.

For time series consistency the area of house gardens between 1960 and 1995 was therefore interpolated to remove the above potential systematic errors during this period.

Since submission 2022, the planted vineyard area of the basic vineyard surveys (Weingartengrunderhebungen) for the years 2009, 2015 and 2020 (Statistik Austria 2011, 2016, 2021) was used for the viticulture area, as these explicitly comprise the vineyard area planted with vine stems. For time series consistency the area of vineyards between 2009, 2015 and 2020 was interpolated.

Areas for land use change and conversion between grassland, annual cropland and perennial cropland have been estimated on basis of IACS data. IACS is the integrated system for the administration and control of EU payments of the CAP established by the Member States. IACS applies to direct support schemes (pillar 1) as well as to rural development measures (pillar 2). In Austria the majority of famers participate in the CAP and therefore the IACS data base comprises about 97% of the total agricultural area according to the FSS (2016: IACS: 2 601 085 ha, FSS: 2 671 174 ha, BMNT, 2018). LPIS is a part of IACS and contains a geographical representation of the agricultural parcels of land per farm. It includes quantitative data including parcel area and boundaries and qualitative data including crop description. In Austria agricultural parcels are – in case of application for CAP subsidies obligatory – identified at the plot level (graphically and digitally) using farm maps (cartographic documents which comprise an aerial photograph and the outline of the individual parcels).

By means of these data, detailed information on the area of Cropland (annual, perennial) and Grassland, as well as changes between the two categories, are derived. Land use change (LUC) from and to wetland is insufficiently collected in IACS and land use changes from and to settlement and other land are also not explicity provided. Essentially, one can only derive parcels of agricultural land that are added to-, or lost from-, the IACS database. However, spatially-explicit land use changes between subsidised croplands and grasslands can be derived and upscaled to national-level estimates. However, as IACS data is primarily used for yearly administration of payments, it does not contain a fully-consistent and complete identification of land use and management of parcels over time. Furthermore, in 2016, the format of the data changed from a classical database structure to a GIS system, whereby the individual fields and land parcels (and associated land use and management information) are now spatially delineated. Some workaround is thus necessary for the analysis of time series (see next paragraph).

With this submission in 2023, the methods for estimating land use changes between annual croplands, perennial croplands and grasslands that were introduced in the 2021 submission have been further improved. In the previous approach, within-category changes between annual and perennial croplands were estimated separately from the between-category changes between Cropland and Grassland. For this submission, a single processing routine was developed to analyse and quantify all respective changes between annual cropland, perennial cropland and grassland. The routine is implemented in four steps:

- **Sampling of IACS GIS data for the years 2016 onwards**. Using the the centre points (centroids) of the 100m x 100m cells of the INSPIRE geographical grid system, land use and management information are systematically sampled from the IACS GIS data for each year from

2016 onwards. Specifically, information on the agricultural land use (*Schlagnutzungsart*) is queried each year from each of the fixed sample points. It should also be noted that respective cadastral parcel-IDs of the 2016 *Digitale Katastralmappe* (DKM; digital cadastral map, polygon data set) have been assigned to each INSPIRE grid point to allow the data from the IACS GIS system to be joined with IACS data from the previous database format.

- **Merging of data from 2016 onwards with the IACS data from the previous database format (2002-2015)**. An SQL query of the previous database generated a 2002-2015 time series of agricultural land use (*Schlagnutzungsart*) and area size for each cadastral parcel-ID contained within the database. Due to some inconsistency and incompleteness issues in the previous database, as well as the consequence that data from 2016 onwards can only joined at the aggregated land parcel level, a subset of the queried data was retained for analysis of LUCs. The selection of the subset was based on land parcels that are:
  - available for all years; and
  - relatively constant in terms of area size over the time series; and
  - categorised by relatively homogenous land-use

  This subset of 2002-2015 data are then merged with the IACS GIS data for the years 2016 onwards using cadastral parcel-IDs as the joining variable common to both datasets. The result is a 2002-2021 time series of IACS agricultural land use (categorised as *annual cropland, perennial cropland, grassland* and *other* based on the *Schlagnutzungsart*) for each INSPIRE grid point of the Austrian territory, albeit incomplete for the years 2002-2015.
- **Correction of short-term land use changes**. For each INSPIRE grid point, the routine checks for- and subsequently corrects short-term land-use changes between annual cropland, perennial cropland, grassland and other. The check and correction is implemented to detect annual changes in agricultural land use, and check when the subsequent land use remains stable for at least the following five years. If within the subsequent 5 years, another land-use change is detected, the initial land-use change is removed by correcting the land use to that of the previous year. Obviously, the routine would be limited in being able to detect and correct short-term land-use changes in the last fives of the time series. Therefore, the above detection and correction process is first applied to the time series up to the last five available years. The partially corrected time series is subsequently analysed to quantify the respective sum of areas for each land-use conversion category (e.g. annual cropland to grassland, grassland to annual cropland etc) for each year. Comparison of the corrected and uncorrected timeseries up to the last five available years, allows respective relative reduction factors for each land-use conversion to be calculated and applied to the total annual land use changes for the last five years of the time series.
- **Calculation of total land-use changes as percentages of total Cropland area and harmonisation and extrapolation over the time series.** After the above correction for short-term land-use changes, the annual land use change areas in ha are expressed as percentages of the total cropland area per year in the respective datasets. For changes between the annual and perennial cropland, as well as changes from grassland to annual/perennial cropland, the changes are expressed in percentages of the total Cropland area in the same year. For changes from annual/perennial cropland to grassland, the annual changes are expressed as percentages of total Cropland area in the previous year. The rationale behind using total Cropland area, rather than respective total Cropland and Grassland areas is that the time series for this total area that we use in the inventory is considered more reliable that the total Grassland area.

The result of the above is a time series of land-use changes between annual cropland, perennial cropland and grassland expressed as percentages of total Cropland area (total area either in the same year or the year before). Before these can be applied to calculate total land-use changes over the Austrian territory, the data from 2002 to 2015 are first harmonised with those from 2016 onwards. First of all, the values for changes between 2015-2016 are omitted, because of the sharp peaks caused by the change from an aggregate land-parcel classification to a classification at ha resolution. Secondly, we adjust the average level of the respective changes between 2002-2015 to that of the average changes from 2016 onwards. As 2002-2015 represents only a subset of the land parcels within IACS, a systematic bias is expected in the data pre-2015 and is thus corrected for by the difference in mean land use changes between 2002-2015 and 2016 onwards. After this level correction, the gaps introduced by omitting the land use changes between 2015-2016 are filled by interpolation. Finally, the historic annual land use changes outside of the IACS data range (between 2001/2002 back to 1970/1971) are filled by extrapolating the respective mean annual land use changes calculated between 2002/2003 and 2009/2010.

The result of the above four steps of the processing routine is a 1971-2021 time series of annual land-use changes between annual cropland, perennial cropland and grassland expressed as percentages of total Cropland area (in the same year of in the year before). In 2021, the following land-use change areas derived from the above method amounted to:

- Annual cropland to perennial cropland – 0.03% of the total Cropland area in 2021
- Perennial cropland to annual cropland – 0.04% of the total Cropland area in 2021
- Grassland to perennial cropland – 0.003% of the total Cropland area in 2021
- Grassland to annual cropland – 0.18% of the total Cropland area in 2021
- Annual cropland to grassland – 0.15% of the total Cropland area in 2020
- Perennial cropland to grassland – 0.005% of the total Cropland area in 2020

The areas of the LUC Forest land to Cropland are measured by the NFIs (see chapter 6.2.2.2).

LUCs from wetland, from settlement and from other land to cropland do not occur in Austria. This assumption is based on the fact that the cropland area shows a steady decrease and that wetland, settlement and other land areas are simply not suitable for conversion to cropland:

a. Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas.
b. Settlement areas and soils – once converted – cannot usually be used for cropland cultivation.
c. There is also a higher economic value for land dedicated to building land than agricultural land i.e. there is no economic incentive for re-conversion.
d. Other lands are located in high altitude or very steep areas and therefore have unfavorable ecological conditions for cultivating crops.

6.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The Statistik Austria (2008) classification was used for land use definitions:

- Annual cropland (arable land planted with annual crops such as e.g. cereals, corn, rape, field vegetables, strawberries, potatoes, soya beans, energy grass);

- Perennial cropland (viticulture, orchards, tree nurseries, Christmas trees, perennial woody energy crops);

House gardens (area of gardening nearby settlements mostly used for non-profit household demand. This category includes annual as well as perennial crops).

6.3.4 Methodological Issues

6.3.4.1 Cropland remaining Cropland (4.B.1)

This section provides information about emissions/removals for cropland remaining cropland and comprises:

a. annual remaining annual cropland
b. perennial remaining perennial cropland
c. annual cropland converted to perennial cropland
d. perennial cropland converted to annual cropland

The areas of annual crops and woody perennial species like orchards, vineyards, house gardens, plantations for Christmas trees and woody energy crops are considered in line with the 2006 IPCC GL, Vol. 4, Ch. 5.1 (IPCC 2006).

The carbon stock changes of living biomass in the subcategory "annual cropland remaining annual cropland" are considered to be zero. For annual crops in the subcategory "annual cropland remaining annual cropland" the increase in biomass stocks in a single year is assumed to be equal to biomass losses from harvest and mortality in the same year – thus there are no net emissions/removals from biomass in the subcategory "annual cropland remaining annual cropland" (IPCC 2006, Vol. 4, Ch. 5.2.1.1).

The emissions/removals were estimated for the changes in woody perennial biomass stocks of the subcategory "perennial cropland remaining perennial cropland" (above-ground and below-ground biomass, see chapter 6.3.4.1.1). In addition, according to 2006 IPCC GL (IPCC 2006), the emissions/removals from stock changes in living biomass (above-ground and below-ground) at conversion areas between annual and perennial croplands have to be considered (IPCC 2006, Vol. 4, Ch. 5.3). So, these emissions/removals were estimated for conversion areas from annual cropland to perennial cropland and vice versa. For that purpose, the carbon stocks of annual crops and perennial crops were estimated and applied to estimate the related emissions/removals (see chapters 0 and 6.3.4.1.3).

All the cropland biomass stocks and stock changes were estimated on basis of country specific values. The root/shoot ratio of 0.3 for Christmas trees as well as for energy crops (wood) was used for the below-ground biomass. This root/shoot ratio was derived from the results of the Af-/Reforestation assessment (see chapter 6.2.4.2.1, Tier 2 for below-ground biomass-accumulation according to the IPCC 2006 GL).

The above- and belowground biomass stock and stock changes of orchards and vineyards are estimated on the basis of country specific values from a national study undertaken in 2016 and 2017 (see chapter 6.3.4.1.1.).

Dead organic matter (DOM) (including the two pools dead wood and litter) is considered not occurring in cropland. This corresponds to the Tier 1 method according to the IPCC 2006 GL (Vol.4, Ch. 5.2.2.1).

All soil carbon stocks and soil carbon stock changes were estimated on basis of country specific values.

The methodology for the assessment of the mineral soil carbon stock changes (CSC) in annual cropland remaining annual cropland and perennial cropland remaining perennial cropland is based on the results of national studies from agricultural long-term field experimental plots (SPIEGEL et al., 2007, UMWELTBUNDESAMT 2010b) and an updated assessment of the impact from different management types (management factors) of tillage and carbon input to the soil. The method assigns land units into combinations of three tillage types (no-tillage, reduced tillage and full tillage) with variations of input types and input type combinations:

- with/without input from cover crops (between two main crops or evergreen system), which are incorporated into the soil,
- with/without manure input and
- with low/high crop residues input.

The area with cover crops (greening measures) was calculated based on IACS data for 2002 and 2016, the greening areas in the years in between were interpolated. The following rules were applied:

- For 2002, the area of the greening variant E (rape) was excluded, because rape is managed as main crop and harvested; thus the remains are not incorporated in the soil in springtime.
- For 2016 the area of the greening variant "evergreen system" has to be adapted, because actually only a share (about 29 %) of these areas is covered by cover crops.

The total annual removals/emissions of *4.B.1* range between -326 and + 48 kt CO_2 (see Table 277).

In the following subchapters the methodologies and used emission factors for the estimates are explained in detail.

6.3.4.1.1 Changes in carbon stock in biomass of annual cropland remaining annual cropland and perennial cropland remaining perennial cropland (4.B.1.a)

In accordance with the 2006 IPCC GL, Vol. 4, Ch. 5.2.1.1, the carbon stock changes of living biomass in the subcategory "annual cropland remaining annual cropland" are estimated to be zero.

For the subcategory "perennial cropland remaining perennial cropland" the C stock changes in biomass are estimated. It includes orchards, vineyards, Christmas tree cultures, perennial woody energy crops and a share (50%) of house gardens, which is assumed to be perennial.

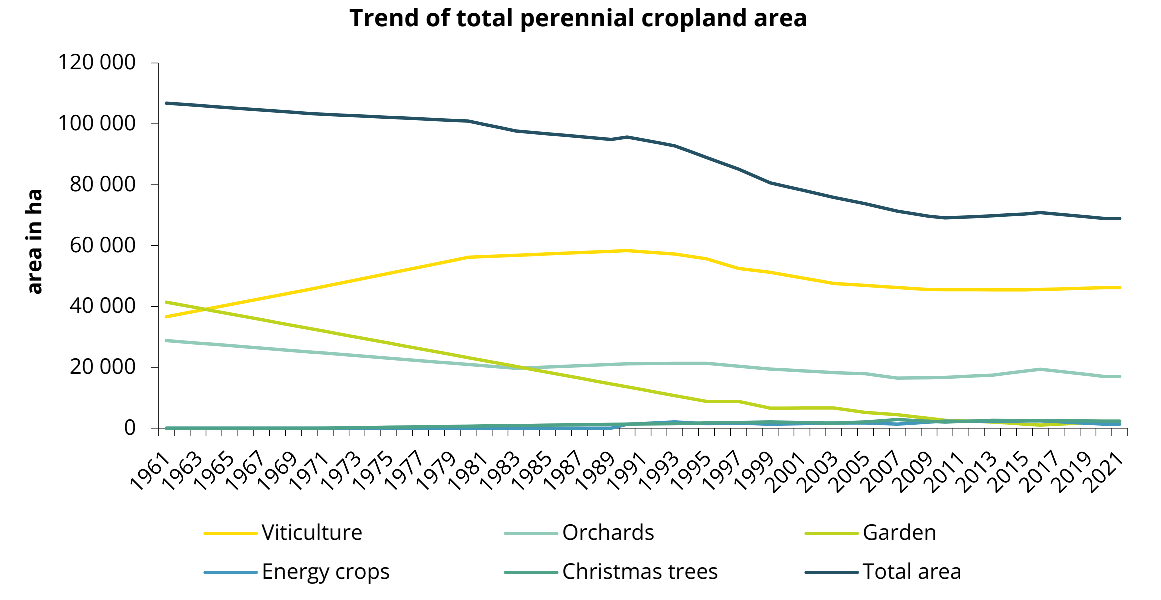
The observation period started in 1960 and based entirely on the activity data from Statistik Austria derived from the Farm Structure Surveys (FSS) data (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014, 2018, 2022a), yearly agricultural statistics (STATISTIK AUSTRIA 1960–2020, STATISTIK AUSTRIA 2021a, 2022b) and vineyards survey (STATISTIK AUSTRIA 2011, 2016, 2021b). As the time series from 1960´s showed some inconsistencies due to the intervals of full agricultural surveys and changes in data collection, the data of the time series were interpolated and thus smoothed across these inconsistent periods. As activity data for perennial cropland, except vineyards since 2009, are available only from Farm Structure Surveys, the areas of the last available FSS are reported until the next FSS data are available. The vineyard area is taken from the vineyard surveys (Weingartengrunderhebungen) for the years 2009, 2015 and 2020 (Statistik Austria 2011, 2016, 2021b), the years between are interpolated.

Table 278: Estimated total area of perennial crops from 1990–2021 in ha.

	Viticulture	Orchards	Garden	Energy crops	Christmas trees	Total area
1990	58 364	21 146	13 572	1 254	1 347	95 683
1991	57 981	21 204	12 613	1 528	1 392	94 717
1992	57 599	21 262	11 653	1 801	1 436	93 751
1993	57 216	21 320	10 693	2 075	1 481	92 785
1994	56 422	21 328	9 734	1 769	1 618	90 869
1995	55 627	21 335	8 774	1 463	1 754	88 953
1996	54 061	20 857	8 776	1 564	1 793	87 051
1997	52 494	20 379	8 778	1 665	1 832	85 148
1998	51 854	19 905	7 686	1 481	1 950	82 876
1999	51 214	19 431	6 593	1 297	2 068	80 603
2000	50 304	19 140	6 609	1 403	1 962	79 418
2001	49 393	18 850	6 625	1 510	1 856	78 233
2002	48 483	18 559	6 641	1 616	1 750	77 048
2003	47 572	18 268	6 657	1 722	1 644	75 863
2004	47 232	18 075	5 924	1 711	1 846	74 788
2005	46 892	17 882	5 191	1 700	2 048	73 713
2006	46 553	17 171	4 818	1 518	2 449	72 507
2007	46 213	16 459	4 444	1 335	2 849	71 300
2008	45 873	16 530	3 821	1 667	2 567	70 457
2009	45 533	16 600	3 199	1 998	2 284	69 615
2010	45 517	16 671	2 576	2 330	2 002	69 096
2011	45 502	16 928	2 393	2 299	2 204	69 325
2012	45 486	17 185	2 209	2 267	2 406	69 554
2013	45 470	17 442	2 026	2 236	2 608	69 782
2014	45 454	18 088	1 690	2 298	2 554	70 084
2015	45 439	18 734	1 355	2 359	2 499	70 386
2016	45 584	19 380	1 019	2 421	2 445	70 849
2017	45 729	18 789	1 279	2 149	2 421	70 367
2018	45 874	18 198	1 539	1 878	2 396	69 886
2019	46 020	17 607	1 799	1 606	2 372	69 404
2020	46 165	17 016	2 060	1 334	2 348	68 923
2021	46 165	17 016	2 060	1 334	2 348	68 923

Figure 37 illustrates the decrease of the total perennial cropland area from 1960 to 2009, remaining rather constant after 2009. This decrease was mainly caused by the continuous decline in the fruit growing area (orchards) and, in particular, the house garden area. The area under vine production – which has the highest share of perennial crop area – increased until 1990, resulting in a net sink of the entire perennial crop category in the first years of the 1990´s. However, the decline of the vine area after 1990 leads to a living biomass change from a sink to a source after 1994. The related losses of older perennial biomass at the end of rotation periods is not compensated by the growth of the replanted areas of "perennial cropland remaining perennial cropland" due to these land use changes and a related unbalanced age/area distribution in "perennial cropland remaining perennial cropland". The above dynamics are thus driving a general trend of loss in biomass C from this subcategory. The variability in biomass C stock changes from year to year is also caused by the conversions from perennial cropland to other agricultural land uses. Such changes are usually due to economic reasons and are carried out at the end of the rotation period. Large areas of such conversions in some years go hand in hand with less harvest in the "remaining" perennial cropland subcategory and vice-versa. The IACS system (see chapter 6.3.2) provides more detailed information of such conversions for the years after 2002 which is the reason for the higher variation in this subsequent period as before.

Figure 39: Trend of total perennial cropland area (ha) from 1960–2021.



Source: Umweltbundesamt, based on data from Statistik Austria

In 2016 and 2017, a national survey to estimate the biomass for viticulture and orchards was conducted. Wine and orchard farmers were contacted with the support of the Austrian agricultural chamber. In case of clearing some vineyards and orchards, the farmers were asked to weigh the cleared biomass and to fill out a questionnaire and provide information on their vineyards and orchards plantation (species, weight of above and belowground biomass of the plants, number of weighted plants, number of plants per ha, age of the plants). From the results of the survey for about 28 vineyards and 20 orchards average Austrian biomass stocks at the end of the rotation period, annual biomass growth rates and the average rotation periods for these perennial cultures were derived (Table 279). The annual biomass growth rate was determined by means of regression analysis. For the conversion from fresh biomass to dry matter the country specific values of 0.56 for wine and 0.5 for orchards were applied.

For calculating the carbon stock change of living biomass of vineyards remaining vineyards the following equation was applied using country specific data:

*Annual change in biomass = (area of viticulture remaining viticulture * annual carbon accumulation rate) – (area of viticulture before 35 years *0.029 (i.e. rate of area at end of rotation period) * biomass carbon stock at end of rotation period)*

From the national survey on viticulture a country specific average value for total above and below ground vineyard biomass stock at the end of rotation period of 3.37 t C ha^{-1} was estimated. The annual accumulation rate of vineyard biomass is 0.096 t C ha^{-1} a^{-1} and the rotation period of wine is 35 years.

For orchards the carbon stock of above and below ground biomass stock at the end of rotation period amounts to 13.41 t C ha^{-1}. Based on the information provided by the famers the average rotation period of orchards is 18 years. The annual biomass accumulation rate is 0.745 t C ha^{-1} a^{-1}.

For calculating the carbon stock change of living biomass from orchards remaining orchards the following equation was applied using country specific data:

*Annual change in biomass = (area of orchard remaining orchard * annual carbon accumulation rate) – (area of orchard before 18 years * 0,056 (i.e. rate of area at end of rotation period)* biomass carbon stock at end of rotation period)*

For 50 % of the house garden area the same emission factor as for orchards is applied. It is assumed that this proportion of house garden area is covered by orchards.

Viticulture and orchards have by far the highest proportion (about 90 %) of the perennial cropland area. Therefore, their biomass emission factors are considered in the LUCs and conversions involving perennial cropland. Weighted means for perennial cropland biomass in case of conversions or LUCs is calculated on basis of the different areas and emission factors for vineyards and orchards. This leads to the following used values for perennial croplands in case of LUCs and conversions: a perennial biomass carbon stock before conversion of 6.09 t C ha^{-1} and an average annual carbon accumulation rate of perennial crops of 0.27 t C $ha^{-1}a^{-1}$.

Christmas trees and woody energy crops have only a small share of the perennial cropland area and the calculation is based on country specific values (Tier 2). For Christmas trees and woody energy crops a country specific steady state of biomass increase over 10 years and 6 years of rotation period, respectively, was assumed. The energy wood crop cultivation was assumed to start in 1990 (according to Statistik Austria), so after a rotation period of 6 years, that is from 1996 onwards, the energy wood crops cause gross emissions parallel to the removals in the growing biomass.

For Christmas trees and energy wood plants country specific carbon biomass stocks, growth rates and rotation periods were applied:

For calculating the carbon stock change of living biomass from Christmas tree cultures remaining Christmas tree cultures the following equation was applied using country specific data:

*Annual change in biomass = (area of Christmas tree cultures remaining Christmas tree cultures * Carbon accumulation rate) – (area of Christmas trees before 10 years * 0.1 (i.e. rate of area at end of rotation period)* biomass carbon stock at end of rotation period)*

According to BMLFUW (2000) and expert judgement a country specific average value of 36 t C ha^{-1} for the carbon stock of Christmas trees at harvest (above-ground biomass) was used. The rotation period for Christmas trees is 10 years, which leads to an accumulation rate of 3.6 t C ha^{-1} a^{-}1 in above-ground biomass. By using the root/shoot ratio of 0.3 for Christmas trees, which was derived from the results of the Af-/Reforestation assessment (see chapter 6.2.4.2.1), also the belowground biomass was estimated. So, 4.68 t C ha^{-1} a^{-1} annual total biomass accumulation rate and a total biomass carbon stock of 46.8 t C ha^{-1} at harvest was computed and applied for Christmas trees cultures (above-ground and below-ground) for all years.

For energy wood crops a country specific value of 30 t C ha^{-1} for the carbon stock at harvest for above ground biomass was used (SPLECHTNA & GLATZEL 2005). According to this literature the rotation period for energy wood crops is six years. This leads to an annual carbon accumulation rate in above ground biomass of 5 t C ha^{-1} a^{-1} for energy crops. By using the root/shoot ratio of 0.3 for energy crops (wood), which was derived from the ARD-NFI-results, the belowground biomass could be estimated as well. Including the root biomass, a factor of 6.5 t C ha^{-1} a^{-1} total annual biomass accumulation rate and a total biomass carbon stock of 39 t C ha^{-1} at harvest was computed and applied for energy wood crops biomass (above-ground and below-ground) for all years.

For calculating the carbon stock change of living biomass on energy wood crops the following equation was applied:

*Annual change in biomass of energy crops = (area of energy wood crops remaining energy wood crops * Carbon accumulation rate) – (area of energy wood crops before 6 years * 0.166 (i.e. rate of area at end of rotation period)* biomass carbon stock at end of rotation period)*

Table 279: Biomass carbon stock and annual biomass carbon accumulation rate of perennial cropland cultures.

Perennial crop	**Carbon stock of above- and belowground biomass at end of rotation period (t C ha^{-1})**	**Annual increase in above- and below-ground biomass carbon stock (t C ha^{-1} a^{-1})**	**Rotation period (years)**	**Method**
Vineyards	3.37	0.096	35	country specific values
Orchards	13.41	0.745	18	country specific values
House gardens	13.41	0.745	18	country specific values
Christmas trees	46.8	4.68	10	country specific values
Energy wood crops	39	6.50	6	country specific values

6.3.4.1.2 Changes in carbon stocks in biomass of annual cropland converted to perennial cropland (4.B.1.b)

The total conversion area from annual cropland converted to perennial cropland over a transition period of 20 years was 11 737 ha in 2021.

The applied method is consistent with the 2006 IPCC approaches for LUCs (IPCC 2006, ch. 5.3 "Land converted to cropland", ch. 5.3.1.1 for biomass calculations). It is important to note that the 2006 IPCC GL do not foresee any method for conversions between annual and perennial cropland in the cropland category. However, annual cropland and perennial cropland have different C stocks and C accumulation rates in both biomass and soil. Therefore our approach to account for the C stock changes due to conversions between annual cropland and perennial cropland gives a more accurate picture of the emissions/removals of the subcategory "cropland remaining cropland". This approach regarding soil C stock changes of such conversion lands does not represent any double accounting to the estimates in the soil C pool (the estimates in chapters 6.3.4.1.4. and 6.3.4.1.6), because the estimates of the soil C stock changes in these subcategories only account for the change in "land management factors" of "annual cropland remaining annual cropland" and for the change between the equilibrium soil C stocks of annual cropland and perennial cropland (or vice versa) when conversions between these two cropland subcategories occur. The activity data for estimating these emissions/removals strictly represent the areas of these "cropland remaining cropland" subcategories. There is thus no double accounting in these "cropland remaining cropland" subcategories.

In accordance with the method described in chapter 5.3.1.1 and equation 2.15 and 2.16 of the 2006 IPCC GL the biomass gains or losses of annual crops due to LUC to/from annual cropland have to be accounted once, namely in the initial year of LUC (even though annual crops represent a biomass C pool only during the growing season and not during the whole year).

For the calculation of the annual change in carbon stocks in living biomass of annual corpland converted to perennial cropland the 2006 IPCC GL equations 2.15 and 2.16 were applied (IPCC 2006). For perennial cropland a weighted average annual growth according to the Austrian survey on viticulture and orchards (0.27 t C $ha^{-1}a^{-1}$) was assumed for each year of the whole transition period of 20 years (see chapter 6.3.4.1.1).

*Annual change in biomass = conversion area for a transition period of 20 years * ΔC_{growth} +*
*annual area of currently converted land * $L_{conversion}$*

L conversion	*= C after –C before*
C_{after}	*= carbon stock immediately after conversion is 0*
ΔC_{growth}	*= value for perennial crops carbon accumulation rate is 0.27 t C $ha^{-1}a^{-1}$ (annual growth rate in each year of the whole transition period of 20 years)*
C_{before}	*= country specific value of carbon stock of annual crops before conversion is 6.67 t C $ha^{-1}a^{-1}$ (biomass loss accounted only for the year of conversion)*

For the annual cropland biomass losses in the year of conversion from annual to perennial cropland, the country specific average biomass stock in annual cropland was calculated from national statistics (STATISTIK AUSTRIA 2007). For all annual crops mentioned in the Statistical Report, the harvested yield biomass has been taken and the related biomass of straw, leaves or other aboveground plant parts not covered by the "yield biomass" have been estimated on basis of plant specific expansion factors yield to total aboveground biomass. Root/shoot ratios for the individual crops of the United States Department of Agriculture were applied to estimate the total plant biomass. Since the U.S. are located also in the temperate region the use of the U.S. root/shoot ratios seem most appropriate. These factors represent the average root/shoot values from 1990–2005 for different types of annual crops (WEST 2008). The estimated Austrian aboveground biomass in annual crops was multiplied with the root/shoot ratios to provide an estimate of the below-ground biomass. The means of the annual aboveground and below ground biomass of the crops were calculated and weighted by the related area of these crops in Austria to get the average annual cropland biomass. The estimated annual cropland biomass stock represents the peak annual cropland biomass during the growing season and the average for a time-period of 10 years.

This led to a figure of 6.67 t C ha^{-1} for the biomass in annual cropland that is used for the estimates of LUCs to and from annual cropland. This country specific value is 33.4 % higher than the 2006 IPCC GL default value (5.0 t C ha^{-1}).

6.3.4.1.3 Changes in carbon stocks in biomass of perennial cropland converted to annual cropland (4.B.1.c)

The total conversion area from perennial cropland converted to annual cropland over a transition period of 20 years was 9 853 ha in 2021.

The rationale for these estimates and the used methods are described in chapter 0. For the calculation of the annual change in carbon stocks of living biomass of perennial cropland converted to annual cropland the 2006 IPCC GL equations 2.15 and 2.16 were applied (IPCC 2006). For the perennial cropland biomass before conversion the average value of 6.09 t C ha^{-1} was applied. This weighted mean is derived from the Austrian survey on carbon stocks of vineyards and orchards (see chapter 6.3.4.1.1)

According to the 2006 IPCC GL the gains of the annual cropland biomass during LUCs to annual cropland are accounted only once, in the initial year of LUC to annual cropland (see also chapter 0 for the considerations in behind):

*Annual change in biomass = annual area of currently converted land * (L $_{conversion}$ + ΔC growth)*

$L_{conversion}$	*= C_{after} –C_{before}*
C_{after}	*= carbon stock immediately after conversion is 0*
ΔC_{growth}	*= country specific value for annual crops carbon accumulation rate is 6.67 t C $ha^{-1}a^{-1}$(see chapter 0; accounted only for the year of LUC)*
C_{before}	*= value for carbon stock of perennial cropland biomass before conversion is 6.09 t C ha^{-1}(accounted only for the year of conversion)*

6.3.4.1.4 Changes of carbon stocks in mineral soils of "annual cropland remaining annual cropland" and "perennial cropland remaining perennial cropland" (4.B.1.a)

According to national soil inventories organic soils are not occurring in cropland in Austria.

Emissions/removals due to soil C stock changes in "annual cropland remaining annual cropland" were calculated using a country specific methodology (Tier 2). For the soil organic carbon content the Austrian specific average value of 50 t C ha^{-1} for 0–30 cm depth of cropland was assumed for 1990 which is based on the results of the Austrian soil inventory (GERZABEK et al. 2003., STREBL et al. 2003). This assumption is supported by the fact that the soil inventories were carried out between 1988 and 1996. Furthermore, we assumed that this Austrian specific soil C stock for cropland represents a steady state that already includes the effects of the management for the period before 1990 and that cropland management was rather stable in that period.

The further methodology follows closely the 2006 IPCC GL, where the IPCC equation 2.25 includes a management factor (F_{MG}), a land-use factor (F_{LU}) and an input factor for input of organic matter (F_I) (Table 5.5, IPCC 2006).

In a study by the Austrian Agency for Health and Food Safety (AGES) and Umweltbundesamt (UMWELTBUNDESAMT 2010b) the IPCC default management factors for SOC (soil organic carbon) stock change have been assessed against results from national long-term field experiments of AGES (SPIEGEL et al., 2007). The results of the C stock change rates for the agricultural experimental plots were allocated to different management types (management factors) like tillage types and input types:

The country-specific land-use factor (F_{LU}) for long-term cultivated cropland soils of 0.93 is applied according to the results of the long-term field experiments of AGES (UMWELTBUNDESAMT 2010b).

The stock change factors for management (F_{MG}) were also applied according to the results of the long-term field experiments of AGES (UMWELTBUNDESAMT 2010b, SPIEGEL et al. 2007), showing the effects of different tillage types (minimum, reduced and conventional tillage) on soil organic carbon.

According to these results, F_{MG}-full and F_{MG}-reduced have the same country specific management factor of 1.0. For F_{MG}-no-till the country specific management factor of 1.09 was derived (UMWELTBUNDESAMT 2010b).

The stock change factors for input (F_I) were also revisited: F_I-Low does not occur in Austria, F_I-medium was assigned a management factor of 1.0 according to UMWELTBUNDESAMT (2010b), F_I-high-without manure was assigned with a factor of 1.05 and for the input type F_I-high-with manure a factor of 1.11 was derived as mean value of the found results in the long-term field experiments (UMWELTBUNDESAMT 2010b).Table 280 shows the revised national factors used compared to the IPCC default values (for cool, temperate, moist regime).

Table 280: Relative stock change factors for cropland according to IPCC default values and revised national factors

Factor value type		Level	IPCC default 2006 IPCC GL (cool, temperate, moist regime)	Applied revised national factors (UMWELTBUNDESAMT 2010b)
Land use (F_{LU})	F_{LU}	Long-term cultivated	0.69	0.93
Tillage (F_{MG})	F_{MG1}	Full	1.00	1.00
	F_{MG2}	Reduced	1.08	1.00
	F_{MG3}	No-Till	1.15	1.09
Input (F_I)	F_{I1}	Low	0.92	0.95
	F_{I2}	Medium	1.00	1.00
	F_{I3}	High – without manure	1.11	1.05
	F_{I4}	High – with manure	1.44	1.11

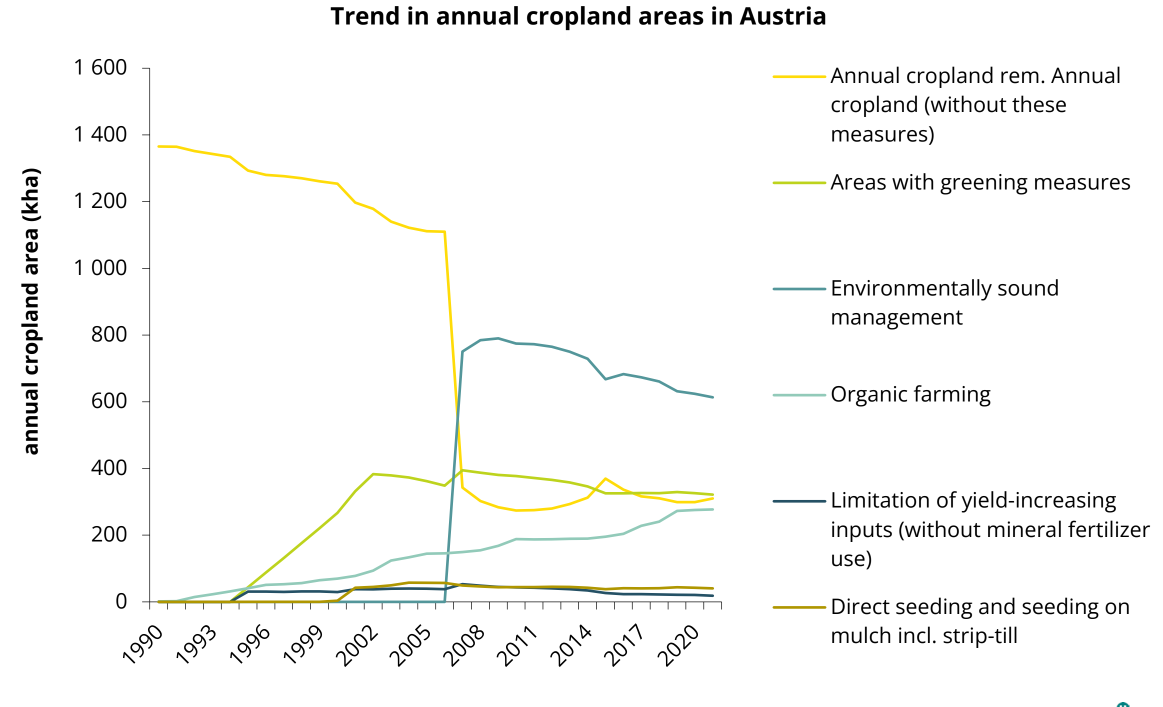
The methodological regime for splitting the annual cropland into the different tillage and input types and assigning the specific management factors is as following:

As a starting point, the annual cropland area per year was splitted into four Agri-environment--climate Measures (AECM) according to the Austrian ÖPUL program (BMLFUW, 2016), which is part of the Rural Development programme (pillar 2 of the Common Agricultural Policy). ÖPUL started in 1995, but these single management measures started at different years (see BMLFUW, 2016):

- cropland with organic farming
- cropland with limitation of yield-increasing inputs (without mineral fertilizer use)
- cropland with environmentally sound management (UBAG, UBB)
- cropland with direct seeding and seeding on mulch incl. strip-till
- the area of annual cropland remaining annual cropland without these measures

These areas are available for the whole time series (Figure 40) and were taken from the agricultural statistics (which are based on IACS since 2002).

Figure 40: Trend of annual cropland areas in Austria with selected Agri-environment-climate measures (kha).



Source: Umweltbundesamt based on IACS data

Each of the annual areas of these five management measures were further divided on basis of the results of an IACS analysis and the FSS survey results into combinations starting from

1. three tillage types: area with no-tillage, area with reduced tillage and area with full tillage. The percentage share of cropland areas was applied according to the results of the last full FSS in 2010 (STATISTIK AUSTRIA, 2013). According to this FSS 973.069 ha (73.3%) of annual cropland were managed with full tillage (conventional ploughing method with mouldboard plough and implement combinations). 326.731 ha (24.6%) were managed by conservation or reduced tillage methods (ploughless tillage systems, with cultivator, harrow) and only 28.349 ha (2.1%) were managed by direct seed without previous tillage (no-tillage systems). The share of no-tillage systems was confirmed by the figures of the FSS 2016. The relative trend across years was adjusted by the trend of the AECM cropland area with direct seeding and seeding on mulch incl. strip-till. This approach is justified by the relationship of this AECM type with reduced tillage approaches.

with combinations of

2. six input types
   a. with/without input from cover crops at cropland, specifically the areas of two dedicated AECM measures : "Cover crops at arable land – intermediate crops (cover crops between two main crops)" and "Cover crops at arable land – "Evergreen" system (both compiled in the trend line "areas with greening measures" in Figure 38 above).
   b. with/without manure input: on basis of figures for the livestock number of each cropland farm. The indicator "Livestock units (GVE) per hectare" was calculated at farm level and if the value was > 0.5 LU/ha, a manure input to cropland is assumed.

c. crop types with low or high crop residues input: The different annual crop types in the Austrian cropland were divided into crops with high residues and crops with low residues based on BMLFUW (2017).

The possible combinations and related soil C stock change factors are shown in Table 281.

Table 281: Possible combinations of management types of annual cropland areas and assigned management factors.

Tillage	Cover crops	Manure	Crop residues	F_{LU}	F_{MG}	F_I	Average equilibrium cropland soil C stock in 1990 (from soil inventories) (t C ha^{-1} for 0–30 cm)	Estimated reference soil C stock based on the factor combination F_{LU} 0.93, F_{MG} 1.0, F_I 1.0 as typical for the management before 1990 (t C ha^{-1} for 0–30 cm)	Estimated new equilibrium soil C stock after 20 years according to management measure combination in line (t C ha^{-1} for 0–30 cm)	Yearly soil C stock change according to management measure combination in line (t C ha^{-1} a^{-1})
Full	No	Yes	Low	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	No	Yes	High	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	No	No	Low	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	No	No	High	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	Yes	Yes	Low	0.93	1.0 (full)	1.11 (High – with manure)	50	53.8	55.5	0.28
Full	Yes	Yes	High	0.93	1.0 (full)	1.11 (High – with manure)	50	53.8	55.5	0.28
Full	Yes	No	Low	0.93	1.0 (full)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
Full	Yes	No	High	0.93	1.0 (full)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
Reduced	No	Yes	Low	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	No	Yes	High	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	No	No	Low	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	No	No	High	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	Yes	Yes	Low	0.93	1.0 (reduced)	1.11 (High – with manure)	50	53.8	55.5	0.28
Reduced	Yes	Yes	High	0.93	1.0 (reduced)	1.11 (High – with manure)	50	53.8	55.5	0.28
Reduced	Yes	No	Low	0.93	1.0 (reduced)	1.05 (High – w.out manure)	50	53.8	52.5	0.13

Tillage	Cover crops	Manure	Crop residues	F_{LU}	F_{MG}	F_I	Average equilibrium cropland soil C stock in 1990 (from soil inventories) (t C ha^{-1} for 0–30 cm)	Estimated reference soil C stock based on the factor combination F_{LU} 0.93, F_{MG} 1.0, F_I 1.0 as typical for the management before 1990 (t C ha^{-1} for 0–30 cm)	Estimated new equilibrium soil C stock after 20 years according to management measure combination in line (t C ha^{-1} for 0–30 cm)	Yearly soil C stock change according to management measure combination in line (t C ha^{-1} a^{-1})
Reduced	Yes	No	High	0.93	1.0 (reduced)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
No	No	Yes	Low	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	No	Yes	High	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	No	No	Low	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	No	No	High	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	Yes	Yes	Low	0.93	1.09 (no)	1.11 (High – with manure)	50	53.8	60.5	0.52
No	Yes	Yes	High	0.93	1.09 (no)	1.11 (High – with manure)	50	53.8	60.5	0.52
No	Yes	No	Low	0.93	1.09 (no)	1.05 (High – w.out manure)	50	53.8	57.2	0.36
No	Yes	No	High	0.93	1.09 (no)	1.05 (High – w.out manure)	50	53.8	57.2	0.36

Based on IACS 2002 and 2016 data, this splitting of cropland area within the individual five management measures was calculated and the relative share of areas with different input combinations and related management factors was interpolated between these two years and was applied regressively backwards until 1990 related to the area trend of the five management measures.

For the subcategory "perennial cropland remaining perennial cropland" the soil carbon stock changes have been calculated as well based on the assignment of the three management factors F_{LU}, F_{MG} and F_I. The IPCC default value for F_{LU} is applied according to 2006 IPCC GL, table 5.5, for perennial/tree crops, which is 1.0. For vineyards as well as for orchards, soil erosion measures (AECM) are in place since 1995 which have the following features: For these areas a management factor F_{MG} for reduced tillage 1.0 (see Table 280) was assigned due to year-round, area-wide cover crops at the machine tracks in vineyards and orchards or, at a minimum, winter cover crops in vineyards in case of a slope gradient <25% (BMLFUW, 2016). However, all the other vineyards and orchards were categorized as full tillage (F_{MG} = 1.0, see Table 280).

For the areas with the soil erosion measure an input factor F_I of 1.05 is applied, which is the Austrian value for high input – without manure, see Table 280. High input was categorized because of the year-round, area-wide cover crops at the machine tracks in vineyards and orchards or, at minimum, winter cover crops in vineyards in case of a slope gradient < 25% (BMLFUW 2016).

The areas, where these soil erosion measures are applied, are taken from IACS data.

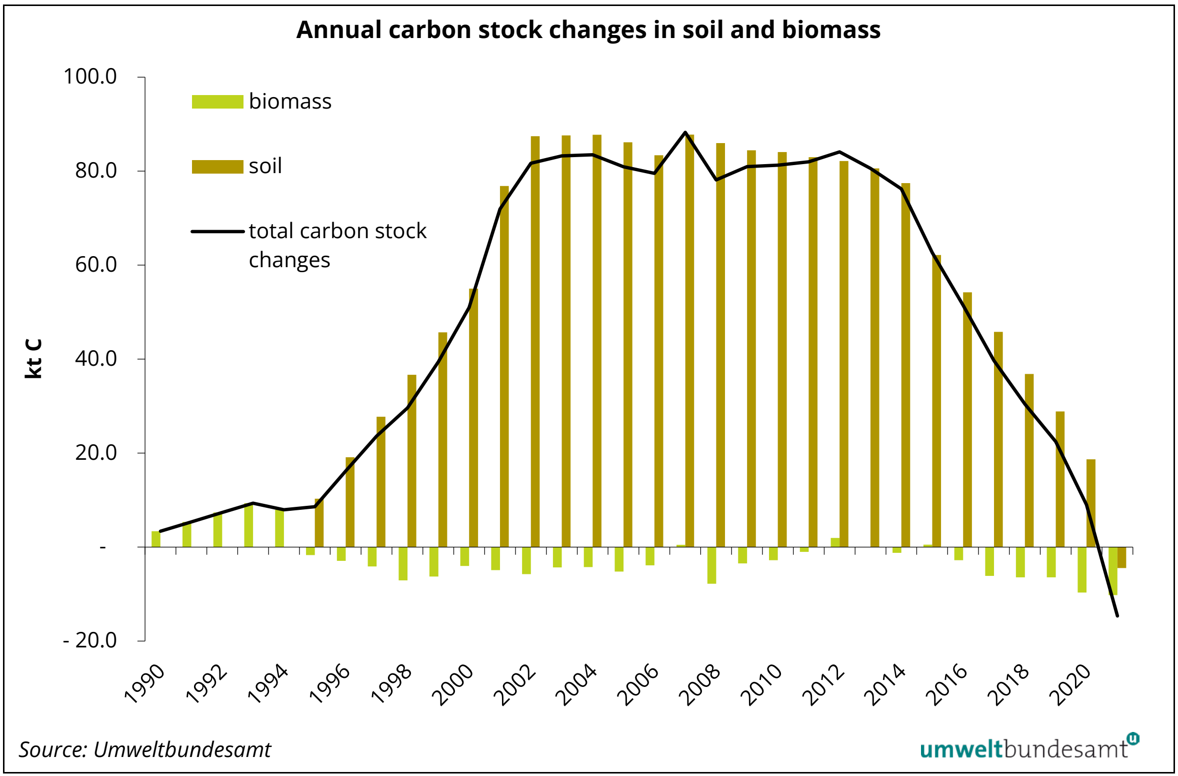
Table 282: Perennial cropland management measures and assigned management factors.

Management measures	**F_{LU}**	**F_{MG}**	**F_I**	**Average equilibrium perennial cropland soil C stock in 1990 (from soil inventories) (t C ha^{-1} for 0–30 cm)**	**Estimated reference soil C stock based on the factor combination F_{LU} 1.0, F_{MG} 1.0, F_I 1.0 as typical for the management before 1990 (t C ha^{-1} for 0–30 cm)**	**Estimated new equilibrium soil C stock after 20 years according to management measure combination in line (t C ha^{-1} for 0–30 cm)**	**Yearly soil C stock change according to management measure combination in line (t C ha^{-1} a^{-1})**
Cropland with soil erosion measure: vineyards	1.0	1.0	1.05	57	57	59.85	0.14
Cropland with soil erosion measure: orchards	1.0	1.0	1.05	57	57	59.85	0.14
Other perennial cropland without soil erosion measures	1.0	1.0	1.00	57	57	57.00	-

An important reason for the inter-annual changes of emissions/removals within the subcategory cropland remaining cropland lies in the increase in the soil carbon stock changes. There is an increase in the soil carbon stock depending on specific management changes in agricultural land as defined and promoted in the Austrian Agri-environment-climate Scheme – ÖPUL (relevant ÖPUL measures are cover crops, organic farming, tillage reduction). The Agri-environment-climate Scheme is part of the second pillar of the CAP (Common Agricultural Policy) in Europe. In 1995 with Austria's joining of the EU the first Agri-environment Scheme was applied and accordingly led to an estimated increase of the annual soil carbon stock change by more than 40 kt C a^{-1}. In the following

CAP periods from 2000-2006 and 2007–2013 further increases in the annual C stock changes occur due to the increase of areas where the specific Agri-environment Measures were implemented (see Figure 39). Figure 39 indicates also a significant decrease in the annual mineral soil C stock changes since 2015, which is caused by achieving the end of the default 20 year transition period for reaching the new equilibrium soil C stock due to the changed cropland management at those cropland areas where the implementation of measures started in 2015. It is planned to further resample the experimental plots in order to check the appropriateness of the 20 years transition period for soil C stock changes due to cropland management changes in Austria.

Figure 41: Annual carbon stock changes in soil and biomass of the subcategory annual cropland remaining annual cropland and perennial cropland remaining perennial cropland (kt C).



6.3.4.1.5 Changes of carbon stock in soils of annual cropland converted to perennial cropland (4.B.1.b)

The conversion area from annual cropland to perennial cropland (in conversion status for a time period of 20 years) changed from 13 243 ha to 11 737 ha from 1990 to 2021.

The rationale for estimating the soil C stock changes of this conversion has been given in chapter 0.

Emissions/removals were calculated by country specific average values for carbon stocks in mineral soils of annual and perennial cropland. According to the Austrian soil inventories (GERZABEK et al. 2003) the C-stock of soils in perennial cropland is between 48–67 t C ha^{-1} (0–30 cm) with a weighted mean of 57 t C ha^{-1}.

According to the 2006 IPCC GL (Equation 2.25, IPCC 2006) annual rates of carbon stock change are estimated as the difference in stocks at two points in time divided by the time dependence of the stock change factors.

*Annual change in carbon stock of mineral soils in annual cropland converted to perennial cropland = ΔSOC_{20} * conversion area for a transition period of 20 years*

$$\Delta SOC = (SOC_0 - SOC_{0\text{-}T})/20 = 0.35\ t\ C\ ha^{-1}\ a^{-1}$$

ΔSOC_{20}	*average annual carbon stock change in soils of annual cropland converted to perennial cropland (t C ha^{-1} a^{-1}) over a conversion transition period of 20 years*
SOC_0	*carbon stock in soils 20 years after conversion from annual to perennial cropland (i.e. average C stock in 0–30 cm of perennial cropland soils in Austria) →57 t C ha^{-1}*
$SOC_{0\text{-}T}$	*carbon stock in Austrian annual cropland soils before conversion (i.e. average C stock in 0 – 30 cm of annual cropland soils in Austria; see chapter 6.3.4.1.4) → 50 t C ha^{-1}*

The average carbon stock in Austrian soils of perennial cropland is 57 t C ha^{-1} and of annual cropland it is 50 t C ha^{-1}. The average annual change in soil C stock for the area over the transition period (20 years) was calculated and the average annual change in soil C stock was then multiplied by the conversion area.

6.3.4.1.6 Changes of carbon stocks in soils of perennial cropland converted to annual cropland (4.B.1.c)

The area in conversion from perennial cropland to annual cropland for a time period of 20 years is rather stable and ranges from 7 244 ha to 9 853 ha from 1990 to 2021.

The rationale for estimating the soil C stock changes of this LUC has been given in chapter 0.

Emissions/removals were calculated by country specific values for carbon stocks in mineral soils of perennial cropland and annual cropland, respectively. Calculation steps and input data are the same as in chapter 6.3.4.1.5:

$$\Delta SOC_{20} = (SOC_0 - SOC_{0\text{-}T})/20 = -\ 0.35\ t\ C\ ha^{-1}\ a^{-1}$$

*Annual change in carbon stock of mineral soils in perennial cropland converted to annual cropland = ΔSOC * conversion area for a transition period of 20 years*

ΔSOC_{20}	*average annual carbon stock change in soils of perennial cropland converted to annual cropland (t C ha^{-1} a^{-1}) over a conversion transition period of 20 years*

6.3.4.1.7 Biomass burning

Burning of crop residues in vineyards occurs to some minor extent in Austria. The CO_2-emissions from burning of these agricultural residues in viticulture are included in the CO_2-emissions from biomass harvesting of perennial cropland (CRF table 4.B biomass) and notation key "IE" is therefore applied in CRF table 4(V). CH_4- and N_2O-emissions from biomass burning of vineyard residues were previously reported under *3.F* of the sector Agriculture. Following a recommendation of the NEC Review 2022 with respect to emissions of air pollutants, emissions from the burning of residual wood from vinicultures on open fields (formerly reported under 3.F.5 Other) have been reallocated to category *5.C.2.1.b Incineration and Open Burning of Waste – Other* of the sector Waste.

6.3.4.2 Land use changes to Cropland (4.B.2)

6.3.4.2.1 Forest land converted to cropland (4.B.2.1)

The methodology and activity data are described in the chapters 6.2.2 and 6.2.4.2. The area in conversion from forest land to cropland (for a time period of 20 years) ranged from 2 785 ha in 2021 to 4 792 ha in 1994 causing annual net emission rates from 34.8 kt CO_2 to 97.2 kt CO_2, respectively, due to the loss of biomass and C stock changes in soil and litter.

For the calculation of the annual change of carbon stocks the IPCC Tier 3 approach is used. Emissions/removals were calculated by country specific values. The changes of the soil carbon stocks were stratified according to five forest growth regions. The stratified LUC areas and soil C stocks according to these growth regions were used for the estimates. The method is described in chapter 6.2.4.2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to CL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter; Table 277). An interpolation across observation periods is considered unsuitable and is therefore not carried out.

Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter in mineral soils resulting from Forest land converted to Cropland (4(III))

To estimate the associated N_2O emissions the Tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.8) from the net carbon stock change (CSC) in the mineral soil due to the land use change, the CSC was divided by the country specific C/N ratios of forest land soils (19, source: see BFW, 1992) and multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 GL. Finally, the result was converted from the amount of annual direct N_2O-N to N_2O emissions.

Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from managed soils, also related indirect emissions occur. The IPCC 2006 Guidelines provide following Tier 2 methodology in Chapter 11:

$$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5 \text{ (eq.11.10)}$$

Where

…N_2O-N = annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils, kg yr^{-1}

… F_{SOM} = the net annual amount of N mineralized in mineral soil associated with loss of soil C from soil organic matter as a result of changes in land use or management kg N yr^{-1}

… $Frac_{LEACH}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff kg N per kg of N additions

$Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER et al., 2013) and the emission factor EF_5 is taken from Table 11.3 of the IPCC 2006 Guidelines.

6.3.4.2.2 Grassland converted to cropland (4.B.2.2)

This section provides information about emissions/removals for Grassland converted to cropland and comprises:

a. Grassland converted to annual cropland
b. Grassland converted to perennial cropland

Data for land use change from grassland to cropland were estimated from IACS as described in chapter 6.3.2. The use of the IACS system for the assessment of the conversions/LUCs within and between CL and GL (see chapter 6.3.2) allows more accurate annual assessments of the activities since 2002. This leads to higher annual variations in this period than before 2002. Activity data of grassland converted to cropland in the 20 year conversion status are reported in

Table 276. Emissions were estimated applying a country specific methodology (Tier 2) for biomass carbon stocks and for soil carbon stocks.

The average area undergoing land use change from grassland to annual cropland over a period of 20 years is 33 059 ha, ranging from 26 116 ha to 49 710 ha for the period 1990 to 2021. Subsequent annual emissions from these land conversions ranged between 91 and 174 kt CO_2.

The average area undergoing land use change from grassland to perennial cropland over a period of 20 years for 1990–2021 is 745 ha.

Changes of carbon stock in biomass of grassland converted to annual cropland

Country specific data for grassland biomass from the Agricultural Research and Education Centre Raumberg-Gumpenstein (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein) were used. According to the research results the stubble biomass is 0.5 t C ha^{-1} and the root biomass is 2.1 t C ha^{-1}. For the aboveground grassland biomass a value of 3.1 t C ha^{-1} was applied (detailed description see chapter 6.4.4.2.2). That leads to a country specific value for carbon stock of above ground and below ground grassland biomass before conversion of 5.7 t C ha^{-1}. For the calculation of the annual change in carbon stocks in living biomass of grassland converted to cropland equations 2.15 and 2.16 were applied (IPCC 2006).

$$\textit{Annual change in biomass} = \textit{annual area of currently converted land} * (L_{conversion} + \Delta C_{growth})$$

$L_{conversion}$ = $C_{after} - C_{before}$

ΔC_{growth} = *country specific value for annual carbon accumulation rate in annual crops is 6.67 t C $ha^{-1}a^{-1}$(see Chapter 0. accounted only for the year of LUC)*

C_{after} = *carbon stock immediately after conversion is 0*

C_{before} = *country specific value for carbon stock of grassland biomass before conversion is 5.7 t C ha^{-1}(see Chapter 6.4.4.2.2; biomass loss accounted only in the year of LUC)*

Changes of carbon stock in biomass of grassland converted to perennial cropland

For perennial cropland a weighted mean for annual growth according to the Austrian survey on viticulture and orchards (0.27 t C $ha^{-1}a^{-1}$, see chapter 6.3.4.1.1) was used for the whole LUC transition period of 20 years:

$$\textit{Annual change in biomass} = \textit{conversion area for a transition period of 20 years} * \Delta C_{growth} + \textit{annual area of currently converted land} * L_{conversion}$$

$L_{conversion}$ = $C_{after} - C_{before}$

For the calculation the following values were used:

ΔC_{growth} = annual carbon accumulation rate in perennial crops is 0.27 t C $ha^{-1}a^{-1}$(annual growth rate in each year of the whole LUC transition period of 20 years)

C_{after} = carbon stock immediately after conversion is 0

C_{before} = country specific value for carbon stock of grassland biomass before conversion. 5.7 t C ha^{-1} (description see Chapter 6.4.4.2.2. biomass loss accounted only in the year of LUC).

The data in the CRF table represent grassland converted to annual cropland and grassland converted to perennial cropland separately.

Changes of carbon stock in mineral soils of grassland converted to annual cropland

Only mineral soils were considered in this category assuming that grassland on organic soils was not converted to cropland (soil inventories have shown that cropland with organic soils does not exist in Austria).

Emissions/removals were calculated by country specific average values for carbon stocks in mineral soils of grassland and cropland. For the estimates Austrian specific values of 70 t C ha^{-1} for 0–30 cm depth of grassland and 50 t C ha^{-1} for 0–30 cm depth of cropland were used which are based on the results of the Austrian soil inventories (GERZABEK et al. 2003, STREBL et al. 2003). For the calculation of the annual change of carbon stocks in grassland soils converted to annual cropland soils the following equation according to IPCC was applied.

$$\Delta SOC = (SOC_0 - SOC_{0\text{-}T})/20 = -1.0 \text{ t C } ha^{-1} a^{-1}$$

*annual change in carbon stock of mineral soils converted from grassland to cropland = Δ SOC * conversion area for a transition period of 20 years*

ΔSOC = average annual carbon stock change in soils of grassland converted to annual cropland (t C ha^{-1} a^{-1}) over a LUC transition period of 20 years

SOC_0 = carbon stock in cropland soils 20 years after conversion from grassland to annual cropland →50 t C ha^{-1}

$SOC_{0\text{-}T}$ = carbon stock in Austrian grassland soils before conversion →70 t C ha^{-1}

Changes of carbon stock in mineral soils of grassland converted to perennial cropland

The land use change area from grassland to perennial cropland ranges from 515 ha to 1 382 ha per year for the period 1990–2021 considering the area to be 20 years in the conversion category.

Emissions/removals were calculated by country specific average values for carbon stocks in mineral soils of grassland and perennial land. For the soil organic carbon content the Austrian specific values of 70 t C/ha^{-1} for 0–30 cm depth of grassland and 57 t C ha^{-1} for 0–30 cm depth of perennial cropland were used which are based on the results of the Austrian soil inventories (GERZABEK et al., 2003; STREBL et al., 2003). For the calculation of the annual change of carbon stocks in grassland soils converted to cropland soils the following equation was applied.

$$\Delta SOC = (SOC_0 - SOC_{0\text{-}T})/20 = -0.65 \text{ t C } ha^{-1} a^{-1}$$

*annual change in carbon stock of mineral soils converted from grassland to perennial cropland = Δ SOC * conversion area for a transition period of 20 years*

ΔSOC = average annual carbon stock change in soils of grassland converted to perennial cropland (t C ha^{-1} a^{-1}) over a LUC transition period of 20 years

SOC_0 = carbon stock in perennial cropland soils 20 years after conversion from grassland →57 t C ha^{-1}

$SOC_{0\text{-}T}$ = carbon stock in grassland soils before conversion →70 t C ha^{-1}

The data in the CRF table represent grassland converted to annual cropland and grassland converted to perennial cropland.

Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter in mineral soils resulting from Grassland converted to Cropland (4(III))

To estimate the associated N_2O emissions the Tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.8) from the net carbon stock change (CSC) in the mineral soil due to the land use change, the CSC was divided by the country specific C/N ratio of grassland soils (12, source: see footnote[105]) and multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 Gl. Finally, the result was converted from the amount of annual direct N_2O-N to N_2O emissions.

Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from managed soils, also related indirect emissions occur. The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11:

$$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5 \ (eq.11.10)$$

Where

....N_2O-N = annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils, kg yr^{-1}

....F_{SOM} = the net annual amount of N mineralized in mineral soil associated with loss of soil C from soil organic matter as a result of changes in land use or management kg N yr^{-1}

....$Frac_{LEACH}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff kg N per kg of N additions

$Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER et al., 2013) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.3.5 Uncertainty assessment

For the Monte Carlo simulations the following uncertainties of the input parameters were used:

Table 283: Uncertainties of areas in the CL category.

	Before 2001	**Since 2001**
Total cropland	±4%	±4%
Perennial cropland	±20%	±20%
Annual LUC area CL to FL or FL to CL	see Chapter 6.2.5., Table 273	see Chapter 6.2.5., Table 273
Annual LUC area pCL to aCL. aCL to pCL. GL to pCL	±300%[1]	±260%[1]
Annual LUC area GL to aCL	±200%[1]	±150%[1]

[1] For area uncertainties > 100%, distributions were truncated at 0 as negative areas are not possible

These uncertainties origin from:

- Total cropland: based on information from data source (Statistik Austria)

- Perennial cropland: based on information from data source (Statistik Austria)
- Annual LUC area pCL to aCL. aCL to pCL. GL to pCL: Expert judgement from two agricultural experts on basis of the original data
- Annual LUC area GL to aCL: Expert judgement from two agricultural experts on basis of the original data

Table 284: Uncertainties of the input data for the emission factors in the CL category (distributions were truncated at the minima and maxima)

	stock	growth rate or emission factor
Annual CL biomass	±15%	±15%
Vineyards	±17%	±42%
Orchards	±23%	±33%
Perennial energy plants	Triangle Distribution with 21-30-45 t C ha^{-1}	Triangle Distribution with 3.5-5.0-7.5 t C ha^{-1}
Christmas trees	±40%	±40%
Grassland biomass	±45%	±45%
Soil C stock change in CL rem Cl		±40%
Soil C stocks for LUC to CL	see Chapter 6.2.5. Table 274	
N_2O emission factor for soil at LUC to CL (default)		Triangle Distribution with 0.003-0.01-0.03
C/N ratio grassland soils	±55%	
C/N ratio forest soils	±58%	
C/N ratio cropland soils	±10%	
N_2O emission from leaching and run-off – FRACleach		±130%
N_2O emission from leaching and run-off – emission factor (default)		Triangle Distribution with 0.0005-0.0075-0.025

These uncertainties were derived from the following sources:

- Annual CL biomass: for yield based on an assessment from the annual yield statistics; for the expansion factors based on expert judgement
- Vineyards and orchards biomass: based on the survey results
- Perennial energy plants: assessment based on the results of the study that was used [SPLECHTNA & GLATZEL 2005]
- Christmas trees: assessment based on the results of the study that was used [BMLFUW 2000]
- Grassland biomass: for yield based on an assessment from the annual yield statistics; for the expansion factors based on expert judgement
- Soil C stock change in CL rem CL: assessment based on the results of UMWELTBUNDESAMT 2010b
- N_2O emission factors for soil at LUC to CL: IPCC 2006 GL
- C/N ratios of soils: assessment on basis of the Austrian soil inventory results

On basis of these input uncertainties the Monte Carlo simulations led to the following average uncertainties of the total emissions/removals of the Cropland category of the time series: ±105 kt CO_2 (range: ±87 kt CO_2 to ±128 kt CO_2). The average relative uncertainty is ±169% (range: ±41% to ±1 457%) depending on the net emissions or removals of the sector. Years with net emissions and removals of the cropland subcategory close to 0 show logically very high relative uncertainties up to more than one thousand %.

It should be noted that the net emission/removals of the CL category are the result of subtractions between emissions and removals of several subcategories and pools. Only in single cases they are correlated. In line with error propagation laws the uncertainty of such net values based on subtractions of uncorrelated parameters are additive and therefore rather high in relative terms.

6.3.6 Category-specific QA/QC

The calculation of the data for category *4.B* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.3.7 Recalculations

The method to estimate land-use changes between Grassland and Cropland based on IACS/LPIS data was further improved for the 2023 submission. In addition, the LUC areas from Forest land to Cropland since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to cropland for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions/removals of the Cropland category: The annual emissions/removals differ from the last submission in 2022 by -250 to -109 kt CO_2e per year.

6.3.8 Planned improvements

See Chapter 6.1.8.

6.4 Grassland (Category 4.C)

6.4.1 Category description

In this category emissions/removals from Grassland (Grassland remaining grassland and Land converted to grassland) are considered. In 2021 1.5 million ha of Austria were managed as Grassland. This estimation is based on data of the full survey of the year 2020 (STATISTIK AUSTRIA 2022a; detailed description see chapter 6.4.2. Since 1990 the area of grassland has generally been decreasing each year. Total Grassland includes one cut meadows, two cut meadows and three or more cut meadows, permanent pastures, litter meadows, rough pastures, alpine meadows and pastures, grassland where agricultural grassland management was stopped and fallow grassland (grassland in good agricultural and ecological condition no longer used for production; formerly called "GLÖZ").

The annual CO_2 emissions from the Grassland category in Austria amounted to 685 kt CO_2 in 1990 and 434 kt CO_2 in 2021. The main drivers of the emissions are carbon stock changes in mineral soils and biomass due to LUC from Forest land to Grassland, as well as carbon stock losses from drained organic soils under Grassland remaining grassland.

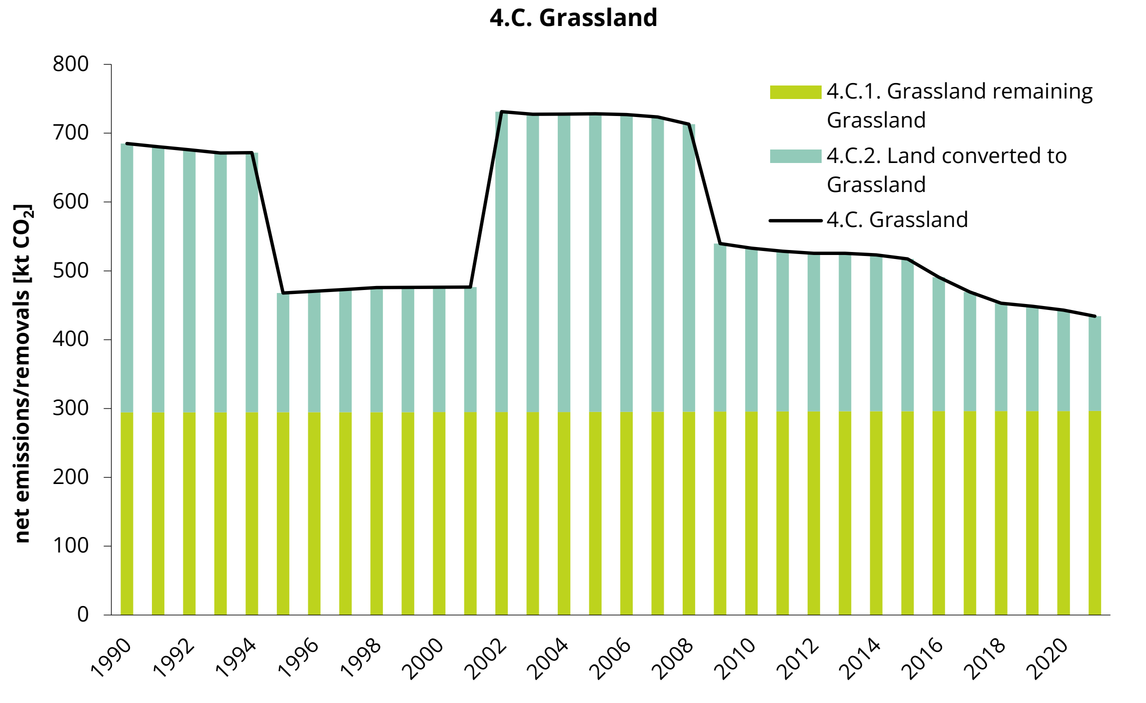
Since 2008 an increase of LUC from cropland to grassland areas can be observed.

Some management practices (e.g. slash and burn etc.) and some subcategories (*4.C.2.3. 4.C.2.4. 4.C.2.5*) do not occur in Austria. Organic soils occur in Austria only in the Grassland remaining grassland category and dead wood and litter is assumed not to occur in grasslands.

Table 285: Sources (or sinks) considered for grassland.

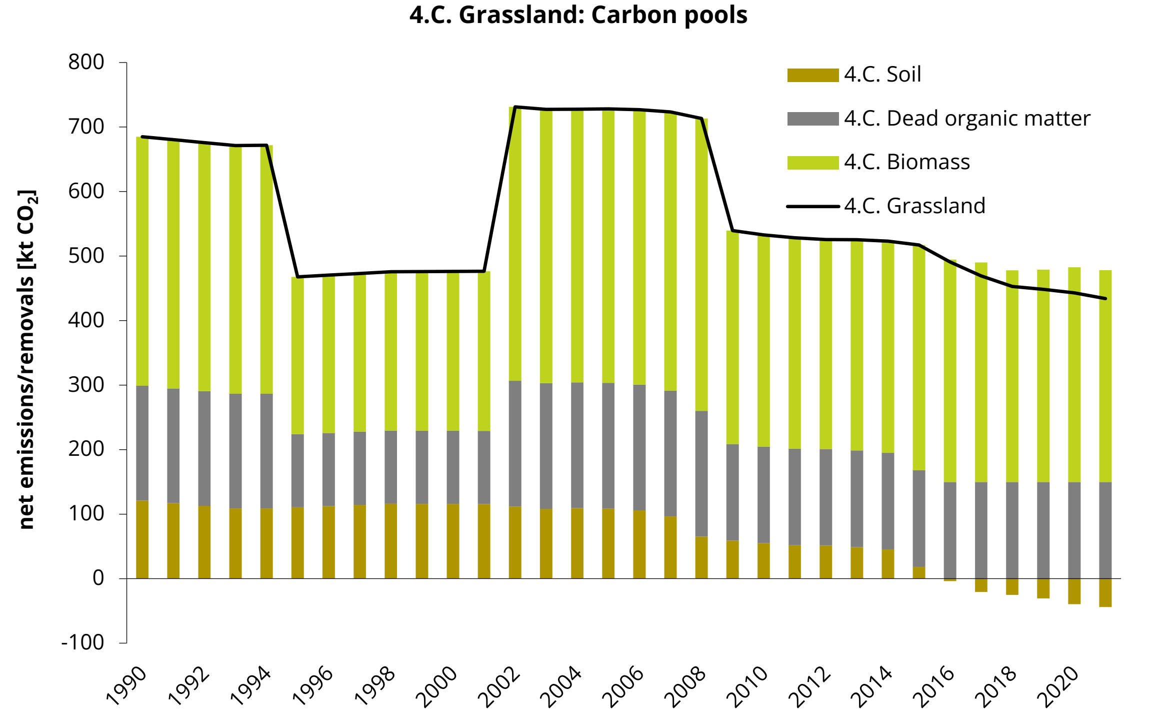
Category/source or sink
4.C Grassland – total
4.C.1 Grassland remaining grassland
- carbon stock changes in soil due to changes in grassland
4.C.2 Land converted to grassland
4.C.2.1 Forest land converted to grassland
- carbon stock change in biomass due to LUC from forest land to grassland
- carbon stock change in DOM due to LUC from forest land to grassland
- carbon stock change in SOM due to LUC from forest land to grassland
4.C.2.2 Cropland converted to grassland
- carbon stock change in biomass due to LUC from cropland to grassland
- carbon stock change in SOM due to LUC from cropland to grassland

Figure 42: Emissions/removals (+/-) from grassland (1990-2021) by grassland remaining grassland and land use change to grassland in kt CO_2



Source: Umweltbundesamt

Figure 43: Emissions/removals (+/-) from grassland (1990-2021) by carbon pools in kt CO_2



Source: Umweltbundesamt

Table 286: Total areas and land-use change areas of grassland 1990–2021 in ha; transition period of 20 years for LUC lands.

	C. Total grassland	1. Grassland remaining grassland	2. Land converted to grassland	2.1 Forest Land converted to grassland	2.2 Cropland converted to grassland - total	a. annual cropland converted to grassland	b.Perennial cropland converted to grassland	2.3 Wetlands converted to grassland	2.4 Settlements converted to grassland	2.5 Other land converted to grassland
1990	1 713 483	1 655 668	57 814	32 467	25 347	25 090	257	NO	NO	NO
1991	1 701 090	1 641 575	59 515	34 203	25 312	25 055	257	NO	NO	NO
1992	1 688 697	1 627 481	61 216	35 939	25 277	25 020	257	NO	NO	NO
1993	1 676 304	1 613 389	62 916	37 675	25 241	24 985	256	NO	NO	NO
1994	1 664 862	1 601 941	62 921	37 716	25 205	24 949	256	NO	NO	NO
1995	1 655 389	1 593 153	62 236	37 069	25 168	24 912	255	NO	NO	NO
1996	1 648 906	1 587 356	61 550	36 421	25 129	24 874	255	NO	NO	NO
1997	1 642 424	1 581 565	60 859	35 773	25 086	24 831	255	NO	NO	NO
1998	1 633 907	1 573 744	60 164	35 125	25 038	24 784	254	NO	NO	NO
1999	1 625 390	1 565 118	60 272	35 284	24 988	24 734	254	NO	NO	NO
2000	1 615 561	1 555 183	60 378	35 442	24 936	24 683	253	NO	NO	NO
2001	1 605 732	1 545 249	60 483	35 601	24 882	24 629	253	NO	NO	NO
2002	1 597 776	1 536 325	61 451	36 621	24 830	24 578	252	NO	NO	NO
2003	1 589 819	1 527 424	62 395	37 640	24 755	24 479	276	NO	NO	NO
2004	1 581 658	1 520 156	61 502	37 037	24 465	24 202	263	NO	NO	NO
2005	1 573 497	1 512 373	61 124	36 433	24 691	24 440	251	NO	NO	NO

	C. Total grassland	1. Grassland remaining grassland	2. Land converted to grassland	2.1 Forest Land converted to grassland	2.2 Cropland converted to grassland - total	a. annual cropland converted to grassland	b.Perennial cropland converted to grassland	2.3 Wetlands converted to grassland	2.4 Settlements converted to grassland	2.5 Other land converted to grassland
2006	1 565 954	1 504 681	61 273	35 830	25 443	25 205	238	NO	NO	NO
2007	1 559 448	1 496 165	63 283	35 227	28 057	27 758	299	NO	NO	NO
2008	1 554 766	1 483 498	71 268	34 623	36 645	36 358	286	NO	NO	NO
2009	1 549 036	1 476 281	72 755	34 146	38 610	38 336	274	NO	NO	NO
2010	1 544 485	1 470 713	73 771	33 840	39 931	39 634	298	NO	NO	NO
2011	1 536 642	1 462 137	74 504	33 534	40 970	40 685	285	NO	NO	NO
2012	1 528 249	1 453 795	74 454	33 228	41 226	40 953	272	NO	NO	NO
2013	1 520 579	1 445 590	74 989	32 923	42 067	41 771	296	NO	NO	NO
2014	1 517 895	1 442 003	75 892	32 617	43 275	42 847	428	NO	NO	NO
2015	1 517 314	1 433 823	83 491	33 001	50 491	49 679	812	NO	NO	NO
2016	1 516 164	1 426 521	89 642	33 384	56 258	55 237	1 021	NO	NO	NO
2017	1 515 344	1 420 984	94 360	33 768	60 592	59 535	1 058	NO	NO	NO
2018	1 513 698	1 418 063	95 635	34 152	61 484	60 403	1 081	NO	NO	NO
2019	1 512 422	1 415 225	97 198	34 535	62 663	61 530	1 132	NO	NO	NO
2020	1 512 113	1 412 351	99 763	34 919	64 844	63 672	1 171	NO	NO	NO
2021	1 510 464	1 409 379	101 084	35 303	65 782	64 551	1 231	NO	NO	NO

Table 287: Emissions/removals (+/-) from grassland in kt CO_2 and CH_4 in CO_2eq (1990–2021).

	4.C Total grassland	1. Grassland remaining grassland	2. Land converted to grassland	2.1 Forest land converted to grassland	2.2 Cropland converted to grassland-total	2.2.a Annual cropland converted to grassland	2.2.b Perennial cropland converted to grassland	2.3 Wetlands converted to grassland	2.4 Settlements converted to grassland	2.5 Other Land converted to grassland	4(II)C Wetlands drainage and rewetting_CH_4 in CO_2eq
1990	684.92	294.33	390.58	478.78	-88.19	-87.60	-0.59	NO	NO	NO	26.64
1991	680.36	294.39	385.98	474.05	-88.07	-87.48	-0.59	NO	NO	NO	26.64
1992	675.78	294.44	381.34	469.28	-87.95	-87.35	-0.59	NO	NO	NO	26.64
1993	671.20	294.49	376.70	464.52	-87.82	-87.22	-0.59	NO	NO	NO	26.64
1994	671.69	294.54	377.15	464.84	-87.69	-87.09	-0.59	NO	NO	NO	26.64
1995	467.79	294.58	173.21	260.76	-87.55	-86.96	-0.59	NO	NO	NO	26.64
1996	470.38	294.61	175.76	263.18	-87.41	-86.83	-0.59	NO	NO	NO	26.64
1997	472.98	294.65	178.32	265.60	-87.27	-86.68	-0.59	NO	NO	NO	26.64
1998	475.60	294.69	180.91	268.03	-87.11	-86.53	-0.59	NO	NO	NO	26.64
1999	475.93	294.73	181.19	268.13	-86.94	-86.35	-0.59	NO	NO	NO	26.64
2000	476.16	294.77	181.39	268.14	-86.75	-86.17	-0.59	NO	NO	NO	26.64
2001	476.40	294.82	181.58	268.15	-86.56	-85.98	-0.58	NO	NO	NO	26.64
2002	731.25	294.86	436.39	522.77	-86.38	-85.80	-0.58	NO	NO	NO	26.64
2003	727.38	294.91	432.47	518.69	-86.23	-85.62	-0.60	NO	NO	NO	26.64
2004	727.65	294.95	432.70	518.58	-85.88	-85.25	-0.63	NO	NO	NO	26.64
2005	728.16	294.99	433.18	518.07	-84.90	-84.30	-0.60	NO	NO	NO	26.64
2006	726.88	295.10	431.77	517.57	-85.80	-85.23	-0.57	NO	NO	NO	26.64
2007	723.49	295.23	428.25	517.07	-88.82	-88.21	-0.61	NO	NO	NO	26.64

	4.C Total grassland	1. Grassland remaining grassland	2. Land converted to grassland	2.1 Forest land converted to grassland	2.2 Cropland converted to grassland-total	2.2.a Annual cropland converted to grassland	2.2.b Perennial cropland converted to grassland	2.3 Wetlands converted to grassland	2.4 Settlements converted to grassland	2.5 Other Land converted to grassland	4(II)C Wetlands drainage and rewetting_CH_4 in CO_2eq
2008	713.16	295.40	417.76	516.57	-98.81	-98.13	-0.68	NO	NO	NO	26.64
2009	539.61	295.53	244.09	373.82	-129.73	-129.08	-0.65	NO	NO	NO	26.64
2010	532.81	295.65	237.16	374.10	-136.94	-136.28	-0.66	NO	NO	NO	26.64
2011	528.43	295.75	232.68	374.39	-141.71	-141.03	-0.68	NO	NO	NO	26.64
2012	525.55	295.84	229.71	375.18	-145.46	-144.81	-0.65	NO	NO	NO	26.64
2013	525.40	295.93	229.46	375.97	-146.50	-145.85	-0.65	NO	NO	NO	26.64
2014	523.05	295.98	227.07	376.75	-149.68	-148.87	-0.81	NO	NO	NO	26.64
2015	517.23	296.07	221.16	375.86	-154.70	-153.33	-1.36	NO	NO	NO	26.64
2016	490.72	296.14	194.58	374.97	-180.39	-178.28	-2.11	NO	NO	NO	26.64
2017	469.28	296.21	173.07	374.08	-201.01	-198.56	-2.45	NO	NO	NO	26.64
2018	452.90	296.26	156.64	373.19	-216.55	-214.02	-2.52	NO	NO	NO	26.64
2019	448.48	296.31	152.17	372.02	-219.84	-217.24	-2.61	NO	NO	NO	26.64
2020	443.03	296.37	146.66	370.84	-224.19	-221.47	-2.72	NO	NO	NO	26.64
2021	434.08	296.45	137.63	369.67	-232.04	-229.22	-2.83	NO	NO	NO	26.64

6.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The area of Grassland remaining grassland represents the total Grassland area minus Land converted to grassland. The areas were estimated from national statistics on Grassland land use (STATISTIK AUSTRIA 1960–2021). However, since the last submission in 2022, consistency issues in these statistics have been identified. Consequently, national statistics on Grassland area provide a first estimate, that is iteratively corrected as part of the process to ensure area consistency in the national land-use change matrices.

National statistics on the total Grassland data area are generated by Austrian Farm Structure Surveys 1993, 1995 (full survey), 1997, 1999 (full survey), 2003, 2005, 2007, 2010 (full survey) and 2020 (full survey) (ÖSTAT 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2018, 2022a). The full surveys are based on the responses to questionnaires sent to all farms and forest enterprises and cover 90% of the area of Austria. In the years between two full surveys the data have been interpolated (eg. 2010-2020). For the years after the last FSS survey year in 2020, Grassland areas for 2021 are extrapolated using the annual trend drived from total grassland areas of 2020. In previous submissions, the inter-/extrapolated time series from the national statistics (albeit with corrections for alpine pastures as described the 2015 submission (UMWELTBUNDESAMT 2015)) were considered as robust estimates of the total Grassland area in Austria. However, after consultations with the providers of these statistics, it emerged that the decline in Grassland area according to these statistics is overestimated. Given that the statistics are based only on agriculturally used grassland areas, the estimates do not adequately account for areas of Grassland, that are no more agriculturally managed and no more owned by farmers, but nonetheless do not loose their status as managed Grassland per national land use definitions (e.g. Grasslands that are no longer owned by farmers, but are used for hunting by the new owners).

The time series of Grassland area derived from the FSS statistics therefore serves as a first estimate that is iteratively corrected to ensure area consistency in the annual land use change matrices for the Austrian territory. Starting with 1989 as an assumed accurate estimate, net change in the following year according to the above statistics on total Grassland area are compared with the net change derived from the respective gross land use changes to and from Grassland. For each year along the time series a correction is derived (an addition or subtraction in ha). This is cumulated over the time series, with the time series of cumulative additions/subtractions applied to correct the first estimate of Grassland area.

Data for land use changes between cropland and grassland were estimated on the basis of IACS. The time series of these lands was changed according to a methodological improvement introduced for this submission (for a detailed description see Chapter 6.3.2).

The LUC areas from forest land to grassland are based on the NFI data (see Chapter 6.2.2).

LUCs from wetland, from settlement and from other land to grassland do not occur in Austria. This assumption is based on the fact that the grassland areas show a steady decrease. In addition, wetland, settlement and other land areas are not suited (anymore) for a land use as grassland:

- Drainage of wetlands for the purpose of grassland use was carried out in Austria in former decades. For reasons of nature conservation this management practice stopped many years ago.
- Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas.
- Settlement areas and soils – once converted – cannot be used for grassland.
- There is also a higher economic value for land dedicated to building land than agricultural land i.e. there is no economic incentive for re-conversion.
- "Other lands" are found at the highest elevations or steepest areas of Austria. The subsequent unfavorable ecological conditions do not allow any agricultural use.

6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The STATISTIK AUSTRIA (2014) classification for grassland was used for land use definitions:

- One cut meadows,
- Two cut meadows,
- Three and more cut meadows,
- Litter meadows,
- Permanent Pastures,
- Rough Pastures,
- Alpine meadows and pastures,
- Grassland where grassland management was stopped and/or the area is no longer managed agriculturally
- fallow grassland: grassland in good agricultural and ecological condition no longer used for production (since 2016 GLÖZ G is called *fallow grassland,* see Statistik Austria 2016).

6.4.4 Methodological Issues

Emissions were estimated by applying country specific methodologies (Tier 2) for both biomass carbon stocks and soil carbon stocks.

6.4.4.1 Grassland remaining grassland (5.C.1)

The area of grassland remaining grassland in 2021 was 1.4 million ha.

The annual CO_2 emissions from grassland remaining grassland between 1990 and 2021 vary only slightly from 294.3 kt CO_2 to 296.4 kt CO_2.

6.4.4.1.1 Changes in carbon stocks in biomass of grassland remaining grassland

According to IPCC 2006 Guidelines the biomass of grassland is not considered in the estimates (it is harvested every year thus there is no long term carbon storage).

6.4.4.1.2 Changes in carbon stocks in mineral soils of grassland remaining grassland

Emissions/removals were calculated using a country specific methodology (Tier 2). For the soil organic carbon content the Austrian specific average value of 70 t C ha^{-1} for 0–30 cm depth of grassland was used (GERZABEK et al. 2003, STREBL et al. 2003). This value is based on the Austrian nationwide soil inventories and it was assumed that it represents the soil carbon stock in 1990. This assumption is supported by the fact that the soil inventories were carried out between 1988 and 1996. Furthermore, we assumed that this Austrian specific soil C stock for grassland represents a steady state that already includes the effects of the grassland management for the period before 1990 and that grassland management was rather stable in that period.

The further methodology follows closely the approach presented by the IPCC guidelines which includes a management factor (F_{MG}), a land use factor (F_{LU}) and an input factor (F_I) (table 6.2, IPCC 2006). The method is similar to cropland described in detail in Chapter 6.3.4.1.4 but less detailed in the time resolution of activities. The soil C stock (SOC_{1990}) for grassland of 70 t C/ha, the management factors for grassland according to table 6.2 of the IPCC guidelines (2006) and the areas of related grassland management in Austria in two years (1990 and 2011) were used.

These default factors were applied to the Austrian situation of grassland management in the years 1990 and 2011 on basis of national area statistics for the grassland management (STATISTIK AUSTRIA 1985–2003; BMLFUW 1985–2011). Management improvements (e.g. increase of organic farming) were considered since 1985. On basis of these areas of different grassland management types and on the IPCC (2006) default management factors an annual increase of soil organic carbon of 0.00162 t C ha^{-1} in grassland remaining grassland across a period of 20 years is calculated.

The carbon stock changes of grassland soil from 1990–2020 were calculated then on basis of this annual soil C stock increase.

Annual change in carbon stock of mineral soils in grassland remaining grassland =
*Δ SOC_{20} * area of grassland remaining grassland*

$$\Delta SOC_{20} = (SOC_{1990+20} - SOC_{1990})/20 = 0.00162 t\ C\ ha^{-1}\ a^{-1}$$

The approach of the IPCC 2006 Guidelines was used to divide *($SOC_{1990+20}$ - SOC_{1990})* the length of the inventory period.

6.4.4.1.3 Changes in carbon stocks of organic soils of grassland remaining grassland

The area of organic grassland soils was estimated with data from the soil inventories of the Federal Provinces of Austria which are compiled in the Austrian Soil Information System – BORIS – (http://www.borisdaten.at/) content from the upper soil horizon (weighted mean for 0–30 cm) was calculated from samples from 200 grassland sites. Sites with more than 17% C_{org} were selected as "organic soils" (NESTROY et al. 2000) and their area was extrapolated to the whole Austrian grassland area.

The estimation resulted in a total area of 12 954 ha organic grassland soils.

The emissions from organic soils were estimated according to the IPCC (2013) Wetlands Supplement which provides updated default emission factors for drained organic soils. The on-site emissions are now calculated with the default emission factor of Table 2.1 of the WL supplement (–6.1 t C/ha). In addition, the off-site emissions from drainage of organic soils were estimated following eq. 2.5 of the WL supplement and by using the default DOC emission factors from Table 2.2 for temperate climate as provided in the the WL supplement, the emission factor for off-site emissions amounts to -0.3 t C/ha. The average annual on- and off-site emissions from organic grassland soils are 304.1 kt CO_2.

Related CH_4 emissions (sector 4(II)) were estimated as well and are explained in the following chapter. The associated N_2O emissions are reported in sector Agriculture (3.D.6) in line with the IPCC (2006) Guidelines.

6.4.4.1.4 CH_4 emissions from drainage and rewetting and other management of organic soils (4.(II))

Since the IPCC (2013) Wetlands supplement provides a default method for CH_4 emissions from drained organic inland soils, equation 2.6 was applied to estimate these emissions for the first time in the 2018 submission. A default fraction of total area of drained organic soil which is occupied by ditches was taken from Table 2.4 for deep drained grassland in temperate climate. The emission factors for the drained soil (EF_{CH4_land}, Table 2.3) and for ditches (EF_{CH_ditch} , Table 2.4) both for deep drained grassland in temperate climate were applied, resulting in average annual emissions of 0.95 kt CH_4.

6.4.4.2 Land use change to Grassland (4.C.2)

6.4.4.2.1 Forest Land converted to Grassland (4.C.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2. The area in conversion from forest land to grassland for a time period of 20 year ranges from 32 467 ha 37 716 ha between the years 1990 and 2021. The main part of conversion occurs from forests to pasture causing annual emissions due to the loss of biomass and C stock changes in soil and litter between 260.8 kt CO_2 and 522.8 kt CO_2.

For the calculation of the annual change of carbon stocks an IPCC Tier 3 approach is used. Emissions/removals were calculated by country specific values. The changes of soil carbon stocks were stratified according to five forest growth regions. The stratified LUC areas and soil C stocks according to these growth regions were used for the estimates. The method is described in Chapter 6.2.4.2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to GL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). The significant contribution of this category to the total GL results is indicated by the same stepwise changes in the emissions/removals of the total GL category (Table 286). An interpolation across these steps is considered unsuitable and is therefore not carried out.

6.4.4.2.2 Cropland converted to Grassland (4.C.2.2)

The average annual land use change area from annual cropland to grassland from 1990–2021 is 2 475 ha. The average annual land use change area (1990–2021) from perennial cropland to grassland is 43 ha. The total area in conversion status for a time period of 20 years amounts to 25 347 ha in 1990 and 65 782 ha in 2021. Considering the area of the 20 years transition period this leads to annual removals of -88.2 kt CO_2 in 1990 and -232.0 kt CO_2 in 2020.

The use of the IACS system for the assessment of the LUCs of other agricultural land uses to GL (see chapter 6.3.2) allows more accurate annual assessments of the activities since 2002. This leads to higher annual variations in this period than before 2002. Since 2008 a higher conversion rate from cropland to GL has been observed. This is likely caused by the changed framework conditions due to EU regulations concerning the protection of grasslands.

Changes of carbon stock in biomass of annual cropland converted to grassland

The carbon stock of living biomass in annual cropland was estimated by using country specific data from Statistic Austria (STATISTIK AUSTRIA 2007). The average mean of the above and belowground biomass of the annual crops in cropland was estimated with 6.67 t C ha^{-1} (see Chapter 0).

A country specific carbon stock in living grassland biomass was estimated. The calculation was done by using country specific grassland biomass data from Statistic Austria (STATISTIK AUSTRIA 2007) and from the Agricultural Research and Education Centre (AREC) Raumberg-Gumpenstein (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein – HBLFA).

The national mean grassland biomass C stock was calculated from the mean of the grassland yields of the categories one cut meadows, two cut meadows, litter meadows, rough pastures and cultivated pastures, which were weighed by the total area of these different grassland categories. The weighting factors are based on the respective 1996-2005 average area contributions of the different grassland types to the total grassland area. The calculation led to an average biomass yield per year of 6.2 t dm ha^{-1} for Austrian grasslands, these are 3.1 t C per ha and year.

As recommended by the ERT and in order to make the estimation process more transparent the weighting factors are presented in the table below.

Table 288: Area weighted mean values of grassland biomass.

	area in ha (avg 10 year)	weighting factor	yield in t (avg 10 year)	contribution to weighted mean (t dm ha^{-1})
one cut meadows	54 827	0.05	3.2	0.2
two and more cut	844 126	0.78	6.8	5.3
litter meadows	17 126	0.02	3.5	0.1
culture pastures	74 839	0.07	6.7	0.5
rough pastures	90 264	0.08	2.4	0.2
weighted grassland yield (t dm ha^{-1})				6.2
weighted grassland yield (t C ha^{-1})				3.1

The country specific root-to-shoot ratios from the Agricultural Research and Education Centre Raumberg-Gumpenstein (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein – HBLFA) were used. According to the research results the above ground stubble biomass is 1.0 t dm ha^{-1} (0.5 t C ha^{-1}) and the root biomass is 4.2 t dm ha^{-1} (2.1 t C ha^{-1}; average of 5 years).

The total grassland biomass of 5.7 t C ha^{-1} comprises the above ground biomass (3.1 t C ha^{-1}) plus the root biomass (2.1 t C ha^{-1}) and the stubble biomass (0.5 t C ha^{-1}). This value is 16% lower than the IPCC default value for cold temperate wet regions (IPCC 2006; table 6.4)

For the calculation of the annual change in carbon stocks of living biomass of annual cropland converted to grassland the following equations were applied – equations 2.15 and 2.16 (IPCC 2006).

*Annual change in biomass =annual area of currently converted land * ($L_{conversion}$ + ΔC_{growth})*

$L_{conversion}$ = $C_{after} - C_{before}$

C_{after} = *carbon stock immediately after conversion is 0*

ΔC_{growth} = *country specific value for grassland biomass 5.70 t C $ha^{-1}a^{-1}$(accounted only for the year of LUC)*

C_{before} = *country specific value of carbon stock of annual crops before conversion is 6.67 t C $ha^{-1}a^{-1}$(see Chapter 0; accounted only for the year of LUC)*

Changes of carbon stock in biomass of perennial cropland converted to grassland

The area of annual land use change from perennial cropland converted to grassland in 2021 is 43 ha. The employed equation and methodological approach is described above (see in Chapter "Changes of carbon stock in biomass of annual cropland converted to grassland"). For the grassland biomass after LUC the same value as described in Chapter "Changes of carbon stock in biomass of annual cropland converted to grassland" before is used (5.7 t C ha^{-1}). The lost perennial cropland biomass due to this LUC is 6.09 t C ha^{-1} (see chapter 6.3.4.1.1):

C_{before} = country specific value (Tier 2) of biomass carbon stock of perennial crops before conversion is 6.09 t C ha^{-1}

The results in the CRF table are split into the biomass carbon stock changes of annual cropland converted to grassland and perennial cropland converted to grassland and the sum of these subcategories.

Changes of carbon stock in mineral soil of annual cropland converted to grassland

The area in conversion from annual cropland converted to grassland for a time period of 20 years amounts to 25 347 ha and 65 782 ha in the years 1990 and 2021, respectively.

The IPCC method, described in the subchapters "Changes of carbon stock in mineral soil grassland to annual cropland" and "Changes of carbon stock in mineral soil grassland to perennial cropland" (see chapter 6.3.4.2.2), was employed to estimate changes in soil C stocks.

Austrian specific values of 70 t C ha^{-1} for 0–30 cm depth of grassland and 50 t C ha^{-1} for 0–30 cm depth of cropland were used which are based on the results of the Austrian soil inventory (GERZABEK et al. 2003, STREBL et al. 2003).

$$\textit{Average annual carbon stock change } (t\ C\ ha^{-1}\ a^{-1}) = (SOC_0 - SOC_{0-T})/20 = 1.0$$

SOC_0 carbon stock in soils 20 years after conversion from annual cropland to grassland →70 t C ha^{-1}
SOC_{0-T} carbon stock change in cropland soils before conversion→ 50 t C ha^{-1}

Changes of carbon stock in mineral soil of perennial cropland converted to grassland

The area in conversion status from perennial cropland converted to grassland for a time period of 20 years amounts to 257 ha and 1 231 ha in the years 1990 and 2021.

For the estimates Austrian specific values of 70 t C ha^{-1} for 0–30 cm depth of grassland and 57 t C ha^{-1} for 0–30 cm depth of perennial cropland were used which are based on the results of the Austrian soil inventory (GERZABEK et al. 2003, STREBL et al. 2003).

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 0.65\ t\ C\ ha^{-1}\ a^{-1}$$

*annual change in carbon stock of mineral soils converted from grassland to perennial cropland = Δ SOC * conversion area for a transition period of 20 years*

SOC_0 carbon stock in soils 20 years after conversion from perennial cropland to grassland →70 t C ha^{-1}
SOC_{0-T} carbon stock in Austrian perennial cropland soils before conversion →57 t C ha^{-1}

The results in the CRF table are split into the soil carbon stock changes of annual cropland converted to grassland and perennial cropland converted to grassland and the sum of these subcategories.

6.4.5 Uncertainty assessment

Table 289: Uncertainties of areas in the GL category.

	Before 2001	Since 2001
Total grassland	±8%	±8%
Area of organic grassland soils	Triangle distribution 9 800 – 12 954 – 40 000 ha	
Annual LUC area CL to FL or FL to CL	see Chapter 6.2.5. Table 273	see Chapter 6.2.5. Table 273
Annual LUC area pCL to GL	±300%[1]	±260%[1]
Annual LUC area aCL to GL	±200%[1]	±150%[1]

[1] *For area uncertainties > 100%, distributions were truncated at 0 as negative areas are not possible*

These uncertainties were derived from the following sources:

- Total grassland: based on information from data source (Statistik Austria)
- Area of organic grassland soils: assessment on basis of the soil inventory results

- Annual LUC area pCL to GL: expert judgement from two agricultural experts on basis of the original data
- Annual LUC area aCL to GL: expert judgement from two agricultural experts on basis of the original data

The uncertainties of the (input variables for or) emission factors were given in the Chapters 6.2.5 and 6.3.5. The only uncertainty values that were not presented so far are those of the soil C stock changes in grassland remaining grassland with ±40%. The uncertainties for the emission factors from organic soils were taken from the corresponding tables in IPCC (2013) Wetlands supplement.

The Monte Carlo simulations resulted in the following average uncertainty for the total emissions/removals of the grassland category in the time series: ±665 kt CO_2. With these values, the grassland category contributes (after the forest land category and HWPs) the third highest share to the uncertainty of the total emissions/removals of the total LULUCF sector. The relative uncertainties in the single years range from ±93 to ±152%. The higher relative uncertainties occur in the most recent years when the net emissions/removals were clearly lower than in the previous years. The uncertainties of the grassland category emissions are mainly influenced by the high emission share as well as uncertainty of the organic soil area (a currently running project will improve this situation, see chapter 6.1.8.).

It should be noted that the net emission/removals of the GL category are the result of subtractions between emissions and removals of several subcategories and pools. Only in single cases are they correlated. In line with error propagation laws the uncertainty of such net values based on subtractions of uncorrelated parameters are additive and therefore rather high in relative terms.

6.4.6 Category-specific QA/QC

The calculation of the data for category *4.C* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.4.7 Recalculations

The total Grassland area was adjusted for grasslands, which are no more agriculturally managed and as a consequence no more tracked by the agricultural statistics, but nonetheless do not lose their status as Managed grassland. Furthermore, the method to estimate land-use changes between Grassland and Cropland based on IACS/LPIS data was further improved for the 2023 submission. In addition, the LUC areas from Forest land to Grassland since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Grassland for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the Grassland category: The annual emissions are in the range of 25 to 190 kt CO_2e per year higher compared to the last submission in 2022.

6.4.8 Planned improvements

See Chapter 6.1.8.

6.5 Wetlands (Category 4.D)

6.5.1 Category description

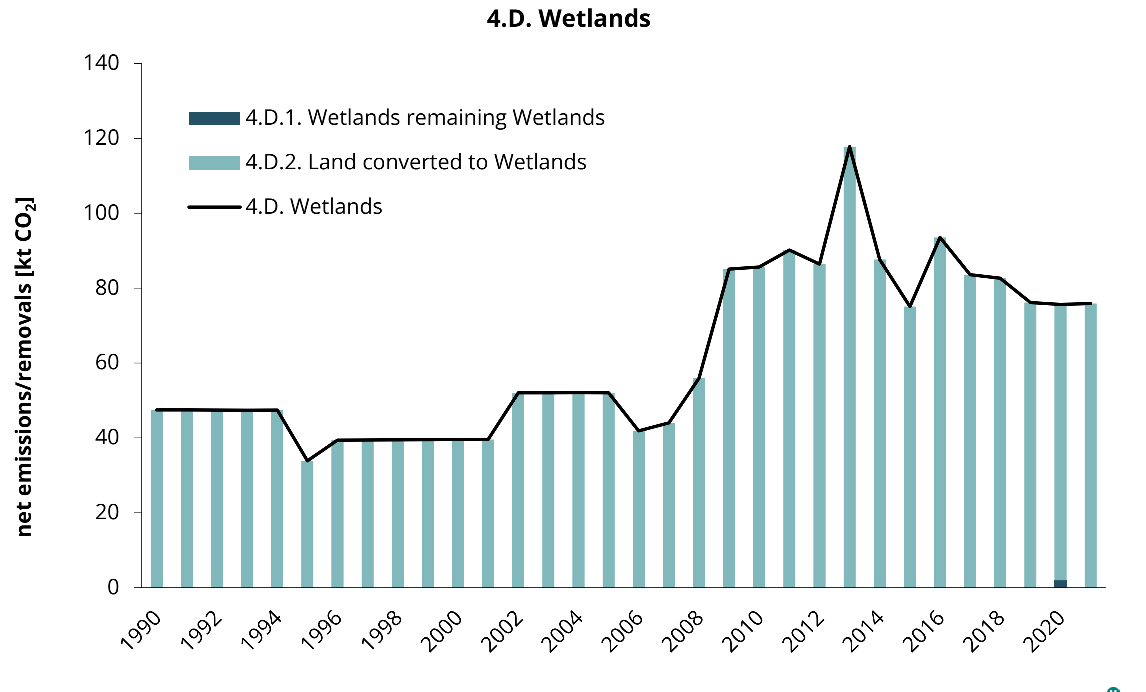
In this category emissions/removals from the subcategories "Wetland remaining wetland" and "Land converted to wetland" are considered.

The wetland area ranges from 132 616 ha in 1990 to 154 371 ha in 2021. Along the time series a steady increase in wetland area could be observed.

The shares of the different previous land use types before conversion to wetland vary between the years. Since 2005 the wetland area was surveyed annually, while interpolations were carried out for the years before. As a consequence, the LUC areas to WL and the emissions show higher year-to-year variations in the years after 2005. The slightly higher LUCs to WL over the last decade have driven the slightly higher emissions of this subcategory.

Table 290 and Table 291 show the land use change and removals/emissions from LUC to wetlands from 1990–2021.

Figure 44: Emissions/removals (+/-) of wetlands (1990–2021) by wetlands remaining wetlands and land use change to wetlands in kt CO_2



Source: Umweltbundesamt

Table 290: Total areas and land-use change areas of wetland 1990–2021 in ha.

	4 D Total wetland	1. Wetland remaining wetland	2. Land converted to wetland	2.1 Forest land converted to wetlands	2.2 Cropland converted to wetlands	2.3 Grassland converted to wetlands	2.4 Settlements converted to wetlands	2.5 Other Land converted to wetlands
1990	132 616	127 105	5 511	1 706	NO	3 804	NO	NO
1991	133 068	126 557	6 510	1 798	NO	4 713	NO	NO
1992	133 519	126 009	7 510	1 889	NO	5 621	NO	NO
1993	133 970	125 461	8 509	1 980	NO	6 529	NO	NO
1994	134 421	125 002	9 420	1 982	NO	7 437	NO	NO
1995	134 873	124 726	10 147	1 948	NO	8 199	NO	NO
1996	135 587	124 449	11 138	1 914	NO	9 223	NO	NO
1997	136 301	124 173	12 128	1 880	NO	10 248	NO	NO
1998	137 016	123 897	13 119	1 846	NO	11 273	NO	NO
1999	137 730	123 579	14 152	1 854	NO	12 297	NO	NO
2000	138 445	123 260	15 185	1 863	NO	13 322	NO	NO
2001	139 159	122 942	16 218	1 871	NO	14 347	NO	NO
2002	139 874	122 305	17 569	1 898	NO	15 671	NO	NO
2003	140 588	121 669	18 919	1 924	NO	16 995	NO	NO
2004	141 303	121 118	20 185	1 865	NO	18 320	NO	NO
2005	142 017	120 567	21 451	1 806	NO	19 644	NO	NO
2006	142 245	120 441	21 804	1 747	NO	20 057	NO	NO
2007	142 575	120 667	21 908	1 688	NO	20 219	NO	NO
2008	143 477	120 893	22 584	1 630	NO	20 955	NO	NO
2009	144 265	121 599	22 665	1 759	NO	20 906	NO	NO
2010	145 084	122 288	22 795	1 898	NO	20 897	NO	NO
2011	146 123	122 977	23 146	2 037	NO	21 109	NO	NO
2012	146 989	123 666	23 323	2 175	NO	21 147	NO	NO
2013	149 360	124 355	25 005	2 314	NO	22 691	NO	NO
2014	150 292	125 044	25 248	2 453	NO	22 795	NO	NO
2015	150 626	125 550	25 076	2 628	NO	22 449	NO	NO
2016	151 849	126 319	25 530	2 803	NO	22 727	NO	NO
2017	152 600	127 088	25 512	2 978	NO	22 534	NO	NO
2018	153 309	127 857	25 452	3 153	NO	22 299	NO	NO
2019	153 708	128 626	25 081	3 327	NO	21 754	NO	NO
2020	153 986	129 396	24 590	3 502	NO	21 088	NO	NO
2021	154 371	130 165	24 206	3 677	NO	20 529	NO	NO

Table 291: Emissions/removals (+/-) of wetland 1990–2021 in kt CO_2.

	4.D Total Wetland	1. Wetland remaining wetland	2. Land converted to wetland	2.1 Forest land converted to wetland	2.2 Cropland converted to Wetland	2.3 Grassland converted to wetland	2.4 Settlements converted to wetland	2.5 Other land converted to wetland
1990	47.47	NO	47.47	28.50	NO	18.97	NO	NO
1991	47.45	NO	47.45	28.48	NO	18.97	NO	NO
1992	47.42	NO	47.42	28.46	NO	18.97	NO	NO
1993	47.40	NO	47.40	28.43	NO	18.97	NO	NO
1994	47.42	NO	47.42	28.46	NO	18.97	NO	NO

	4.D Total Wetland	1. Wetland remaining wetland	2. Land converted to wetland	2.1 Forest land converted to wetland	2.2 Cropland converted to Wetland	2.3 Grassland converted to wetland	2.4 Settle-ments con-verted to wet-land	2.5 Other land converted to wetland
1995	33.87	NO	33.87	17.97	NO	15.90	NO	NO
1996	39.41	NO	39.41	18.01	NO	21.40	NO	NO
1997	39.45	NO	39.45	18.06	NO	21.40	NO	NO
1998	39.50	NO	39.50	18.10	NO	21.40	NO	NO
1999	39.52	NO	39.52	18.12	NO	21.40	NO	NO
2000	39.54	NO	39.54	18.15	NO	21.40	NO	NO
2001	39.56	NO	39.56	18.17	NO	21.40	NO	NO
2002	52.05	NO	52.05	24.39	NO	27.66	NO	NO
2003	52.06	NO	52.06	24.40	NO	27.66	NO	NO
2004	52.07	NO	52.07	24.41	NO	27.66	NO	NO
2005	52.05	NO	52.05	24.39	NO	27.66	NO	NO
2006	41.88	NO	41.88	24.38	NO	17.50	NO	NO
2007	43.99	NO	43.99	24.37	NO	19.62	NO	NO
2008	55.93	NO	55.93	24.36	NO	31.58	NO	NO
2009	85.07	NO	85.07	66.94	NO	18.13	NO	NO
2010	85.62	NO	85.62	66.84	NO	18.78	NO	NO
2011	90.14	NO	90.14	66.74	NO	23.39	NO	NO
2012	86.41	NO	86.41	66.66	NO	19.75	NO	NO
2013	117.77	NO	117.77	66.57	NO	51.20	NO	NO
2014	87.62	NO	87.62	66.48	NO	21.13	NO	NO
2015	75.07	NO	75.07	66.40	NO	8.67	NO	NO
2016	93.53	NO	93.53	66.31	NO	27.22	NO	NO
2017	83.59	NO	83.59	66.23	NO	17.36	NO	NO
2018	82.63	NO	82.63	66.14	NO	16.49	NO	NO
2019	76.15	NO	76.15	66.15	NO	10.00	NO	NO
2020	75.62	1.97	73.65	66.15	NO	7.50	NO	NO
2021	75.88	NO	75.88	66.16	NO	9.72	NO	NO

6.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The total wetland area was taken from the regional information derived from the Real Estate Database available since 1995 (BEV 2022). This database covers the whole area of Austria and gathers the land uses of real estate within the municipalities in digital cadastral maps. It is provided by the Austrian Federal Weights and Measures Office and is since 2005 updated annually. The change in the annual water body area pre-2005 was calculated from the mean average increase of water bodies for the periods 1971–1981, 1981–1995 and 1995–2005.

Due to the fact that peat areas are protected in Austria, it is assumed that there is no further draining of peat land. According to the peat land database (STEINER & REITER 1992) a constant bog area of 22 239 ha was taken into account for the total reporting period.

In Austria the increase of wetlands (rivers, standing water bodies) – derived from national statistics (Real Estate Database) – is mainly due to the building of water reservoirs e.g. for water power stations or quarry ponds as well as the reconstruction from natural river courses. The LUC areas from forest land to wetlands are based on the NFI data (see Chapter 6.2.2). The remaining year-to-year increase of wetlands is assumed to result from LUC from grassland. This expert judgment is based on the consideration that these activities occur (besides on forest areas) primarily on grassland sites and do not affect cropland, settlements or other land. Furthermore national statistics show a steady increase of settlement area and since 2000 a general increase in other land. Thus, LUC from these categories to wetlands is considered not to occur in Austria.

The area in conversion status of land converted to wetland for a time period of 20 years ranges from 5 511 ha to 25 530 ha for the period 1990 to 2021.

6.5.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (e.g. land use and land-use change matrix)

The wetland area in correspondence to the LULUCF category comprises the following subcategories of the national Real Estate Database classification system:

- Rivers
- Lakes and reservoirs
- Water's edge areas
- Peatland areas.

6.5.4 Methodological Issues

6.5.4.1 Wetland remaining wetland

According to the peat land database (Steiner & Reiter 1992) the bog/fens area in Austria amounts to 22 239 ha. As bogs/fens are protected in Austria it is assumed that the area remains constant and that peat extraction is not occurring (NO). For the latter reason the bog/fens area is reported under the subcategory other wetlands. Emissions are not occurring because bogs/fens are not managed in Austria. According to the IPCC 2006 GL only emissions from managed wetland are considered in this category whereas emissions from unmanaged wetland are not estimated (Chapter 6.1).

Flooded Lands are defined as water bodies where human activities have caused changes in the amount of surface area covered by water (e.g. reservoirs for hydro-electricity). As it is not possible to distinguish the areas of managed water bodies from natural lakes and rivers on basis of the used wetland area data sources, all areas of flooded lands remaining flooded are included (IE) in subcategory other wetlands remaining other wetlands. Therefore no emissions/removals are estimated from the subcatergory wetland remaining wetland.

6.5.4.1.1 Biomass burning

The emissions caused by biomass burning due to wildfires are included in category *4(V)D.1 Wetlands remaining Wetlands*. This category is included since a major wildfire incident occurred in the reed belt of lake Neusiedlersee in 2020. Estimates of emissions of CO_2, CH_4 and N_2O from this category are reported. Based on the IPCC 2006 Guidelines, equation (2.27) following a Tier 2 method was applied.

$$L_{fire}\ (t\ GHG) = A*M_B*C_f*G_{ef}*10^{-3}$$

A area burnt (ha)
M_B mass of available fuel, t dm ha^{-1} (Table 2.4)
C_f combustion factor
G_{ef} emission factor, g kg^{-1} dm (Table 2.5)

Data on the area affected by this wildfire is based on aerial images of the concerned area provided by the authorities of Nationalpark Neusiedler See – Seewinkel. In a national study conducted in the Neusiedlersee area, the biomass stock of reed was measured throughout the whole vegetation period (Hübl 1966). According to the study, the dry mass of the biomass of reed amounts to 7.65 t ha^{-1} in spring, which is the time when the fire occurred. The default factor for C_f was taken from table 2.6 of the IPCC 2006 Guidelines for Wheat residues which appeared most suitable (0.9). The default emission factors (G_{ef}) for N_2O and CH_4 are derived from table 2.5 of the IPCC 2006 Guidelines (for agricultural residues).

CO_2 emissions for this incident amounted to 1.97 kt CO_2 and for N_2O and CH_4, 0.027 and 0.088 kt CO_2 equivalents, respectively.

6.5.4.2 Land use changes to Wetland (4.D.2)

The increase of wetlands (rivers, standing water bodies) can be derived from national statistics (Real Estate Database) and occurs mainly due to the building of water reservoirs e.g. for water power stations or quarry ponds as well as the reconstruction from natural courses of rivers. Therefore the land-use changes to wetland are reported in subcategory land to flooded lands. Land-use changes in the other wetlands subcategories are not occurring.

6.5.4.2.1 Forest Land converted to Wetland (4.D.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2.

The area in conversion from forest land to wetland for a time period of 20 years ranges from 1 630 ha to 3 677 ha between the years 1990 and 2021 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 18 kt CO_2 to 66.9 kt CO_2.

For the calculation of the annual change of carbon stocks the IPCC Tier 3 approach is used. Emissions/removals were calculated by country specific values.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to WL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). Any interpolation across was considered unsuitable and is therefore not carried out.

6.5.4.2.2 Cropland converted to Wetland (4.D.2.2)

Based on expert judgment it is assumed that no conversion occurs from cropland to wetland in Austria. The residual conversion area for a full accounting or the increase of the total wetland area is assumed to originate from grassland.

6.5.4.2.3 Grassland converted to Wetland (4.D.2.3)

Changes in carbon stocks in biomass of grassland converted to wetland

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to wetland the following equation was applied (equation 7.10 in 2006 IPCC GL)

Annual change in carbon stocks of living biomass in land converted to wetland (tonnes $C.a^{-1}$):

$$\Delta C_{LW flood} = (Sum\ A_i*(B_{after}-B_{before})) * CF$$

A_i = *annual area of land currently converted to flooded land from original land use. ha*

B_{before} = *living biomass in land immediately before conversion to wetland = for grassland 5.7 t C* $ha.a^{-1}$*(see Chapter 6.4.4.2.2)*

B_{after} = *living biomass in land immediately after conversion to wetland (default = 0 t C* $ha.a^{-1}$*)*

CF = *carbon fraction of dry matter (default = 0.5), tonnes C* $(tonne\ d.m.)^{-1}$

The area in conversion status from grassland land to wetlands for a time period of 20 years ranges from 3 804 ha to 22 795 ha between the years 1990 and 2021 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 7.5 kt CO_2 to 51.2 kt CO_2.

Changes in carbon stocks in soil of grassland converted to wetland

In response to a previous review finding, the soil C stock changes in the LUC-categories to WL were assumed to be 0. In submissions before 2014 wetlands (flooded land) were assumed to have a 0 soil C stock. Using the 2006 IPCC GL approach of calculating the C stock change between a period of 20 years led to unrealistic annual C stock losses in mineral soils for lands with such LUC. Due to a lack of information in the literature, no C-stock changes in mineral soil are assumed for LUC areas to wetland.

6.5.5 Uncertainty assessment

The following uncertainties of the activity data were used: Annual LUC area FL to WL – see Chapter 6.2.5, Table 273; annual LUC area GL to WL: ±20%. The uncertainty of these LUCs were estimated by assessing the minimum and maximum potential of available areas that could contribute to such LUCs on basis of the area consistency with other related land use change subcategories and their uncertainties.

The uncertainties of the emission factors are given in Chapter 6.2.5. (Table 274) and Chapter 6.3.5. (Table 284). Since only the subcategories FL to WL and GL to WL exist, no further emission factors and uncertainties were necessary.

The uncertainties of the total wetland emissions/removals are in the range between ±13 and ±49 kt CO_2 with a steady increase across the time series or between ±33 and ±64% of the total emissions in the single years. The low absolute uncertainty reflects the low LUC activity in this subcategory.

6.5.6 Category-specific QA/QC

The calculation of the data for category 4.D is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.5.7 Recalculations

The LUC areas from Forest land to Wetland since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Wetland for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the Wetland category: The annual emissions are in the range of 3.6 to 16.9 kt CO_2e per year higher compared to the last submission in 2022.

6.5.8 Planned improvements

See Chapter 6.1.8.

6.6 Settlements (Category 4.E)

6.6.1 Category description

About 0.58 million ha of Austria's surface can be allocated to the IPCC land use category settlements (BEV 2022). Along the time series a steady increase in settlement areas could be observed. In this category only emissions/removals from the subcategories Land converted to settlements are considered. Dead wood and litter is assumed not to occur at settlement areas.

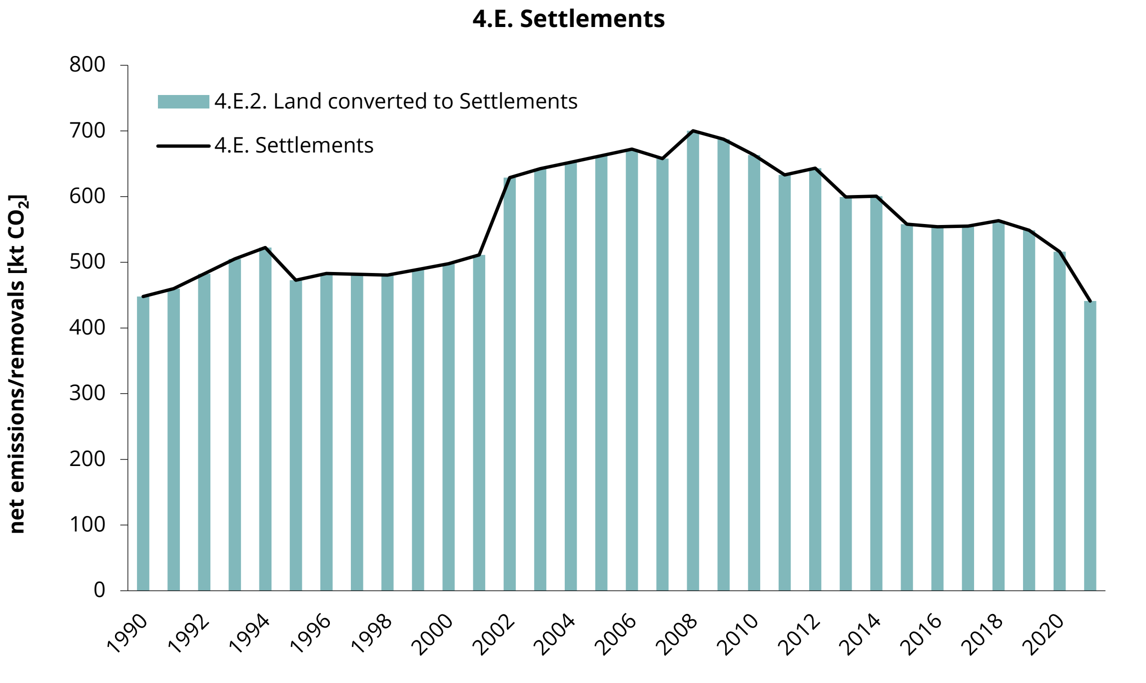
The shares of the different previous land use types before conversion to settlements vary from year to year. Since 2006 the settlement area was taken in annual resolution while interpolations were carried out for the years before (survey data available between 1971 and 1981, 1981–2003 and 2003–2006). As a consequence, the LUC areas to SL and the emissions show higher interannual variations in the years after 2005.

The area in conversion status from Land converted to Settlements for a time period of 20 years ranges from 134 278 ha to 153 545 ha between the years 1990 and 2021 causing annual emission rates due to C stock changes of biomass, dead organic matter and soils ranging from 441 kt CO_2 to 700 kt CO_2. The LUCs from forest land and grassland to settlement are the main sources of emissions in this subcategory.

Annual LUCs to settlement occur from the subcategories Forest Land, Cropland and Grassland. The proportions of these categories vary between the years, which cause variations of CO_2 emissions and Implied Emission Factor (IEF) for the sum of net C stock changes in living biomass and soils in the category LUC to settlements. Consequently, the trend in total emissions in this category does not strictly mirror the trend in the total settlement area.

Table 292 and Table 293 show the land use changes and removals/emissions from LUC to settlements for the period 1990 to 2021.

Figure 45: Emissions/removals (+/-) from land use changes to settlement (1990-2021) in kt CO_2



Source: Umweltbundesamt

Table 292: Total areas and land use change areas for the subcategory settlements 4.E for the period 1990 to 2021 in ha.

	4.E Total Settlements	4.E.1. Settlements remaining settlements	4.E.2. Land converted to Settlements	4.E.2.1 Forest Land converted to Settlements	4.E.2.2 Cropland converted to Settlements	4.E.2.3 Grassland converted to Settlements	4.E.2.4 Wetland converted to Settlements	4.E.2.4 Other land converted to Settlements
1990	380 055	230 483	149 572	9 792	95 550	44 230	NO	NO
1991	386 858	236 470	150 388	10 315	91 005	49 068	NO	NO
1992	393 661	242 308	151 353	10 839	86 563	53 951	NO	NO
1993	400 465	248 146	152 319	11 362	82 122	58 834	NO	NO
1994	407 268	255 375	151 893	11 375	78 018	62 501	NO	NO
1995	414 071	262 854	151 217	11 180	74 277	65 760	NO	NO
1996	420 874	270 333	150 542	10 984	73 787	65 771	NO	NO
1997	427 678	277 812	149 866	10 789	73 295	65 782	NO	NO
1998	434 481	285 290	149 191	10 593	70 773	67 824	NO	NO
1999	441 284	292 107	149 177	10 641	68 541	69 994	NO	NO
2000	448 088	298 924	149 163	10 689	64 998	73 476	NO	NO
2001	454 891	305 741	149 149	10 737	61 454	76 959	NO	NO
2002	461 694	313 012	148 682	11 151	58 176	79 355	NO	NO
2003	468 497	320 283	148 214	11 565	55 122	81 527	NO	NO
2004	475 395	327 324	148 071	11 490	52 125	84 456	NO	NO
2005	482 293	334 365	147 928	11 414	49 126	87 388	NO	NO

	4.E Total Settlements	4.E.1. Settlements remaining settlements	4.E.2. Land converted to Settlements	4.E.2.1 Forest Land converted to Settlements	4.E.2.2 Cropland converted to Settlements	4.E.2.3 Grassland converted to Settlements	4.E.2.4 Wetland converted to Settlements	4.E.2.4 Other land converted to Settlements
2006	489 190	341 406	147 784	11 339	47 377	89 069	NO	NO
2007	494 950	348 447	146 504	11 263	45 037	90 203	NO	NO
2008	502 903	355 488	147 415	11 188	41 413	94 815	NO	NO
2009	513 017	362 623	150 394	11 056	41 322	98 016	NO	NO
2010	521 598	369 734	151 863	10 976	42 999	97 888	NO	NO
2011	529 188	376 846	152 342	10 896	43 919	97 527	NO	NO
2012	537 502	383 957	153 545	10 816	46 259	96 470	NO	NO
2013	543 587	391 068	152 519	10 736	47 932	93 851	NO	NO
2014	550 122	398 179	151 942	10 656	52 881	88 405	NO	NO
2015	555 150	405 041	150 110	10 784	53 701	85 624	NO	NO
2016	559 699	411 902	147 797	10 912	51 558	85 327	NO	NO
2017	564 200	418 763	145 437	11 040	49 667	84 730	NO	NO
2018	569 569	425 624	143 945	11 168	52 337	80 440	NO	NO
2019	574 878	432 485	142 393	11 296	54 946	76 151	NO	NO
2020	579 341	439 347	139 994	11 423	58 017	70 554	NO	NO
2021	580 486	446 208	134 278	11 551	57 779	64 948	NO	NO

Table 293: Emissions/removals (+/-) from land use changes to settlement for the period 1990 to 2021 in kt CO_2 and N_2O emissions in CO_2eq.

	4.E.2. Land converted to Settlements_CO_2	4.E.2.1 Forest land converted to settlements_CO_2	4.E.2.2 Cropland converted to settlements_CO_2	4.E.2.3 Grassland converted to settlements_CO_2	4.E.2.4 Wetland converted to settlements_CO_2	4.E.2.5 Other Land converted to settlements_CO_2	4(III)E2_N_2O emissions due to C losses in managed soils_N_2O	4(IV)A2_N_2O emissions from N leaching and runoff_N_2O in CO_2eq
1990	448	262	-4	190	NO	NO	52	6
1991	460	267	-55	248	NO	NO	54	6
1992	483	272	-52	263	NO	NO	56	6
1993	505	277	-49	278	NO	NO	58	7
1994	523	277	-30	275	NO	NO	59	7
1995	473	214	-21	279	NO	NO	59	7
1996	483	213	38	233	NO	NO	59	7
1997	482	211	38	233	NO	NO	59	7
1998	481	209	3	268	NO	NO	59	7
1999	489	210	5	275	NO	NO	60	7
2000	498	210	-17	304	NO	NO	61	7
2001	511	211	-14	315	NO	NO	62	7
2002	629	324	-3	308	NO	NO	63	7
2003	643	329	3	311	NO	NO	63	7
2004	652	328	-3	328	NO	NO	64	7
2005	662	327	-2	337	NO	NO	65	7
2006	672	326	22	324	NO	NO	65	7

	4.E.2. Land converted to Settlements_CO_2	4.E.2.1 Forest land converted to settlements_CO_2	4.E.2.2 Cropland converted to settlements_CO_2	4.E.2.3 Grassland converted to settlements_CO_2	4.E.2.4 Wetland converted to settlements_CO_2	4.E.2.5 Other Land converted to settlements_CO_2	4(III)E2_N_2O emissions due to C losses in managed soils_N_2O	4(IV)A2_N_2O emissions from N leaching and runoff_N_2O in CO_2eq
2007	658	326	13	320	NO	NO	65	7
2008	700	325	-8	384	NO	NO	67	8
2009	687	253	59	375	NO	NO	68	8
2010	663	253	59	352	NO	NO	69	8
2011	633	252	-9	390	NO	NO	69	8
2012	643	251	15	377	NO	NO	69	8
2013	599	251	2	347	NO	NO	68	8
2014	601	250	75	276	NO	NO	66	7
2015	558	251	7	300	NO	NO	65	7
2016	554	253	13	288	NO	NO	64	7
2017	555	254	19	282	NO	NO	63	7
2018	563	256	63	245	NO	NO	62	7
2019	549	257	60	232	NO	NO	60	7
2020	516	258	43	215	NO	NO	58	7
2021	441	260	-16	198	NO	NO	55	6

6.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The basis for the area that can be allocated to this land use category is the regional information derived from the Real Estate Database (BEV 2022). This database covers the whole area of Austria and gathers the land uses of real estate within the municipalities in digital cadastral maps. It is provided by the Austrian Federal Weights and Measures Office and is updated since 2005 every year. Before 2005, the Real Estate Database was updated less frequently and in previous submissions respective stable mean annual increases were applied to certain parts of the time series pre-2005 to extrapolate the time series back to 1971.

For this 2023 submission, the calculation of total settlements area as well as certain land conversions to settlements have also been revised as part of the adjustments in other land use categories to ensure interannual area consistency in the land use change matrices. In the previous submission, instead of using the whole time series from the Real Estate Database for total Settlement areas, only the estimate for the most recent year (2020) was used. From this value, the rest of the time series was extrapolated backward using the respective annual land conversions involving Settlements e.g. total area in the previous year is calculated by subtracting from the current year's total area that year's area of land conversions to settlements, while the respective land conversion from settlements to other land use categories are added. For this submission, the above method was changed, with the whole time series from the Real Estate Database for total Settlement areas now used as the basis for the settlement LU and LUC areas. The reason for this, was an adjustment of the hierarchy in which the respective LU and LUC data sources are ranked in terms of accuracy. Due to consistency issues identified in the statistics on total grassland area, the BEV statistics on total settlement area are now considered more reliable than the statistics on total grassland area data (see chapter 6.4).

For this submission total settlement area and areas of land use conversion to settlements are based on the following data sources and assumptions:

- Total settlement area is given by the BEV statistics on total settlement area. Gaps in data pre-2005 filled by interpolation and extroplation of the time series back to 1971. Small adjustments in certain years are made in cases of inconsistency between LU and LUC areas (see final bullet point below).
- Land use conversions between Settlements and Forest land are based on the statistical results of the NFI
- Land use conversions to Settlements from Cropland are derived from the residuals in the respective category area balance. It is considered that the remaining increase in Settlement area (after taking into account conversions to and from Forest land) is due to the conversion from Cropland and Grassland. This remaining increase in Settlements area is first filled with conversions from Croplands. These are calculated for each year by taking the yearly net change in total Cropland area and subtracting the total gross land conversion to Cropland as well as subtracting the land conversions from Cropland to all other land use categories (other than conversions to settlements). The residual in this balance is thus the respective land use change from Cropland to Settlements.
- After taking into account the above conversions, the remaining increase in Settlements area is considered to come from Grasslands. If the remaining increase in Settlements area is negative i.e. the sum conversions from Forest land and Cropland to Settlements is larger than the annual increase in Settlements area, an iterative adjustment of the total Grassland and total Settlement areas is implemented to achieve consistency between the respective LU and LUC areas. This occurred for the years 2018-2021 and led to a small upward correction of the BEV statistics for total Settlements area ranging from +0.02 to +2 kha. After the above adjustment of the total areas, a positive (or zero-) residual conversion to Settlements is derived, and this is considered to come Grasslands.

Other land use conversions to/from Settlements are considered to be not occurring in Austria and are thus not considered in the above calculation procedure.

6.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The settlement area in correspondence to the LULUCF category comprises the following subcategories of the national classification system:

- building land – sealed, partly sealed and unsealed area
- parks and gardens
- roads, railway tracks
- industrial and business areas
- mining areas, dumps, landfills
- other, not further differentiated settlement area

6.6.4 Methodological Issues

6.6.4.1 Land use changes to settlement (4.E.2)

6.6.4.1.1 Biomass

Estimates for living biomass in settlement areas were based on the results of a scientific study carried out in Vienna (DÖRFLINGER et al. 1995). In this study the total living biomass was calculated for different ecological sub-systems in Vienna. For this category biomass data from the sub systems gardens, urban, industrial areas and brown fields were taken into consideration. Based on the biomass data of trees, shrubs and ground vegetation in this study an average biomass per ha Viennese settlement area was calculated (see table below). An average rotation period of 60 years for trees and 20 years for shrubs was defined by expert judgement to derive an average annual biomass increment. The biomass of ground vegetation is calculated as C-pool which accumulates with the first year of LUC.

The following stocks (t C ha^{-1}) and average annual increments (t C $ha^{-1}a^{-1}$) of biomass were calculated:

Table 294: Stocks and average annual stock changes of biomass.

	biomass stocks t C ha^{-1}				annual biomass stock change t C ha^{-1} a^{-1}			
	trees	**shrubs**	**ground veg.**	**total**	**trees**[1]	**shrubs**[1]	**ground veg.**[2]	**total**
Vienna	31.4	1.2	1.5	34.1	0.52	0.06	1.5	2.08
adjustment for total Austria					0.62	0.07	1.79	2.48

[1] *annual change in each year of the land-use change transition period of 20 years*

[2] *annual change in the year of land-use change*

Since the submission in 2017 the share of sealed area in settlements in total Austria has been recalculated based on a new assessment of data from the Real Estate Database for the whole time series since 1971 (see chapter 6.6.4.1.2). Accordingly, the biomass data from Vienna based on the typical share of sealed area in the settlement category of Vienna were adjusted for the share of sealed area in total Austria. The increase of living biomass of perennial species (trees and shrubs) at LUC areas to settlement is calculated with 0.69 t C ha^{-1} a^{-1}. This value is used for the whole transition period of 20 years. Annual increase of ground vegetation (annual plants) is accounted only at the areas of current LUC to settlement (in the year of LUC).

6.6.4.1.2 Litter and soil

For the calculation of the annual changes of carbon stocks in mineral soils converted to settlement the IPCC approach of 20 years discounting of soil C stock changes is used in combination with country specific soil data. Areas with litter stocks losses and subsequent emissions are assumed to occur in the year of LUC.

The calculations of emissions from litter and mineral soils due to land use changes from forests to settlements are based on regionally stratified carbon stocks in litter and soils of forest land and carbon stocks in mineral soils of settlement land (see Chapter 6.2.4.2). These C stocks refer to a mineral soil depth of 0 to 50 cm.

Calculations of emissions from soil C stocks changes due to land use changes from other IPCC land use categories refer to a soil depth of 0–30 cm. By expert judgement the carbon stocks on unsealed areas of settlement is estimated to be as high as in intensively managed grassland soils (70 t C ha^{-1}). Carbon stocks of sealed areas are set zero. The share of sealed area for the years 1971, 1981, 2003 and all years since 2006 was estimated by visual interpretation of sample digital orthophotos for different settlement types. The result has been stratified in order to reflect the real situation in the different subcategories (residential areas, industrial areas, mining areas, and landfills) which have different sealing shares. The specific shares of area sealed in the settlement subcategories were weighted by the respective size of the subcategory in the total settlement area of Austria. The shares for "sealed"[108] areas in settlements in the single years were calculated and resulted in a rather constant value in the single years (43.5%). Based on this, the carbon stocks in biomass and soil in settlements and the related stock changes for land-use changes from cropland and grassland to settlement were recalculated.

That results in a carbon stock in soil for settlement area of 40 t C ha^{-1} (= (1-0.435)* 70 t C ha^{-1}) on average (0–30 cm soil depth). For the cropland and grassland categories the following values based on the Austrian soil inventories were used (0–30 cm soil depth).

- Cropland: 50 t C ha^{-1}
- Grassland: 70 t C ha^{-1}

6.6.4.1.3 Forest Land converted to Settlement (4.E.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2. The area in conversion status from Forest Land to Settlement for a time period of 20 years ranges from 9 792 ha to 11 565 ha between the years 1990 and 2021, causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 209 kt CO_2 to 329 kt CO_2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to SL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). Any interpolation was considered unsuitable and is therefore not applied.

Changes in carbon stocks in biomass of forest land converted to settlement

The annual net emission rates due to loss of forest biomass and increase of biomass on settlement area range from 72 to 149 kt CO_2 in the years 1990 to 2021.

Changes in carbon stocks in litter and mineral soils of forest land converted to settlement

For the calculation of the annual change of carbon stocks in forest litter and mineral soils converted to soils of settlements the IPCC Tier 2 approach is used. Emissions/removals were calculated by country specific values for carbon stocks stratified according to five forest growth regions. The

[108] It should be noted that „sealed" is used here for any settlement area which is expected not to contain any soil C. This includes the sealed settlement area (41.4% of the settlement area) plus the unsealed but unvegetated share of mining areas, dumps and landfills.

stratified LUC areas and C stocks according to these growth regions were used for the estimates. The method is described in Chapter 6.2.4.2

The annual emission rates due to C stock changes in dead organic matter range from 32 to 65 kt CO_2 in the years 1990–2021.

The annual emission rates due to C stock changes in soil range from 97 to 115 kt CO_2 in the years 1990–2021.

6.6.4.1.4 Cropland converted to Settlement (4.E.2.2)

The area in conversion status from cropland to settlement for a time period of 20 years ranges from 41 322 to 95 550 ha in the years 1990–2021. Note that due to changes in the calculaction procedures for Cropland and Settlement areas these data now differ from those previously reported. In the years 1990 to 2021 net emissions range from -55 to 75 kt CO_2. The variation between net removals and net emissions is due to changes in the annual rate of LUC from Croplands to Settlements. Typically, long-term gains in biomass are larger than the long-term net losses in soil C; however, peaks in annual conversion rates and associated short-term losses can lead to overall net CO_2 emissions in those years.

Changes in carbon stocks in biomass of cropland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in cropland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in Chapters 6.3.4.2.2 and 6.4.4.2.2 with the use of country specific biomass data for annual cropland and settlements as described in Chapter 6.6.4.1.1. The average biomass stock for annual cropland biomass is higher than the average biomass stock of perennial cropland biomass (see Chapter 6.6.4.1.1). The share of annual cropland and perennial cropland which are converted to settlements is not known, but the use of the annual cropland biomass as loss due to LUCs from cropland to settlement represents a conservative estimate. The perennial plants in the settlement areas are estimated with a continued annual growth during the whole LUC transition period of 20 years as described in Chapter 6.6.4.1.1.

Changes in carbon stocks in soil of cropland converted to settlement

Soil represents a source of net emissions during conversion of cropland to settlement (ranging from 79.1to 183.0 kt CO_2).

6.6.4.1.5 Grassland converted to Settlement (4.E.2.3)

The area in conversion from grassland to settlement for a time period of 20 years ranges from 44 230 ha to 98 016 ha in the years 1990–2021 resulting in annual emission rates due to C stock changes of biomass and soils from 190 kt CO_2 to 390 kt CO_2. Note that due to changes in the calculaction procedures for Grassland and Settlement areas these data now differ from those previously reported.

Changes in carbon stocks in biomass of grassland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to settlement the IPCC Tier 2 approach is used. The method is the same as described in the Chapters 6.3.4.2.2 and 6.4.4.2.2 with country specific biomass data for grasslands and settlements (see

Chapter 6.6.4.1.1). The perennial plants in the settlement areas are estimated with a continued annual growth during the whole LUC transition period of 20 years as described in Chapter 6.6.4.1.1.

In the years 1990–2021 the annual removal rates (net change) range from 26.0 to 217.5 kt CO_2.

Changes in carbon stocks in soils of grassland converted to settlement

For the calculation of the annual change in carbon stocks of soils in grassland converted to settlement the IPCC Tier 2 approach is used. The method is the same as described in Chapters 6.3.4.2.2 and 6.4.4.2.2 with country specific soil C stocks for grassland and settlement areas (see Chapter 6.6.4.1.2).

The annual emission rate due to loss of soil carbon ranges from 247 to 547 kt CO_2 in the years 1990–2021.

6.6.4.1.6 Wetland converted to Settlement (4.E.2.4)

It is assumed by expert judgement that in Austria no conversion from wetland to settlement occurred in the years 1990–2021.

6.6.4.1.7 Other land converted to Settlement (4.E.2.5)

It is assumed by expert judgement that in Austria no conversion from other land to settlement occurred in the years 1990–2021.

6.6.4.1.8 Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter in mineral soils resulting from land use changes to settlements (4(III))

Increases in available N due to soil C losses from human induced land use changes enhance the mineralisation of soil organic N and therefore cause N_2O emissions. These emissions were calculated for forest land, cropland and grassland converted to settlements because of related C losses in mineral soils. To estimate the associated N_2O emissions the tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.8) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by the country specific, and land-use specific C/N ratios:

- for forest soils: 19 (source: BFW 1992),
- for cropland soils: 9 (source: GERZABEK et al, 2003)
- for grassland soils: 12 (source: see footnote[105]).

Then the amount of N was multiplied by the default emission factor (EF_1) from Table11.1 in the IPCC 2006 GL. Then the result was converted from the amount of annual direct N_2O-N to N_2O emissions.

6.6.4.1.9 Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from managed soils, also related indirect emissions occur. The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11:

$$N_2O\text{-}N = F_{SOM}*Frac_{LEACH}*EF_5 \ (eq.11.10)$$

Where

… N_2O-N = annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils, kg yr^{-1}

… F_{SOM} = the net annual amount of N mineralized in mineral soil associated with loss of soil C from soil organic matter as a result of changes in land use or management kg N yr^{-1}

… $Frac_{LEACH}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff kg N per kg of N additions

$Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER et al., 2013) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.6.5 Uncertainty assessment

The following uncertainties of the input data were used:

For the annual LUC area FL to SL see Chapter 6.2.5., Table 273. For the area of LUC from CL to SL and GL to SL an uncertainty of ±100% was assumed.

The uncertainties of the emission factors were given in the Chapter 6.2.5. (Table 274) and Chapter 6.3.5. (Table 284). For the settlement biomass growth rates ±75% based on expert judgement were used.

The uncertainty of the totals of the emissions/removals of the settlement category across the time series ranges from ±133 kt CO_2 to ±211 kt CO_2. Expressed in % of the total emissions of the settlement category, the uncertainty lies between ±27 and ±38% depending on the magnitude of the net emissions in the single years.

6.6.6 Category-specific QA/QC

The calculation of the data for category *4.E* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.6.7 Recalculations

In this submission, the hierachy in which the respective LU and LUC data sources are ranked in terms of accuracy was adjusted. Due consistency issues identified in the statistics on total Grassland area, the BEV statistics on total settlement area are now considered more reliable than the statistics on total Grassland area data. Therefore, BEV statistics on total Settlement area are used over the whole time series, rather than extrapolating backwards from the latest year area using the repective LUCs to and from Settlements. Furthermore, in this submission the method to estimate land-use changes between Grassland and Cropland were based on IACS/LPIS data was revised. To ensure area consistency in the LUC matrices, the changes in these LUC areas also had an impact on the LUC areas from Cropland and Grassland to Settlements. Finally, the LUC areas from Forest land to Settlements since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Settlements for the whole time series were changed on the basis of the new NFI 2016/21 results. For Settlements, the above improvements led to annual category emissions that are 58 to 418 CO_2e higher compared to the last submission in 2022.

6.6.8 Planned improvements

See Chapter 6.1.8.

6.7 Other Land (Category 4.F)

6.7.1 Category description

The emissions/removals of the LUC categories to OL were revised for the whole time series due to updates of the LUC timeseries in the other categories. The changes have been implemented to ensure interannual area consistency between the yearly land use change matrices of Austria.

Figure 46: Emissions/removals (+/-) from land use changes to Other Land (1990-2021) in kt CO_2.

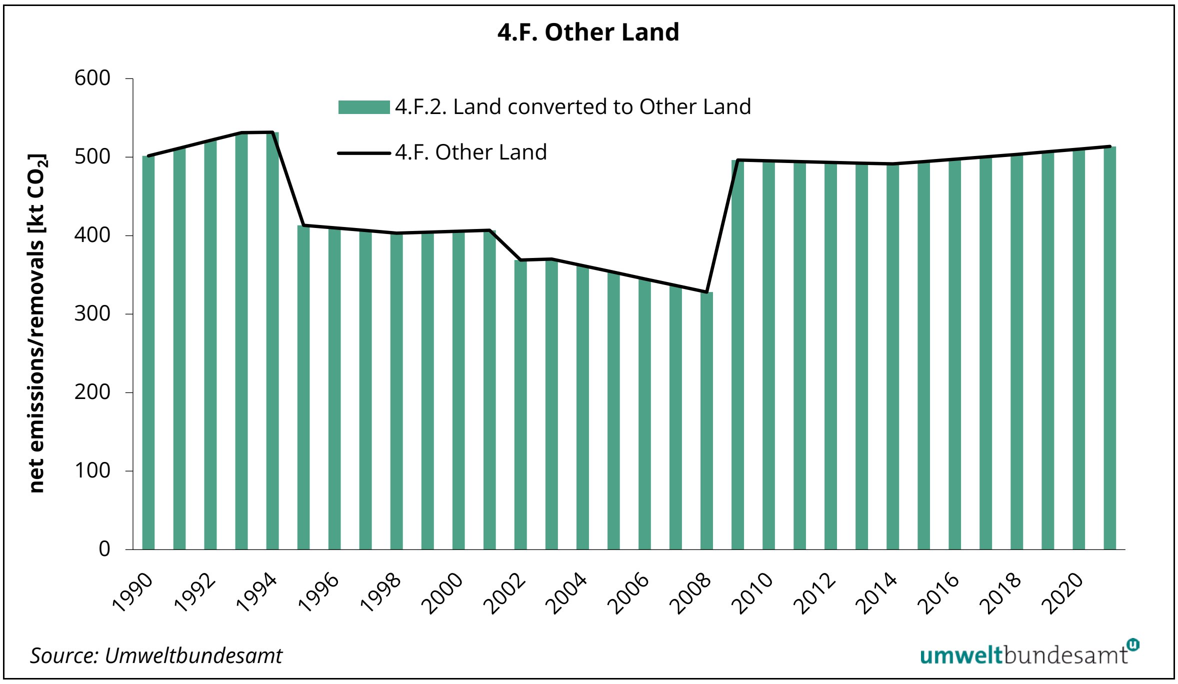


Table 295: Total areas and land-use change areas for the subcategory Other Land 4.F for the period 1990 to 2021 in ha.

	4.F Total Other Land	**4.F.1. Other Land remaining Other Land**	**4.F.2. Land converted to Other Land**	**4.F.2.1 Forest Land converted to Other Land**	**4.F.2.2 Cropland converted to Other Land**	**4.F.2.3 Grassland converted to Other Land**	**4.F.2.4 Wetland converted to Other Land**	**4.F.2.4 Settlement converted to Other Land**
1990	767 504	749 370	18 134	18 134	NO	NO	NO	NO
1991	766 123	747 019	19 104	19 104	NO	NO	NO	NO
1992	764 742	744 668	20 073	20 073	NO	NO	NO	NO
1993	763 360	742 317	21 043	21 043	NO	NO	NO	NO
1994	761 979	740 913	21 066	21 066	NO	NO	NO	NO
1995	761 016	740 312	20 704	20 704	NO	NO	NO	NO
1996	760 053	739 710	20 343	20 343	NO	NO	NO	NO
1997	759 090	739 109	19 981	19 981	NO	NO	NO	NO
1998	758 127	738 508	19 619	19 619	NO	NO	NO	NO
1999	757 164	737 456	19 708	19 708	NO	NO	NO	NO
2000	756 201	736 404	19 796	19 796	NO	NO	NO	NO
2001	755 238	735 353	19 885	19 885	NO	NO	NO	NO
2002	753 421	733 576	19 844	19 844	NO	NO	NO	NO
2003	751 604	731 800	19 804	19 804	NO	NO	NO	NO
2004	749 787	730 930	18 857	18 857	NO	NO	NO	NO
2005	747 970	730 060	17 910	17 910	NO	NO	NO	NO
2006	746 152	729 190	16 963	16 963	NO	NO	NO	NO
2007	744 335	728 320	16 016	16 016	NO	NO	NO	NO
2008	742 518	727 450	15 069	15 069	NO	NO	NO	NO
2009	741 679	726 644	15 035	15 035	NO	NO	NO	NO
2010	740 839	725 743	15 096	15 096	NO	NO	NO	NO
2011	740 000	724 841	15 158	15 158	NO	NO	NO	NO
2012	739 160	723 940	15 220	15 220	NO	NO	NO	NO
2013	738 321	723 039	15 282	15 282	NO	NO	NO	NO
2014	737 481	722 137	15 344	15 344	NO	NO	NO	NO
2015	736 642	720 851	15 791	15 791	NO	NO	NO	NO
2016	735 802	719 565	16 237	16 237	NO	NO	NO	NO
2017	734 963	718 278	16 684	16 684	NO	NO	NO	NO
2018	734 123	716 992	17 131	17 131	NO	NO	NO	NO
2019	733 283	715 706	17 578	17 578	NO	NO	NO	NO
2020	732 444	714 419	18 025	18 025	NO	NO	NO	NO
2021	731 604	713 133	18 472	18 472	NO	NO	NO	NO

Table 296: Emissions/removals (+/-) from land use changes to Other Land for the period 1990 to 2021 in kt CO_2.

	4.F.2. Land converted to Other land	4.F.2.1 Forest land converted to Other land	4.F.2.2 Cropland converted to Other land	4.F.2.3 Grassland converted to Other land	4.F.2.4 Wetland converted to Other land	4.F.2.5 Settlement converted to Other land	4(III)F2_N_2O emissions due to C losses in managed soils_N_2O in CO_2eq	4(IV)A2_N_2O emissions from N leaching and runoff_N_2O in CO_2eq
1990	502	502	NO	NO	NO	NO	11	1.29
1991	511	511	NO	NO	NO	NO	12	1.36
1992	521	521	NO	NO	NO	NO	13	1.43
1993	531	531	NO	NO	NO	NO	13	1.50
1994	532	532	NO	NO	NO	NO	13	1.50
1995	413	413	NO	NO	NO	NO	13	1.47
1996	410	410	NO	NO	NO	NO	13	1.45
1997	407	407	NO	NO	NO	NO	12	1.42
1998	403	403	NO	NO	NO	NO	12	1.39
1999	404	404	NO	NO	NO	NO	12	1.40
2000	406	406	NO	NO	NO	NO	12	1.41
2001	407	407	NO	NO	NO	NO	12	1.41
2002	369	369	NO	NO	NO	NO	12	1.42
2003	370	370	NO	NO	NO	NO	13	1.43
2004	362	362	NO	NO	NO	NO	12	1.37
2005	353	353	NO	NO	NO	NO	12	1.31
2006	345	345	NO	NO	NO	NO	11	1.25
2007	337	337	NO	NO	NO	NO	11	1.20
2008	328	328	NO	NO	NO	NO	10	1.14
2009	496	496	NO	NO	NO	NO	10	1.13
2010	495	495	NO	NO	NO	NO	10	1.12
2011	494	494	NO	NO	NO	NO	10	1.12
2012	493	493	NO	NO	NO	NO	10	1.11
2013	492	492	NO	NO	NO	NO	10	1.11
2014	491	491	NO	NO	NO	NO	10	1.10
2015	494	494	NO	NO	NO	NO	10	1.13
2016	497	497	NO	NO	NO	NO	10	1.15
2017	500	500	NO	NO	NO	NO	10	1.17
2018	503	503	NO	NO	NO	NO	11	1.19
2019	507	507	NO	NO	NO	NO	11	1.22
2020	510	510	NO	NO	NO	NO	11	1.24
2021	514	514	NO	NO	NO	NO	11	1.26

6.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The total area of this category is estimated in accordance to the 2006 IPCC Guidelines. For this reason other land is understood to be the difference of the area of all other land use categories and the whole area of Austria in order to avoid double accounting or omission of an area.

The Real Estate Database (BEV) of Austria (see for instance in Chapter 6.6.2) allows an assessment of the area of the category "other land". Comparison of the inventory land use residual of the category other land and the BEV other land data allows the area consistency of the inventory method to be validated. If the areas for "other land" were taken from this database (instead calculating the "other land" area as the difference between the area sum of all land categories except other land and the area of total Austria) the resulting area sum of all land use categories would be each year 1 to 2% lower than the real total area of Austria. From that small difference we assume that the used statistics (though different data bases for all land uses) give a rather good picture of Austria.

In previous submissions, a method was implemented to estimate land use change from Grassland to Other land. After adjusting the Cropland, Grassland and Settlement areas and respective land-use changes between these categories for consistency reasons (see previous chapters), the trend in total grassland areas and the land-use changes to/from Grassland resulted for part of the time series in a discrepancy between both, which were assumed to be land-use changes from Grassland to Other land. However, in preparation for this 2023 submission, consistency issues in the statistics on total Grassland area were identified (see chapter 6.4). A correction of these statistics was thus implemented, which together with the improved estimates of LUC between Croplands and Grasslands, removed the residual in the Grassland area balance that was previously assigned as Grassland conversion to Other land. Consequently, Grassland conversions to Other land are considerd to be not occurring; only conversions from Forest land to Other land are considered to occur in Austria. These assumptions make sense due to the location of this land in extreme ecological conditions. Any change from other categories to other land would be geographically and/or rationally non-plausible (e.g.: Any reconversion of wetlands and settlements to other land is unlikely due to the steady increase of wetlands and settlements and the missing incentives for such conversions. Cropland occurs only in ecologically favorable conditions).

The LUC areas from Forest land to Other land are based on the NFIs.

6.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The other land area is defined in correspondence to the LULUCF category and contains the following subcategories of the national classification system:

- rocks and screes.
- glaciers.
- unmanaged alpine dwarf shrub heaths.

6.7.4 Methodological Issues

6.7.4.1 Land use changes to other land

6.7.4.1.1 Forest Land converted to Other Land (4.F.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2. The area in conversion from Forest land to Other land for a time period of 20 years ranges from 15 035 ha to 21 066 ha in the years 1990 to 2021 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 328 kt CO_2 to 532 kt CO_2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes between NFI observation periods while they remain constant within the NFI observation periods themselves (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to OL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). Any interpolation across these steps was considered unsuitable and is therefore not carried out.

Changes in carbon stocks in biomass of forest land converted to other land

For the calculation of the annual change in carbon stocks of living biomass of forest land converted to other land the IPCC Tier 3 approach is used (see Chapter 6.2.4.2).

The annual net emission rates due to the loss of biomass on areas of land use change from forest land to other land range from 109 to 228 kt CO_2 in the years 1990–2021.

Changes in carbon stocks in litter and mineral soils of forest land converted to other land

For the calculation of the annual change of carbon stocks in forest litter and mineral soils converted to soils of other land the IPCC Tier 2 approach is used. Emissions/removals were calculated by country specific values for carbon stocks stratified according to five forest growth regions. The stratified LUC areas and C stocks according to these growth regions were used for the estimates. The method is described in Chapter 6.2.4.2.

The annual emission rates in the years 1990–2021 due to C stock changes in litter and deadwood range from 49 to 99 kt CO_2 and from 1.2 to 2.6 kt CO_2, respectively. .

The annual emission rates due to C stock changes in mineral soils range from 162 to 220 kt CO_2 in the years 1990–2021.

6.7.4.1.2 Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Increases in available N due to soil C losses from human induced land use changes enhance the mineralisation of soil organic N and therefore cause N_2O emissions. These emissions were calculated for Forest land converted to Other land because of related C losses in mineral soils. To estimate the associated N_2O emissions the tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.8) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by the country specific C/N ratios:

- for forest soils: 19 (source: BFW 1992)

Then the amount of N was multiplied by the default emission factor (EF_1) from Table11.1 in the IPCC 2006 Gl. Then the result was converted from the amount of annual direct N_2O-N to N_2O emissions.

6.7.4.1.3 Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from managed soils, also related indirect emissions occur. The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11:

$$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5 \text{ (eq.11.10)}$$

Where

...N_2O-N = annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils, kg yr^{-1}

... F_{SOM} = the net annual amount of N mineralized in mineral soil associated with loss of soil C from soil organic matter as a result of changes in land use or management kg N yr^{-1}

... $Frac_{LEACH}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff kg N per kg of N additions

$Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER et al., 2013) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.7.5 Uncertainty assessment

The following uncertainties of the input data were used:

For the annual LUC area FL to OL see Chapter 6.2.5, Table 273.

The uncertainties of the emission factors were given in the Chapter 6.2.5, Table 274.

The uncertainty of the totals of the emissions/removals of the for Other land ranges from ±300 kt CO_2 to ±632 kt CO_2. Expressed in % of the total emissions of the other land category, the uncertainty lies between ±70 and ±123%.

6.7.6 Recalculations

The correction of the total Grassland area statistics, as well as the improved estimates of LUC between Grassland and Cropland, removed the residual in the Grassland area balance that was previously assigned as Grassland conversion to Other land. Consequently, in contrast to the previous submission, Grassland conversions to Other land are considered to be not occurring. In addition, the LUC areas from Forest land to Other land since 2009 and the increment, harvest and dead wood stock change values for LUC areas Forest land to Other land for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the Other land category, with annual emissions deviating from the last submission in 2022 by -163 to +273 kt CO_2e.

6.7.7 Category-specific QA/QC

The calculation of the data for category 4.E is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.7.8 Planned improvements

See Chapter 6.1.8.

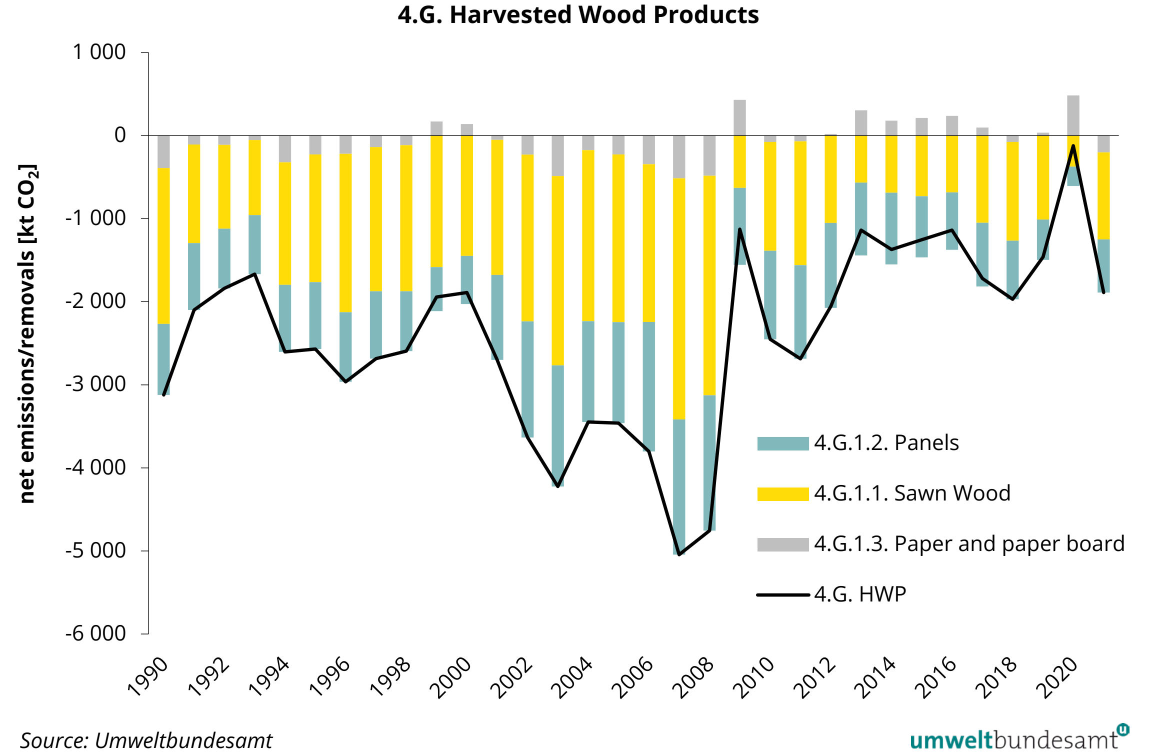
6.8 Harvested Wood Products (Category 4.G)

6.8.1 Category description

The category Harvested Wood Products (HWP) is the second largest sink in Austria. In 2021 this category contributed to net removals of -1 889 kt CO_2 equivalent. The largest contribution results from the product category sawn wood, followed by wood panels and paper/paper products. Due to the nature of the input data and subsequent calculations, HWPs produced and exported are included in the same category as HWPs produced and consumed domestically. HWP disposal as solid waste is not occurring in Austria due to the restrictive landfill legislation.

With regard to the trend it can be seen that after the low domestic production and consequently exceptionally low HWP sink in 2020 (due to a huge amount of salvage logged disturbance wood in Central Europe from the years before, as well as low wood prices and Corona pandemic influences), the net sink of the HWP category has increased again in 2021 to a comparable level to the period before 2020.

Figure 47: Emissions/removals from Harvested wood products for the period 1990 to 2021 by product category in kt CO_2



Source: Umweltbundesamt

Table 297: Emissions/removals from Harvested wood products for the period 1990 to 2021 in kt CO_2.

	Harvested wood products (produced and consumed domestically)	Sawn wood	Panels	Paper and paper board	Harvested wood products (produced and exported)	HWP in SWDS
1990	-3 122	-1 877	-854	-391	IE	NO
1991	-2 098	-1 186	-804	-108	IE	NO
1992	-1 840	-1 009	-719	-112	IE	NO
1993	-1 667	-904	-710	-53	IE	NO
1994	-2 604	-1 477	-807	-320	IE	NO
1995	-2 569	-1 537	-806	-227	IE	NO
1996	-2 964	-1 908	-839	-218	IE	NO
1997	-2 686	-1 736	-811	-138	IE	NO
1998	-2 595	-1 760	-721	-115	IE	NO
1999	-1 943	-1 583	-530	170	IE	NO
2000	-1 889	-1 448	-581	140	IE	NO
2001	-2 701	-1 626	-1 023	-52	IE	NO
2002	-3 635	-2 008	-1 399	-229	IE	NO
2003	-4 223	-2 279	-1 458	-487	IE	NO
2004	-3 448	-2 058	-1 215	-175	IE	NO
2005	-3 461	-2 020	-1 216	-226	IE	NO
2006	-3 803	-1 900	-1 560	-344	IE	NO
2007	-5 045	-2 904	-1 629	-513	IE	NO
2008	-4 755	-2 643	-1 630	-483	IE	NO
2009	-1 126	-630	-926	429	IE	NO
2010	-2 452	-1 311	-1 064	-77	IE	NO
2011	-2 687	-1 491	-1 128	-68	IE	NO
2012	-2 055	-1 052	-1 023	20	IE	NO
2013	-1 138	-566	-876	305	IE	NO
2014	-1 372	-687	-864	179	IE	NO
2015	-1 254	-729	-737	212	IE	NO
2016	-1 137	-683	-692	238	IE	NO
2017	-1 719	-1 050	-765	96	IE	NO
2018	-1 969	-1 189	-704	-77	IE	NO
2019	-1 462	-1 011	-486	35	IE	NO
2020	-122	-373	-233	484	IE	NO
2021	-1 889	-1 048	-640	-201	IE	NO

6.8.2 Methodological issues

Emissions/removals from HWPs are based on calculation of the stocks derived from domestic harvest by applying the production approach (or approach B) of the 2006 IPCC Guidelines. Production data has been derived from the FAO Stat database on forestry production and trade statistics from 1961 to 2018. For the years 2019 to 2021 the data from the Joint Forest Sector Questionnaire (JFSQ 2020 and JFSQ 2021) was used, which was provided by the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML), because it contains the latest forestry statistics which enter into the FAO database but were not yet included there at the time of the submission. Table 298 shows the domestic production of sawn wood, wood panels and paper/paper board as calculated from production and trade data from the FAO Stat database and the JFSQ 2020 and JFSQ 2021.

Table 298: Production of harvested wood products based on domestic harvest in Austria for the period 1990 to 2021 in cubic metres or tonnes calculated from FAO statistics and the JFSQ 2021.

	Sawn wood [m³]	wood panels [m³]	Paper and paper board [t]
1990	5 615 705	1 325 979	1 701 371
1991	4 826 955	1 301 609	1 580 640
1992	4 655 112	1 242 690	1 606 355
1993	4 555 523	1 253 340	1 587 744
1994	5 266 318	1 363 873	1 790 465
1995	5 377 673	1 375 427	1 790 818
1996	5 866 057	1 428 600	1 832 165
1997	5 724 410	1 421 280	1 820 711
1998	5 793 968	1 354 623	1 832 760
1999	5 620 759	1 190 307	1 653 067
2000	5 496 399	1 251 063	1 638 620
2001	5 751 680	1 697 890	1 747 175
2002	6 251 856	2 053 190	1 884 750
2003	6 632 695	2 165 566	2 117 721
2004	6 420 993	1 972 161	1 996 754
2005	6 430 551	2 005 363	2 069 826
2006	6 315 069	2 289 502	2 201 610
2007	7 586 538	2 464 987	2 395 356
2008	7 331 267	2 512 103	2 481 355
2009	4 963 695	1 880 660	1 928 748
2010	5 811 867	2 048 785	2 201 453
2011	6 064 727	2 133 739	2 211 644
2012	5 561 243	2 018 614	2 162 515
2013	4 997 590	1 914 609	1 954 311
2014	5 161 458	1 930 385	1 980 232
2015	5 232 621	1 830 333	1 919 134
2016	5 188 675	1 815 209	1 856 156
2017	5 647 474	1 906 001	1 907 844
2018	5 841 881	1 865 734	2 011 693
2019	5 644 690	1 666 129	1 947 728
2020	4 906 193	1 443 147	1 618 298
2021	5 733 763	1 827 783	2 008 066

As the original FAO production data does not differentiate the product categories between wood originating from domestic and imported harvest, the share for the domestic harvest needs to be obtained (equation 2.8.1 of chapter 2 of the IPCC (2014) KP supplement):

$$f_{IRW,i} = \frac{IRW_{p,i} - IRW_{ex,i}}{IRW_{p,i} + IRW_{im,i} - IRW_{ex,i}}$$

Where:

$f_{IRW,\,I}$ = *share of wood from domestic harvest for year i, dimensionless*

$IRW_{p,i}$ = *Industrial roundwood production (wood in the rough) for year i,* $m^3\ a^{-1}$

$IRW_{ex,\,i}$ = *Industrial roundwood – export quantity for year i,* $m^3\ a^{-1}$

$IRW_{im,\,i}$ = *Industrial roundwood – import quantity for year i,* $m^3\ a^{-1}$

In addition, the paper production on basis of domestic harvest is further adjusted by equation 2.8.2 of chapter 2 of the IPCC (2014) KP supplement which corrects for the paper production on basis of imported pulp:

$$f_{PULP,i} = \frac{PULP_{p,i} - PULP_{ex,i}}{PULP_{p,i} + PULP_{im,i} - PULP_{ex,i}}$$

Where

$f_{PULP,\,I}$ = share of domestically produced pulp for the domestic production of paper and paperboard in year i

$PULP_{p,i}$ = production of wood pulp in year i, t a^{-1}

$PULP_{ex,\,i}$ = export of wood pulp in year i, t a^{-1}

$PULP_{im,\,i}$ = import of wood pulp in year i, t a^{-1}

The original FAO production data for the diverse wood products are then multiplied by the relevant $f_{IRW,I}$ and, in case of paper, additionally with the $f_{PULP,\,I}$ factors and aggregated to derive the production data on basis of domestic harvest presented in Table 298. For calculating the annual carbon stock inflow associated with the domestically produced wood products, the derived data are multipled by the respective C conversion factors in kt C m^{-3} or kt C t dm^{-1}.

The production approach requires a time series of C stock in domestically produced wood starting with year 1900 in order to reflect current emissions from HWPs which were harvested many decades ago. As the FAO statistics start from 1961, the annual carbon stock inflow from domestic wood production needs to be extrapolated backwards to obtain a full time series from the 1901 onwards. This is done by applying equation 12.6 of Vol 4, chapter 12 of the 2006 IPCC Guidelines separately to the sawn wood, wood panels and paper time series:

$$inflow_t = inflow_{1961} * e^{[U*(t-1961)]}$$

Where

$inflow_t$ = annual C inflow from production on basis of domestic harvest of aggregated sawn wood, wood panels, or paper for year t (pre 1961), kt C yr^{-1}

t = year (pre 1961)

$inflow_{1961}$ = annual C inflow from production on basis of domestic harvest of aggregated sawn wood, wood panels, or paper for the year 1961, kt C yr^{-1}

U = estimated continuous rate of change in industrial roundwood consumption for the region that includes the reporting country between 1900 and 1961 (Table 12.3 of Vol 4, chapter 12 of the 2006 IPCC Guidelines), 0.0151

For each of the 3 wood product categories, an associated annual total C stock is calculated by starting in 1900, and applying the equation below (equation 12.1 of Vol 4, chapter 12 of the IPCC 2006 Guidelines) to each subsequent year up to the present:

$$C_i = e^{-k} * C_{i-1} + \left[\frac{(1-e^{-k})}{k}\right] * inflow_i$$

Where:

C_i = the carbon stock of the HWP pool for the year i, kt C

C_{i-1} = the carbon stock of the HWP pool for the previous year i, kt C

k = decay constant of first-order decay given in units, yr^{-1} (k = ln(2)/HL, where HL is half-life of the HWP pool in years. Tier 2 half-lives are used for sawn wood, wood panels and paper according to Table 2.8.2 of the KP supplement.

Finally, emissions/removals from the HWPs for a given year are calculated from the annual carbon stock change in the HWP pool ($\Delta C_i = C_i - C_{i-1}$).

6.8.3 Uncertainty assessment

The methods follow closely the IPCC 2006 GL, therefore the uncertainty of ±50% as listed in the IPCC 2006 GL for this category was applied. This leads to absolute uncertainties in the range of ±60 to ±2 472 kt CO_2.

6.8.4 Recalculations

The HWP production figures for the year 2020 were updated in the most recent JFSQ statistics. Consequently, the removal figures for this year had to be updated accordingly. The recalculations in the HWP category led to 2020 removals that are 51 kt CO_2e lower than previously reported.

6.8.5 Planned Improvements

See Chapter 6.1.8.

7 WASTE (CRF SECTOR 5)

7.1 Sector overview

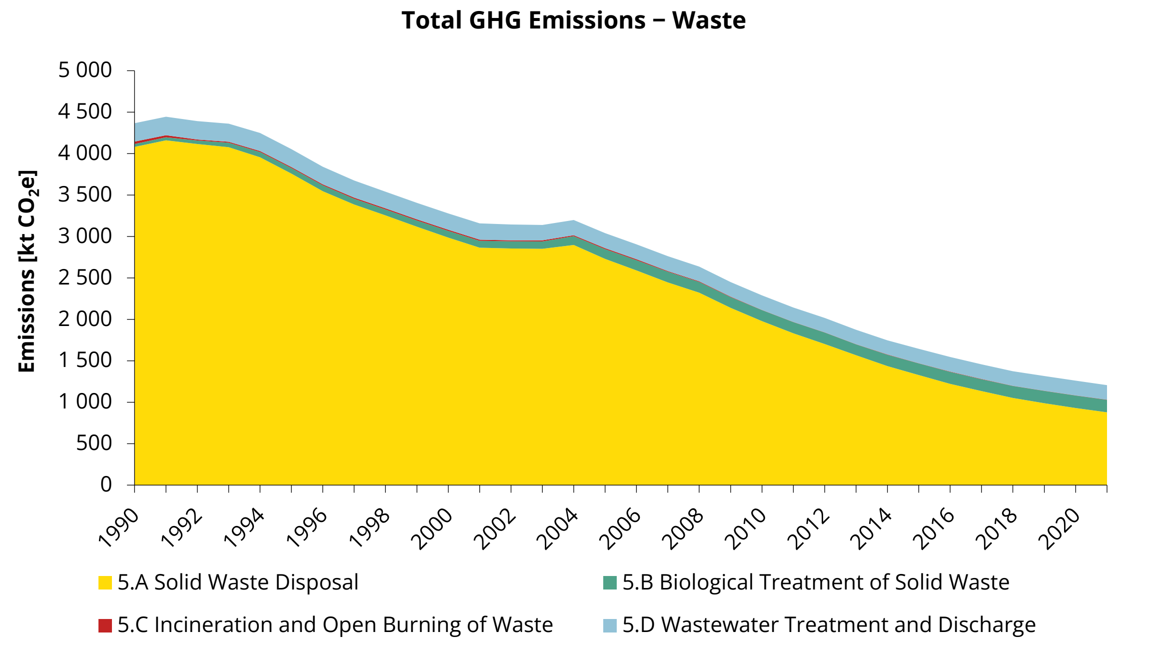
This chapter includes information on methods for estimating greenhouse gas emissions as well as references of activity data and emission factors concerning waste management and treatment activities reported under CRF Category 5 *Waste*: *Solid Waste Disposal (5.A)*, *Biological Treatment of Solid Waste (5.B)*, *Incineration and Open Burning of Waste (5.C)* and *Waste Water Treatment and Discharge (5.D)*.

Waste management and treatment activities are sources of methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions.

7.1.1 Emission Trend

Overall greenhouse gas emissions from waste management and treatment activities in the year 2021 amounted to 1 211 kt CO_2 equivalent (1990: 4 367 kt CO_2 equivalent). These are about 1.6% of total greenhouse gas emissions in Austria in 2021 and 5.5% in 1990. In 2021, greenhouse gas emissions from the waste sector were 72% below the level of 1990.

Figure 48: GHG emissions from CRF 5 Waste.



Source: Umweltbundesamt

Table 299 presents the emission trend by gas. The major greenhouse gas emitted from this sector is CH_4, which represents 81% of all emissions from this sector in 2021, followed by N_2O (19%) and CO_2 (0.2%).

CH_4 emissions

CH_4 emissions from sector Waste amounted to 983 kt CO_2 equivalent in 2021; that is 77% below the level of 1990. CH_4 emissions originate from all sub-categories within this sector, but the largest source is *5.A Solid Waste Disposal*, contributing 89% to total CH_4 emissions from this sector.

The decrease of CH_4 emissions is a result of waste management policies. The amount of landfilled waste decreased significantly, the organic fraction within this waste decreased as well and methane recovery systems have increasingly been implemented during the period, reducing the amount of methane emitted. Furthermore, the decrease of inhabitants connected to septic tanks or cesspools contributed to the reduction of CH_4 emissions.

N_2O emissions

N_2O emissions from sector Waste amounted to 225 kt CO_2 equivalent in 2021. Emissions increased by 112% since 1990.

67% of N_2O emissions originate from *5.D. Wastewater Treatment and Discharge*, 33% are from *5.B Biological Treatment of Solid Waste*. In both categories emissions are increasing; waste incineration (municipal solid waste and waste oil) is a minor source of N_2O emissions.

CO_2 emissions

CO_2 emissions from sector Waste amounted to 2.1 kt CO_2 equivalent in 2021 and decreased by 93% compared to 1990.

CO_2 emissions originate from waste incineration (municipal solid waste, waste oil and hospital waste). The only plant incinerating municipal waste without energy recovery was shut down in 1991, which resulted in a drop of CO_2 emissions from 1991–1992. The decrease in emissions since 2005 is due to the waste incineration regulation specifying more stringent emission limits for all facilities to be complied by 2005 and thus reducing the number of facilities and thus waste incinerated.

Table 299: Greenhouse gas emissions from Waste sector by gas.

Year	CO_2	CH_4	N_2O	Total CRF 5
	[kt]	[kt CO_2e]	[kt CO_2e]	[kt CO_2e]
1990	27.9	4 233	106	4 367
1991	24.4	4 312	108	4 445
1992	11.1	4 267	113	4 391
1993	10.8	4 230	121	4 361
1994	10.8	4 108	131	4 249
1995	11.1	3 906	137	4 055
1996	11.4	3 687	144	3 842
1997	11.8	3 517	147	3 676
1998	12.1	3 376	152	3 540
1999	12.4	3 235	157	3 405
2000	12.4	3 099	166	3 277
2001	12.4	2 972	172	3 157
2002	12.4	2 957	175	3 145
2003	12.4	2 949	178	3 139
2004	12.4	2 999	187	3 199
2005	12.4	2 835	194	3 041
2006	10.3	2 698	198	2 906

Year	CO_2	CH_4	N_2O	Total CRF 5
	[kt]	[kt CO_2e]	[kt CO_2e]	[kt CO_2e]
2007	8.2	2 554	200	2 762
2008	6.2	2 430	200	2 636
2009	4.1	2 244	202	2 450
2010	2.1	2 083	205	2 289
2011	2.1	1 935	206	2 143
2012	2.1	1 807	208	2 017
2013	2.1	1 667	205	1 874
2014	2.1	1 538	207	1 747
2015	2.1	1 433	210	1 645
2016	2.1	1 328	216	1 546
2017	2.1	1 238	217	1 457
2018	2.1	1 154	217	1 373
2019	2.1	1 093	221	1 315
2020	2.1	1 035	223	1 259
2021	2.1	983	225	1 211
1990–2021	**-93%**	**-77%**	**+112%**	**-72%**

Table 300 presents the greenhouse gas emissions by sub-category. As can be seen, the dominant sub-category is *5.A Solid Waste Disposal*, contributing 73% (2021) to greenhouse gas emissions from sector Waste.

Table 300: Greenhouse gas emissions from Waste sector by subcategories.

Year	5.A	5.B	5.C	5.D	Total
			[kt CO_2e]		
1990	4 081	35	29	223	4 367
1991	4 160	36	25	223	4 445
1992	4 115	43	12	221	4 391
1993	4 078	54	11	218	4 361
1994	3 956	64	11	218	4 249
1995	3 758	67	12	218	4 055
1996	3 546	71	12	213	3 842
1997	3 386	70	12	207	3 676
1998	3 254	72	13	201	3 540
1999	3 118	76	13	198	3 405
2000	2 987	81	13	196	3 277
2001	2 865	83	13	196	3 157
2002	2 855	87	13	191	3 145
2003	2 851	90	13	185	3 139
2004	2 897	106	13	183	3 199
2005	2 730	116	13	182	3 041
2006	2 591	123	11	181	2 906
2007	2 446	128	8.7	179	2 762
2008	2 322	129	6.7	178	2 636
2009	2 138	130	4.6	176	2 450
2010	1 978	134	2.6	175	2 289
2011	1 831	136	2.6	174	2 143
2012	1 701	140	2.6	173	2 017
2013	1 566	132	2.6	172	1 874
2014	1 435	138	2.6	171	1 747

Year	5.A	5.B	5.C	5.D	Total
			[kt CO_2e]		
2015	1 328	141	2.6	173	1 645
2016	1 221	146	2.6	176	1 546
2017	1 135	144	2.6	176	1 457
2018	1 052	144	2.6	175	1 373
2019	988	148	2.6	176	1 315
2020	931	150	2.6	176	1 259
2021	878	153	2.6	177	1 211
1990–2021	**-78%**	**+340%**	**-91%**	**-21%**	**-72%**

7.1.2 Key Categories

Methodology and results of the key category analysis is presented in Chapter 1.5. Table 301 summarizes the key categories in the waste sector.

Table 301: Key sources of Category 5 Waste (T1, excluding LULUCF).

IPCC Category	Source Categories	Key Categories	
		GHG	KS-Assessment
5.A	Solid Waste Disposal	CH_4	LA; TA

LA = Level Assessment (if not further specified – for the years 1990 and 2021)

TA = Trend Assessment 1990–2021

CH_4 from solid waste disposal has been identified as the only key category in this sector applying KCA Tier 1 approach.

7.1.3 Completeness

Table 302 gives an overview of the IPCC categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated.

Table 302: Overview of subcategories of Category Waste: transformation into SNAP Codes and status of estimation.

IPCC Category	SNAP	CO_2	CH_4	N_2O
5.A solid waste disposal				
5.A.1 Managed waste disposal sites	090401 Solid Waste Disposal on Land	NA	✓	NA
5.A.2 Unmanaged waste disposal sites*)	090402 Unmanaged Waste Disposal	NO	NO	NO
5.A.3 Uncategorized waste disposal sites	090403 Other	NO	NO	NO
5.B Biological treatment of solid waste				
5.B.1 Composting	091005 Compost production	NA	✓	✓
5.B.2 Anaerobic digestion at biogas facilities – Municipal Solid Waste	091006 Biogas production	NA**)	✓	NA***)
5.C INCINERATION AND OPEN BURNING OF WASTE				

IPCC Category	SNAP	CO_2	CH_4	N_2O
5.C.1 Waste incineration	090201 Incineration of domestic or municipal waste	✓	✓	✓
	090207 Incineration of hospital wastes	✓	✓	✓
	090208 Incineration of waste oil	✓	NA	✓
5.C.2 Open burning of waste		NA	✓	✓
5.D WASTE WATER treatment and discharge				
5.D.1 Domestic wastewater	091002 Wastewater treatment in residen-tial/commercial sect.	NA	✓	✓
5.D.2 Industrial wastewater	091001 Wastewater treatment in industry	NA	✓	✓****)
5.D.3 Other (please specify)		NO	NO	NO

*) *In Austria all waste disposal sites are managed.*

**) *CO_2: of biogenic origin and thus reported as an information item in the Energy sector*

***) *According to the 2006 IPCC GL emissions negligible (Vol. 5, p.4.4 and table 4.1); no EF provided in the IPPC GL*

****) *covered: N_2O from (on-site) industrial wastewater treatment. N_2O from industrial wastewater treated together with domestic wastewater in wastewater treatment plants is included in 5.D.1*

7.1.4 Methodological issues

For the emissions calculation of *CRF 5.A Solid Waste Disposal* the First Order Decay (FOD) Tier 2 method is applied. Data on the amounts of waste disposed at solid waste disposal sites – including also waste from industrial sources – is available on a yearly basis. Table 306 summarises the parameters used, which are partly country specific, partly IPCC defaults.

The calculation for *CRF 5.B Biological Treatment of Solid Waste* is based on the 2006 IPCC GL, but country-specific emission factors are applied (Tier 2). Emissions from composting and mechanical-biological treatment are calculated by multiplying waste quantities by emission factors taken from national studies. For the calculation of emissions from biogas plants the IPCC 2006 default EF of 5% CH_4/biogas produced is applied (Tier 1) until 2015. Since then a linear decline until 1% in 2030 is assumed (see chapter 7.3.2.2).

For *CRF 5.C.1 Waste Incineration* the CORINAIR methodology is applied: the quantity of waste is multiplied by an emission factor for CO_2, CH_4 and N_2O. For *CRF 5.C.2 Open Burning of Waste* a simple country specific method with country specific emission factors is applied for CH_4 and N_2O.

N_2O emissions from *CRF 5.D.1 Domestic Wastewater* are calculated using a country specific method (CS), based on the 2006 IPCC Guidelines, applying CS EF (direct N_2O) and IPCC defaults (indirect N_2O). Main differences to the default methodology are described in Chapter 7.5.2. Calculation of CH_4 emissions from this category follows the methodology of the 2006 IPCC GL, but including a CS methane correction factor. N_2O and CH_4 emissions from *CRF 5.D.2 Industrial Wastewater* are determined based on a study conducted in 2019 (UMWELTBUNDESAMT 2019c), applying a CS emission factor for the calculation of direct N_2O emissions and the default value for indirect N_2O emissions. For methane it is assumed that 1% of the gas generated in the anaerobic pre-treatment of waste water is actually emitted.

7.1.5 Quality Assurance and Quality Control (QA/QC)

In addition to the general QC activities described in Chapter 1.3.3, the following QA/QC activities are done on a regular basis:

- To ensure, that most up-to-date data and parameters (e.g. landfill gas recovery, connection rate etc.) are considered, national waste experts, mostly within the Umweltbundesamt are contacted. After finalisation of the calculation but prior to submission, the respective section of the NIR is sent to relevant experts for a final check of descriptions and trend analysis.
- Activity data is checked for plausibility and time series consistency. If dips and jumps exceeding 20% compared to the year before are observed, other experts or data providers are consulted to either provide the explanation or to identify a possible inconsistency or an error.
- Recalculations are validated in detail by comparing several parameters and partial results over the whole time series. Explanations for recalculations are documented.
- In case of new or refined methods the calculation sheets are validated to ensure there are no transcription errors and are finally protected against accidental modification.

Further category-specific QA/QC steps and results are described in the respective subchapters.

7.2 Solid Waste Disposal (Category 5.A)

Emissions: CH_4

Key Source: Yes

In 2021 emissions from *5.A Solid Waste Disposal* contributed 73% to greenhouse gas emissions from sector Waste and 1.1% to total greenhouse gas emissions in Austria. From 1990 to 2021 greenhouse gas emissions from this source decreased by 78% (see Table 300).

In the Austrian inventory two main categories of waste are distinguished: residual waste and non-residual waste. Residual waste refers only to the part of municipal solid waste[109] collected by the municipal system (mixed composition) that is directly deposited without any pre-treatment. Non-residual waste comprises among others municipal solid waste having been pre-treated, sludge from wastewater treatment and waste from industrial sources.

It has to be noted that from 2009 on no waste is allowed to be deposited any more without being pre-treated (due to the Landfill Ordinance[110]), so since 2009 no disposal of 'residual waste' is reported by landfill operators and therefore no new and additional amount of residual waste is taken into account in the inventory. Emissions from this subcategory are therefore only affected by waste deposited before 2009. Waste from households and similar sources covered by the municipal waste collecting system but undergoing a pre-treatment before deposition is not included in this category, but in category 'non-residual waste' (sub-category 'sorting residues', among others from

[109] i.e. waste from households as well as other waste which, because of its nature or composition, is similar to waste from household (Article 2 (b): Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste).

[110] Ordinance on Landfills (Landfill Ordinance 1996), Federal Law Gazette No 164/1996; Ordinance on Landfills (Landfill Ordinance 2008), Federal Law Gazette II No 39/2008

mechanical-biological treatment) and in sector 'energy' respectively, as incineration is a pre-treatment option too.

'Residual waste' corresponds to waste:

- originating from private households and similar sources (administrative facilities of commerce, industry and public administration, kindergartens, schools, hospitals, small enterprises, agriculture, market places and other generation points)
- remaining after separation of paper, glass, plastic etc. at the source
- covered by the municipal waste collecting system
- directly landfilled without having passed any pre-treatment

'Non residual waste'

- comprises pre-treated waste from households (e.g. sorting residues from mechanical-biological treatment) and waste with biodegradable lots from other sources, including industrial waste and sludge.
- is divided into the categories wood, construction waste, paper, green waste, sludge, sorting residues/stabilized material (incl. bulky waste), textiles and fats.

Stabilized material and sorting residues remaining after mechanical, biological and mechanical-biological treatment and bulky waste are the main fraction deposited. Other fractions deposited are sludge and construction waste. Bio waste, paper and wood are mainly composted, recycled or reused (due to the implementation of the Waste Management Law), fat and textiles are not deposited any more (see Table 306). It has to be noted that from 2009 on no waste with high organic content is allowed to be deposited any more without being pre-treated (due to the Landfill Ordinance). Residues from MBT plants are exempted from this ordinance.

Table 303 presents a summary of all considered waste types and the corresponding identification numbers (list of waste).

Table 303: Considered types of waste (list of waste[111] pursuant to Article 1 (a) of Directive 75/442/EEC on waste).

Waste Identification No	Type of Waste	Waste Identification No	Type of Waste
0303	wastes from pulp, paper and cardboard production and processing	170903	other construction and demolition wastes (including mixed wastes) containing dangerous substances
1905	wastes from aerobic treatment of solid waste	170904	mixed construction and demolition waste
1908	wastes from wastewater treatment plants not otherwise specified	190805	sludge from treatment of urban wastewater
1909	wastes from the preparation of water intended for human consumption or water for industrial use	190809	grease and oil mixture from oil/water separation containing only edible oil and fats

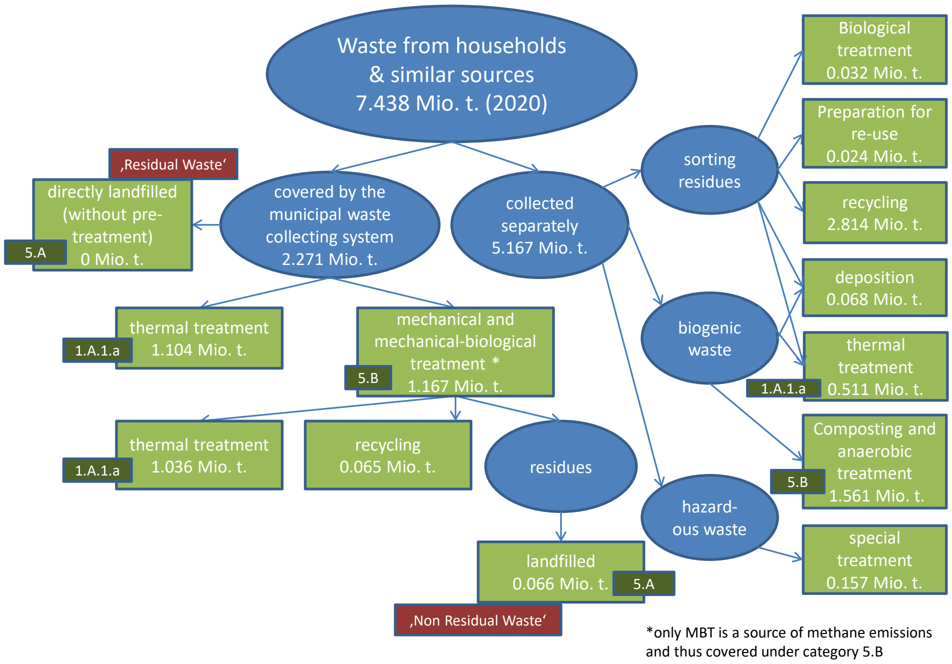
[111] Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste

Waste Identification No	Type of Waste	Waste Identification No	Type of Waste
1912	wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	200101/ 200102	paper and cardboard
20303	waste from solvent extraction	200108	biodegradable kitchen and canteen waste
30105	Sawdust, shavings, cuttings, wood, particle board and veneer	200111	textiles
30304	de-inking sludge from paper recycling	200201	Bio-degradable wastes
30307	mechanically separated rejects from pulping of waste paper and cardboard	200302	waste from markets
30310	fibre rejects, fibre-, filler-, and coating sludge from mechanical separation	200307	bulky waste
40106	Sludge, in particular from on-site effluent treatment containing chromium	190811–14	sludge from treatment of industrial wastewater
40109	waste from dressing and finishing	200125	edible oil and fat
40221	wastes from unprocessed textile fibres	170201	wood
150103	wooden packaging		

Figure 49 below is only to inform about the waste management practices in Austria, and data presented herein is not used for the calculation of GHG emissions. The main streams of treatment and disposal of waste from households and similar sources are shown in Figure 47. It also aims to transparently show the distinction between residual and non-residual waste (with regard to municipal solid waste[112]) and to demonstrate that all relevant activity data are taken into account in the inventory.

[112] In fact non-residual waste also comprises waste from other (industrial) sources.

Figure 49: Waste from households and similar sources – treatment and disposal routes 2020. Please note: This illustration only covers data from households and similar sources. Waste from industrial and similar sources (e.g. wastewater treatment plants) is not considered in this figure, but included in the inventory.



Sources: Data: BMK (2023b), Chart: Umweltbundesamt

Almost 100% of waste from households and similar sources is incinerated, recycled or treated mechanical-biologically. Since 2009 only minor amounts of stabilized residues have been still directly deposited.

In Austria all waste disposal sites are managed sites. Only landfills for mass waste contain relevant organic material and are hence sources of CH_4 emissions. All other landfill types are not relevant for GHG emissions. According to the most recent information taken from the latest Federal Waste Management Plan (BMK 2023b), 25 mass waste landfills were in operation in 2020, compared to 61 sites in 2002.

In the inventory waste amounts deposited from 1950 onwards are taken into account. From 1950 till the end of the 1980s waste amounts were increasing, with a peak in 1989. The decrease after 1989 is partly due to the introduction of a landfill levy. This levy originates from an Austrian Law for cleaning up contaminated sites[113] with the objective to finance cleaning up and securing activities for contaminated site.

[113] Law on the Remediation of Contaminated Sites (1989), Federal Law Gazette No 299/1989

Figure 50: Waste ('residual waste' and 'non-residual waste') with a relevant share of degradable organic carbon (deposited on mass waste landfills), period 1950–2021.

Source: Umweltbundesamt

In 1990 waste management was for the first time regulated by law (Austrian Waste Management Law[114]). As a result, waste separation, reuse and recycling activities increased and the amounts of deposited waste decreased significantly until 1994.

The amount of deposited waste peaked once more in 2003 due to the remediation of contaminated sites, and then dropped as from the beginning of 2004 generally only pre-treated waste was allowed to be deposited. This is due to the implementation of the Landfill Ordinance[115], which – apart from some exemptions[116] – prohibits the disposal of untreated waste with relevant content of organic matter in Austria from 2004 on and therefore leads to reduced waste volumes as well as decreased carbon content in deposited waste.

Since beginning of 2009 no waste with relevant content of organic matter is allowed to be deposited any more without being pre-treated (Landfill Ordinance).

7.2.1 Methodological Issues

For the emissions calculation the First Order Decay (FOD) method is applied, assuming that the degradable organic carbon (DOC) in waste decays throughout a few decades. Good quality activity

[114] Waste Management Act of 2002, Federal Law Gazette I No 102/2002

[115] Landfill Ordinance 1996, Federal Law Gazette No 164/1996; Landfill Ordinance 2008, Federal Law Gazette II No 39/2008

[116] Under certain circumstances there were some exceptions to this pre-treatment-obligation granted to some Austrian provinces (regulated in § 76 Abs. 7 AWG 2002). In four of the nine Austrian provinces it was still allowed to deposit waste directly without any pre-treatment until the end of 2008.

data on historical and current waste amounts is available. Parameters used are partly country-specific (e.g. landfill gas collection), partly default values. The method has therefore been characterized as a Tier 2 method.

7.2.1.1 Activity data

The quantities of 'residual waste' have been taken from the following sources:

- Data for 2008–2021 have been taken from the EDM[117], an electronic database administered by the BMLFUW and delivering data as input to the national Federal Waste Management Plan. Since the beginning of 2009 landfill operators are obliged to register their data directly and electronically (per upload) at the portal of http://edm.gv.at;
- Data for 1998–2007 were taken from a database for solid waste disposals called „Deponiedatenbank" ('Austrian landfill database'), a database administered and maintained by the Umweltbundesamt until the end of 2008;
- Data for 1950–1997 on the amounts of deposited residual waste were taken from national studies (HACKL & MAUSCHITZ 1999, UMWELTBUNDESAMT 2001c) and the respective Federal Waste Management Plans (BMLFUW 1995, BMLFUW 2001).

In the national study (HACKL & MAUSCHITZ 1999) as well as in the Federal Waste Management Plans the amounts of residual waste from administrative facilities of businesses and industries were not considered and therefore originally not included in the data of the years 1950 to 1999. Waste from these sources is however deposited and hence reported by the operators of landfill sites (therefore included in the Austrian landfill database) and thus considered in the time series from 1998 onwards. To achieve a consistent time series, data of the two overlapping years[118] (1998 and 1999) were examined and the difference – which represents the residual waste from administrative facilities of industries and businesses – was calculated. This difference, relative to the change of residual waste from households, was then applied to the years 1950 to 1997 accordingly.

The quantities of 'non residual waste' of the years 1998–2007 were taken from the database for solid waste disposal ('Deponiedatenbank', 'Austrian landfill database'), data for 2008–2021 have been taken from the EDM (Electronic Data Management). Only the types of waste with biodegradable lots were considered. There are no data available for the years before 1998, thus extrapolation was done using the Austrian GDP (gross domestic product) per inhabitant (KAUSEL 1998) as indicator. In order to get a more robust estimate, a 20 year average value was used.

Table 304 presents activity data and CH_4 emissions from managed waste disposal on land for the period 1990–2021.

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[117] Electronic Data Management

[118] Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

Table 304: Activity data for 'residual waste' and 'non residual waste', greenhouse gas emissions and implied emission factors 1990–2021

Year	Non-Residual Waste	Residual Waste	Total Waste		CH_4 Emissions		IEF CH_4
	[t/a]	[t/a]	[t/a]	inter-annual change [%]	[t/a]	inter-annual change [%]	[t/t]*
1990	648 702	1 995 747	2 644 448		145 756		0.1
1991	661 676	1 799 718	2 461 394	-6.9%	148 568	1.9%	0.1
1992	674 909	1 614 157	2 289 067	-7.0%	146 970	-1.1%	0.1
1993	688 407	1 644 718	2 333 126	1.9%	145 630	-0.9%	0.1
1994	702 175	1 142 067	1 844 242	-21.0%	141 273	-3.0%	0.1
1995	716 219	1 049 709	1 765 928	-4.2%	134 204	-5.0%	0.1
1996	730 543	1 124 169	1 854 713	5.0%	126 643	-5.6%	0.1
1997	745 154	1 082 634	1 827 788	-1.5%	120 946	-4.5%	0.1
1998	760 057	1 081 114	1 841 171	0.7%	116 208	-3.9%	0.1
1999	822 179	1 084 625	1 906 804	3.6%	111 348	-4.2%	0.1
2000	826 874	1 052 061	1 878 935	-1.5%	106 674	-4.2%	0.1
2001	772 786	1 065 592	1 838 378	-2.2%	102 319	-4.1%	0.1
2002	792 753	1 174 543	1 967 296	7.0%	101 956	-0.4%	0.1
2003	890 640	1 385 944	2 276 584	15.7%	101 805	-0.1%	0.1
2004	344 747	282 656	627 403	-72.4%	103 466	1.6%	0.2
2005	389 660	241 733	631 393	0.6%	97 510	-5.8%	0.2
2006	425 091	260 068	685 159	8.5%	92 547	-5.1%	0.2
2007	464 109	154 517	618 626	-9.7%	87 357	-5.6%	0.2
2008	319 927	129 324	449 251	-27.4%	82 943	-5.1%	0.2
2009	256 340	0	256 340	-42.9%	76 372	-7.9%	0.3
2010	244 969	0	244 969	-4.4%	70 637	-7.5%	0.3
2011	273 313	0	273 313	11.6%	65 403	-7.4%	0.3
2012	166 263	0	166 263	-39.2%	60 766	-7.1%	0.4
2013	185 156	0	185 156	11.4%	55 941	-7.9%	0.3
2014	174 500	0	174 500	-5.8%	51 251	-8.4%	0.3
2015	131 959	0	131 959	-24.4%	47 419	-7.5%	0.4
2016	132 182	0	132 182	0.2%	43 618	-8.0%	0.4
2017	151 866	0	151 866	14.9%	40 535	-7.1%	0.3
2018	163 663	0	163 663	7.8%	37 572	-7.3%	0.3
2019	166 659	0	166 659	1.8%	35 300	-6.0%	0.2
2020	165 576	0	165 576	-0.7%	33 243	-5.8%	0.2
2021	197 067	0	197 067	19.0%	31 365	-5.6%	0.2

* *IEF calculated on basis of gross CH_4 emissions: (CH_4 emissions + CH_4 recovery) / MSW*

Significant reductions of deposited waste volumes occurred 2003/2004 and 2008/2009, due to the restrictions pursuant to the Landfill Ordinance. The high decrease (in relative numbers not in absolute numbers) in 2011/2012 is caused by the shutdown of two bigger mechanical biological treatment plants. CH_4 emissions also declined, but quite steadily and not in the same extent as the volumes develop from year to year because these are – according to the FOD method – also affected by historical DOC depositions. Since 1990, less than 10% of the annual emissions stem from the most recently deposited waste, and more than 90% from waste deposited in previous years.

The smaller the annual amount of waste deposited, the larger the IEF and vice versa. E.g. in 1990 2 644 kt waste were deposited resulting in an IEF of 0.06 t CH_4/t waste, whereas in 2021 only 197 kt were landfilled resulting in an IEF of 0.2 t CH_4/t waste. Fluctuations of the IEF are thus due to inter-annual fluctuations of annually reported waste amounts deposited at quite steadily declining emissions.

Table 305: Mass of decomposable DOC deposited [kt], by waste type.

	Residual waste	Non-Residual waste							
	mixed MSW	wood	paper	sludges	sorting residues	bio-waste	textiles	construction waste	fats
	Decomposable DOC (DDOCm) deposited [kt]								
1990	239	3.0	6.9	7.8	36.1	1.9	0.4	1.5	0.0
1991	205	3.1	7.1	8.0	36.8	1.9	0.5	1.5	0.0
1992	174	3.1	7.2	8.1	37.6	1.9	0.5	1.5	0.0
1993	168	3.2	7.3	8.3	38.3	2.0	0.5	1.5	0.0
1994	110	3.2	7.5	8.4	39.1	2.0	0.5	1.6	0.0
1995	94	3.3	7.6	8.6	39.9	2.1	0.5	1.6	0.0
1996	94	3.4	7.8	8.8	40.7	2.1	0.5	1.6	0.0
1997	84	3.4	7.9	9.0	41.5	2.1	0.5	1.7	0.0
1998	84	3.5	8.1	9.1	42.3	2.2	0.5	1.7	0.0
1999	78	2.6	6.8	8.3	47.4	3.6	1.4	2.2	0.0
2000	81	1.7	5.2	6.2	53.7	1.3	1.0	2.7	0.0
2001	88	1.2	7.2	7.0	46.4	2.1	0.9	2.5	0.0
2002	104	1.5	5.3	8.0	50.3	1.2	0.8	1.5	0.0
2003	130	1.7	6.1	22.0	38.1	1.9	0.7	1.2	0.0
2004	28	1.1	0.0	4.3	22.1	0.3	0.0	0.7	0.0
2005	24	0.4	0.1	0.5	31.8	0.1	0.0	0.8	0.0
2006	26	1.0	0.8	0.5	33.7	0.2	0.0	1.0	0.0
2007	16	0.9	0.3	0.4	38.5	0.1	0.0	0.7	0.0
2008	13	0.0	0.3	0.4	27.1	0.0	0.0	0.2	0.0
2009	0	0.0	0.0	0.3	22.1	0.0	0.0	0.0	0.0
2010	0	0.0	0.0	0.1	21.3	0.0	0.0	0.0	0.0
2011	0	0.0	0.0	0.1	23.8	0.0	0.0	0.0	0.0
2012	0	0.0	0.0	0.2	14.3	0.0	0.0	0.0	0.0
2013	0	0.0	0.0	0.5	15.5	0.0	0.0	0.0	0.0
2014	0	0.0	0.0	0.4	14.8	0.0	0.0	0.0	0.0
2015	0	0.0	0.1	0.1	11.3	0.0	0.0	0.0	0.0
2016	0	0.0	0.0	0.3	11.1	0.0	0.0	0.0	0.0
2017	0	0.0	0.1	0.5	12.6	0.0	0.0	0.0	0.0
2018	0	0.0	0.1	0.4	13.7	0.0	0.0	0.0	0.0
2019	0	0.0	0.1	0.7	13.5	0.0	0.0	0.0	0.0
2020	0	0.0	0.1	0.8	13.4	0.0	0.0	0.0	0.0
2021	0	0.0	0.1	0.7	16.3	0.0	0.0	0.0	0.0

7.2.1.2 Emission Parameters

Where available, country specific parameters are used after they have been checked if they are in the range of the IPCC guidelines. If country specific parameters were not available IPCC default values are taken. The following table summarises the parameters used plus the corresponding references.

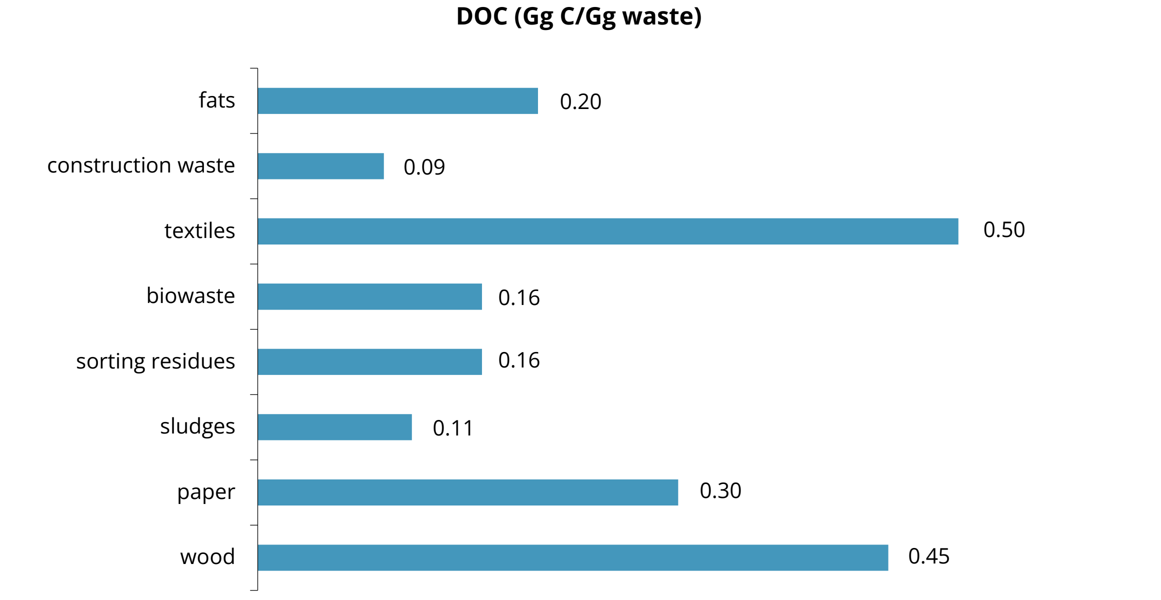
Table 306: Parameters for calculating CH_4 emissions from SWDS.

Waste category/ Parameters	residual waste	wood	paper	sludges	sorting residues	bio-waste	textiles	construc-tion waste	fats
Methane correction factor (MCF)	1 IPCC default for managed SWDS								
Fraction of degradable organic carbon dissimilated (DOC_F)	0.6	0.5	0.55	0.55	0.55	0.55	0.55	0.55	0.77
	national waste expertise (UMWELTBUNDESAMT 2005)								
DOC (kt C/kt waste)	See Table 307	0.45	0.3	0.11	0.16	0.16	0.5	0.09	0.2
		(BAUMELER et al. 1998), (UMWELTBUNDESAMT 2005)							
Half life period ($t_{1/2}$)	7	25	15	7	20	10	15	20	4
	National waste experts	(GILBERG et al. 2005)	(GILBERG et al. 2005)	Assumption: same as residual waste	IPCC default slow decay	Assumption: similar to paper	Assumption: same as paper	IPCC default slow decay	(GILBERG et al. 2005)
Fraction of CH_4 in Landfill Gas (F)	From 2018 onwards: 0.5 (IPCC 2006) 2009-2018: linearly declining from 0.55 (2008) to 0.5 (2018) 1950-2008: 0.55 as cited in various Austrian and German literature (FLÖGL, W. 2002, ÖWAV 2003, LFU 1992, UMWELTBUNDESAMT (2008a), UMWELTBUNDESAMT (2014b)								
Methane Oxidation in the upper layer (OX)	10% IPCC default								
Landfill gas recovery (R)	see Figure 50 (UMWELTBUNDESAMT 2004c, 2008a, 2014b, 2019b)								
Process start (M)	13 Delay time of 6 months, with an average residence time of 6 months (IPCC default)								

7.2.1.2.1 Biodegradable organic carbon (DOC)

Austria applies the waste composition modelling approach. The DOCs of the different waste categories under '**non residual waste'** are thus held constant for the entire time series, at the level shown in Table 306. These are clearly defined (wood, paper, sludge etc.) and quite 'homogenous'.

Figure 51: DOC of non-residual waste fractions.



Source: Umweltbundesamt

The DOC of '**residual waste'** however has changed over the years in accordance with its changing composition. The separate collection of biogenic waste, paper and cardboard, and glass, and the increase of food waste in recent years etc. have clearly influenced the trend of the DOC.

For the year 1990 a DOC content of 200 g/kg residual waste was taken (UMWELTBUNDESAMT 2003). For 2008, the last year in which this waste category has been deposited, the DOC was 169 g/kg waste. It was calculated on basis of updated information on the composition of residual waste published in the Annual update (2009) of the Federal Waste Management Plan 2006 (BMLFUW 2006a), taking into account the different carbon content of the fractions as published in (UMWELTBUNDESAMT 2003). From 2009 on, only pre-treated waste, referred to as non-residual waste, is allowed to be deposited in Austria. Hence, only historical amounts are relevant and the DOC does not need to be updated any more.

Table 307: Time series of bio-degradable organic carbon content of residual waste (mixed MSW, directly deposited).

Year	kg C/kg Residual Waste	Year	kg C/kg Residual Waste
1950–1959	0.20[1)]	1998	0.13[2)]
1960–1969	0.20[1)]	1999	0.12[2)]
1970–1979	0.20[1)]	2000	0.13[*)]
1980–1989	0.20[1)]	2001	0.14[*)]
1990	0.20[2)]	2002	0.15[*)]
1991	0.19[2)]	2003	0.16[*)]
1992	0.18[2)]	2004	0.17[3)]
1993	0.17[2)]	2005	0.17[*)]
1994	0.16[2)]	2006	0.17[*)]
1995	0.15[2)]	2007	0.17[*)]
1996	0.14[2)]	2008	0.17[4)]

Year	kg C/kg Residual Waste	Year	kg C/kg Residual Waste
1997	0.13[2)]	2009–2021	n.r.[**)]

[1)] *assumed to be equal to the DOC of 1990*

[2)] *(UMWELTBUNDESAMT 2003)*

[3)] *calculated according to waste composition 2001 (BMLFUW 2006a)*

[4)] *calculated according to waste composition 2009 (annual update of BMLFUW 2006a)*

[*)] *interpolated values (2000–2003) and (2005–2007)*

[**)] *no deposition of residual waste any more*

The intensified separate collection of bio-organic and paper waste and the corresponding decreasing share of these materials in the residual waste fraction (deposited directly) was the reason for the decrease of the DOC in residual waste during the 1990ies. The increase of the DOC of residual waste in 2000 and the following years is due to the increasing share of biogenic components especially of food waste in residual waste (as can be seen in Table 308).

Table 308: Composition of residual waste.

Residual waste	1990[1)]	1993[1)]	1996[1)]	1999[1)]	2004[2)]	2008[3)]
	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]
Paper, cardboard	22	18	14	14	11	12
Glass	8	6	4	3	5	4
Metal	5	4	4.5	5	3	3
Plastic	10	9	11	15	10	10
Composite materials	11	11	14	–	8	10
Textiles	3	3	4	4	6	6
Hygiene materials	–	–	–	12	11	8
Biogenic components	30	34	30	18	37	40
Hazardous household waste	1	2	1	0.3	2	1
Mineral components	7	8	4	–	4	3
Wood, leather, rubber, other components	2	4	1	3	1	–
Residual fraction	–	–	14	27	2	2

[1)] *(UMWELTBUNDESAMT 2003)*

[2)] *(BMLFUW 2006a)*

[3)] *Annual update (2009) of (BMLFUW 2006a)*

DOCf

The DOCf values used for calculation are shown in Table 306.

Austria does not apply the bulk DOCf option of the IPCC 2006 GL as detailed information is available on the waste deposited (to be reported by landfill operators according to § 41 Landfill Ordinance). Based on this information the calculation is done separately for each waste fraction (wood, paper, sludges, sorting residues, bio waste, textiles, construction waste, fats, residual waste). The composition of the different landfilled waste fractions (waste types) is well known, allowing for applying an appropriate DOCf accordingly (see UMWELTBUNDESAMT 2005). Higher DOCf values than the IPCC 2006 default (0.5) are applied for most of the waste types (except wood) as the composition data shows a low share of lignin in the waste deposited.

For 'residual waste', the predominant waste stream in Austria in terms of contribution to total CH_4 generated (86% in 1990, 73% in 2005 and 46% in 2021), a calculation of the DOCf (0.6) was performed based on waste analyses carried out in Austria in 2004[119] (presented in the Federal Waste Management Plan 2006 and the NIR 2008). Using the default DOCf values presented in the 2019 Refinement to the 2006 IPCC GL, Table 3.0, our calculations for residual waste would result in a DOCf of 0.592. This value would be even slightly higher if the average value of 0.523 for moderately decomposable waste (indicated in the notes to Table 3.0) were used instead of the default value given of 0.5. The relatively high DOCf for Austria is mainly due to the high share of kitchen waste (about 37% of the total waste composition or almost 49% only regarding fractions with degradable organic substance).

A justification regarding the DOCf values of further waste fractions is given hereinafter:

- 'Sludges' do not contain lignin, therefore a slightly higher DOCf is in line with the GL.
- The default DOCf of green waste according to Table 3.0 of the 2019 Refinement to the 2006 IPCC GL is 0.7 and thus even higher than the value used in Austria. However in Austria the fraction 'biowaste' also includes branches, thus a slightly lower DOCf is appropriate.
- The waste category 'sorting residues' does not only include wood, but also compost like output from MBTs. Therefore a higher DOCf is justified.
- The decomposition of 'paper', even of newsprints, is higher than of 'wood' - again a higher DOCf is justified.

Also in (BAYARD 2018) the biodegradation of different waste streams was investigated showing typically higher DOCf values than the recommended DOCf of the IPCC GL 2006 of 0.5.

Fraction of CH_4 in generated landfill gas (F)

For the historical years **1950–2008** Austria uses a country-specific value of 0.55 for the fraction of CH_4 in generated landfill gas (F), based on various literature, among others RETTENBERGER G., MEZGER, H. (1992), FLÖGL, W. 2002, ÖWAV 2003, UMWELTBUNDESAMT 2008a. This fraction is slightly higher than the default from the IPCC 2006 Guidelines (0.5) and based on the following considerations:

- The methane concentration in the generated landfill gas changes over time. After a few months already before the so called "stable methane phase" begins, the methane concentration rises to about 55%. During the stable methane phase (this phase lasts several years/decades) the CH_4-concentration typically is about 55% (RETTENBERGER G., MEZGER, H. (1992).
- Further, the methane concentration in the landfill gas depends on the waste fractions deposited. Fats and proteins show substantially higher concentrations than carbohydrates (WEILAND, P. 2001). In biogas plants, fats and oils show very high methane concentrations (about 68%), legumes show concentrations between 52% and 65%, food waste about 60% (LFL 2017). Separately collected biowaste also contains proteins and fats, kitchen and canteen waste even higher proportions. In Austria it was allowed to landfill untreated waste until 2004, in some federal provinces until 2008, therefore a higher methane concentration in landfill gas is to be expected as not only cellulose and hemicellulose (with a theoretical methane concentration of about 50%) but also proteins and fats were deposited until 2008.

[119] the analysis of 2004 is used as since 2004 a ban of landfilling of untreated residual waste came into force (with exemptions until 2008)

From 2018 onwards, a value of 0.5 is applied, based on the IPCC 2006 GL.

For the years **2008–2018** a linear decline from 0.55 to 0.5 is assumed as the change of the methane concentration does not occur within one year.

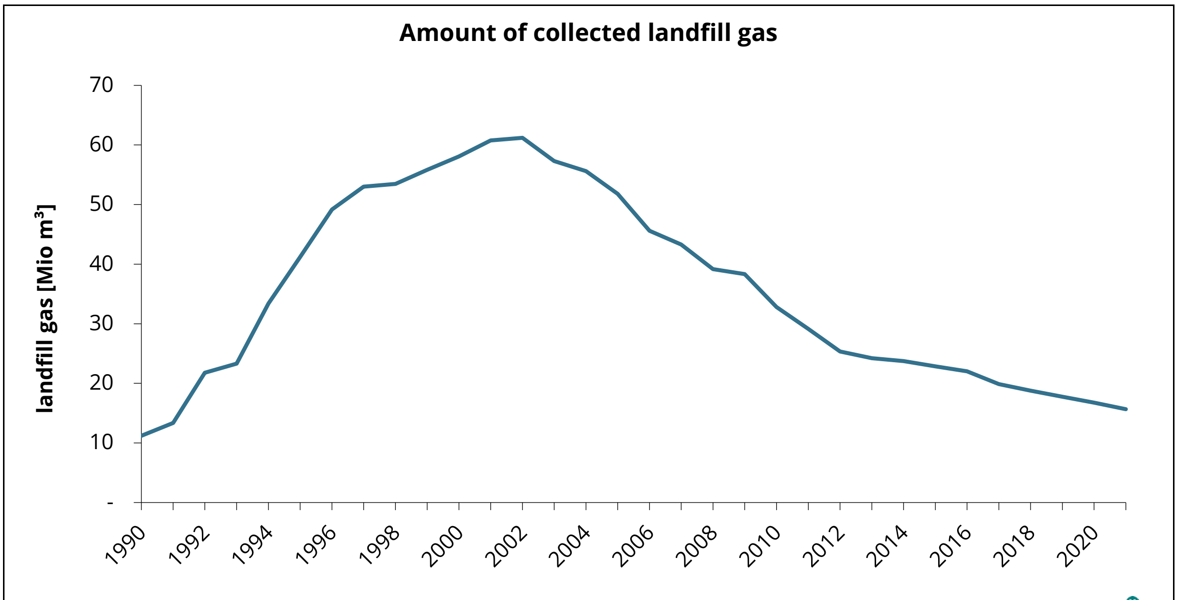
This approach is applied since the 2021 submission as, depending on the waste age, the amount of CO_2 absorbed in water increases (0.01% to 10% of CO_2 might be absorbed in water according to RETTENBERGER G., MEZGER, H. (1992)). This was not reflected in the historical submissions, and addressed during the 2020 comprehensive ESD-Review (EEA 2020).

Landfill gas recovery

In 2004, Umweltbundesamt investigated the amount of annually collected landfill gas by questionnaires sent to landfill operators (UMWELTBUNDESAMT 2004c) showing that in 2001 the amount of collected landfill gas was more than 5 times higher than in 1990. In 1990 only nine landfills were equipped with landfill gas wells, whereas in 2001 at all operating mass landfills landfill gas was collected.

In 2008, 2013 and 2018 further surveys were conducted (UMWELTBUNDESAMT 2008a, UMWELTBUNDESAMT 2014b, UMWELTBUNDESAMT 2019b) to get new data on collected landfill gas as well as information on its use from landfill operators. Landfill gas volumes and their treatment are thus surveyed in a 5-year cycle (2008, 2013, 2018 so far). For the most current years not covered by a survey update, assumptions had to be made on the collected gas quantities. Until the 2020 submission a mean value of the annual decreases between 2008 and 2017 was used for the calculation (minus 0.12 percentage points compared to the previous year). From the 2021 submission onwards, however, individual assumptions were made based on historical trends of data in the federal provinces of Austria, leading to more plausible results.

Figure 52: Amount of collected landfill gas 1990 to 2021.



Source: Umweltbundesamt (2004c, 2008a, 2014b, 2019b)

From 2002 onwards, the amount of landfill gas collected decreased (despite a consistent recovery practice) as a consequence of:

- Reduced carbon content of deposited waste and consequently reduced landfill gas production
- Slightly decreasing methane concentration in recovered landfill gas – an effect that is due to the extensive capturing of landfill gas which can lead to the dilution of the landfill gas captured.

Compared to 2002 (maximum amount of landfill gas captured), landfill gas collected decreased by 74% by 2021.

7.2.2 Uncertainties and time series consistency

The Uncertainty Assessment is originally based on a national study (WINIWARTER & RYPDAL 2001) and was improved and revised by expert judgement for the submission 2005. These values were confirmed in the latest uncertainty study (WINIWARTER 2007).

The uncertainties have been determined based on the following considerations

- IPCC Tier 2 method applied;
- Country-specific activity data taken from Austrian databases;
- Availability of data on landfill recovered on a regular basis.

Table 309: Uncertainty assessment for managed waste disposal on land.

	(WINIWARTER & RYPDAL 2000)	**Expert judgement 2005 (WINIWARTER 2007)**
Activity data	25%	12%
Emission factor	35%	25%

7.2.3 Category-specific QA/QC

Beginning from the year 1998 until the end of the year 2007, activity data on deposited waste was reported annually by landfill operators to the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, since 2020 the BMK – Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology). After a first check the reports were forwarded to the Umweltbundesamt, who in turn incorporated the reports into a landfill database. Landfill operators in default were prosecuted. In the course of the data collection and administration, a quality control of the incoming data was implemented: data was checked in terms of completeness and plausibility. To clarify any discrepancies landfill operators were contacted. Lists of landfill owners were sent to competent authorities of each province (responsible for licensing and controlling) in order to check if number and type of landfill facilities were correct. Last but not least, plausibility was gained by comparison of the data with previous reports.

Since the year 2008 landfill operators are obliged[120] to report their data directly and electronically at the portal of http://edm.gv.at (EDM: **E**lectronic **D**ata **M**anagement in environmental and waste management). Every person or installation collecting and treating waste is obliged to register in EDM and submit annually reports of each waste input and output (yearly balance of type, quantity, origin and destination of waste). In various meetings and training courses especially landfill operators were educated in using this new reporting tool. Responsible institution for administration of the EDM is the Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). The former landfill database is not maintained any more, but its data were used for checking accurately whether all landfill operators have registered in EDM. Analysis and quality control of the data is carried out on an on-going basis. Although the comparison with previous reports is an important tool, the advantage of having the landfill data embedded in the general input-output reports is obvious (counterchecking with the reports of partners).

In addition, supervisors appointed by the competent authority for each landfill are obliged to monitor regularly not only the landfill site itself but also each registration in EDM and the reporting of data. As there is a special tax on wastes being landfilled, another independent mechanism of control on landfills is realised by the ministry of finance (via former customs executives).

Input Data Audit 2014/2015

At the end of 2014/beginning 2015 a multi-step audit was conducted by the IBE sectoral waste experts at the BMLFUW (Department responsible for analysis and quality check of EDM data on landfilled waste) and the Umweltbundesamt (Expert Team responsible for data query on behalf of the BMLFUW). Aim was to get insight into collection, processing and quality control of data, i.e. waste amounts deposited, and clarify issues on transparency, accuracy, completeness, consistency, comparability and timely availability of data.

The audit showed a very strong commitment on quality. There is close cooperation with relevant data providers, in particular related to waste treating facilities. QA/QC takes place at different stages, and an improvement program ensures adaption of the system to changing requirements. Some recommendations on improvements have been given by the IBE, but mainly with regard to documentation and archiving.

7.2.4 Recalculations

Minor revisions are reported for category *5.A Solid Waste Disposal* for the years 2016-2020 (2020: -0.005 kt CO_2e) due to slightly revised input (disposal) data as a result of more comprehensive QA/QC activities in 2022.

The whole time series of recalculations is included in Annex 8 to the NIR.

[120] According to § 41 (1) Landfill Ordinance

7.2.5 Planned improvements

A further survey[121] among Austrian landfill site operators on landfill gas recovery and utilisation is carried out in 2023. Results will be included in the next inventory submitted in 2024.

7.3 Biological Treatment of Solid Waste (Category 5.B)

Emissions: CH_4, N_2O

Key Source: no

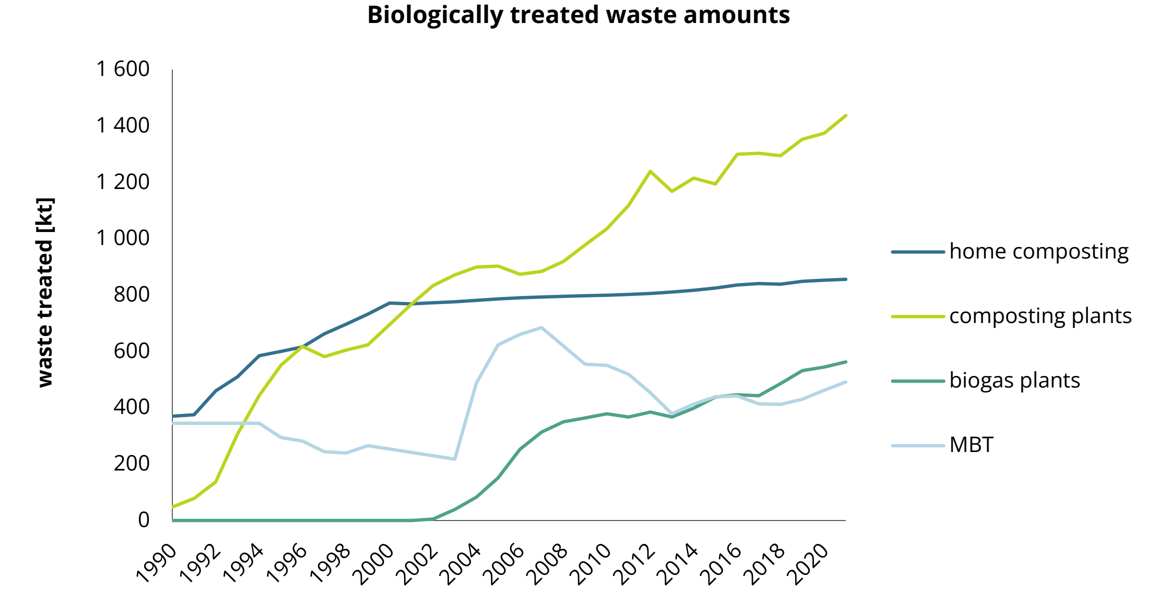
7.3.1 Source category description

In this category biological treatment of solid waste is considered, including CH_4 and N_2O emissions from mechanical-biological treatment (MBT), composting and anaerobic digestion.

- mixed waste treated in Mechanical-Biological Treatment (MBT) plants, covering waste from households and similar sources covered by the municipal waste collecting system, but also significant amounts of waste from waste water treatment (e.g. sewage sludge) or smaller amounts of waste from industrial sources (e.g. residues from processing of recovered paper) are included.
- biogenic waste composted, covering centralised composting plants and home composting
- biogenic waste treated in biogas plants (anaerobic treatment)

[121] Update of UMWELTBUNDESAMT 2019b

Figure 53: Amounts of waste treated (mechanical-) biologically.



Source: Umweltbundesamt

Emissions increased by 340% over time as the result of the increasing amount of composted waste, the construction of biogas plants and to a minor part to increased amounts of mechanical-biologically treated waste.

7.3.2 Methodological issues

7.3.2.1 Composting (5.B.1)

Emissions from mechanical-biological treatment as well as composting are calculated by multiplying the quantity of waste by the corresponding emission factor, using Equation 4.1 respectively Equation 4.2 from the IPCC 2006 GL.

$$CH_4 \text{ emissions} = M_i * EF_i$$

$$N_2O \text{ emissions} = M_i * EF_i$$

Where

M_i *mass of organic waste treated by biological treatment type i (composting, MBT)*

EF_i *emission factor for treatment i (MBT, composting)*

7.3.2.2 Anaerobic digestion at biogas facilities (5.B.2)

Biogas plants became operational in Austria in 2002. For the years before (2001 and former years) "NO" is reported as no anaerobic digestion of waste took place in Austria.

CH_4 emissions from biogas plants, i.e. emissions due to unintentional leakages during process disturbances or other unexpected events as well as from storage of fermentation residues, are calculated applying the IPCC 2006 default value of 5% CH_4 emissions of biogas produced. From 2015 to 2030 it is assumed that the leakage will gradually decrease to stabilise at a leakage rate of 1%. The reasoning for this continuous decrease is that gas-tight storage tanks are required for new biogas plants to obtain approval. As the average lifetime of a biogas plant is estimated with 15 years, it can be assumed that by 2030 only gas-tight biogas plants are in operation. But still a leakage of 1% will be assumed, also after 2030.

$$CH_4\ emissions = M * L_0 * F * CH_4\ density * EF$$

Where:

M *mass of organic waste treated by anaerobic treatment plants*
L_0 *CH_4 generation potential*
F *fraction of methane in biogas*
EF *emission factor (% of CH_4 generated)*

N_2O emissions for category 5.B.2 – Municipal Solid Waste are reported as "NA" in CRF table 5.B from 2002 onwards as the 2006 IPCC Guidelines (vol. 5) (1) do not include a default methodology and EF and (2) N_2O emissions from anaerobic digestion of organic waste are assumed to be negligible (vol. 5, p.4.4 and table 4.1).

7.3.2.3 Activity data

Activity data were taken from national publications and regional sources as listed in Table 310. The data sources for the four main categories can be summarized as follows:

- From 2009 onwards, data on **mechanical-biologically treated waste** is taken directly from the Electronic Data Management (EDM). For the years prior to 2008, several national studies provided the required activity data.
- The data source for amounts treated in **composting plants** is the EDM from 2010 onwards, and before that the values are taken from studies published by Umweltbundesamt.
- Current **home composted amounts** are taken from the latest Federal Waste Management Plan (BMK 2023b). Historical amounts (2000 and earlier years) are available in national studies (Amlinger). To create a time series, a per capita value was derived from both sources (see Table 310) and an average per capita volume was applied to the population figures (STATISTIK AUSTRIA 2022).

  In submission 2023 the amounts of waste composted in private and community gardens have been entirely revised. [122] The reason is a change of the estimation method done in the course of the preparation of the BAWP 2023 in view of an upcoming reporting obligation regarding home-composted quantities to the European Commission[123]. Based on an estimated total volume of biogenic waste produced (covering food waste as well as grass, leaves,

[122] Until submission 2022 home composted amounts for the years 2010 ff were calculated based on a per-capita value of 215 kg/person/a, whereas for Vienna only 15% of the population was considered due to the lower number of gardens in this urban area. This approach was in line with the method applied for the BAWP (BMNT 2018a).

[123] In the future home composting will be included in the AT recycling rate for municipal waste.

branches from green urban areas) the biogenic waste collected via municipal waste management system (residual waste) and via separate collection was deducted to get a value of biogenic waste potentially be composted in home and community gardens.

- Regarding **biogas plants**, EDM data on waste treated anaerobically is available since 2011. For the years prior to 2011 an increase of activity from 2002 onwards in line with the increasing feeding-in of renewable energy from biogas plants into the national grid is assumed. Anaerobic digestion started to become a treatment option in 2002 in Austria when the Green Electricity Act (Ökostromgesetz 2002; Federal Law Gazette No 149/2002) entered into force.

Since 2008, the 'Electronic Data Management' (EDM) is the primary data basis. The EDM is an information network operated by Umweltbundesamt. It is a central *eGovernment* initiative by the Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (www.edm.gv.at) enabling enterprises, waste collectors and conditioners as well as authorities to handle registration, notification and reporting obligations in the waste and environment sectors online. Waste amounts collected and treated (input-output records) have to be reported on an annual basis via this electronic tool.

The EDM is the main data source of biogenic waste treated in composting and anaerobic treatment plants. Regarding EDM data on composting plants, research by waste experts from Umweltbundesamt (2015) indicates higher amounts of waste being composted than covered by the EDM due to some minor exemptions in the EDM reporting requirements and in some cases missing reports. Based on a study conducted in 2015 on municipal green waste (UMWELTBUNDESAMT 2016b), it is assumed that in 2011 10% of waste volumes reported are additionally composted, whereas this additional share is expected to decrease linearly to 5% in 2014 as it is expected that reporting irregularities will be further decreased. The 5% assumption is continued from 2014 and onwards.

Table 310: Activity data and sources for 5.B 'Biological Treatment of Solid Waste'.

	Total waste	**Mechanical-Biological Treatment (MBT)**		**Composting**				**Anaerobic treatment**	
				Composting plants		**Home composting**			
	[kt]	**[kt]**	**Data source**	**[kt]**	**Data source**	**[kt]**	**Data source**	**[kt]**	**Data source**
1990	763	345	BAUMELER et al 1998	48	sum of data reported by the Austrian Federal Provinces, (AMLINGER 2003)	370	AMLINGER 2003	0	Activity not occurring
1991	798	345		78		375		0	
1992	942	345		137		460		0	
1993	1 161	345		306		510		0	
1994	1 373	345		444		585		0	
1995	1 446	295	ANGERER 1997	551		600		0	
1996	1 515	281	interpolated	617		616		0	
1997	1 488	244	UMWELTBUNDESAMT 1998b	582		663		0	
1998	1 541	240	UMWELTBUNDESAMT 2000b	604		696		0	
1999	1 621	266	UMWELTBUNDESAMT 2001e	623		732		0	
2000	1 721	254	Interpolated	695	interpolated	772	AMLINGER et al 2005	0	
2001	1 778	242		767		769	Calculated*	0	
2002	1 841	230		834		773		5	intrapolated based on EJ by UMWELTBUNDESAMT (2015)
2003	1 904	218	UMWELTBUNDESAMT 2008b	871		776		39	
2004	2 251	488		899		781		83	
2005	2 464	623		903		786		152	
2006	2 577	660		874		791		252	
2007	2 675	684		884		793		314	
2008	2 685	619	interpolated	919		796		350	
2009	2 694	555	EDM	977		798		364	
2010	2 763	551		1 035		799		378	
2011	2 806	519		1 118	EDM + EJ by UMWELT-BUNDES-AMT (2015)	802		367	EDM
2012	2 883	453		1 239		806		385	
2013	2 724	379		1 168		811		367	
2014	2 844	413		1 215		817		399	
2015	2 897	439		1 194		825		438	
2016	3 023	442		1 300		836		446	
2017	3 000	414		1 303		841		443	
2018	3 031	412		1 294		839	BMK 2023b	486	
2019	3 164	430		1 353		849	Calculated*	532	
2020	3 233	462		1 374		853		544	
2021	3 347	492		1 437		856		563	

* *calculated applying an average per capita volume based on Amlinger et al 2005 and BMK 2023b (95 kg per capita and year)*

7.3.2.4 Emission factors

Different references provide emission factors for mechanical-biologically treated waste, thus an average value was used. The emission factor for composted waste is taken from a national study. The emission factors are within the IPCC default range as presented in Table 4.1 of the IPCC 2006 GL.

Table 311: Emission factors used for 'Composting' (5.B.1).

	CH_4 [kg/t FS*]	N_2O [kg/t FS]	References
Mechanical-biological treatment	0.6	0.1	(UBA BERLIN 1999) (AMLINGER 2003, AMLINGER et al. 2005) (ANGERER & FRÖHLICH 2002) (DOEDENS et al. 1999)
Composting (bio-waste, loppings, home composting)	0.75	0.1	(AMLINGER 2003, AMLINGER et al. 2005)

* *'Feuchtsubstanz'/'Wet mass'*

The EFs provided here refer to the wet mass ('FS-Feuchtsubstanz'), the EFs in the CRF however refer to the dry mass. For the input material a moisture content of 60% was assumed. Accordingly, the IEF refers to the AD in dry matter. Furthermore it should be noted that in the CRF the IEF is calculated for MBT and for composting together, which has an impact to the total IEF of CH_4. However, the input to MBT is much smaller than the input to composting (only about 18 % of the total input in *5.B.1* in 2021) and therefore the emission factor is dominated by the EF for composting.

For CH_4 the following IEF are based on dry matter:

- MBT: 1.5 kg CH_4/t dry matter; Composting: 1.875 kg CH_4/t dry matter. Taking into account the different amounts of treated waste an IEF of 1.81 kg CH_4/t can be derived for 2021.
- For N_2O for MBA and for Composting an EF of 0.1 kg N_2O/t wet weight is used, corresponding to 0.25 kg N_2O/t dry matter (0.1 / 0.4 = 0.25).

Table 312: Emission parameters used for 'Anaerobic digestion at biogas plants' (5.B.2).

	Parameter		References
L_0	CH_4 generation potential	110 m³/t	UMWELTBUNDESAMT 2011b
F	Fraction of CH_4 in biogas	0.6	UMWELTBUNDESAMT 2011b
$EF_{until\ 2015}$	EF (emitted CH_4)	5%	(IPCC 2006)
$EF_{2016\ onwards}$	EF (emitted CH_4)	See below	Expert judgement

The emission factor for CH_4 emitted is gradually decreasing from 2016 to 2030, as Austrian approval authorities require 'zero' leakage from new biogas plants. For this reason, the leakage of 5% is gradually decreasing to 1% in 2030, considering the average lifetime of a biogas plant with 15 years.

A CH_4 density (D) of 0.65 kg/m³ is applied.

The 2006 IPCC GL do not provide an N_2O emission factor for 'anaerobic digestion', and emissions are assumed to be negligible (Volume 5, Chapter 4.1.3.1, Table 4.1). Hence Austria reports 'NA' for that source.[124]

[124] The UNFCCC Reporting Guidelines (Dec. 24/CP.19) state in footnote 6 to article 37 b (page 12), that "the notation key 'NE' could also be used – i.e. does not have to be used (no 'shall requirement') – when an activity occurs in the Party but the 2006 IPCC Guidelines do not provide methodologies to estimate the emissions/removals". Based on this paragraph, our understanding in this matter is that reporting of "NA" is valid in the absence of an IPCC default methodology and emission factor.

7.3.3 Uncertainties and time-series consistency

The following uncertainties are determined for that category:

Table 313: Uncertainty assessment for CRF 5.B Biological Treatment of Solid Waste.

	CH_4	N_2O
Activity data	20%	20%
Emission factor	50%	50%

7.3.4 Recalculations

A new method for estimating home composted waste amounts (part of 5.B.1 Composting) was developed for the Federal Waste Management Plan (BMK 2023b) delivering a more plausible result than the data used in previous submissions (see chapter 7.3.5.1). Due to this improvement the waste amounts for 2001-2020 needed to be revised in order to get a consistent time series. The revision resulted in lower CH_4 and N_2O emissions for the reporting period (2020: -34 kt CO_2e).

The whole time series of recalculations is included in Annex 8 to the NIR.

7.3.5 Category-specific QA/QC

See Chapter 7.1.5.

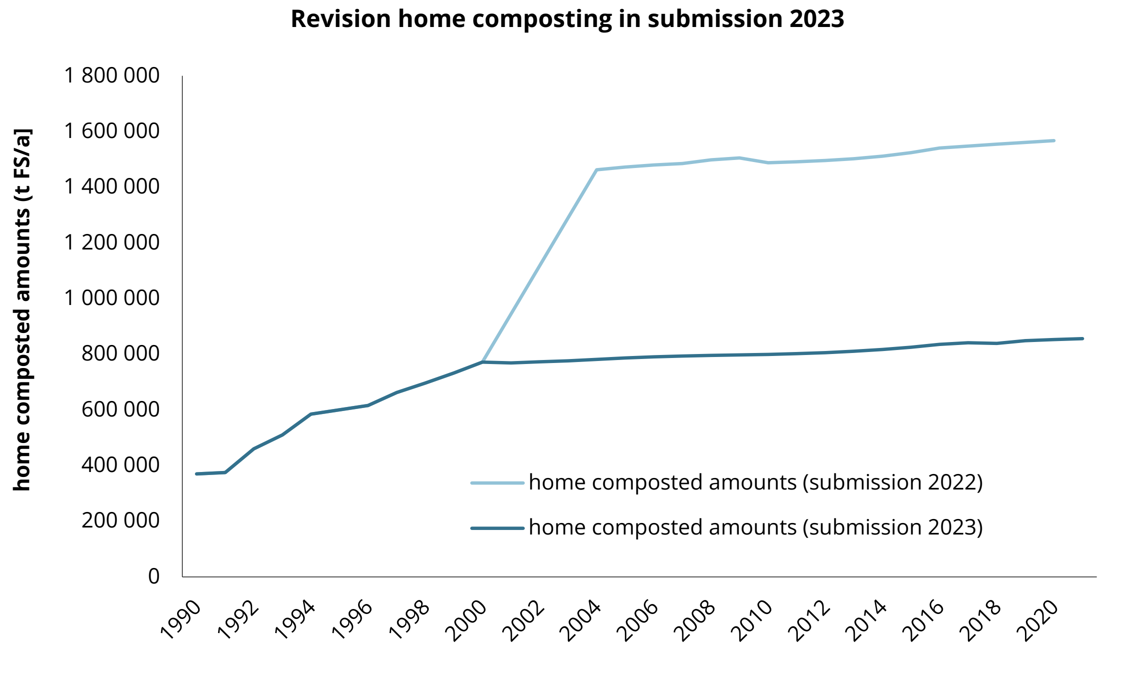
All QA/QC steps have been undertaken for this category. A comparison of EF with the IPCC defaults proved that these are in the range of the IPCC 2006 GL. In addition, the input data audit described under the CRF *5.A Solid Waste Disposal* to a large extent also considers this sub-category as the data basis (EDM) is the same.

7.3.5.1 Composted amounts

For the years 2011–2014 activity data on the input in **composting plants** reported via Electronic Data Management (EDM) were checked for accuracy and completeness. As according to current knowledge the EDM reporting obligation does not cover all potential composting plants in Austria, some waste amounts not reported via EDM (estimation of 69 kt in 2021) have to be considered additionally to achieve time-series consistency (Expert judgement by Umweltbundesamt 2015).

Data on **home composted amounts of waste** are provided by two different sources: The Federal Waste Management Plan (BMK 2023b) as well as national studies conducted by a national expert (Amlinger 2003, 2005). Since data is not available for all years of the time series, an average per capita volume was calculated and applied for 2001-2017 as well as 2019-2021. This was done on basis of 2000 data (taken from Amlinger 2005) as well as 2018 data (taken from the BAWP 2023). A comparison of the per capita values has shown that the results coincide very well (0.096 t per capita versus 0.095 t per capita) and that a consistent time-series can be achieved.

Figure 54: Home composted amounts – submission 2023 versus submission 2022



Source: Umweltbundesamt

Until submission 2022, the method applied for determining home composted amounts was based on a per capita volume derived from only one analysis provided for a city in Austria (215 kg/person/a). This approach was in line with the method applied for the BAWP (BMNT 2018a). To complete the time series, an interpolation between 2000 and 2004 was necessary causing a striking jump in the time series, as can be seen in Figure 54.

With the new method applied from submission 2023 onwards, a more plausible time series of activity data and emissions could be generated.

7.3.5.2 Verification – CH_4 from biogas plants

An alternative approach for calculation was considered, using the EF included in chapter 4.1.3.1 of the IPCC 2006 GL – corrigendum of July 2015 (0.8 kg CH_4/t waste treated) leading to lower CH_4 emissions (20 vs 39 kg CO_2e/t waste treated) than applying the IPCC default for CH_4 in terms of emissions per gas produced (as actually applied and included in chapter 4.1 of the IPCC 2006 GL). Due to the higher gas generation potential of biogenic waste fermented (mainly municipal biogenic and kitchen waste) the more conservative option was chosen for the Austrian inventory.

7.3.6 Planned improvements

No improvements are currently planned.

7.4 Incineration and Open Burning of Waste (Category 5.C)

The Austrian Federal clean air act (Bundesluftreinhaltegesetz, BGBl. I Nr. 137/2002)[125] prohibits the burning of waste outside stationary combustion facilities with the general exception of fire grills, bonfires and barbecues as well as activities which need a specific permit (e.g. burning of agricultural residues).

7.4.1 Waste Incineration (5.C.1)

Source Category Description

Emissions: CO, CH_4, N_2O

Key source: No

In this category, emissions from incineration of waste oil are included as well as emissions from municipal waste incineration without energy recovery. All CO_2 emissions from waste are caused by waste incineration. The share of 5.C.1 in total emissions from waste is 0.7% for the year 1990 and 0.2% for the year 2021.

In Austria, waste oil has been incinerated in especially designed so called "USK-facilities" (**U**mwelt**s**chutz**k**omponenten GmbH). The emissions of waste oil combustion for energy recovery (e.g. in cement industry) are reported under fuel combustion. In 2002, the Austrian waste incineration regulation[126] came into force, introducing ambitious emission limits (from 2005 on[127]) for air pollution for all kind of waste incineration plants without any limit of size. The number of facilities, which do have the allowance for incineration of waste oil other than cement plants and large waste incineration plants, was only five since the year 2010.

In general, municipal, industrial and hazardous waste are combusted for energy recovery in district heating plants or in industrial sites and therefore the emissions are reported under fuel combustion. There is only one waste incineration plant without energy recovery which has been operated until 1991 with a capacity of 22 000 tons of municipal waste per year. This plant has been rebuilt as a district heating plant, starting operation in 1996. Therefore, the emissions since the re-opening of this plant are reported under fuel combustion from 1996 onwards.

Table 314: Greenhouse gas emissions from Category 5.C.1.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	27.92	0.0009	0.0004	28.06
1991	24.36	0.0008	0.0004	24.49
1992	11.13	0.0006	0.0001	11.18
1993	10.80	0.0005	0.0001	10.84
1994	10.79	0.0003	0.0001	10.82
1995	11.11	0.0003	0.0001	11.15

[125] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20002155

[126] Abfallverbrennungs-(Sammel-)Verordnung (AVV; BGBl. II Nr. 389/2002 i. d. g. F.): Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und des Bundesministers für Wirtschaft und Arbeit über die Verbrennung von Abfällen.

[127] Old facilities had to conform to the new regulation 2005 at the latest.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1996	11.43	0.0003	0.0001	11.47
1997	11.76	0.0003	0.0001	11.79
1998	12.08	0.0003	0.0001	12.11
1999	12.40	0.0003	0.0001	12.44
2000	12.40	0.0003	0.0001	12.44
2001	12.40	0.0003	0.0001	12.44
2002	12.40	0.0003	0.0001	12.44
2003	12.40	0.0003	0.0001	12.44
2004	12.40	0.0003	0.0001	12.44
2005	12.40	0.0003	0.0001	12.44
2006	10.26	0.0003	0.0001	10.29
2007	8.21	0.0002	0.0001	8.23
2008	6.16	0.0002	0.0001	6.17
2009	4.10	0.0001	0.0000	4.12
2010	2.05	0.0001	0.0000	2.06
2011	2.05	0.0001	0.0000	2.06
2012	2.05	0.0001	0.0000	2.06
2013	2.05	0.0001	0.0000	2.06
2014	2.05	0.0001	0.0000	2.06
2015	2.05	0.0001	0.0000	2.06
2016	2.05	0.0001	0.0000	2.06
2017	2.05	0.0001	0.0000	2.06
2018	2.05	0.0001	0.0000	2.06
2019	2.05	0.0001	0.0000	2.06
2020	2.05	0.0001	0.0000	2.06
2021	2.05	0.0001	0.0000	2.06
1990–2021	**-93%**	**-94%**	**-96%**	**-93%**

Methodological Issues

A simple tier1 methodology is applied: the quantity of waste is multiplied by an emission factor for CO_2, CH_4 and N_2O.

Emission factors

National emission factors for CH_4 are derived from residual fuel oil VOC emission factors (BMWA-EB 1990, BMWA-EB 1996, UMWELTBUNDESAMT 2001a). N_2O emission factors are taken from a national study (ORTHOFER et al. 1995).

For municipal solid waste and clinical waste the CO_2 emission factor is calculated by means of IPCC GPG 2001 default assumptions for total carbon content and fossil carbon share. The selected calculation parameters are presented in Table 315. Because of the absence of plant specific data a combustion efficiency of 100% has been selected.

For waste oil, the same CO_2 emission factor (80 t CO_2/TJ) as for *1.A.1.a* heavy oil is used and a heating value of 40.3 GJ/t (source: Energy balance-residual fuel oil) is used to convert the emission factors from [t/TJ] to [kg/t].

Table 315: Emission factors and parameters of IPCC Category 5.C.1 Waste Incineration.

Waste Type	Carbon content	Share in fossil carbon	Combustion efficiency	CO_2 [kg/t]	CH_4 [g/t]	N_2O [g/t]
Municipal Waste	40%	40%	100%	586.67	0.2[(1)]	12.18
Clinical Waste	60%	40%	100%	880.00	100.00	12.00
Waste Oil	–	–	–	3 224.00	NA	24.18

[(1)] *IPCC 2006 Guidelines table 5-3, technology 'continuous incineration/stoker'.*

Activity data

For municipal solid waste, the capacity (22 000 tons of waste per year) of one operating waste incineration plant without energy recovery was used.

Waste oil activity data 1990 to 1999 were taken from (UMWELTBUNDESAMT 1995). For 2000 to 2005 the activity data of 1999 was used. (UMWELTBUNDESAMT 2001d) quotes that in 2001 total waste oil accumulation was about 37 500 t. Nevertheless, waste oil is mainly used for energy recovery in cement kilns or public power plants and it is consequently accounted for in the energy balance as *Industrial Waste*.

Activity data of clinical waste is determined by data interpretation of the waste flow database at the *Umweltbundesamt* considering the waste key number '971' („Abfälle aus dem medizinischen Bereich") for the years 1990 and 1994 and extrapolated for the remaining time series.

Since 2005, the Austrian waste incineration regulation gives ambitious emission limits for air pollution for all kind of waste incineration without any limit of quantity. Since then, all operators which do have an allowance for incineration of a specific type of waste, needs to be registered in a federal database. The number of waste incineration plants which are not considered under sector *1.A* is:

- Waste oil: 8
- Clinical waste: 1
- Municipal solid waste: None

At current there is one facility which has the permit to incinerate hazardous waste (including hospital waste) in larger amounts which is allocated in *1.A.1.a*. Additionally there is one hospital with a permit to incinerate waste (capacity < 2 t/h) but it is not known if and how the energy is used. Assuming a capacity of 1 t/hour of plastics waste and 500 hours yearly operating time it was estimated to be 500 t/year. However, waste experts at the Umweltbundesamt doubt if this hospital makes use of the permit. Thus from the expert view this is rather an over- than an underestimate.

Under the new waste regulation 8 companies have the permit to incinerate waste oil although it is not known if they make use of their permit in reality. These companies are mostly road transport companies or car dealers which are considered not to use the energy. Each of the 8 companies is assumed to have installations with a capacity of 60.8 t waste oil/year (UMWELTBUNDESAMT 2001d). This is the same average capacity that has been used for estimating the waste oil quantity for 1990 to 2005. This results in a rounded value of 500 t waste oil/year. Activity data for the years 2006–2009 has been interpolated. Activity data for clinical waste and waste oil has been kept constant since the year 2010 because the number of facilities with a permit did not change.

Table 316: Activity data for IPCC Category 5.C Waste Incineration.

Year	Municipal Waste [Mg]	Clinical Waste [Mg]	Waste Oil [Mg]
1990	22 000	9 000	2 200
1991	22 000	7 525	1 500
1992	NO	6 050	1 800
1993	NO	4 575	2 100
1994	NO	3 100	2 500
1995	NO	3 100	2 600
1996	NO	3 100	2 700
1997	NO	3 100	2 800
1998	NO	3 100	2 900
1999–2005	NO	3 100	3 000
2006	NO	2 500	2 500
2007	NO	2 000	2 000
2008	NO	1 500	1 500
2009	NO	1 000	1 000
2010–2021	NO	500	500

The following table shows activity data of waste incineration with energy recovery.

Table 317: Activity data for waste incineration with energy recovery.

Year	1.A.1.a Public Electricity and Heat[1)]			1.A.2 Industrial waste		1.A.2 Manuf. Industries[3)]
	MSW [t]	hazardous waste [t] [4)]	sewage sludge [t]	Industrial waste [t]	of which waste oil [t]	Ind. Waste [TJ]
1990	299 256	80 000	55 000	59 422	11 716	3 220
1991	341 001	80 000	55 000	66 552	22 069	4 556
1992	403 307	80 000	55 000	78 803	24 141	5 271
1993	421 907	72 500	64 500	78 568	21 273	4 179
1994	442 479	75 000	61 600	82 658	25 047	4 726
1995	441 502	71 337	60 672	86 998	28 675	5 270
1996	438 549	75 812	61 372	100 036	25 719	6 349
1997	446 471	95 334	64 778	101 063	22 781	5 693
1998	608 505	86 098	68 316	121 719	28 279	5 891
1999	526 928	70 513	80 406	135 065	26 607	5 387
2000	528 365	70 513	80 406	169 888	27 794	6 250
2001	498 590	70 513	75 117	218 048	26 437	8 277
2002	498 590	70 513	64 225	238 959	30 017	9 385
2003	561 801	70 513	62 970	253 874	30 057	10 897
2004	923 830	90 771	59 460	257 360	28 370	13 951
2005	944 948	103 058	58 979	338 491	27 028	7 891
2006	1 180 898	113 695	60 216	436 596	21 697	9 758
2007	1 124 139	109 724	62 376	514 071	23 996	9 342
2008	1 146 547	95 548	60 082	359 879	22 206	10 175
2009	1 348 681	96 505	54 243	336 691	14 881	9 631
2010	1 418 176	109 772	57 002	359 589	21 911	11 210
2011	1 456 520	108 220	164 636	393 857	19 597	11 941
2012	1 438 921	98 227	176 809	388 235	12 662	11 401

Year	1.A.1.a Public Electricity and Heat[1]			1.A.2 Industrial waste		1.A.2 Manuf. Industries[3]
	MSW [t]	hazardous waste [t] [4]	sewage sludge [t]	Industrial waste [t]	of which waste oil [t]	Ind. Waste [TJ]
2013	1 516 986	143 848	173 637	428 759	10 365	11 264
2014	1 774 538	168 985	177 894	462 892	11 963	11 022
2015	1 850 216	114 110	201 061	481 311	15 370	10 966
2016	1 783 095	399 848	197 201	478 954	20 396	11 928
2017	1 895 859	104 892	201 374	476 084	18 267	11 834
2018	1 842 933	101 684	182 822	513 896	19 782	12 140
2019	1 910 989	99 344	180 179	487 055	22 070	11 026
2020	2 077 348	86 853	168 996	470 651	18 756	11 644
2021	2 081 197	97 521	97 824	481 066	18 628	12 252

1) *Umweltbundesamt, IEA JQ 2022.*

2) *(Hackl & Mauschitz 1995, 1997, 2001, 2003, 2007, Mauschitz 2004), From 2005 onwards ETS data is used*

3) *1.A.2.f other fuels – activity data*

4) *including waste oil and clinical waste*

Recalculations

No recalculations were carried out.

Planned improvements

No improvements are planned.

7.4.2 Open Burning of Waste (5.C.2)

Emissions from the burning of residual wood of vinicultures on open fields in Austria are calculated within sector Agriculture, but reported in the Waste sector. From the current submission onwards, this category, formerly reported under 3.F.5 Other, is reallocated to category 5.C.2.1.b Incineration and Open Burning of Waste – Other. In response to the ESD Review 2023, biogenic CO_2 emissions from this source were included in the present submission.

A simple country specific method with country specific emission factors is applied for estimation of CH_4 and N_2O emissions. For the calculation of biogenic CO_2, the simple Tier 1 methodology of the 2006 IPCC GL (Volume 5, Chapter 5, equation 5.1) is used.

Activity data

The planted vineyard area of the basic vineyard surveys (Weingartengrunderhebungen) for the years 2009, 2015 and 2020 (Statistik Austria 2011, 2016, 2021) was used for acivity data, as these explicitly comprise the vineyard area planted with vine stems. For time series consistency the area of vineyards between 2009, 2015 and 2020 was interpolated. Land use areas are harmonized with sector Land Use, Land Use Change and Forestry (LULUCF) of Austria's GHG inventory to be consistent within the Austrian Inventory and across all sectors. Further details are given in chapter 6.3 *Cropland (Category 4.B).*

According to an expert judgement from the *Federal Association of Viniculture* (Bundesweinbau-verband Österreich) the amount of residual wood per hectare viniculture is 1.5 to 2.5 t residual wood and the part of it that is burnt is estimated to be 1 to 3%. For the calculations the upper limits (3% of 2.5 t/ha) have been used resulting in a factor of 0.075 t burnt residual wood per hectare viniculture area.

Table 318: Activity data for field burning of agricultural residues 1990–2021.

Year	Viniculture Area [ha]	Burnt Residual Wood [t]	Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377	2006	46 553	3 491
1991	57 981	4 349	2007	46 213	3 466
1992	57 599	4 320	2008	45 873	3 440
1993	57 216	4 291	2009	45 533	3 415
1994	56 422	4 232	2010	45 517	3 414
1995	55 627	4 172	2011	45 502	3 413
1996	54 061	4 055	2012	45 486	3 411
1997	52 494	3 937	2013	45 470	3 410
1998	51 854	3 889	2014	45 454	3 409
1999	51 214	3 841	2015	45 439	3 408
2000	50 304	3 773	2016	45 584	3 419
2001	49 393	3 704	2017	45 729	3 430
2002	48 483	3 636	2018	45 874	3 441
2003	47 572	3 568	2019	46 020	3 451
2004	47 232	3 542	2020	46 165	3 462
2005	46 892	3 517	2021	46 165	3 462

Emissions factors

The emission factors (4 828 g CH_4/t and 49.7 g N_2O/t burnt wood) were calculated by multiplying the emission factors of 7 kg N_2O/TJ and 680 g CH_4/TJ (STANZEL et al. 1995) with a calorific value of 7.1 MJ/kg burnt wood which corresponds to burning wood logs in poor operation furnace systems.

For biogenic CO_2, the default parameters (fraction of carbon in the dry matter, oxidation factor) were taken from Table 2.4 and Table 5.2 (IPCC 2005, Volume 5, Chapter 2 and Chapter 5).

Recalculations

Following a recommendation of the NEC Review 2022 (EC, 2022), the burning of agriculture residues reported under 3.F in previous inventories is now reported under category 5.C.2.1.b Incineration and Open Burning of Waste – Other. This reallocation results in higher emissions of CH_4 and N_2O in this category for the entire time series (+0.51 kt CO_2e).

7.5 Wastewater Treatment and Discharge (Category 5.D)

Emissions: CH_4, N_2O

Key Source: no

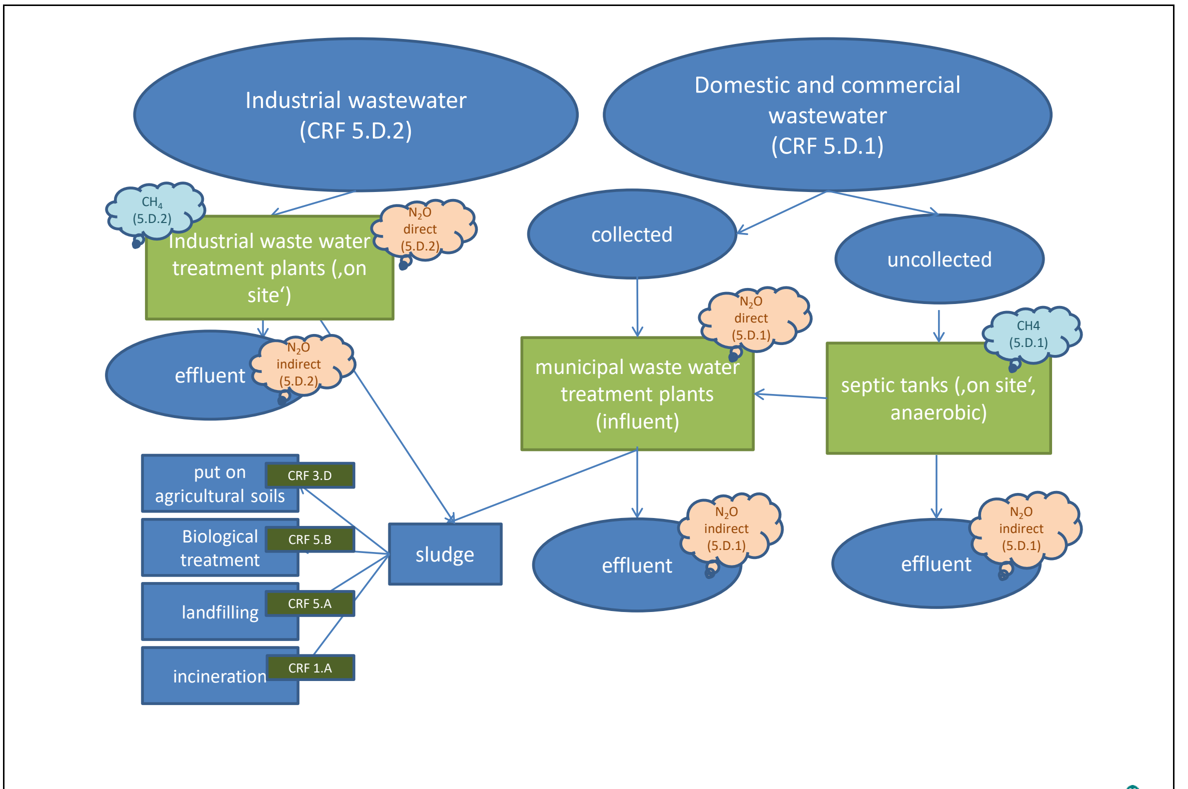
7.5.1 Source category description

Emissions: CH_4, N_2O

Key Source: No

This category covers CH_4 emissions from domestic and industrial wastewater as well as direct and indirect N_2O emissions from wastewater of domestic and industrial origin. CH_4 emissions stem from septic tanks as well as from anaerobically pre-treated waste water. Direct N_2O emissions stem from wastewater treatment plants using aerobic procedures with nitrification and denitrification steps whereas indirect N_2O emissions stem from the discharge of treated wastewater (nitrogen effluent) into aquatic environments. N_2O emissions reported under *5.D.1 domestic wastewater* also include commercial and some industrial wastewater ('co-discharger'). N_2O and CH_4 emissions from the on-site treatment of industrial wastewater are reported under *5.D.2 industrial wastewater*.

Figure 55: Wastewater treatment systems and discharge pathways (schematic illustration).



Source: Umweltbundesamt

In the year 2021, greenhouse gas emissions from *5.D Wastewater Treatment and Discharge* contributed 15% to greenhouse gas emissions from sector Waste and 0.2% to total greenhouse gas emissions in Austria. From 1990 to 2021, greenhouse gas emissions from this category decreased by 21%.

This is due to the decrease of CH_4 emissions from domestic wastewater handling, affected by the declining number of people disposing their wastewater into septic systems. On the other hand N_2O emissions from wastewater treatment plants strongly increased in line with the growing share of population connected to modern centralized wastewater treatment plants. GHG emissions from *5.D.2* contribute only minor to GHG emissions from sub-category *5.D* (3.0% in 2021).

Table 319: Greenhouse gas emissions from wastewater treatment (5.D) 1990–2021

	5.D.1 – domestic wastewater							**5.D.2 – industrial wastewater**					**5.D**
	CH_4		**N_2O**				**GHG**	**CH_4**		**N_2O**		**GHG**	**GHG**
Source	**septic systems**		**indirect effluent plants**	**effluent population**	**direct plants**	**total**	**total**	**On-site**		**On-site**		**total**	**total**
	[t CH_4]	**[t CO_2e]**	**[t N_2O]**	**[t N_2O]**	**[t N_2O]**	**[t CO_2e]**	**[t CO_2e]**	**[t CH_4]**	**[t CO_2e]**	**[t N_2O]***	**[t CO_2e]**	**[t CO_2e]**	**[t CO_2e]**
1990	4 850	135 798	205	117	0	85 433	221 230	34	942	1.4	363	1 305	222 535
1991	4 837	135 431	211	116	0	86 454	221 885	35	990	1.4	375	1 365	223 250
1992	4 705	131 737	225	107	0	87 970	219 707	37	1 037	1.5	388	1 425	221 132
1993	4 557	127 592	239	98	0	89 263	216 855	39	1 100	1.5	400	1 500	218 355
1994	4 387	122 829	229	88	37	93 766	216 594	41	1 149	1.6	413	1 562	218 156
1995	4 205	117 753	215	79	77	98 421	216 174	42	1 180	1.6	419	1 600	217 773
1996	3 867	108 281	198	71	120	103 125	211 406	44	1 236	1.6	436	1 672	213 078
1997	3 527	98 762	188	64	151	106 620	205 382	48	1 357	1.7	454	1 812	207 194
1998	3 186	89 219	176	57	183	110 281	199 500	50	1 407	1.8	467	1 874	201 373
1999	2 934	82 152	163	52	215	113 886	196 038	52	1 460	1.8	481	1 941	197 979
2000	2 682	75 092	138	47	266	119 327	194 420	52	1 461	2.1	544	2 005	196 424
2001	2 432	68 095	110	42	319	124 813	192 908	94	2 636	1.8	489	3 125	196 033
2002	2 181	61 057	113	38	326	126 265	187 322	97	2 711	1.9	502	3 213	190 536
2003	1 946	54 500	115	34	333	127 675	182 175	100	2 794	2.0	519	3 314	185 488
2004	1 794	50 236	118	34	335	128 991	179 228	103	2 896	2.0	527	3 423	182 651
2005	1 641	45 941	101	34	363	131 986	177 927	105	2 944	2.4	637	3 582	181 509
2006	1 483	41 517	83	26	404	135 876	177 393	111	3 103	2.1	566	3 669	181 062
2007	1 389	38 888	79	24	414	136 893	175 781	111	3 107	2.1	567	3 675	179 456
2008	1 294	36 236	74	22	424	137 929	174 166	111	3 108	2.1	566	3 674	177 839
2009	1 198	33 548	75	21	430	139 356	172 904	105	2 934	2.0	539	3 473	176 378
2010	1 102	30 846	75	19	437	140 792	171 638	109	3 061	2.1	545	3 606	175 244
2011	1 051	29 425	74	18	440	140 960	170 385	105	2 950	2.2	570	3 519	173 904
2012	1 001	28 029	73	17	443	141 278	169 307	108	3 022	2.3	600	3 622	172 929
2013	961	26 917	70	17	447	141 478	168 395	110	3 069	2.8	745	3 814	172 209
2014	923	25 837	68	16	452	141 908	167 745	111	3 103	2.4	642	3 745	171 490
2015	913	25 574	70	16	457	143 901	169 475	109	3 055	2.4	643	3 697	173 172
2016	906	25 372	75	16	463	146 874	172 246	116	3 255	2.6	678	3 934	176 180
2017	841	23 549	77	15	468	148 114	171 662	124	3 479	2.7	728	4 207	175 869
2018	774	21 670	76	13	472	148 674	170 344	134	3 752	3.0	797	4 549	174 893
2019	768	21 508	78	13	474	149 970	171 478	134	3 751	3.3	875	4 626	176 104
2020	762	21 342	74	13	477	149 541	170 883	130	3 634	6.2	1 655	5 289	176 173
2021	762**	21 342	74	13	479	150 021	171 363	131	3 663	5.9	1 567	5 230	176 593
1990–2021	**−84%**		**−64%**	**−89%**	**-**	**+73%**	**−23%**	**+289%**		**+332%**		**+301%**	**−21%**
2020–2021	**0.0%**		**−0.2%**	**0.0%**	**+0.4%**	**−0.1%**	**0.3%**	**0.8%**		**−5.3%**		**−1.1%**	**0.2%**

* *covered: direct and indirect N_2O from industrial waste water treatment on site*

** *CH_4, AD and IEF reported for 2021 are identical to the values reported for 2020 because the same population figure was applied due to a lack of updated information on the connection rate to cesspools. Unlike the population connected to the municipal wastewater treatment system (only relevant for N_2O emissions) the number of people using septic tanks are not assumed to increase with the growing population (please refer to Figure 56)*

7.5.2 Methodological issues

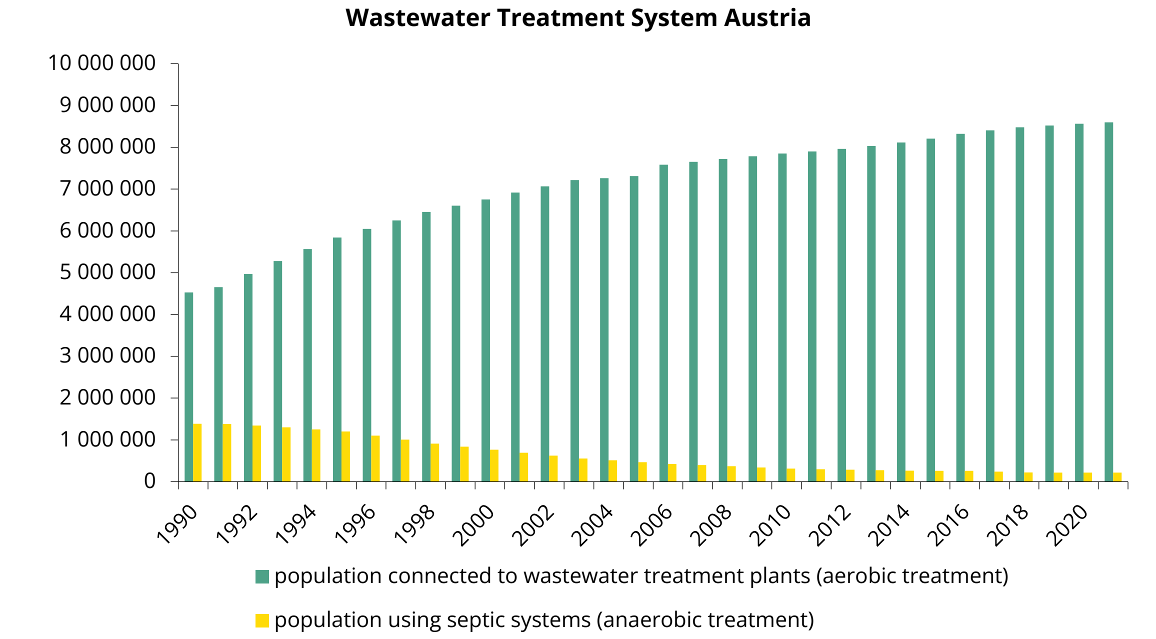
7.5.2.1 Domestic waste water treatment

CH_4 emissions from domestic wastewater disposed to septic tanks are calculated applying a Tier 2 method following the IPCC 2006 GL, using partly default values (B_o), partly country specific factors (MCF). For calculation of CH_4 emissions only the share of population disposing the wastewater to septic systems (anaerobic conditions) is considered.

N_2O emissions from the treatment and discharge of domestic and commercial wastewater (including industrial sources ("co-dischargers")) are calculated applying a country-specific method, as described in chapter 7.5.2.2.

For calculation of N_2O emissions the whole population is considered, in separate calculation steps. Most wastewater in Austria is treated in centralised wastewater treatment plants. There are only some sparsely populated areas where inhabitants are not connected to the public sewage system, but use septic tanks and cesspools for their wastewater disposal. From 1990 to 2021 the connection rate to wastewater treatment plants increased from 59.0% to 96.1%.

Figure 56: Domestic Wastewater Treatment in Austria[128].



Source: Umweltbundesamt, BMLFUW 1993, 1996, 1999, 2002, 2006b, 2008b, 2010, 2012, 2014, 2016b, BMNT 2018b, BMLRT 2020, BML 2022b, Statistik Austria 2022

umweltbundesamt

In order to prevent uncontrolled putrefaction, sewage sludge is stabilized. In smaller facilities such stabilization is usually carried out aerobically (open pool with oxygen input) and only a negligible amount of methane is produced. In bigger plants (typically > 30 000 pe) stabilization is carried out anaerobically in a digestion tower. The methane gas produced in the course of the anaerobic treat-

[128] Note that direct discharge of sludge on landfill is prohibited since 2004 resp. 2009

ment is used for energy recovery in combined heat/power generation systems (CHP). Related emissions are covered in CRF sector 1.A fuel combustion. The 'NA' reported .under category 5.D.1 in CRF table 5.D only refers to the emissions source 'cesspools', where no recovery and no flaring takes place.

Only if technical disruptions or overloads occur, the methane gas is flared off. In both treatment methods, no significant amounts of methane emissions are released into the environment. In 2021 about 45% of sewage sludge was incinerated (included in *1.A*), about 30% treated "another way", in Austria mainly in composting and to a minor part in mechanical-biological treatment plants (included in *5.B*). 25 % were applied on agricultural soils (included in *3.D*).

CH_4 emissions

CH_4 emissions reported under *CRF 5.D.1 Wastewater Treatment and Discharge* originate from the disposal of domestic wastewater to cesspools and septic tanks and are calculated following the method of the IPCC 2006 GL. Emissions are a function of the amount of Total Organics in Wastewater (TOW = P * BOD * 365) disposed to septic systems and an emission factor.

$$CH_4\ (domestic\ wastewater) = P * T_{[septic\ tanks]} * BOD * 365 * EF$$

Where:

P = *country population*
$T_{[septic\ tanks]}$ = *degree of utilisation of septic tanks for wastewater discharge*
BOD =*per capita BOD value (IPCC 2006 default: 60 g* BOD_5*/person/day)*
EF = *emission factor:* B_0 * *MCF = 0.16*
B_0 = *methane producing capacity (IPCC 2006 default: 0.6 kg* CH_4*/kg BOD)*
MCF =*methane correction factor (country specific: 0.27)*

For calculation, the share of population disposing their wastewater to septic tanks is taken into account:

Table 320: Share of population using septic tanks (1991–2020).

1991	2001	2003	2006	2008	2010	2012	2014	2016	2018	2020
17.8%	8.6%	6.8%	5.1%	4.4%	3.8%	3.4%	3.1%	3.0%	2.5%	2.4%

In the year 2020[129] 96.0% of the Austrian population is connected to municipal wastewater treatment plants. The remaining wastewater is treated either in septic tanks (2.4%), domestic wastewater handling systems (1.4%), or disposed otherwise ('unspecified disposal routes': 0.2%).

Data on wastewater disposal routes and connection rates to the sewage system are taken from the respective Austrian reports on water pollution control (Gewässerschutzberichte – BMLFUW 1993, 1996, 1999, 2002) and situation reports on municipal wastewater (BMLFUW 2006b, BMLFUW 2008b, BMLFUW 2010, BMLFUW 2012, BMLFUW 2014, BMLFUW 2016b, BMNT 2018b, BMLRT 2020, BML 2022C). Data are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010, 2012, 2014, 2016, 2018 and 2020, thus every two years. 2020 is the latest year for which data on the connection

[129] the latest year for which data on connection rate is currently available

rate is currently available. The population number using septic tanks in 2021 was assumed to be the same as 2020.

Until 1998, a detailed statistic on waste water disposal routes was provided: in addition to wastewater treated in municipal plants, also domestic wastewater handling systems, septic tanks and 'unspecified disposal routes' were covered. However, Statistics Austria has changed its data collection in 2001 and did not offer a detailed split of the population not connected to municipal wastewater treatment plants any more. For this reason, the derivation of the share (%) of inhabitants using septic tanks – a parameter necessary for the calculation of CH_4 emissions – had to be extrapolated from the year 2000 onwards.

BOD and B_o are default values from the IPCC 2006 GL. For determining the Methane Correction Factor (MCF) a country specific approach was chosen, taking into account that the MCF is temperature dependent. The MCF defines the share of methane producing capacity (B_o) that degrades anaerobically and may vary between 0.0 (completely aerobic) to 1.0 (completely anaerobic).

(GIBBS & WOODBURY 1993) identify a MCF of 100% at 30–40°C, a MCF of 35% at 20°C and a MCF of 10% at 10°C. Taking into account the temperature conditions in Austria (average temperature of 20°C for 8 months and 10°C for 4 months the year) the mean value for the whole year (0.27) has been calculated by (STEINLECHNER et al. 1994) as follows:

$$MCF\ (mean\ value\ for\ whole\ year) = 0.35 * 2/3 + 0.10 * 1/3 = 0.27$$

N_2O emissions

N_2O emissions from *CRF 5.D.1.Wastewater Treatment and Discharge* are calculated using a country specific method. Emissions are calculated separately for N_2O from effluent (indirect emissions) and N_2O from advanced centralized wastewater treatment plants, hereinafter referred to as 'plants', (direct emissions), and are then summed up.

$$N_2O\ emissions = N_2O_{PLANTS} + N_2O_{EFFLUENT}$$

N_2O emissions	*= total N_2O emissions from wastewater handling and discharge*
N_2O_{PLANTS}	*= N_2O from advanced wastewater treatment plants*
$N_2O_{EFFLUENT}$	*= N_2O from plant effluent + N_2O from effluent of the population not connected to plants*

The main differences to the default methodology of the IPCC 2006 GL are as follows:

- In the Austrian approach the different nitrogen flows (nitrogen influent to plants, nitrogen effluent from plants and nitrogen effluent from wastewater of the population not connected to plants) are considered separately and related emissions are then summed up. The different paths considered are illustrated in Figure 53.
- Instead of estimating $N_{EFFLUENT}$ based on protein consumption and co-discharged fractions (IPCC 2006 GL), measured/reported values (country-specific N) are used, based on EMREG ($N_{EFFLUENT\ PLANTS}$) and ZESSNER & LINDTNER ($N_{EFFLUENT\ POPULATION}$).
- For the calculation of direct emissions from wastewater treatment plants a country-specific EF, based on measurements at Austrian wastewater treatment plants (2013/2014) is used. Only the population connected to plants with controlled nitrification and denitrification ('modern/advanced plants') is considered.

Direct N_2O emissions from plants (N_2O_{PLANTS})

N_2O emissions from wastewater treatment plants are based on a national measurement programme delivering results (EF) for 2013 (BMLFUW 2015a). Emissions for the whole time series (except for 2013) are calculated based on the EF derived and applying Equation 6.9 of the IPCC 2006 GL:

$$N_2O_{PLANTS} = P * T_{CND\text{-}PLANTS} * F_{IND\text{-}COM} * EF_{PLANT}$$

N_2O_{PLANTS}	*= N_2O emissions from modern wastewater treatment plants*
P	*= Austrian population*
$T_{CND\text{-}PLANTS}$	*= connection rate to modern, centralized wastewater treatment plants (CS)*
$F_{IND–COM}$	*= fraction of industrial and commercial co-discharge (CS)*
EF_{PLANT}	*= emission factor for Austrian wastewater treatment plants (CS)*

Activity data

Data on the Austrian **population (P)** is taken from national statistics provided by Statistik Austria (STATISTIK AUSTRIA 2022). Data on connection rates to the public sewage system are from Austrian reports on water pollution control (Gewässerschutzberichte – BMLFUW 1993, 1996, 1999, 2002) and situation reports on municipal wastewater (BMLFUW 2006b, BMLFUW 2008b, BMLFUW 2010, BMLFUW 2012, BMLFUW 2014a, BMLFUW 2016b, BMNT 2018b, BMLRT 2020, BML 2022c). Data are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010, 2012, 2014, 2016, 2018 and 2020; missing data were interpolated. In the year 2021, 96.1% of the Austrian population was assumed to be connected to municipal wastewater treatment plants, based on the 2020 connection rate (BML 2022c) and the population number 2021 (Statistik Austria 2022).

As only modern wastewater treatment plants with controlled nitrification and denitrification steps are relevant for N_2O emissions, only these so-called 'CND-plants' are considered in the calculation. Since 2010 all municipal wastewater treatment plants are classified as CND-plants, due to the high overall denitrification rate in Austria (80% in 2010). In 2021 the denitrification rate reached a level of 81.0% Minor fluctuations are mainly due to the changing waste water temperature. On the contrary, until 1994 there was almost no plant with nitrification and denitrification in Austria and nitrogen removal has largely taken place as sludge removal (10%). It is assumed that between 1994 and 2010 their share was rising, in line with the N-removal. The **$T_{CND\text{-}PLANTS}$** was calculated on basis of connection rates to the public sewage system (national statistics) and the assessed share of CND-plants in Austria.

Table 321: Activity data for calculation of direct N_2O emissions (plants).

	Population	$T_{CND\text{-}PLANTS}$		Denitrification rate
		connection rate plants	share CND-plants	
	no.	[%]	[%]	[%]
1990	7 677 850	59.0%	0.0%	10.0%
1991	7 754 891	60.0%	0.0%	10.0%
1992	7 840 709	63.4%	0.0%	10.0%
1993	7 905 632	66.8%	0.0%	10.0%
1994	7 936 118	70.1%	11.9%	18.3%
1995	7 948 278	73.5%	23.8%	26.7%
1996	7 959 016	76.0%	35.7%	35.0%
1997	7 968 041	78.4%	43.3%	40.3%

	Population	$T_{CND-PLANTS}$		Denitrification rate
		connection rate plants	share CND-plants	
	no.	[%]	[%]	[%]
1998	7 976 789	80.9%	51.0%	45.7%
1999	7 992 323	82.6%	58.6%	51.0%
2000	8 011 566	84.3%	70.7%	59.5%
2001	8 042 293	86.0%	82.9%	68.0%
2002	8 082 121	87.5%	82.9%	68.0%
2003	8 118 245	88.9%	82.9%	68.0%
2004	8 169 441	88.9%	82.9%	68.0%
2005	8 225 278	88.9%	89.3%	72.5%
2006	8 267 948	91.7%	95.7%	77.0%
2007	8 295 189	92.2%	97.1%	78.0%
2008	8 321 541	92.8%	98.6%	79.0%
2009	8 341 483	93.4%	99.3%	79.5%
2010	8 361 069	93.9%	100.0%	80.0%
2011	8 388 534	94.2%	100.0%	80.0%
2012	8 426 311	94.5%	100.0%	80.0%
2013	8 477 230	94.8%	100.0%	80.8%
2014	8 543 932	95.0%	100.0%	81.5%
2015	8 629 519	95.1%	100.0%	81.1%
2016	8 739 806	95.2%	100.0%	80.6%
2017	8 795 073	95.6%	100.0%	80.3%
2018	8 837 707	95.9%	100.0%	80.9%
2019	8 877 637	96.0%	100.0%	80.5%
2020	8 916 845	96.0%	100.0%	81.0%
2021	8 951 520	96.1%	100.0%	81.0%

$F_{IND-COM}$: It is assumed that 30% of total nitrogen influent to wastewater treatment plants is attributable to commercial and industrial sources (ORTHOFER et al 1995).

Emission Factor (EF_{PLANT})

The country specific EF used for modern wastewater treatment plants (**EF_{PLANT}**) is 43 g N_2O/population equivalent/year and is derived from a national measuring programme 2013/2014, measuring and analyzing N_2O emissions from 24 field measurements at 8 representative wastewater treatment plants in Austria (BMLFUW 2015a). The EF considers current operational conditions, in particular nitrogen removal (denitrification) at Austrian wastewater treatment plants. The waste water emission ordinance for municipal wastewater treatment plants with an organic design capacity larger than 5 000 population equivalents forces a minimum reduction rate of 70% of total nitrogen. The objective of N-removal is to reduce the risk of eutrophication of surface waters.

Indirect N_2O emissions from wastewater effluent ($N_2O_{EFFLUENT}$)

For the calculation of indirect N_2O emissions Equation 6.7 from the IPCC 2006 GL is applied:

$$N_2O_{EFFLUENT} = N_{EFFLUENT} * EF_{EFFLUENT} * 44/28$$

$N_2O_{EFFLUENT}$ = N_2O emissions from effluent to surface water bodies
$N_{EFFLUENT}$ = $N_{EFFLUENT\ PLANTS}$ + $N_{EFFLUENT\ POPULATION}$ (CS)
$EF_{EFFLUENT}$ = emission factor for wastewater discharge (IPCC 2006)

Activity data

$N_{EFFLUENT}$ includes nitrogen effluent from the population not connected to the public sewage system ($N_{EFFLUENT\ POPULATION}$) as well as nitrogen effluent from wastewater treatment plants ($N_{EFFLUENT\ PLANTS}$). Both are country specific values and thus did not need to be calculated based on protein intake statistics (as provided for Equation 6.8 of the IPCC 2006 GL).

Data on $N_{EFFLUENT\ PLANTS}$ are retrieved from the Electronic Emission Register of Surface Water Bodies („Emissionsregister – Oberflächenwasserkörper", abbreviated "EMREG-OW"[130]), an electronic register of material emissions to surface water bodies from point sources, especially municipal sewage treatment plants. It is administered by the Federal Ministry of Agriculture, Regions and Tourism and serves the collection of information for the National Water Management Plan and for management plans for international river catchment areas. Data is so far available for the years 2001, 2004, 2006, 2008, 2010, 2012, 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021 published in the Austrian reports on water pollution control and situation reports on municipal wastewater (references see further up in the text on methodological issues). Data for the years in between had to be interpolated. For the years before 2001 the $N_{effluent}$ plants were derived taking the population as well as the denitrification rate into account.

$N_{EFFLUENT\ POPULATION}$ is based on investigations made by ZESSNER & LINDTNER (2005), assessing specific N loads from households in Austria to be within the range 11–13 g N/inhabitant/d. Based on the higher value of this range (13 g) and the Austrian statistics on population the $N_{EFFLUENT\ POPULATION}$ was calculated.

Table 322: Activity data for calculation of N_2O from wastewater effluent.

	$N_{EFFLUENT\ PLANTS}$	$N_{EFFLUENT\ POPULATION}$	$N_{EFFLUENT\ TOTAL}$
	[t N/yr]	**[t N/yr]**	**[t N/yr]**
1990	26 094	14 937	41 031
1991	26 803	14 719	41 522
1992	28 624	13 626	42 250
1993	30 398	12 473	42 871
1994	29 090	11 250	40 340
1995	27 420	9 994	37 415
1996	25 154	9 076	34 230
1997	23 867	8 154	32 021
1998	22 442	7 229	29 671
1999	20 704	6 599	27 303

[130] BGBl. II Nr. 29/2009: Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über ein elektronisches Register zur Erfassung aller wesentlichen Belastungen von Oberflächenwasserkörpern durch Emissionen von Stoffen aus Punktquellen (EmRegV-OW)

	$N_{EFFLUENT\ PLANTS}$	$N_{EFFLUENT\ POPULATION}$	$N_{EFFLUENT\ TOTAL}$
	[t N/yr]	[t N/yr]	[t N/yr]
2000	17 507	5 968	23 475
2001	14 003	5 342	19 345
2002	14 341	4 813	19 154
2003	14 679	4 276	18 955
2004	15 017	4 303	19 320
2005	12 804	4 332	17 136
2006	10 591	3 257	13 849
2007	10 033	3 051	13 084
2008	9 474	2 843	12 317
2009	9 526	2 632	12 158
2010	9 578	2 420	11 998
2011	9 409	2 309	11 718
2012	9 240	2 199	11 440
2013	8 933	2 112	11 045
2014	8 625	2 027	10 652
2015	8 966	2 006	10 972
2016	9 604	1 991	11 595
2017	9 738	1 848	11 585
2018	9 632	1 700	11 332
2019	9 965	1 687	11 653
2020	9 475	1 674	11 150
2021	9 460	1 674	11 135

Emission Factor ($EF_{EFFLUENT}$)

The default emission factor for N_2O emissions from domestic wastewater nitrogen effluent of the IPCC 2006 GL is applied: 0.005 kg N_2O-N/kg N.

7.5.2.2 Industrial waste water treatment (on site)

CH_4 and N_2O emissions from sub-category *5.D.2* (see Table 319) are estimated on the basis of a study conducted in 2019 (UMWELTBUNDESAMT 2019c), investigating the practice of wastewater handling in industrial plants in Austria, covering the following industrial branches:

- Paper and pulp
- Food and beverages, covering
  - dairy processing,
  - breweries,
  - fruit juice production,
  - starch production,
  - sugar production,
  - meat production,
  - vegetable oils,
  - pet food production,
  - rendering

CH_4 emissions

The IPCC 2006 GL state that only industrial wastewater with significant carbon loading that is treated under intended or unintended anaerobic conditions will produce CH_4. Accordingly, all relevant industrial plants in Austria in the area of food production and pulp and paper – i.e. with significant carbon loading – were contacted in the framework of a national study (UMWELTBUNDESAMT 2019c), to get information on:

- their wastewater treatment practice (on-site treatment/indirect discharge, aerob/anaerob treatment, sludge digestion, gas recovery, etc.)
- bottom-up data on gas generated in the pre-treatment of waste water and methane concentration (based on measurements).

It turned out that anaerobic wastewater pre-treatment only partially takes place in individual industrial sectors – such as the paper industry, breweries, starch, sugar and fruit juice production. All plants with anaerobic pre-treament have gas collection with subsequent energy recovery. For industrial wastewater treatment plants practicing no anaerobic wastewater pre-treatment on-site – e.g. in the milk and meat production – a MCF of zero is assumed in accordance with the IPCC 2006 Guidelines as they are well managed in Austria.

In addition most of the industrial plants do not have anaerobic treatment of the sludge. The sludge is incinerated on-site or off-site or transferred to external treaters (biogas plants, domestic waste water treatment plants). The few plants with an anaerobic treatment of sludge use the biogas produced for energy prodution.

Nevertheless, emission of methane can occur as diffuse emissions e.g. during the subsequent aerobic treatment of the anaerobic pre-treated waste water (partly stripping of methane if methane is included in the pre-treated waste water). For this reason, an EF of 1% of the methane generated was applied for all plants with an anaerobic pre-treatment.

The assumption of 1% fugitive methane emission is also supported in (IFEU 2008), where a fugitive emission of 1% is assumed for biogas plants.

Emissions data for 1990 – 2018 were taken directly from the study (Umwelbundesamt 2019c), data for subsequent years were extrapolated mainly using production data of primary and secondary pulp (AUSTROPAPIER 2022) as paper industry is the main source of CH_4 emissions from this sub-category (share of 83% in 5.D.2).

N_2O emissions

N_2O is produced, if modern waste water treatment is applied (N–removal by nitrification/ denitrification). However, industrial waste water often shows only small nitrogen concentrations and therefore direct N_2O emissions are low. Furthermore indirect N_2O emissions are caused by the N-load in the effluent emitted to the receiving waters. Indirect N_2O emissions were calculated using measured N-loads from industrial direct discharges reported annually within the EMREG data base and the emission factor for wastewater discharge of 0.005 kg N_2O-N/kg N (IPCC 2006).

Until submission 2022 study results (UMWELTBUNDESAMT 2019c) have been extrapolated, using production data of primary and secondary pulp (AUSTROPAPIER 2022) as indicator for the most N_2O emitting paper industry[131]. From submission 2023 onwards, however, N_2O emissions are calculated based on $N_{effluent}$ data retrieved from the Electronic Emission Register of Surface Water Bodies (EMREG) and applying the default methodology from the IPCC 2006 GL. This is the same approach as also applied in the study for the estimation of indirect emissions (using the IPCC default EF and reported nitrogen loads from direct dischargers)

7.5.3 Uncertainties and time-series consistency

The uncertainty, originally based on ORTHOFER et al (1995), was re-evaluated and adapted for the N_2O EF based on an expert judgement by Umweltbundesamt (2015). The compared to the previous estimate higher EF uncertainty is due to the relatively low uncertainty assessment of previous submissions, the very large uncertainty associated with the default EF for indirect N_2O emissions (IPCC 2006 GL) as well as the wide dispersion of the individual measurement results influencing the EF for wastewater treatment plants (Expert judgement by Umweltbundesamt (2015)). Also fluctuating nitrogen flows and removals affects the uncertainty of the applied CS EF.

Uncertainties for CH_4 remain unchanged compared to previous estimations.

Table 323: Uncertainty assessment for CRF 5.D.1 Wastewater Treatment and Discharge.

	CH_4	N_2O
Activity data	20%	20%
Emission factor	50%	100%

Up to now no uncertainty assessment for waste water treatment at industrial sites was carried out.

7.5.4 Category-specific QA/QC

7.5.4.1 CH_4 from septic tanks (5.D.1)

The country specific **MCF** used – 0.27 based on (STEINLECHNER et al. 1994), which is lower than the IPCC 2006 default for septic systems (0.5) – has been validated during the In-Country Review 2013 by comparison with a study on 'Evaluation of Greenhouse Gas Emissions from Septic Systems' of the Water Environment Research Foundation (WERF 2010), on emission rates (measurements) of methane from septic tanks in California. According to the study, a MCF value of about 0.22 would be applicable for septic systems[132]. As the measurements have been carried out under conditions (air temperatures) similar to the average temperature of Austria the results can directly be com-

[131] Based on the study (UMWELTBUNDESAMT 2019c) 76% of the N_2O emissions were caused by the paper industry in 2018.

[132] A MCF value of 0.22 was calculated using the mean methane emission value measured for the septic tanks from this project.

pared and the use of 0.27 be supported. Using a MCF of 0.22 is also supported by an article on 'Methane, carbon dioxide, and nitrous oxide emissions from septic tank systems' (ENVIRONMENTAL SCIENCE & TECHNOLOGY 2011).

7.5.4.2 N_2O from domestic wastewater treatment (5.D.1)

An extensive QA/QC on the methodology has been conducted in 2014/2015 to best adapt the method for estimating N_2O emissions from wastewater to the IPCC 2006 GL. In this context different options were considered and discussed with other wastewater experts. Results for the year 2013 range from 122 t N_2O to 757 t N_2O (using no country-specific data at all). The currently applied option was chosen as it delivers the most accurate emissions result, considering actual nitrogen flows and a CS emission factor reflecting up-to-date operating conditions at Austrian wastewater treatment plants.

Results of the measurement program (RelaKO) were presented to a wide range of national stakeholders at two events organised by the Austrian Water and Waste Management Association (ÖWAV)[133] and published as a scientific article in Energy Procedia (PARRAVICINI. ET AL 2016[134]) as well as in the JOURNAL OF ENVIRONMENTAL MANAGEMENT 279 (2021).

Verification EF_{PLANTS}

As a QA and verification measure Austria plans to regularly evaluate plant specific N flows (influent to and effluent from wastewater treatment plants) and take this data for extrapolation of plant specific N_2O emissions – as determined by the national measuring programme 2013/2014 RelaKO (BMLFUW 2015a) – to national N_2O emissions from wastewater treatment plants on basis of the regression equation of the RelaKO project. This way, changing operating conditions at wastewater treatment plants can be considered and emissions (or the EF_{PLANT}) adjusted accordingly.

This verification was done in 2017 leading to lower total N_2O emissions from wastewater treatment plants for 2015 (421 t N_2O) than those determined by applying the fixed emission factor (42.8 g/pe/a based on 2013 data) to 2015 population data (456 t N_2O). This lower emission value can be explained by the improved denitrification (national D: 82% in 2015 compared to 80% in 2012).

7.5.5 Recalculations

N_2O emissions from 5.D.2 Industrial Wastewater were revised for 2019 and 2020 (2020: +0.9 kt CO_2e) as emissions for these years were calculated based on reported N-flow data (direct dischargers) in this years' submission instead of derived using production data as done for submission

[133] Parravicini V.; Svardal K. (2015). Klimarelevante Emissionen aus der Abwasserreinigung. ÖWAV-TU-Seminar 2015, NEW: Nährstoffe – Energie – Wasser; Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der technischen Universität Wien, Wiener Mitteilungen, Band 232, 183-204 sowie Parravicini V., Valkova T. (2014). Lachgasemissionen aus kommunalen Kläranlagen. Vortrag: ÖWAV-Seminar "Abwasserreinigung - Werte erhalten, Effizienz steigern und Ressourcen schonen", Wien; 24.-25.2.2014; in: "Wiener Mitteilungen", Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft, Band 230, 125 - 156.

[134] Parravicini V., Svardal K., Krampe J. (2016). Greenhouse Gas Emissions from Wastewater Treatment Plants. Energy Procedia, 97 (2016), S. 246 – 253.

2022. Only minor revisions were reported for CH_4 (-0.0001 kt CO_2e) due to the correction of a transcription error.

The whole time series of recalculations is included in Annex 8 to the NIR.

7.5.6 Planned improvements

No improvements are currently planned.

8 OTHER (CRF SECTOR 6)

Austria does not report any emissions under CRF Sector 6.

9 INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

Austria does not separately report any indirect CO_2 emissions from the atmospheric oxidation of CH_4, CO and NMVOCs in CRF Table 6, but has partly covered these emissions in categories *1.A* and *2.D.3* as described below.

Austria does not report indirect N_2O emissions from sources other than agriculture and LULUCF in CRF Table 6.

Table 324: Indirect emissions as reported in CRF Table 6 for the year 2021

Greenhouse Gas Source and Sink Categories	**Indirect Emissions**	
	CO_2	**N_2O**
1. Energy	IE,NE	NE
2. Industrial Processes and Product Use	IE	NE
3. Agriculture	NO	NO
4. LULUCF	NO	0.04
5. Waste	NA	NA
6. Other (please specify)	NO	NO

The reasons for the notation keys reported in CRF Table 6 are:

1. Energy
   - CO_2 emissions reported in category 1.A consider total carbon of fossil fuels and thus also covers all potential indirect CO_2 emissions (reported as "IE" in CRF Table 6)
   - CO_2 emissions from carbon included in fugitive CH4 emissions reported in category 1.B are not estimated (reported as "NE" in CRF Table 6)
2. Industrial processes and product use:

Indirect CO_2 emissions from solvent use (from NMVOC) are reported under 2.D.3 Solvent Use in CRF table Table2(I).A-Hs2 ("IE")

10 RECALCULATIONS AND IMPROVEMENTS

Recalculations of previously submitted inventory data are performed with the purpose to improve the GHG inventory. This chapter quantifies the changes in emissions for all greenhouse gases compared to the previous submission. Recalculations are quantified for total GHG emissions for all years.

It has to be noted, that the CO_2-equivalent (CO_2e) emissions presented in this report and the corresponding CRF tables submitted were calculated for the first time by applying the Global Warming Potentials ('GWPs') according to the 5th Assessment Report ('AR5') of the Intergovernmental Panel on Climate Change (IPCC 2014). As a result, the values for CH_4, N_2O and F-gas emissions expressed in metric tons of CO_2e deviate significantly from the previous years' report (NIR 2023), which presented the CO_2 equivalents in accordance with the 4th Assessment Report ('AR4', IPCC 2007). The effects of this change in GWPs from AR4 to AR5 are summarised in Table 328.

10.1 Explanations and justifications for recalculations, including in response to the review process

Compiling an emission inventory includes data collecting, data transfer and data processing. Data has to be collected from different sources, for instance national statistics, plant operators, studies, personal information or other publications. The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions by applying methodologies on the collected data and the final computing of time series into a predefined format (CRF) are further steps in the preparation of the final submission. Finally the submission must be delivered in due time. Even though a QA/QC system gives assistance so that potential error sources are minimized it is sometimes necessary to make some revisions (called recalculations) under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data. The causes might be: Previous data were preliminary data only (by estimation, extrapolation), improvements in methodology.
- Occurrence of errors in data transfer or processing: wrong data, unit-conversion, software errors etc.
- Methodological changes: a new methodology must be applied to fulfil the reporting obligations caused by one of the following reasons:
  - to decrease uncertainties.
  - an emission source becomes a key source.
  - consistent input data needed for applying the methodology is no longer accessible.
  - input data for more detailed methodology is now available.
  - the methodology is no longer appropriate.

Detailed information on recalculations and their justifications can be found in the following subchapters as well as the corresponding Sector-specific Chapters *3 Energy – 7 Waste*, in which all methodological changes and activity data updates that led to recalculations of emissions with respect to the previous submission are listed.

10.1.1 Energy (Sector 1)

10.1.1.1 Stationary sources

Update/Improvement of activity data

Revision of the energy balance

The federal statistics office "Statistik Austria" revised the energy balance (mainly for year 2020) with the following **main implications** for energy consumption as used in the inventory and the corresponding CO_2 emissions:

- Natural gas 2020: Gross inland consumption has been revised by +1.5 PJ (+ 85 kt CO_2) and allocated to final energy consumption, of which 0.8 PJ (+ 44 kt CO_2) has been allocated to *1.A.2* (+10 kt CO_2 for *1.A.2.a*, +5 kt CO_2 for *1.A.2.b*, +23 kt CO_2 for *1.A.2.c*, +28 kt CO_2 for 1.A.2.d, +14 kt CO_2 for *1.A.2.e*, -36 kt for *1.A.2.g*). Another 0.7 PJ of final consumption (+ 41 kt CO_2) has been allocated to *1.A.4* (mainly to *1.A.4.b.1*).
- Gasoil 2020: Minor shifts between *1.A.2* (-0.06 PJ), *1.A.4.a* (-0.29 PJ) and *1.A.4.b* (+0.43 PJ)
- LPG 2020: Minor shifts from non-energy use (-0.07 PJ) to *1.A.4.b.1*.
- Hard coal 2020: 0.2 PJ (-19 kt CO_2) have been shifted from *1.A.4.b.1* residential to *1.A.2.f* non-metallic minerals industry although *1.A.2.f* has not been revised because hard coal consumption is 100% covered by the ETS.
- Coke oven coke 2020: 0.06 PJ (- 5 kt CO_2) have been shifted from *1.A.4.b* to *1.A.2.a* final consumption.
- Solid biomass: 0.07 PJ of fuel wood has been shifted from *1.A.4.c* agriculture to *1.A.4.a* commercial. For the years 2018-2020, 0.05 to 0.3 PJ have been shifted between *1.A.2* and *1.A.4* sub categories.

Methodological changes

- For 1990 to 2020, up to 260 kt of CO_2 from solid fuels have been shifted from iron and steel (*1.A.2.a*) to industrial processes *(2.C.1)*, e.g. 230 kt for 1990, 167 kt for 2005 an 56 kt for 2020.
- For 1990 to 2020, minor changes in greenhouse gas emissions of categories *1.A.4.a.1 Commercial/Institutional: Stationary Combustion* and *1.A.4.b.1 Residential: Stationary Combustion* occur because of updated heating stock data and newly allocated shares of combustion technologies per energy carrier (updated energy demand model for space heating).

10.1.1.2 Mobile sources

Update of activity data

1.A.3.b Road transport

- **Update of specific vehicle mileage per year**
  A statistical evaluation of the specific annual mileage from the central assessment database (ZBD - annual "sticker check" in accordance with §57a KFG) for the years 2018, 2019 and

2020 was carried out for passenger cars, light duty vehicles, buses and 2-wheelers. The revision of this data resulted in a shift between inland vehicle kilometres and mileage of vehicles in the category fuel export (mainly HDV). In detail the ZBD data shows that there was an overestimation of inland vehicle kilometres in 2018 and 2019 by the model and an underestimation of inland vehicle kilometres in the pandemic year 2020. This was corrected accordingly in this years' submission.

Update of methodology

1.A.3.b Road transport

- Update of fuel consumption and emission factors according to HBEFA Version V4.2:
  Update of hot emission factors and characteristic motor curves for EURO 6 passenger cars and EURO VI HDV trucks. Adaptation of the fleet data to HBEFA V4.2 (HDV EUROVI_ABC_DE).
  Update of aging factors for cars and HDV.

All these changes resulted in recalculations of -2.5 kt CO_2e for *1.A.3.b. Road Transport* in 2020.

10.1.1.3 Fugitive Emissions

Minor recalculations (+ 0.08 kt CO_2e in 2020) are reported for *1.B.2.a.4 Refining/Storage* due to revisions (refinery intake data 2020) of the annual energy balance as well as to a lesser extent for *1.B.2.b.2 Natural Gas Production* for some historical years due to the correction of rounding errors.

10.1.2 Industrial Processes and Other Product Use (Sector 2)

Reallocation of emissions

2.A.1 Cement Production / 2.A.2 Lime Production / 2.A.3 Glass Production/ 2.A.4.a Bricks and Tiles / 2.A.4.c Magnesia Production / 2.B.2.10.b CO_2 emissions from chemical industry (ETS)

During extensive quality checks several minor errors of the ETS data analysis (allocation of process streams, as well as some rounding errors) for the years 2013ff were identified for single years and categories, and subsequently corrected.

2.A.2 Lime Production / 2.A.4.d Other Use of Carbonates

Following a recommendation from the 2022 UNFCCC review, all emissions from lime production i.e. those previously reported under *2.A.4.d* (desulphurization) and *2.C.5.a* Carbide Production are now reported together with emissions from lime kilns, as well as from processes using or producing PCC (precipitated calcium carbonate) under *2.A.2*.

2.B.1 Ammonia Production / 2.D.3 Other: Urea used as a catalyst

Updated urea amounts used in road traffic for the years 2005–2020 led to a redistribution of minor amounts between these two categories.

2.C.1.a Steel

During extensive quality checks, it became obvious that one process stream (tar) was considered incorrectly in the disaggregation of total CO_2 emissions from Iron & Steel production (which is verified ETS data) into process specific and energy related emissions reported under *1.A.2.a*. The correction led to a minor shift of emissions between those two categories.

Update of activity or emissions data

2.B.10.ii Fertilizer Production

During extensive quality checks, a minor error of the year 2010 was found and corrected (-0.04 kt CO_2 in 2010).

2.C.5 Lead Production

Activity data from the year 2016 onwards were updated (+0.5 kt CO_2 in 2020).

2.D.3 Solvent Use

During extensive quality checks several minor errors of the VOC directive data analysis used as basis for the bottom up approach for the years 2015 and 2019 were identified and subsequently corrected. As data from 2002 to 2015 is interpolated, this affected emissions from 2003 onwards (+0.01 kt CO_2e in 2020).

2.F.1.d Transport Refrigeration

Additional research identified an additional supplier of transport refrigeration equipment and furthermore showed that refill data previously used was incomplete. Therefore new assumptions on stock and especially stock composition were made, taking into account all available information. This affected emissions from 2007 onwards (-6.4 kt CO_2e in 2020).

2.F.1.e MAC

A minor correction of amounts filled into new equipment for trains in 2019 led to recalculations of the stock back to 1996, as stocks are calculated back in time using newly filled in amounts (+0.03 kt CO_2e in 2020).

2.F.3 Fire protection

Disposal emissions from 2019 had mistakenly not been considered in previous submissions, but are now included (+0.2 kt CO_2e in 2019).

2.G.1 Electrical equipment

Updated stock data for 2020 became available, and was included in this year's inventory (+ 1.0 kt CO_2e).

2.G.2 Other uses of SF6- particle accelerators.

Activity data for some new equipment were updated for 2020 (+1.4 kt CO_2e).

Improvements of methodologies and emission factors

2.A.2 Lime Production

CO_2 recovery in the process of PCC production of one site, for which emissions from the calcination step have been considered in the inventory, was included in the calculation. This affected emissions from 1990-2019, e.g. -1.1 kt CO_2 in 2019).

2.B.5.b Calcium Carbide Production

Following a recommendation from the 2022 UNFCCC review, the EF for carbide production was reevaluated and emissions from acetylene production were included for the first time. As already described above, emissions from the calcination step in carbide production were reallocated to *2.A.2 Lime Production*. The overall effect on emissions from this category is -5.4 kt CO_2 in 2020.

2.C.1.b Pig Iron

Methane emissions from coke production are now estimated using plant specific data. Furthermore emissions reported for sinter production were corrected, as previously only CH_4-C was reported (+2.2 kt CO_2e in 2020).

2.F.1.a Commercial refrigeration, 2.F.1.c Industrial Refrigeration and 2.F.1.f Stationary air conditioning

Additional research on stationary air conditioning showed that

- less equipment was filled on site than previously assumed. Thus the gap between quantities surveyed bottom up and import figures is now higher, raising both stocks and emission from stocks for the categories **commercial and industrial refrigeration**, those two categories where the residual amounts are allocated to.
- for one type of equipment the assumed filling capacity for the years 2009ff was too low, increasing the stock and emissions for **stationary air conditioning** from 2009 onwards.

Furthermore, as the GWP was changed to AR5, also the blend categories used for modelling the residual amounts of refrigerants not surveyed bottom up, had to be revised.

The overall effect of recalculations in these three sub categories is + 58.5 kt CO_2e in 2020.

10.1.3 Agriculture (Sector 3)

Update of activity data

3.A Enteric Fermentation, 3.B Manure Management, 3.D Agricultural Soils

Livestock data – poultry and deer

Updated livestock data for poultry (layers, broilers, turkeys and other poultry) and deer became available for the year 2020, based on the final results of the farm structure survey 2020 (STATISTIK AUSTRIA 2022[135]). For 2016, activity data of the farm structure survey 2016 was used (STATISTIK AUSTRIA 2018[136]). The numbers for the years 2017, 2018 and 2019 have been derived by interpolation.

[135] Statistik Austria (2022): Final results of the farm structure survey 2020 Agrarstrukturerhebung_2020_20221117 (statistik.at)

[136] STATISTIK AUSTRIA (2018): Agrarstrukturerhebung: Stichprobenerhebung 2016. Schnellbericht 1.17, Wien.

Background data for feeding and nutrition of cattle

New values for the protein content of milk for the years 2019 and 2020 and for the fat content of milk for 2020 became available (AMA 2021[137]). In addition, for the years 1996-2004 and 2014-2020 the data on distribution of cattle breeds were slightly updated. These improvements resulted in minor revisions of the values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ of dairy and suckling cows.

Biogas plants

Updated figures on biogas plants (E-CONTROL 2022b[138]) resulted in slight revisions of CH_4 and N_2O with an impact in source categories *3.B Manure Management*, *3.D.a.2.a Animal manure applied to soils* and *3.D.a.2.c Other organic fertilizers applied to soils*.

3.A Enteric Fermentation (CH_4)

This category has been slightly revised due to updated activity and nutrition data (GE-intake, livestock numbers of poultry and deer – see above).

The improvements resulted in updated emissions for the years 1996-2004 and 2014-2020 (+0.04 kt CH_4 for 2020).

3.D.a.4 Crop Residues (N_2O)

For 2020, sugar beet harvest amounts have been marginally revised resulting in lower N_2O amounts (-0.0005 kt N_2O for 2020).

3.D.a.5 Mineral Soils (N_2O)

Revisions of activity data (perennial cropland to annual cropland, for more information see chapter 10.1.4 on LULUCF) resulted in revised emissions for the entire time series (+0.001 kt N_2O for 2020).

Improvements of methodologies and emission factors

3.B Manure Management (CH_4, direct and indirect N_2O)

Methane and direct N_2O emissions have been revised for the years 1996-2004 and 2014-2020 (+0.001 kt CH_4 for 2020 and -0.001 kt N_2O for 2020), as a result of updated activity and nutrition data (see above).

Austria's agriculture model is based on the N-flow concept. Thus, revisions within Austria's air emission inventory affect calculation results in Austria's GHG inventory. In Austria's air emission inventory, the decreasing share of tied systems from 2017 onwards was taken into account for the first time. This improvement contributed to the increased emissions for indirect N_2O (+0.01 kt N_2O for 2020).

3.D Agricultural Soils (N_2O)

3.D.1.2.a Animal Manure Applied to Soils

Updates and improvements in the area of animal husbandry described above resulted in minor revisions of emissions from animal manure application (-0.01 kt N_2O for 2020).

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[137] AMA (2021): Rohmilchqualität | AMA - AgrarMarkt Austria

[138] E-CONTROL (2022): EC_EAG_Monitoringb_15.09_DRUCK.indd (e-control.at) accessed in November 2022

3.D.1.3 Urine and dung deposited by Grazing Animals

Livestock related updates as already described before, resulted in revised N_2O emissions for the years 1996-2004 and 2014-2020 (-0.001 kt N_2O for 2020).

3.D.b Agricultural Soils (indirect soil emissions – N_2O)

Atmospheric deposition: the main reasons for revised emissions are the correction of a linkage error in the ammonia inventory and the adjusted activity data ($N_{excretion}$ values for cattle, livestock numbers poultry and deer, biogas). As a result, the indirect N_2O emissions from atmospheric deposition were revised downwards for the years 1991-2020 (-0.004 kt N_2O for 2020).

N leaching and run-off: updated AD (see above) are the reason for revised emissions for the entire time series (-0.001 kt N_2O for 2020).

Reallocation of emission sources

3.F Field burning

Following a recommendation of the NEC Review 2022, emissions from the burning of residual wood from vinicultures on open fields (formerly reported under *3.F.5 Other*) have been reallocated to category *5.C.2.1.b Incineration and Open Burning of Waste – Other*. This reallocation results in lower emissions of CH_4 and N_2O for the entire time series (-0.02 kt CH_4 and -0.0002 kt N_2O).

10.1.4 LULUCF (Sector 4)

4.A Forest land

The forest areas, land use change areas, increment, drain and dead wood results of the NFI 2016/21 were taken to update the time series for the *Forest land* category for the years since 2009. In addition, biomass and dead wood C stock changes for forests not-in-yield representing about 15 % of the *Forest land* were estimated for the first time for the whole time series based on measured results from the NFI 2016/21 and backwards modelling for the whole time series. The forest soil C stock changes were recalculated for the complete series based on an improved calibration and spin-up procedure of the model and the latest YASSO model version 20. Furthermore, instead of using average annual soil C stock changes as in previous submissions the yearly values are reported to better reflect the impacts and annual variations due to weather conditions, litterfall and harvest residues. These improvements caused changes of the annual net removals for the whole time series of the *Forest land* category in the range of -16 477 to +7 513 kt CO_2e per year compared to the last submission in 2022.

4.B Cropland

The land-use changes between *Grassland* and *Cropland* are assessed by a changed method based on IACS/LPIS data since submission 2022, which was further improved for submission 2023. The land parcel numbers are no more available in the IACS/LPIS system, so the assessment for the whole time series was changed to a grid point survey by using the INSPIRE grid of 100 x 100 m to sample geographic land use information in IACS/LPIS. In addition, the LUC areas from *Forest land* to *Cropland* since 2009 and the increment, harvest and dead wood stock change values for LUC areas *Forest land* to *Cropland* for the whole time series were changed on basis of the new NFI 2016/21 results. These improvements had an impact on the emissions/removals of the *Cropland* category: The annual emissions/removals are in the range of -109 to -250 kt CO_2e per year different compared to the last submission in 2022.

4.C Grassland

The total *Grassland* area was adjusted for grasslands, which are no more agriculturally managed and as a consequence no more tracked by the IACS system, but do not lose their status as grasslands. The land-use changes between *Grassland* and *Cropland* are assessed since submission 2022 by a changed method based on IACS/LPIS data, which was further improved for submission 2023.The land parcel numbers are no more available in the IACS/LPIS system, so the assessment for the whole time series was changed to a grid point survey by using the INSPIRE grid of 100 x 100 m to sample geographic land use information in IACS/LPIS. In addition, the LUC areas from *Forest land* to *Grassland* since 2009 and the increment, harvest and dead wood stock change values for LUC areas *Forest land* to *Grassland* for the whole time series were changed on basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the *Grassland* category: The annual emissions are in the range of 25 to 190 kt CO_2e per year higher compared to the last submission in 2022.

4.D Wetlands

The LUC areas from *Forest land* to *Wetland* since 2009 and the increment, harvest and dead wood stock change values for LUC areas *Forest land* to *Wetland* for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the *Wetland* category: The annual emissions are in the range of 4 to 17 kt CO_2e per year higher compared to the last submission in 2022.

4.E Settlements

The land-use changes between *Grassland* and *Cropland* were assessed by a changed method based on IACS/LPIS data and the total *Grassland* area was adjusted for non-agriculturally used *grassland* (see above at the *Cropland* and *Grassland* categories). For area consistency in the LUC matrices, these LUC and area changes also had an impact on the LUC areas from *Cropland* and *Grassland* to *Settlements*. In addition, the LUC areas from *Forest land* to *Settlements* since 2009 and the increment, harvest and dead wood stock change values for LUC areas *Forest land* to *Settlements* for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the *Settlements* category: The annual emissions are in the range of 58 to 418 kt CO_2e per year higher compared to the last submission in 2022.

4.F Other land

The land-use changes between *Grassland* and *Cropland* were assessed by a changed method based on IACS/LPIS data and the total *Grassland* area was adjusted for non-agriculturally used grassland (see above at the *Cropland* and *Grassland* categories). For area consistency in the LUC matrices, these LUC and area changes also had an impact on the *Other land* category – LUCs from *Grassland* to *Other land* and related emission/removal estimates do not exist anymore, but the non-agriculturally used Grasslands are reported in the Grassland category. In addition, the LUC areas from *Forest land* to *Other land* since 2009 and the increment, harvest and dead wood stock change values for LUC areas *Forest land* to *Other land* for the whole time series were changed on the basis of the new NFI 2016/21 results. These improvements had an impact on the emissions of the *Other land* category: The annual emissions are in the range of -163 to +273 kt CO_2e per year different compared to the last submission in 2022.

4.G HWPs

The *HWP* production figures for the year 2020 were updated in the most recent FAO statistics. Consequently, the removal figures for this year had to be updated accordingly. The recalculations in the *HWP* category led to lower removals of this subcategory of 51 kt CO_2e for 2020.

10.1.5 Waste (Sector 5)

Update of activity data

5.A Solid Waste Disposal

Minor revisions are reported for category *5.A Solid Waste Disposal* for the years 2016-2020 (2020: -0.01 kt CO_2e) due to slightly revised input (disposal) data following more comprehensive QA/QC activities.

5.B Biological Treatment of Solid Waste

The reason for this revision is a new estimation of home composted waste amounts (part of *5.B.1 Composting*) developed in view of a future reporting obligation regarding home-composted quantities to the European Commission (In the future home composting is to be included in the AT recycling rate for municipal waste). A new method of estimation was developed[139], which provides a more plausible estimate compared to the method previously applied (based on a per capita volume derived from one analysis provided for a city in Austria). This change leads to lower emission for 2001-2020 (2020: -34 kt CO_2e)

5.C Incineration and Open Burning of Waste

Following a recommendation of the NEC Review 2022, emissions from the burning of residual wood from vinicultures on open fields (formerly reported under *3.F.5 Other*) have been reallocated to category *5.C.2.1.b Incineration and Open Burning of Waste – Other*. This reallocation results in higher emissions of CH_4 and N_2O in this category for the entire time series (2020: +0.51 kt CO_2e).

5.D Wastewater Treatment and Discharge

N_2O emissions from *5.D.2 Industrial Wastewater* were revised for 2019 and 2020 (2020: +0.9 kt CO_2e) as emissions for these years were calculated based on reported N-flow data (direct dischargers) instead of derived using production data. Only minor revisions were reported for CH4 (-0.0001 kt CO_2e) due to correction of a transcription error.

10.2 Implication for emission levels

As a result of the continuous improvement of Austria's GHG inventory, emissions of some sources have been recalculated on the basis of updated data or revised methodologies. Moreover, as al-

[139] Input for the 2023 Federal Waste Management Plan

ready noted under chapter 10, the Global Warming Potentials ('GWPs') according to the 5th Assessment Report ('AR5', IPCC 2014) were applied for the first time in this years' submission, resulting in revised CO_2-equivalent (CO_2e) data over the whole time series.

The effects of these changes are presented separately in the following sub-chapters.

10.2.1 Effect due to inventory improvements

Considering the recalculations of Austria's GHG emissions solely due to methodological improvements, total GHG emissions (excluding LULUCF) reported this year differ only slightly from the data reported in submission 2022.

National total emissions **1990** (without LULUCF) have hardly changed since last years' submission (+0.02 %; +16 kt CO_2e). The effect of inventory revisions to the **2020** national total emission amount (without LULUCF) is + 0.14% (+ 102 kt CO_2e) when excluding the effect of shifting from AR4 to AR5 GWPs in submission 2023.

Table 325 presents the recalculation differences of national total GHG emissions for all years.

Table 325: Recalculation Difference of National Total GHG Emissions.

	National Total GHG emissions without LULUCF			
	OLI 2022 (AR5)	OLI 2021 (AR5)*	Recalculation Difference	
	[kt CO_2e]	[kt CO_2e]	[kt CO_2e]	[%]
1990	79 047	79 031	16	0.02%
1995	79 953	79 925	28	0.04%
2000	80 619	80 566	53	0.07%
2005	92 589	92 488	101	0.11%
2010	84 693	84 556	137	0.16%
2011	82 506	82 370	136	0.16%
2012	79 788	79 659	129	0.16%
2013	80 229	80 105	123	0.15%
2014	76 663	76 535	128	0.17%
2015	78 884	78 771	113	0.14%
2016	79 821	79 732	89	0.11%
2017	82 132	82 057	76	0.09%
2018	78 854	78 798	56	0.07%
2019	79 994	79 962	32	0.04%
2020	73 911	73 809	102	0.14%

* *Note: In order to make a reasonable, technically correct comparison of this years' (submission 2023) with previous years' (submission 2022) data, it was necessary to analyze the recalculations on basis of national totals considering AR5 GWPs. For this reason, the results of the 2022 submission (OLI 2021) – originally converted to tonnes CO_2 equivalent by applying the GWPs according to AR4 – were converted to AR5 GWPs to allow for a discussion of recalculations purely due to methodological improvements.*

The following tables present the recalculation difference with respect to last years' submission for each gas and each sector (positive values indicate that this years' estimate is higher).

Table 326: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission by gas.

	1990 (Base year)	2020
	Recalculation Difference [kt CO_2e]	
Total	**+16**	**+102**
CO_2	+22	+84
CH_4	-5.1	-15
N_2O	-0.7	-22
HFC, PFC, SF_6, NF_3	0.00	+55

without emissions from LULUCF

CO_2 emissions for 2020 were revised upwards (+84 kt CO_2), whereas N_2O (-22 kt CO_2e) and CH_4 (-15 kt CO_2e) emissions were revised downwards. Emissions of fluorinated gases have been revised upwards by 55 kt CO_2e.

Recalculations of CH_4 and N_2O are largely attributable to revisions in sector *5 Waste*, category *5.B.1 Composting,* where volumes of home composted waste were re-estimated using a new method (balance approach) delivering more plausible results than previously reported. Emissions reported under *2.F.1 Refrigeration and Air Conditioning* (F gases) were revised due to more comprehensive research on stationary air conditioning leading to improvements in the Austrian refrigerant model.

Table 327: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission by sector

	OLI 2022 (AR5)		OLI 2021 (AR5)		Recalculation Difference	
THG	**1990**	**2020**	**1990**	**2020**	**1990**	**2020**
	[kt CO_2e]		**[kt CO_2e]**		**[kt CO_2e]**	
Total*	**79 047**	**73 911**	**79 031**	**73 809**	**16**	**102**
1. Energy	52 665	49 930	52 903	49 927	-238	3.2
2. IPPU	13 615	15 524	13 361	15 391	255	132
3. Agriculture	8 400	7 197	8 401	7 199	-1.3	-1.4
4. LULUCF	-12 207	-5 222	-12 077	-1 267	-130	-3 956
5. Waste	4 367	1 259	4 367	1 292	0.6	-32

**without emissions from LULUCF*

A description of all recalculations by each sector is given in Chapter 10.1 as well as the relevant sectoral methodological chapters. Recalculation differences at sub-category level for the time-series 1990-2020 are provided in Annex 8.

10.2.2 Effect of GWP change (AR5)

Table 328 shows the effect of the GWP ('global warming potentials') change from AR4 (IPCC 2007) to AR5 (IPCC 2014) for the latest inventory (2023 submission) over the whole time series.

Table 328: Effect of GWP switch from AR4 to AR5

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste	National Total*
			kt CO_2e			
1990	97	-209	282	-11	440	611
1995	51	-95	295	-12	401	652
2000	33	-126	272	-12	311	490
2005	13	-81	255	-12	280	467
2010	12	-68	263	-13	198	405
2011	8.5	-75	245	-13	182	360
2012	11	-79	245	-12	168	344
2013	9.0	-84	250	-12	153	328
2014	4.6	-90	241	-12	139	295
2015	3.5	-93	243	-12	127	281
2016	3.2	-92	234	-12	115	261
2017	6.1	-93	245	-12	106	264
2018	-2.1	-99	244	-12	97	239
2019	-4.4	-105	240	-12	90	221
2020	-2.3	-102	235	-11	83	214
2021	-1.6	-104	235	-11	77	206

* *without emissions from LULUCF*

The effect of the new GWPs (higher total GHG emissions over the time series) decreased from +611 kt in 1990 to +206 kt in 2021. This trend is mainly explained by decreasing CH_4 emissions from sectors Waste (-116 kt CH_4) and Agriculture (-31 kt CH_4) from 1990 to 2021. For more information refer to chapters 5 and 7.

The following table presents a comparison of the GWPs according to the '4th Assessment Report' (IPCC 2007) and the '5th Assessment Report' (IPCC 2014):

Table 329: GWPs according to AR5 und AR5

	GWP (AR4[140])	GWP (AR5[141])
CO_2	1	1
CH_4	25	28
N_2O	298	265
F Gases:		
SF_6	22 800	23 500
NF_3	17 200	16 100
HFCs	124 – 14 800	4 – 12 400
PFCs	7 390 – 12 200	6 630 – 11 100

[140] https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf (Table 2.14)

[141] https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf (Table 8.A.1)

10.3 Planned improvements, including in response to the review process, and planned improvements to the inventory

The Umweltbundesamt is responsible for the management of the improvement programme. It is supported by the QA/QC programme based on the international standard EN ISO/IEC 17020:2012.

The overall goal is to produce emission inventories which are fully consistent with the UNFCCC reporting guidelines and the IPCC 2006 Guidelines and achieve the quality objectives set. To meet this goal, an improvement programme has been established that is driven by the results of various review processes, as e.g. internal reviews and audits (see chapter 1.2.3), the review under the UNFCCC and/or under the Kyoto Protocol as well as other international and European reviews, e.g. under the European Union Monitoring Mechanism ("Effort Sharing Decision Review") or under CLRTAP. The Improvement programme requires the establishment of improvement plans set up and maintained for each sector as well as for general issues (incl. improvement of the Quality Management System), that are updated every year after the results from the UNFCCC review process become available and are carefully monitored.

10.3.1 Planned improvements

Source specific planned improvements are presented in the respective subchapters of Chapters 3–7. Planned improvements attributable to the previous UNFCCC Review 2020 are summarized below:

Table 330: Planned improvements made in response to the UNFCCC Review 2020

Finding	Reference*	Improvement planned	Chapter
1.B.2 Oil, natural gas and other emissions from energy production – oil and natural gas – CH_4: The Party reported in its NIR (p.187) that emissions from oil exploration (1.B.2.a.1) and natural gas exploration (1.B.2.1) are reported together under gas production (1.B.2.b.2). [...] The ERT recommends that Austria [...] make efforts to report the emissions for category 1.B.2 disaggregated into categories 1.B.2.a.i and 1.B.2.b.i.	ARR 2020 E.8	To increase the transparency it is planned to investigate on the possibility to disaggregate emissions data currently reported under category 1.B.2.b.2 into sub-categories 1.B.2.a.2 and 1.B.2.b.2.	Chapter 3.3.7

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10.3.2 Improvements made in response to the review process

In 2020 Austria was reviewed by the UNFCCC. Results of this review – conducted as a desk review – are published in an Annual Review Report (ARR)[142].

[142] UNFCCC – United Nations Framework Convention on Climate Change (2021): Report on the individual review of the annual submission of Austria submitted in 2020. FCCC/ARR/2020. https://unfccc.int/documents/271316

Table 331: Improvements made in response to the UNFCCC Review.

Finding	Reference*	Improvement made	Chapter
General			
General QA/QC and verification –Convention reporting adherence, QA/QC and verification - Adherence to the UNFCCC Annex I inventory reporting guidelines: Enhance the QC practices, or the application of the existing practices, in order to ensure consistency between the NIR and the CRF tables, in particular: (a) key categories reported in CRF table 7 and the NIR; (b) reporting of 2.F in NIR table 105 and CRF table 10 for 1990 and 1991; (c) PFC emissions trend between NIR and CRF table 10; (d) emission trends for 2.B Chemical industry between NIR and CRF table 10. However, the ERT noted that the inconsistencies (b) and (c) are not yet addressed. For (b), the Party reported emissions for category 2.F for 1992 as "NO" in NIR table 122, while an estimate (0.02 kt CO_2 eq) was reported in CRF table 10s1. For (c), the Party reported in the NIR (p.204) that PFC emissions decreased from 1 183 kt CO_2 eq in 1990 to 44 kt CO_2 eq in 1993. The Party reported the same value for 1990 in CRF table 10s5, but it reported 63.52 kt CO_2 eq for 1993.	ARR 2020 G.1	The inconsistencies (NIR - CRF) detected in the NIR 2020 were adressed as follows: b) reporting on 2.F for 1992 is now corrected and consistent between NIR and CRF Table 10s1 c) reporting on PFC emissions increase 1990-1993 is now corrected and consistent between NIR and CRF Table 10s5	b) Chapter 4.1.1 (Table 144) c) Chapter 4.1.1
General – Uncertainty analysis: The Party did not include in the NIR an uncertainty analysis for its base year under the Convention (1990). […] The ERT recommends that Austria include in the NIR an uncertainty analysis for its base year under the Convention (1990).	ARR 2020 G.3	An uncertainty for the base year 1990 is now included in the NIR.	Chapter 2.4 Annex 2

Finding	Reference*	Improvement made	Chapter
General – Other: According to NIR chapter 9, Austria does not report indirect emission in CRF table 6 and the only indirect CO_2 emissions reported in the inventory are reported for subcategory solvent use under category 2.D.3 other (non-energy products from fuels and solvent use). The ERT noted that indirect CO_2 emissions for the IPPU sector were also reported as "IE" in CRF table 6. However, indirect CO_2 emissions from the energy sector were also reported as "IE" in the same table. […] The ERT recommends that the Party update the reporting of indirect CO_2 emissions from the energy sector in CRF table 6 by using the correct notation keys in accordance with para 37 of the UNFCCC Annex I inventory reporting guidelines. The ERT also recommends that Austria update the information about indirect CO_2 emissions from the energy sector in NIR chapter 9, including revising the statement that only indirect CO_2 emissions from solvents (IPPU sector) were reported in the inventory. The ERT further recommends that the Party present the national totals with and without indirect CO_2 in the CRF tables and in the NIR, in accordance with paragraph 29 of the UNFCCC Annex I inventory reporting guidelines.	ARR 2020 G.4	Information about indirect CO_2 emissions from the energy sector is now more clearly provided in the NIR and the notation key corrected in the CRF. In the CRF national totals with indirect CO_2 are automatically shown as "NA" as no indirect CO_2 are provided.	CRF Table 6 Chapter 9
Energy			
1.A.3.a Civil aviation – jet kerosene – CO_2, CH_4 and N_2O: In its NIR (p.129), Austria explained that it used two different methodologies to estimate CO_2, CH_4 and N_2O emissions from IFR flights (i.e. cruise and LTO): a country-specific methodology consistent with IPCC tier 3b for 1990–1999 and a tier 3a methodology for 2000 onward. The ERT noted that the use of different methods within the time series may imply time-series consistency issues. According to the 2006 IPCC Guidelines (vol. 1, chap. 5.3.3.1), when new inventory methods become available, splicing techniques such as overlap should be applied. During the review Austria confirmed its use of two different methodologies to estimate emissions from IFR flights and indicated that it will apply the splicing techniques in the next submission to ensure time-series consistency.	ARR 2020 E.5	From submission 2021 onwards, Austria has applied the Tier 3A methodology for 2000 onwards and a trend extrapolation (as described in the IPCC 2006 GL volume 1 chapter 5.3.3) for 1990-1999. Due to the lack of consistent data for 1990-1999 Austria was not able to use overlap or surrogate techniques. For more details please refer to the sectoral chapter.	Chapter 3.2.13.1

Finding	Reference*	Improvement made	Chapter
1.A.3.e.ii Other (other transportation) – CO_2, CH_4 and N_2O: The ERT considers that the emissions from airport ground activities should be reported under category 1.A.3.e.ii (off-road transportation) in accordance with the 2006 IPCC Guidelines that form part of the UNFCCC Annex I inventory reporting guidelines. During the review Austria indicated that all emissions from national flights are reported under category 1.A.3.a. This includes cruise and LTO emissions. LTO emissions incorporate all taxi-in and taxi-out emissions from aircraft, including auxiliary power units. Emissions from all other ground activities in airports, including buses and tankers, are reported under category 1.A.3.b. The ERT recommends that Austria report emissions from ground activities in airports under category 1.A.3.e.ii. in line with the 2006 IPCC Guidelines (vol. 2, chap. 3.3, table 3.1.1).	ARR 2020 E.6	Austria has investigated the possibility to separate emissions from airport ground activities and now reports it under category 1.A.3.e.ii.	Chapter 3.2.13.6 CRF Table1.A(a)s3
1.A.5.b Mobile – liquid fuels – CO_2, CH_4 and N_2O: In its NIR (p.177), Austria explained that from 2000 onward, the fuel combustion for military aviation activities was estimated using linear extrapolation. The ERT noted that the 2006 IPCC Guidelines (vol. 1, chap. 5.3.3.4) mention that this method should not be used over long periods of time without checks to confirm the validity of the trend. The ERT considers that 2000–2018 is a long period of time and that Austria has not confirmed the validity of the trend. The ERT noted that although the methodology used for estimating emissions from military aviation during 2000–2018 might appear to be sound because the validity of the trend was confirmed during the review, in view of the Party's acknowledgement of the increase in the military aviation fleet the ERT recommends that the Party makes effort to improve the accuracy of the estimates by developing a more efficient cooperation with the Austrian Ministry of Defence to resolve confidentiality issues. If the Party continues using linear extrapolation for the estimates, the ERT recommends that it demonstrate the validity of the trend in the NIR.	ARR 2020 E.7	The Austrian Ministry of Defence has been contacted in 2021. Further activities to establish a cooperation were set in 2022. For submission 2022 the methodology applied for estimating emissions from military aviation 2000–2018 was re-evaluated.	Chapter 3.2.15

Finding	Reference*	Improvement made	Chapter
1.B.2 Oil, natural gas and other emissions from energy production – oil and natural gas – CH_4: The Party reported in its NIR (p.187) that emissions from oil exploration (1.B.2.a.1) and natural gas exploration (1.B.2.1) are reported together under gas production (1.B.2.b.2). […] The ERT recommends that Austria explain in the NIR that 59 per cent of CH_4 emissions for category 1.B.2.b were estimated using a tier 2 method and make efforts to report the emissions for category 1.B.2 disaggregated into categories 1.B.2.a.i and 1.B.2.b.i.	ARR 2020 E.8	Information on the share of CH_4 for category 1.B.2.b estimated using a tier 2 method is now included in the NIR. To increase transparency it is planned to investigate on the possibility to disaggregate emissions data currently reported under category 1.B.2.b.2 into sub-categories 1.B.2.a.2 and 1.B.2.b.2.	Chapter 3.3.3.2 Chapter 3.3.7 planned improvement
1.B.2.c Venting and flaring (flaring, gas) – natural gas – CO_2: Austria reported in its NIR (pp.191 and 193) that natural gas production occurs in the only refinery in the country and that all emissions from combustion in the refinery, including flaring, are included in category 1.A.1.b (petroleum refining) and not in 1.B.2.c (venting and flaring). […] The ERT recommends that Austria include in the NIR the explanation provided during the review related to the reporting of CO_2 emissions from gas flaring in category 1.A.1.b (petroleum refining) instead of category 1.B.2.c.2.ii (flaring (gas)) and provide in the NIR the specific basis, including the legal basis, for designating that information as confidential.	ARR 2020 E.9	An explanation on the reporting of CO_2 from flaring, including information on the legal basis (regarding confidentiality), is now included.	Chapter 3.3.3.2

Finding	Reference*	Improvement made	Chapter
IPPU			
2.A.2 Lime production – CO_2: Austria reported in its NIR (chap. 4.2.2.2, p.220) that non-marketed lime production in the chemical industry is reported under category 2.A.3 (glass production). The Party also reported that CO_2 emissions from the lime production step in calcium carbide production are included in category 2.B.4. Austria stated in the NIR that the only identified non-marketed lime production in Austria is in calcium carbide production and sugar production. The ERT noted that CO_2 emissions from lime production in sugar production are reported under category 2.A.2 but could not identify in category 2.A.3 information on non-marketed lime in the chemical industry. The ERT also noted that for category 2.B.4, Austria reported production of caprolactam, glyoxal and glyoxylic acid as "NO" (CRF table 2(I)s1). The ERT also noted that the IPCC 2006 Guidelines (vol. 3, chap. 2, p.2.20) indicate all lime production, whether produced as a marketed or a non-marketed product, should be reported under category 2.A.2 lime production. […] The ERT recommends that the Party report all lime production, whether produced as a marketed or a non-marketed product, under category 2.A.2 lime production.	ARR 2020 I.6	The text in the NIR was adapted accordingly to clearly inform that all lime production, whether produced as marketed or non-marketed product is reported under category 2.A.2.	Chapter 4.2.2.2
2.B.1 Ammonia production – CO_2: Ammonia production has been identified as a key category in the Austrian GHG inventory. The Party reported in its NIR (p.230) that ammonia is produced by catalytic steam reforming of natural gas in one plant, which includes the downstream processes. The Party reported that the CO_2 recovered from ammonia production is included in urea production and fertilizer production and stored in melamine (see ID# I.2 in table 3). The total CO_2 recovered is reported in NIR table 134 and CRF table 2(I).A-Hs1. The ERT noted, however, that the Party presented the CO_2 estimation methodology in its NIR for the production of fertilizers and urea (chap. 4.3.7.2, p.242) while for carbon stored in melamine information is provided only to justify that the carbon is stored in melamine (p.233). […] The ERT recommends that the Party describe in its NIR the methodology it uses to estimate CO_2 recovered by incorporating carbon in melamine.	ARR 2020 I.7	An explanation on the methodology used to estimate CO_2 recovered by incorporating carbon in melamine is included in the NIR.	Chapter 4.3.1.2

Finding	Reference*	Improvement made	Chapter
2.C.1 Iron and steel production – CH_4: The ERT noted that Austria did not include information in its NIR on CH_4 emissions from iron and steel production under category 2.C.1. Under this category, the Party reported CH_4 emissions from steel and pig iron production as "IE" and from sinter production as "NO" in CRF table 2(I).A-Hs2. The ERT also noted that in its description of category 1.A.2.a in the NIR Austria reported estimates for CH4 emissions from steel and pig iron (NIR table 44, p.112) and specified the methodology (tier 1) (NIR p.110). The ERT also noted that in NIR table 138 (chap. 4.4.1.2, p.246) on AD, IEF and emissions for category 2.C.1, the title includes CH4 emissions but those are not presented in the table. […] The ERT recommends that the Party report CH_4 emissions from iron and steel production, including sintering and pig iron production under category 2.C.1 (or the category where those emissions are reported) for the entire data series using a methodology consistent with the decision tree in the 2006 IPCC Guidelines (vol. 3, chap. 4, figure 4.8). […]. Alternatively, if the Party considers these emissions as insignificant, the ERT recommends that the Party report them as "NE" and demonstrate that the likely level of emissions is below the significance threshold mentioned in paragraph 37 of the UNFCCC Annex I inventory reporting guidelines.	ARR 2020 I.9	CH_4 from 2.C.1.a Steel is reported as "NA" indicating that no EF is provided in the IPCC 2006 GL (implemented in submission 2021 for the first time) CH_4 from 2.C.1.b Pig iron - sinter production is estimated using plant specific data (reported in submission 2022 for the first time). Title of table (chapter 4.4.1.2) was corrected as recommended.	Chapter 4.1.7 (Completeness), Table 147 Chapter 4.4.1.2, Table 159

Finding	Reference*	Improvement made	Chapter
2.C.4 Magnesium production – SF_6: The Party reported in its NIR (table 123, p.208) that category 2.C.4 represents SF_6 used in aluminium and magnesium foundries and identified it as a key category. Austria also estimated the uncertainty for the AD, EFs and SF_6 emissions for the same category (i.e. SF_6 from aluminium and magnesium foundries) (table 124, p.209). However, the ERT noted that the UNFCCC Annex I inventory reporting guidelines names category 2.C.4 as magnesium production and that the 2006 IPCC Guidelines (vol. 1, table 8.2) indicate that this category includes GHG emissions from both primary magnesium production and oxidation protection of magnesium metal during processing (recycling and casting), excluding those emissions relating to fuel use. The ERT also noted that in the NIR (chap. 4.4.4, p.251), the description of category 2.C.4 indicates that only SF_6 emissions from magnesium foundries are included in this category. […] The ERT recommends that the Party correct the NIR tables 123 (on key categories in the IPPU sector) and 124 (on uncertainty analysis for the IPPU sector) by including the information that only SF_6 emissions from magnesium foundries are reported in category 2.C.4.	ARR 2020 I.10	NIR tables on key categories and uncertainty analysis in the IPPU chapter were corrected, so that under category 2.C.4 only SF_6 from magnesium foundries is reported, whereas SF_6 from aluminium foundries is covered under 2.C.3.	Chapter 4.1.2 (Table 145) Chapter 4.1.4 (Table 146)
2.C.7 Other (metal industry) – SF_6: Austria reported the uncertainty assessment of AD, EFs and SF6 emissions for category 2.C.7 in its NIR (chap. 4.1.4, table 124, p.209). However, the ERT noted that Austria reported AD and SF_6 emissions from this category as blank in CRF tables 2(II) and 2(II)B-Hs1. During the review, the Party clarified that SF_6 emissions from metal production were reallocated from category 2.C.7 to category 2.C.3 (see ID# I.5 above) but NIR table 124 has not yet been updated. It indicated that this will be corrected in its next submission. The ERT recommends that Austria corrects NIR table 124 on the uncertainty analysis for the IPPU sector by deleting the uncertainty values for AD, EFs and SF_6 emissions for this category.	ARR 2020 I.11	The NIR Table on the uncertainty assessment for the IPPU sector was corrected accordingly.	Chapter 4.1.4 (Table 146)

Finding	Reference*	Improvement made	Chapter
LULUCF			
4.A.1 Forest land remaining forest land – CO_2: Recommendation made in previous review report: Provide estimates of the carbon stock changes for forests not in yield when the new NFI data become available and use the correct notation key. **Addressing**. Austria has not provided estimates but reported carbon stock changes in living biomass for forests not in yield as "NE", in accordance with the recommendation from the previous reviews, pending availability of the new data. NIR (section 6.1.8, p. 387) explains that a new NFI started in 2016 and it will provide estimates for the forest not in yield.	ARR 2020 L2	The monitoring of the NFI 2016/21 was completed, the estimates of the biomass and dead wood stock changes of these forests were included in submission 2023.	Chapter 6
4.A.1 Forest land remaining forest land – CO_2: Recommendation made in previous review report: Provide estimates of the carbon stock changes in mineral soils for forests not in yield using the best available data. Alternatively, use the appropriate notation key and provide information justifying its use in the annual submission. **Addressing**. Austria again reported carbon stock changes in mineral soils for forests not in yield as "NE" in CRF table 4.A. Information justifying the notation key is not provided in CRF table 4.A and CRF table 9.	ARR 2020 L3	The monitoring of the NFI 2016/21 was completed, modelled estimates of the mineral soil and litter stock changes of these forests were carried out and indicate a steady increase of these stocks. Due to a lack of measured validation data for the soils of these forests, a conservative approach of reporting no carbon stock changes in these soils was chosen for submission 2023.	Chapter 6
WASTE			
5. General (waste) – CO_2, CH_4 and N_2O – Transparency: […] Addressing. The Party reported a mass balance of solid waste in NIR figure 38, equivalent to figure 40 in the 2018 NIR. According to the NIR (table 300) the updated figure specifies that rotting losses (i.e. emission to air) are not included. However, the ERT noted that the issue is not fully resolved because the mass flow still does not sum across the parts: (a) The value reported for mechanical and mechanical-biological treatment (0.52 Mt) does not match the sum of its parts (0.45 Mt), the sum of thermal treatment (0.34 Mt), recycling (0.03 Mt) and landfilled residues (0.08 Mt). […]; (b) Waste collected separately (2.6 Mt) does not match the sum of its parts (2.655 Mt, or 2.7 Mt; hazardous waste, biogenic waste, sorting residues and recyclable material). During the review, the Party indicated that this error will be resolved in the 2021 submission.	ARR 2020 W.1	An updated and quality-checked figure on the "Treatment and disposal routes 2020" is now included in the NIR.	Chapter 7.2 Figure 49

Finding	Reference*	Improvement made	Chapter
5.B.1 Composting – CH_4 and N_2O: The Party reported the country-specific CH_4 and N_2O EFs for mechanical-biological treatment and composting waste in NIR table 285 (p.498) that are used for the estimates for category 5.B.1 (composting). The EFs are provided separately for CH_4 and N_2O in kg/t FS. However, the ERT could not identify the definition of "FS" and could not follow how the values for CH_4 EFs reported in the NIR (0.6 kg/t FS for mechanical-biological treatment and 0.75 kg/t FS for composting) are combined into the CH_4 IEF for category 5.B.1 reported in CRF table 5.B (1.83 g/kg waste; no recovery, no flaring); or how the N_2O EF reported in the NIR (0.1 kg/t FS) is converted into the N_2O IEF reported for category 5.B.1 in CRF table 5.B (0.25 g/kg waste). [...] The ERT recommends that the Party describe in more detail in the NIR its mechanical-biological and composting treatment of waste and how the data and EFs presented in the NIR relate to the data and IEFs reported in CRF table 5.B.	ARR 2020 W.2	An explanation, including the conversion factor for dry matter, is included in the NIR.	Chapter 7.3.2.4

Finding	Reference*	Improvement made	Chapter
5.B.2 Anaerobic digestion at biogas facilities – N_2O: The Party reported N_2O emissions for category 5.B.2 as "NA" in NIR table 276 (p.480) with a footnote explaining that these emissions are negligible. However, those emissions were reported as "NO, NA" in CRF tables 5 and 5.B. [...] The ERT recommends that the Party report N_2O emissions for category 5.B.2 as "NE" in CRF tables 5 and 5.B and the NIR, consistent with the UNFCCC Annex I inventory reporting guidelines (para. 37(b)), and justify its reporting by explaining that the 2006 IPCC Guidelines (vol. 5) (1) do not include a default EF and (2) indicate that N_2O emissions from anaerobic digestion of organic waste are assumed to be negligible (vol. 5, p.4.4 and table 4.1).	ARR 2020 W.3	An explanation of the notation key applied for reporting on N_2O from sub-category 5.B.2 Anaerobic digestion at biogas facilities - Municipal Solid Waste is included in the NIR, including an indication that the 2006 IPCC Guidelines (vol. 5) (1) do not include a default EF and (2) N_2O emissions from anaerobic digestion of organic waste are assumed to be negligible (vol. 5, p.4.4 and table 4.1). The UNFCCC Annex I inventory reporting guidelines, in a footnote to subparagraph 11(e), indicate that "NE" **could also be used** when an activity occurs in the Party but the 2006 IPCC Guidelines do not provide methodologies to estimate the emissions. For reasons of comparability between the reports of the EU Member States, however, Austria remained with the notation key "NA". Additionally, as currently no IPCC calculation method is available, it is not possible for Austria to check whether potential emissions (additional to the UNFCCC requirements) are significant as required for the reporting of NE. Remark: The "NO" reported additionally throughout the time series in CRF Table 5 refers to 5.B.2 Anaerobic digestion at biogas facilities - "Other (please specify)".	CRF table 5 CRF table 5.B Chapter 7.3.2.2

Finding	Reference*	Improvement made	Chapter
5.C.1 Waste incineration – CO_2, CH_4 and N_2O: The Party reported that the incinerated waste consists of municipal, clinical and waste oil fractions (NIR chap. 7.4.2.1, p.501). However, CRF table 5.C indicates that only municipal waste is incinerated, and reports other wastes as "NO". The ERT noted that as the Party has the corresponding fractions of incinerated waste (municipal, clinical and waste oil), the use of the category other for estimating emissions from clinical waste and waste oil would be more appropriate. The ERT recommends that the Party report emissions from the incineration of clinical waste and waste oil separately from the emissions from municipal waste incineration.	ARR 2020 W.4	Emissions from the incineration of clinical waste and waste oil is now reported separately from the emissions from municipal waste incineration in CRF Table 5.C from 2022 submission onwards.	Chapter 7.4.1 CRF Table 5.C
5.D.1 Domestic wastewater – CH_4: The Party reported that the CH_4 produced in the course of anaerobic treatment at wastewater treatment plants is recovered and used in the combined heat and power generation systems, and is flared in the case of overload or technical disruptions (NIR chap. 7.5.2.1, p.506). However, both flared and recovered CH_4 from domestic wastewater are reported as "NA" in CRF table 5.D. […] The ERT recommends that the Party provide consistent information in CRF table 5.D and the NIR (either estimates or the correct notation key for the recovered and flared CH_4 from domestic wastewater).	ARR 2020 W.5	The "NA" reported under 5.D.1 only refers to the emission source "cesspools" where no recovery takes place.	CRF Table 5.D Chapter 7.5.2.1
5.D.2 Industrial wastewater – CH_4: The Party reported in its NIR (chap. 7.1.4, p.481, and chap. 7.5.2.2, p.512) that the country-specific CH_4 EF for CH_4 emissions from industrial wastewater plants is based on the assumption that only 1 per cent of the CH_4 generated in the anaerobic treatment is emitted. […] The ERT recommends that the Party review the assumption of the chosen coefficient (1 per cent) for all the industrial wastewater plants […] and improve transparency of reporting by more clearly specifying scope and results of the survey (Umweltbundesamt 2019).	ARR 2020 W.6	More details on the scope of the study (Umweltbundesamt 2019) as well as on the assumption that 1% of CH_4 generated during anaerobic treatment of wastewater is emitted is included in the NIR.	Chapter 7.5.2.2

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11 ABBREVIATIONS

General

AMA.................................. Agrarmarkt Austria

AECM................................ Agri-environment-climate Measures

BAWP .... Bundes-Abfallwirtschaftsplan
Federal Waste Management Plan

BFW.................................. Bundesamt und Forschungszentrum für Wald
Austrian Federal Office and Research Centre for Forest

BMK.................................. Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation & Technologie;
Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology) (formerly BMNT)

BMLFUW........................... Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft;
Federal Ministry of Agriculture, Forestry, Environment and Water Management

BMLRT............................... Bundesministerium für Landwirtschaft, Regionen und Tourismus;
Federal Ministry of Agriculture, Regions and Tourism (formerly BMNT)

BML .... Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft. Federal Ministry of Agriculture, Forestry, Regions and Water Management (formerly BMLRT)

BMNT .... Bundesministerium für Nachhaltigkeit und Tourismus;
Federal Ministry for Sustainability and Tourism (formerly BMLFUW)

BMUJF .... Bundesministerium für Umwelt, Jugend und Familie;
Federal Ministry for Environment, Youth and Family (before 2000)

BMWA .... Bundesministerium für Wirtschaft und Arbeit
Federal Ministry for Economic Affairs and Labour (renamed as BMWFJ)

BMWFJ .... Bundesministerium für Wirtschaft, Familie und Jugend
Federal Ministry of Economy, Family and Youth (formerly BMWA)

BUWAL.............................. Bundesamt für Umwelt, Wald und Landschaft, Bern
The Swiss Agency for the Environment, Forests and Landscape (SAEFL), Bern

CAN .... Calcium Ammonium Nitrate (Fertilizer)

COP .... Conference of the Parties

CORINAIR .... Core Inventory Air

CORINE .... Coordination d´information Environmentale

CRF .... Common Reporting Format

DKDB.................................. Dampfkesseldatenbank
Austrian annual steam boiler inventory

DOC.................................... Degradable Organic Carbon

EC .... European Community

EDM.................................... Electronic Data Management

EEA .... European Environment Agency

EF.. Emission Factor

EFTA .... European Free Trade Association

EIONET............................... European Environment Information and Observation NETwork

EMEP .... Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

EMREG .... Electronic Emission Register of Surface Water Bodies

EN....................................... European Norm

EPER................................... European Pollutant Emission Register

ETC/AE .... European Topic Centre on Air Emissions

EU....................................... European Union

ERT .... Expert Review Team (in context of the UNFCCC review process)

EZG..................................... Emissionszertifikategesetz

FAME.................................. Fatty Acid Methyl Ester (Fettsäuremethylester, Biodiesel)

FAO .... Food and Agricultural Organisation of the United Nations

FMRL .... Forest Management Reference Level

GHG .... Greenhouse Gas

GLOBEMI .... Globale Modellbildung für Emissions- und Verbrauchsszenarien im Verkehrssektor
(Global Modelling for Emission- and Fuel consumption Scenarios of the Transport Sector) see (HAUSBERGER 1998)

GPG.................................... Good Practice Guidance

GWP .... Global Warming Potential

HDV.................................... Heavy Duty Vehicle

IPCC.................................... Intergovernmental Panel on Climate Change

ICR...................................... In-Country Review (by the UNFCCC)

IEA .... International Energy Agency

ISO..................................... International Standards Organisation

LDV.................................... Light Duty Vehicle

LTO.................................... Landing/Take-Off cycle

LULUCF............................. Land Use, Land-Use Change and Forestry – IPCC-CRF Category 4

MMS.................................. Manure Management System

NACE .... Nomenclature des activites economiques de la Communaute Europeenne

NAPFUE .... Nomenclature for Air Pollution Fuels

ND .... Natural Disturbances

NEMO .... Network Emission Model

NFI..................................... National Forest Inventory

NFR.................................... Nomenclature for Reporting (Format of Reporting under the UNECE/CLRTAP Convention)

NISA .... National Inventory System Austria

NPK .... Nitrogen (N) Phosphorus (P) and Potassium (K) (Fertilizer)

NRMM............................... Non-Road Mobile Machinery

OECD................................. Organisation for Economic Co-operation and Development

OLI..................................... Österreichische Luftschadstoff Inventur / Austrian Air Emission Inventory

OMV .... Österreichische Mineralölverwaltung / Austrian Mineraloil Company

PC .... Passenger cars

PPSR.................................. Previous Period Surplus Reserve

PHARE............................... Phare is the acronym of the Programme's original name: '**P**oland and **H**ungary: **A**ction for the **R**estructuring of the **E**conomy'. It covers now 14 partner countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, the Former Yugoslav Republic of Macedonia (FYROM), Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. (However, Croatia was suspended from the Phare Programme in July 1995.)

PRTR.................................. Pollutant Release and Transfer Register

QA/QC............................... Quality Assurance/Quality Control

QMS .... Quality Management System

RWA................................... Raiffeisen Ware Austria (see www.rwa.at)

SNAP .... Selected Nomenclature on Air Pollutants

SWDS .... Solid Waste Disposal Sites

TERT .... Technical Expert Review Team (under the EU Monitoring Mechanism)

UNECE/CLRTAP .... United Nations Economic Commission for Europe,
Convention on Long-range Transboundary Air Pollution

UNFCCC .... United Nations Framework Convention on Climate Change

Notation Keys

According to the revised UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (FCCC/CP/2013/10/Add.32002/8, Decission 24/CP.19)

"NO" (not occurring)	for categories or processes, including recovery, under a particular source or sink category that do not occur within a Party;
"NE" (not estimated)	for AD and/or emissions by sources and removals by sinks of GHGs which have not been estimated but for which a corresponding activity may occur within a Party. Where "NE" is used in an inventory to report emissions or removals of CO_2, N_2O, CH_4, HFCs, PFCs, SF_6 and NF_3 the Party shall indicate in both the NIR and the CRF completeness table why emissions or removals have not been estimated. Furthermore the Party should provide justifications for exclusion in terms of the likely level of emissions
"NA" (not applicable)	for activities under a given source/sink category that do occur within the Party but do not result in emissions or removals of a specific gas. If the cells for categories in the CRF tables for which "NA" is applicable are shaded, they do not need to be filled in.
"IE" (included elsewhere)	for emissions by sources and removals by sinks of GHGs estimated but included elsewhere in the inventory instead of the expected source/sink category. Where "IE" is used in an inventory, the Annex I Party should indicate, in the CRF completeness table, where in the inventory the emissions or removals from the displaced source/sink category have been included, and the Annex I Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality.
"C" (confidential)	for emissions by sources and removals by sinks of GHGs which the reporting could lead to the disclosure of confidential information, given the provisions of paragraph 27 of above

Chemical Symbols

Greenhouse gases

CH_4 .... Methane

CO_2 .... Carbon Dioxide

N_2O .... Nitrous Oxide

HFCs .... Hydroflurocarbons

PFCs .... Perfluorocarbons

SF_6 .... Sulphur hexafluoride

NF_3 .... Nitrogen trifluoride

Further chemical compounds

CO .... Carbon Monoxide

Cd .... Cadmium

NH_3 .... Ammonia

Hg .... Mercury

NO_x .... Nitrogen Oxides (NO plus NO_2)

NO_2 .... Nitrogen Dioxide

NMVOC .... Non-Methane Volatile Organic Compounds

PAH .... Polycyclic Aromatic Hydrocarbons

Pb .... Lead

POP .... Persistent Organic Pollutants

SO_2 .... Sulfur Dioxide

SO_x .... Sulfur Oxides

Units and Metric Symbols

UNIT	Name	Unit for
g	gram	mass
t	ton	mass
W	watt	power
J	joule	calorific value
m	meter	length

Mass Unit Conversion		
1g		
1kg	= 1 000 g	
1t	= 1 000 kg	= 1 Mg
1kt	= 1 000 t	= 1 Kt
1Mt	= 1 Mio t	= 1 Tg

Metric Symbol	Prefix	Factor
P	peta	10^{15}
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
h	hecto	10^{2}
da	deca	10^{1}
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}

12 REFERENCES

ABFALLWIRTSCHAFT (2003): Artikel „Situation der Monoverbrenner, E.H.Reil, Fernwärme Wien“ aus „Abfallwirtschaft und Klimaschutz, Umweltbundesamt, Oktober 2003, Wien“.

AGENCY FOR RENEWABLE RESOURCES (2021): https://biogas.fnr.de/daten-und-fakten/faustzahlen accessed in November 2021

AMA (2021): Fettgehalt und Eiweißgehalt der Anlieferungsmilch ab 1991: https://www.ama.at/marktinformationen/milch-und-milchprodukte/rohmilchqualitaet, accessed in November 2022.

AMA (2022): Auswertung zum Mineraldüngerverbrauch in Österreich für 2015, 2016, 2017, 2018, 2019, 2020 und 2021. Agrarmarkt Austria. September 2022.

AMLINGER (2003): information from Dipl.Ing. Florian Amlinger – Compost Consulting & Development, Hochbergstrasse A-2380 Perchtoldsdorf.

AMLINGER, F.; PEYR, S.; HILDEBRANDT, U.; MÜSKEN, J.; CUHLS, C. & CLEMENS, J. (2005): Stand der Technik der Kompostierung. Grundlagenstudie. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. http://www.umweltnet.at/article/articleview/30919/1/6954

AMON, B. & HÖRTENHUBER, S. (2008): Revision der österreichischen Luftschadstoff-Inventur (OLI) für NH_3, NMVOC und NO_x; Sektor 4, Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien. (unpublished)

AMON, B. & HÖRTENHUBER, S. (2010): Revision of Austria's National Greenhouse Gas Inventory, Sector Agriculture. Final Report. Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU), study on behalf of Umweltbundesamt GmbH. Wien. (unpublished)

AMON, B. & HÖRTENHUBER, S. (2014):Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien 2014 (unveröffentlicht).

AMON, B. & HÖRTENHUBER, S. (2019): Implementierung der TIHALO II Ergebnisse sowie des EMEP/EEA Guidebooks 2016 in das Landwirtschafts-Emissionsmodell für die OLI 2018. Endbericht. Priv. Doz. Dr. nat. techn. Barbara Amon und Dr. nat. techn. Stefan Hörtenhuber (Forschungsinstitut für Biologischen Landbau FiBL) im Auftrag vom Umweltbundesamt. Wien 2019 (unveröffentlicht).

AMON, B.; FRÖHLICH, M.; WEIßENSTEINER, R; ZABLATNIK, B. & AMON, T. (2007): Tierhaltung und Wirtschaftsdüngermanagement in Österreich. Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft, Wien.

AMON, B.; HOPFNER- SIXT, K. & AMON, T. (2002): Emission Inventory for the Agricultural Sector in Austria – Manure Management, Institute of Agricultural, Environmental and Energy Engineering (BOKU – University of Agriculture, Vienna), July 2002.

AMON, B.; KRYVORUCHKO, V. & AMON, T. (2006): Influence of different levels of covering on greenhouse gas and ammonia emissions from slurry stores. International Congress Series (ICS) No 1293 “2nd International Conference on Greenhouse Gases and Animal Agriculture.

AMON, B.; KRYVORUCHKO, V.; FRÖHLICH, M.; AMON, T.; PÖLLINGER, A.; MÖSENBACHER, I. & HAUSLEITNER, A. (2007a). Ammonia and greenhouse gas emissions from a straw flow system for fattening pigs: Housing and manure storage. Livestock Science 112, 199–207.

AMON, B.; MOITZI, G.; SCHIMPL, M.; KRYVORUCHKO, V. & WAGNER-ALT, C. (2002a): Methane, Nitrous Oxide and Ammonia Emissions from Management of Liquid Manures. Final Report November 2002. Research project no. 1107, BMLF GZ 24.002/24-IIA1a/98 and extension GZ 24.002/33-IIA1a/00. On behalf of Federal Ministry of Agriculture, Forestry, Environment and Water Management, and Federal Ministry for Education, Science and Culture. Vienna.

AMON, B. (2010): expert judgement, personal communication. Vienna.

AMON, T. (2011): expert judgement, personal communication. Vienna.

AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG (1996): Bodenzustandsinventur Burgenland. Amt der Burgenländischen Landesregierung, Eisenstadt.

AMT DER KÄRNTNER LANDESREGIERUNG (1999): Kärntner Bodenzustandsinventur. Amt der Kärntner Landesregierung, Klagenfurt.

AMT DER NIEDERÖSTERREICHISCHEN LANDESREGIERUNG (1994): Bodenzustandsinventur Niederösterreich. Amt der Niederösterreichischen Landesregierung, St. Pölten.

AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG (1993): Oberösterreichischer Bodenkataster – Bodenzustandsinventur 1993. Amt der Oberösterreichischen Landesregierung, Linz.

AMT DER SALZBURGER LANDESREGIERUNG (1993): Salzburger Bodenzustandsinventur. Amt der Salzburger Landesregierung, Salzburg.

AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG (1988–1996): Steiermärkische Bodenschutzberichte 1988–1996. Amt der Steiermärkischen Landesregierung, Graz.

AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG (2021): Sonderauswertung der Heizungs-Datenbank. Abteilung 15 Energie, Wohnbau, Technik FA Energie und Wohnbau. Stand: 1.Quartal 2021.

AMT DER TIROLER LANDESREGIERUNG (1988): Bericht über den Zustand der Tiroler Böden. Amt der Tiroler Landesregierung, Innsbruck.

AMT DER VORARLBERGER LANDESREGIERUNG (2021): Sonderauswertung der Altersverteilung von Öl- und Gaskesseln aus Messperiode 2016-2018. Abteilung Allgemeine Wirtschaftsangelegenheiten (VIa), Fachbereich Energie und Klimaschutz. Stand: 01.03.2021.

ANGERER, T. & FRÖHLICH, M. (2002): Thermisch Regenerative Oxidation als Verfahren der Abluftreinigung bei mechanisch-biologischen Anlagen zur Behandlung von Abfällen. Schriftenreihe des BMLFUW. Study is not published but can be made available to the ERT upon request.

ANGERER, T. (1997): Stand der Mechanisch-Biologischen Restabfallbehandlung vor der Deponierung (MBRVD) in Österreich – November 1997 – MUL Leoben.

APCC – Austrian Panel on Climate Change (2014): Österreichischer Sachstandsbericht – Klimawandel 2014. Verlag der Österreichischen Akademie der Wissenschaften, Wien, Österreich. 1 096 Seiten. ISBN 978-3-7001-7699-2

ASFINAG (2022): Yearly analysis of mileage on Austrian highways - nonstandard analysis for 2021 (not published). Wien, 2022.

AUSTRIAN CHAMBER OF AGRICULTURE (2022): Statistical data of burning straw. Mag. Längauer (email), November 2022.

AUSTRO CONTROL (2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2016): Flight movements Austria – nonstandard analysis for 2006 – 2015 (not published). Austro Control.

AUSTRO CONTROL (2022): Flight movements Austria 2021 – yearly nonstandard analysis (not published). Austro Control.

AUSTROPAPIER (2022). Vereinigung der Österreichischen Papierindustrie. Statistik Papier & Zellstoff. https://austropapier.at/website2020/wp-content/uploads/2022/04/zellstoff21.pdf

BARBER, M.A.; (1996): (Alcan International Limited) Alcans's P-FKW Emission Reduction Program. A Case Study, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

BARNERT, H. (1998): Österreichisches Lackinstitut: Möglichkeiten und Grenzen umweltverträglicher Beschichtung (Lacke, Klebstoffe, Bautenschutzmittel, Holzschutzmittel), Wien.

BAUMELER, A.; BRUNNER, P. H.; FEHRINGER, R.; KISLIAKOVA, A. & SCHACHERMAYER, E. (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft (CH_4). Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs. Wien.

BAYARD, R., BENBELKACEM, H., GOURDON, R., BUFFI, P. (2018): Characterization of selected municipal solid waste components to estimate their biodegradability; Journal of Environmental Management 216

BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT (LFL) (2020): Gruber Tabelle zur Fütterung in der Rindermast. Freising-Weihenstephan: Institut für Tierernährung und Futterwirtschaft.

BEKAT – BURGENLÄNDISCHER EMISSIONS- UND ENERGIEKATASTER (2021): Auswertung der Anzahl der Haushalte nach Enerigeträger der Beheizung. Amt der Burgenländischen Landesregierung, Abteilung 4 - Ländliche Entwicklung, Agrarwesen, Natur- und Klimaschutz, Referat Luftreinhaltung und Luftgüte, Stand: Februar 2021.

BERNHAUSER, O. (2014): Personal Communication. Expert of the Regional Chamber of Agriculture in Lower Austria.

BEV – Bundesamt für Eich- und Vermessungswesen (2022): Regional Information derived from the Austrian real estate database BEV – Austrian Federal Office of Metrology and Surveying, Wien.

BFW (1992): Österreichische Waldbodenzustandsinventur. Mitteilungen der Forstlichen Bundesversuchsanstalt Wien, Vol. 168/I, Vol. 168/II, Federal Office and Research Centre for Forests, Wien.

BFW (2009): BioSoil - das europäische Waldboden-Monitoring. In: BFW-Praxisinformation Nr. 20 p. 13-15. Federal Office and Research Centre for Forests, Wien.

BFW (2022): Waldinventurergebnisse der Perioden 1992/96, 2000/02, 2007/09, 2016/21. Federal Office and Research Centre for Forests, Wien. http://bfw.ac.at/rz/wi.home

BFW (2022a pers. comm.): Annual growth indices. Personal communication, Federal Office and Research Centre for Forests, Wien.

BFW (2011b): Emissionen aus natürlichen Schadereignissen im Wald. Report for the Federal Ministry of Agriculture, Forestry, Environment and Water Management, 42 pp.

BFW (2019): Holzvorrat auf neuem Höchststand. In: BFW-Praxisinformation Nr. 50 p. 8-12. Federal Office and Research Centre for Forests, Wien.BGBL. Nr. 440/1975: Forest Act of the Republic of Austria. Federal Ministry of Agriculture, Forestry, Environment and Water Management – Vienna/Austria.

BIERMAYR, P. et al. (2013): Innovative Energietechnologien in Österreich. Marktentwicklung 2012. Bundesministerium für Verkehr, Wirtschaft und Technologie, Wien.

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2020): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2020 (Referenzjahr 2018), Wien

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2021): Holzströme in Österreich. Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna/Austria. https://www.klimaaktiv.at/erneuerbare/energieholz/holzstr_oesterr.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022a). ZBD: Zentrale Beguchtachtungsdatenbank (periodically updated specific mileage).

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022b): Schodl, B.: CO_2-Monitoring der Neuzulassungen von Leichten Nutzfahrzeugen 2021. im Auftrag des BMK, Wien 2022. https://www.bmk.gv.at/themen/klima_umwelt/luft/luft/co2_monitoring/lnf.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022c): Schodl, B.: Statusbericht zu den CO_2-Emissionen neu zugelassener Pkw in Österreich 2021; im Auftrag des BMNT, Wien 2022. https://www.bmk.gv.at/themen/klima_umwelt/luft/luft/co2_monitoring/pkw.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022d): Yearly growth rates on Austrian road network for 2021; nonstandard analysis (not published). Wien, 2022.

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2023a): Winter, R.; Erneuerbare Kraftstoffe und Energieträger im Verkehrssektor in Österreich 2022 (für 2021), BMK, Wien 2023. https://www.bmk.gv.at/themen/energie/energieversorgung/biomasse/alternative-kraftstoffe/biokraftstoffbericht.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2023b). Bundesabfallwirtschaftsplan 2023. Wien. https://www.bmk.gv.at/themen/klima_umwelt/abfall/aws/bundes_awp/bawp2023.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2000): Empfehlungen für die sachgerechte Düngung von Christbaumkulturen. Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2001): Bundesabfallbericht 2001, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2002): Gewässerschutzbericht gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006a): Bundes-Abfallwirtschaftsplan 2006 (BAWP 2006), Wien. www.bundesabfallwirtschaftsplan.at

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006b): Kommunale Abwasserrichtlinie der EU – 91/271 EWG, Österreichischer Bericht 2006. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2007): Sonderrichtlinie des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW) für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft. Anlage I, Anhänge zum Agrarumweltprogramm und zur Tierschutzmaßnahme (ÖPUL 2007). http://www.ama.at/Portal.Node/ama/public?gentics.rm=PCP&gentics.pm=gti_full&p.contentid=10008.47092&SRL_O4_20071126.pdf

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1993, 1996, 1999, 2002): Gewässerschutzberichte gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008a): Statusbericht 2008 zum Bundesabfallwirtschaftsplan 2006. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2008. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2009): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2009 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2010. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011a): Bundes-Abfallwirtschaftsplan 2011 (BAWP 2011). Wien. http://www.bundesabfallwirtschaftsplan.at/

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2011 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien http://www.lebensministerium.at/publikationen/wasser/abwasser/05012011.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2012): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2012. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014): Stork, C.; Windhofer, G. & Zieritz, I.: Kommunales Abwasser: Österreichischer Bericht 2014. Kombinierter Bericht gemäß Artikel 15 und Artikel 16 der Richtlinie 91/271/EWG für den Zeitraum 2011 – 2012. Wien, Juni 2014.
http://www.bmlfuw.gv.at/wasser/wasserqualitaet/abwasserreinigung/Lagebericht2014.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1964–2011): Österreichische Waldberichte; Jahresberichte über die Forstwirtschaft. Edited annually by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015a): Parravicini, V.; Valkova, T.; Haslinger, J.; Saracevic, E.; Winkelbauer, A.; Tauber, J.; Svardal, K.; Hohenblum, P.; Clara, M.; Windhofer, G.; Pazdernik, K. & Lampert, C.: ReLaKO – Reduktionspotential bei den Lachgasemissionen aus Kläranlagen durch Optimierung des Betriebes. Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der TU Wien & Umweltbundesamt GmbH. Wien.
https://www.bmlfuw.gv.at/service/publikationen/wasser/Lachgasemissionen---Kl-ranlagen.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015b): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2014. Wien, Dezember 2015.
http://www.bundesabfallwirtschaftsplan.at/dms/bawp/AW_Statusbericht_2015_final.pdf

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015c): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2015. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2016a): Sonderrichtlinie des BMLFUW für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft (ÖPUL 2015).
https://www.bmnt.gv.at/english/agriculture/Rural-development/-pul2015until2020.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2016b): Kommunales Abwasser. Österreichischer Bericht 2016. Wien.
https://www.bmlfuw.gv.at/wasser/wasser-eu-international/europaeische_wasserpolitik/Lagebericht-2016.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2017): Richtlinien für die sachgerechte Düngung. 7. Auflage Fachbeirat für Bodenfruchtbarkeit und Bodenschutz. Wien.

BMLRT – Bundesministerium für Landwirtschaft, Regionen und Tourismus (2020): Kommunales Abwasser. Österreichischer Bericht 2020. Wien.
https://www.bmlrt.gv.at/dam/jcr:40608892-831f-40d1-bc22-106972fb1ef4/Lagebericht_2020.pdf

BML – Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft (2022a): Geodatenkatalog des BMLRT. Übersicht über Geodatensätze in der GDI GDS R17, Oktober 2021. Vorabzug. BML Abteilung II/1. Projektbezogene Nutzung des Gebäude- und Wohnungsregister (GWR), Wien.

BML – Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft (2022b): Grüner Bericht 1999, 2000, 2002, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Grüner Bericht gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. www.gruenerbericht.at . In 2022, the Federal Ministry of Agriculture, Regions and Tourism (BMLRT) has become the BML.

BML – Bundesministerium für Landwirtschaft, Regionen und Wasserwirtschaft (2022c): Kommunales Abwasser. Österreichischer Bericht 2022. Wien. https://info.bml.gv.at/dam/jcr:ee735108-3eec-47d2-a1b6-ebb478b964af/UWWTD_Lagebericht_2022_2022-06-22.pdf

BMLRT (1964–2021): Holzeinschlag in Österreich. Edited annually by the Federal Ministry for Agriculture, Regions and Tourism, Wien. https://info.bmlrt.gv.at/themen/wald/wald-in-oesterreich/wald-und-zahlen/Holzeinschlag.html

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2018a): Bundes-Abfallwirtschaftsplan 2017. Wien https://www.bmnt.gv.at/umwelt/abfall-ressourcen/bundes-abfallwirtschaftsplan/BAWP2017-Final.html

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2018b): Kommunales Abwasser Österreichischer Bericht 2018. Wien

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2019a) Standardfaktoren für Brennstoffe aus der nationalen Treibhausgasinventur zur Anwendung für die Ebene 2a in Österreich, gültig 2019-2021. https://www.bmk.gv.at/dam/jcr:81f399e8-e965-4a16-b118-9402e05778f3/Standardfaktoren_Ebene2a_ua.pdf

BMNT – Bundesministeriums für Nachhaltigkeit und Tourismus (2019b): Schodl, B.: Statusbericht zu den CO_2-Emissionen neu zugelassener Pkw in Österreich 2018; im Auftrag des BMNT, Wien 2019. https://www.bmk.gv.at/themen/klima_umwelt/luft/luft/co2_monitoring/pkw.html

BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung 1990. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung 1996. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1999): Energiebericht der Österreichischen Bundesregierung 1999. Bundesministerium für wirtschaftliche Angelegenheiten, Wien. Anhang Emissionsfaktoren. Wien, 1999.

BMWA – Bundesministerium für Wirtschaft und Arbeit (2008): Die österreichischen Bergbauproduktion 2008, Wien 2008.

BMWFW – Bundesministerium für Wirtschaft und Arbeit (2010-2017): Österreichisches Montan-Handbuch 2010-2017. Bergbau – Rohstoffe – Grundstoffe – Energie, Wien 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017.

BMWFW – Bundesministerium für Wirtschaft und Arbeit (2014): NEEAP 2014. Erster Nationaler Energieeffizienzaktionsplan der Republik Österreich 2014 gemäß Energieeffizienzrichtlinie 2012/27/EU. Anhang B: Gebäuderenovierungsstrategie Österreich. Österreichische Energieagentur – AEA / Monitoringstelle im Auftrag des Bundesministeriums für Wissenschaft, Forschung und Wirtschaft. Wien, April 2014.

BORIS – Bodeninformationssystem des Umweltbundesamtes: http://www.borisdaten.at

BRITISH GEOLOGICAL SURVEY (2001): World Mineral Statistics 1995–1999. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2005): World mineral production 1999–2003. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2006): World mineral production 2000–2004. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2007): World mineral production 2001–2005. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2008): World mineral production 2002–2006. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2009): World mineral production 2003–2007. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2010): World mineral production 2004–2008. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2011): World mineral production 2005–2009. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2012): World mineral production 2006–2010. Keyworth, Nottingham: British Geological Survey. http://www.bgs.ac.uk/mineralsuk/statistics/worldStatistics.html

BRITISH GEOLOGICAL SURVEY (2021): Data for 2012 to 2020 were obtained by personal communication

BRUNSTERMANN, R. (2007): Übung Biologische Abfallbehandlung Teil 1; Universität Essen. https://www.uni-due.de/imperia/md/content/abfall/__bungbiologie1bsc2007.pdf

BUCHGRABER, K.; AMLINGER, F.; TULNIK, R. (2003) Produktion und Einsatz von Kompost in der Landwirtschaft und im Gemüsebau; Landwirt Heft 12/2003 Sonderbeilage

BUNDESANSTALT FÜR AGRARWIRTSCHAFT UND BERGBAUERNFRAGEN (2022): Federal Institute of Agricultural Economics. Download from data pool. https://bab.gv.at/index.php?lang=de.

CHARLES, D., JONES, B.M.R., SALWAY, A.G., EKTLESTON, H.S., MILNE, R., 1998: Treatment of uncertainties for national estimates of greenhouse gas emissions. AEAT-2688-1, AEA Technology, Culham, UK.

DETZEL, A; VOGT, R; FEHRENBACH, H. et al. (2003): Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationalen Richtlinien. Institut für angewandte Ökologie (IFEU). Institute for Applied Ecology.

DIPPOLD, M. / REXEIS, M. / HAUSBERGER, S. (2012): NEMO – A Universal and Flexible Model for Assessment of Emissions on Road Networks. 19th International Conference "Transport and Air Pollution", 26. – 27.11.2012, Thessaloniki.

DIPPOLD, M., HAUSBERGER, S. (2021): Ermittlung von Emissionsfaktoren für Diesel-Pkw mit Softwareupdate (EFA-SU). UBA (Umweltbundesamt) Deutschland, Dessau-Roßlau. https://www.umweltbundesamt.de/publikationen/ermittlung-von-emissionsfaktoren-fuer-diesel-pkw

DLG – Deutsche Landwirtschafts-Gesellschaft (1997): DLG-Futterwerttabelle für Wiederkäuer. 7. erweiterte und überarbeitete Auflage. DLG-Verlag, Frankfurt/Main, Germany.

DOEDENS, H.; CUHLS, C.; MÖNKEBERG, F.; LEVSEN, K.; KRUPPA, J.; SÄNGER, U. & KOCK, H. (1999): Bilanzierung von Umweltchemikalien bei der biologischen Vorbehandlung von Restabfällen, Phase 2: Emissionen, Schadstoffbilanzen und Abluftbehandlung. BMB+F Verbundvorhaben: Mechanisch-biologische Vorbehandlung von zu deponierenden Abfällen.

DÖRFLINGER, A.; HIETZ, P.; MAIER, R.; PUNZ, W. & FUSSENEKTER, K. (1995): Ökosystem Großstadt Wien – Quantifizierung ökologischer Parameter unter besonderer Berücksichtigung der Vegetation; Bundesministerium für Wissenschaft und Forschung und MA 22.

ECKMÜLLNER, O. (2006): Allometric relations to estimate needle and branch mass of Norway spruce and Scots pine in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions. 123. Jg., Heft 1/2, 7–16.

ECOFYS, FRAUNHOFER INSTITUTE FOR SYSTEMS AND INNOVATION RESEARCH, ÖKO-INSTITUT (Eds.) (2009): Methodology for the free allocation of emission allowances in the EU ETS post 2012 - Sector report for the chemical industry. By order of the European Commission. Study Contract: 07.0307/2008/515770/ETU/C2. Ecofys project Number: PECSNL082164. http://www.ecofys.com/files/files/091102_chemicals.pdf

E-CONTROL (2008): Ökostrombericht 2008. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Oktober 2008. Wien.

E-CONTROL (2010): Ökostrombericht 2010. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Juli 2009. Wien.

E-CONTROL (2011): Ökostrombericht 2011. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2011. Wien.

E-CONTROL (2013): Ökostrombericht 2013. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2013. Wien.

E-CONTROL (2013): Rohstoffbilanzen für 2011. Personal communication by DI Michael Sorger, 18.09.2013.

E-CONTROL (2014): http://www.e-control.at/portal/page/portal/medienbibliothek/publikationen/dokumente/pdfs/Oekostrombericht2014_final.pdf; accessed October 2014

E-CONTROL (2015): http://www.e-control.at/documents/20903/388512/Oekostrombericht-2015.pdf/592ed7a3-4913-401d-a6d4-d57780c2776d; accessed in January 2016

E-CONTROL (2016): https://www.e-control.at/documents/20903/388512/e-control-oekostrombericht-2016.pdf/bbd26620-e1a3-4243-aed7-33c95e317d7a accessed in December 2016

E-CONTROL (2017): https://www.e-control.at/documents/20903/388512/e-control-oekostrombericht-2017.pdf/ce32088b-b8dc-85d3-2585-c6af224b3113 accessed in November 2017

E-CONTROL (2018): https://www.e-control.at/documents/20903/388512/%C3%96kostrombericht_2018.pdf/6d5a9de6-7b65-5c72-740e-3a8d16282368 accessed in November 2018

E-CONTROL (2019): https://www.e-control.at/documents/1785851/1811582/%C3%96kostrombericht_FINAL.pdf/f689b909-2088-77b0-0c9e-eeb260effe7b?t=1569999423109 accessed in October 2019.

E-CONTROL (2020): EC_Ökobericht20_08.09_NEU.indd (e-control.at) accessed in October 2020.

E-CONTROL (2021): EC_Ökobericht21_18.10.indd (e-control.at) accessed in October 2021.

E-CONTROL (2022a): Speicherbewirtschaftung. https://www.e-control.at/statistik/g-statistik/archiv/marktstatistik/speicherbewirtschaftung, accessed in 24.11.2022

E-CONTROL (2022b): EC_EAG_Monitoringb_15.09_DRUCK.indd (e-control.at) accessed in November 2022.

EDER, A.; FEICHTINGER, F.; STRAUSS, P. & BLÖSCHL, G. (2013): Calculation of nitrogen leaching values for the annual greenhouse gas inventory of Austria – Evaluation of long term lysimeter time series. Federal Agency for Water Management, Institute for Land and Water Management Research, Petzen-kirchen,and Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria.

EDER, A.; BLÖSCHL G.; FEICHTINGER, F.; HERNDL, M.; KLAMMLER, G.; HÖSCH, J.; ERHART, E. & STRAUSS, P. (2014): Indirect nitrogen losses of managed soils contributing to greenhouse emissions of agricultural areas in Austria: results from lysimeter studies. Article in Nutr Cycl Agroecosyst. DOI 10.1007/s10705-015-9682-9. 2015.

EEA – European Environment Agency (2009): EMEP/EEA air pollutant emission inventory guidebook – 2009. Technical report No 6/2009. Copenhagen. http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

EEA – European Environment Agency (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013. EEA Technical report No. 12/2013. http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

EEA – European Environment Agency (2016): EMEP/EEA air pollutant emission inventory guidebook – 2016. EEA Technical report No. 21/2016. Copenhagen.

EEA – European Environment Agency (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019. EEA Technical report No. 19/2019. https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

EEA – European Environment Agency (2020): 2020 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 4(3) of Regulation (EU) No 2018/842 and to Article 3 of Decision No 406/2009/EC – Austria. Final Review Report. August 2020.

EAGER – European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

EGGER-DANNER, C.; FÜRST-WALTL, B.; FÜRST, C.; GRUBER, L.; HÖRTENHUBER, S.; KOECK, A.; LEDINEK, M.; PFEIFFER, C.; STEININGER, F.; WEIẞENSTEINER, R.; WILLAM, A.; ZOLLITSCH, W.; ZOTTL, K. (2016): EFFICIENT COW. Analyse und Optimierung der Produktionseffizienz und der Umweltwirkung in der österreichischen Rinderwirtschaft. Wien: Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter ZAR.

EGLE, L.; RECHBERGER, H.; ZESSNER, M. (2014) Phosphorbilanz Österreich Grundlage für ein nachhaltiges Phosphormanagement – gegenwärtige Situation und zukünftige Entwicklung; Hrsg. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Sektion VII Wasser

ELLINGER, R. & KRACHER, M. (2020). CO_2-Bilanz für den Flughafen Wien. Bilanzjahr 2019. Wien: Auftraggeber Flughafen Wien AG. Wien, 2021.

ENTEC UK LIMITED (2006): European Commission, Support for the Development and Adoption of Monitoring and Reporting Guidelines as Harmonized Benchmarks for N_2O activities for unilateral inclusion in the EU ETS for 2008-12, final report.

ENVIRONMENTAL SCIENCE & TECHNOLOGY (2011): Diaz-Valbuena, L.; Leverenz, H.L.; Cappa, C.D.; Tchobanoglous, G.; Horwath, W.R., and Darby, J.L.; Methane, carbon dioxide, and nitrous oxide emissions from septic tank systems. Department of Civil and Environmental Engineering, Department of Land, Air, and Water Resources, University of California.

EUROPEAN COMMISSION (2007): Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers. BAT Reference Document LVIC-AAF August 2007. Brussels. http://eippcb.jrc.es/reference/BREF/lvic_aaf.pdf

EUROSTAT (2008): Structural business statistics (NACE Rev.1.1) – online statistics. Luxembourg. http://epp.eurostat.ec.europa.eu

FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V. (FNR, 2010): Leitfaden Biogas. Von der Gewinnung zur Nutzung. Herausgegeben von der Fachagentur Nachwachsende Rohstoffe mit Förderung des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz aufgrund eines Beschlusses des Deutschen Bundestages 5., vollständig überarbeitete Auflage, Gülzow, 2010.

FAO AGR. STATISTICAL SYSTEM (2001): FAO Agricultural Statistical System. http://faostat.fao.org/site/339/default.aspx

FINNISH ENVIRONMENT INSTITUTE (2011): Soil Carbon Model Yasso. Finnish Environment Institute, Helsinki, http://www.ymparisto.fi/default.asp?contentid=250208&lan=en&clan=en

FLÖGL, W. (2002): Klimarelevanz der Deponien in Oberösterreich. Hydro Consulting Engineers. Erstellt im Auftrag für das Amt der OÖ Landesregierung. Abteilung Umweltschutz, UA Abfallwirtschaft. Linz

FOEN – FEDERAL OFFICE FOR THE ENVIRONMENT (2021): Switzerland's Greenhouse Gas Inventory 1990–2019. National Inventory Report including reporting elements under the Kyoto Protocol. Submission of April 2021 under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Bern, 2021.

FNR (FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V.; 2006): Handreichung - Biogasgewinnung und –nutzung. 3. überarbeitete Auflage. Gülzow, Germany

FRANKHAUSER, J. (2007): Personal Communication, Austrian Chamber of Agriculture, May. Vienna.

FREIBAUER, A. & KALTSCHMITT, M. (2001): Biogenic greenhouse gas emissions from agriculture in Europe. European Summary Report (Project Report Task 3) of the EU-Concerted Action FAIR3-CT96-1877 "Biogenic Emissions of Greenhouse Gases Caused by Arable and Animal Agriculture".

FVGW – Fachverband der Gas- und Wärmeversorgungsunternehmungen (2022): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2022 – Auswertung Rohrleitungsnetz GAS in Österreich für die Jahre 2002 bis 2021 (personal communication; Email 07.11.2022).

FVMI – Fachverband der Mineralölindustrie (1999-2021): Jahresberichte des Fachverbandes der Mineralölindustrie Österreichs. Jeweilige Jahresberichte für die Jahre 1999 bis 2021. Wien. https://www.wko.at/Content.Node/branchen/oe/Mineraloelindustrie/Jahresberichte.html

FVMI – Fachverband der Mineralölindustrie (2022): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2022 – Emissionen der Mineralölkette (personal communication; Email 24.10.2022).

GEBETSROITHER, E.; STREBL, F. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; Report ARC-S-0175, ARC Seibersdorf research, July 2002.

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2003). Quantification of carbon pools in agriculturally used soils of Austria by use of a soil information system as basis for the Austrian carbon balance model. OECD Expert Meeting: Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analyses., C. A. S. Smith (ed., 14–18 October 2002, Ottawa, Canada, Agriculture and Agri-Food Canada, Ottawa, CA & Organisation of Economic Co-operation and Development, Paris, FR.

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2005). Quantification of organic carbon pools for Austria's agricultural soils using a soil information system. Can. J. Soil Sci. 85: 491–498.

GIBBS, M. (ICF Inc.) & JACOBS, C. (US EPA) (1996): Reducing P-FKW Emissions from Primary Aluminium Production in the USA, from: Light Metal Age, February 1996.

GILBERG, U. et al. (2005): Waste management in Europe and the Landfill Directive, Background paper from the ETC/RWM to the ETC/ACC workshop "Inventories and Projections of Greenhouse Gas Emissions from Waste"; European Environment Agency.

GRABNER, R.; KLATZER, R.; MEIER, W.; STEINWIDDER, A.; STÖGER, E. & TOIFL, G. (2004): Mutterkuh- und Ochsenhaltung 2003. Ergebnisse und Konsequenzen der Betriebszweigauswertung aus den Arbeitskreisen Mutterkuh und Ochsenhaltung [Husbandry of mother cows and bullocks 2003]. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien.

GRUBER, L. & STEINWIDDER, A. (1996): Einfluß der Fütterung auf die Stickstoff- und Phosphorausscheidung landwirtschaftlicher Nutztiere – Modellkalkulationen auf Basis einer Literaturübersicht in: Die Bodenkultur – Austrian Journal of Agricultural Research, 47. Band/Heft 4/Dezember 1996/ISBN 0006-5471, WUV-Universitätsverlag, Wien.

GRUBER, L. & PÖTSCH, E. M. (2006): Calculation of nitrogen excretion of dairy cows in Austria. Die Bodenkultur, 2006, Vol. 57, Heft 1–4, Vienna.

GRUBER, L.; ETTLE, T.; SCHWARZ, F. J.; SUSENBETH, A.; ROYER, M.; PRIES, M.; FISCHER, B.; JILG, T.; KOCH, C.; TERLER, G.; MEYER, U.; HAMMON, H. M.; KUNZ, H.-J. & GUGGENBERGER T. (2021): Untersuchungen zur Futteraufnahme und zum Energieaufwand von Aufzuchtrindern der Rasse Fleckvieh und Holstein von der Geburt bis 220 kg Lebendmasse. 48. Viehwirtschaftliche Fachtagung, 1–26.

GSCHWANTNER, TH. & SCHADAUER, K. (2006): Branch biomass functions for broadleaved tree species in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions, 123 Jg.; Heft 1/2, 17–34.

GSCHWANTNER, TH., GABLER, K., SCHADAUER, K. & WEISS, P. (2010): National Forest Inventory Reports, Chapter 1: Austria. In: TOMPPO, E.; GSCHWANTNER, TH.; LAWRENCE, M. & MCROBERTS, R.E. (Eds.): National Forest Inventories: pathways for common reporting. Springer, Heidelberg, Dordrecht, London, New York, 57–71.

HACKL, A. & MAUSCHITZ, G. (1995, 1997, 2001, 2003, 2007): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

HACKL, A. & MAUSCHITZ, G. (1996): Methangas und Kohlendioxid aus der Bereitstellung in Österreich genutzter Energieträger, TU-Wien, Wien, 1996.

HACKL, A. & MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.

HADORN, R. & WENK, C. (1996): Effect of different sources of dietary fibre on nutrient and energy utilization in broilers. 2. Energy and N-balance as well as whole body composition. Archiv für Geflügelkunde.

HARNISCH, J. & SCHWARZ, W. (2003): Final Report on the Costs and the impact on emissions of potential regulatory framework for reducing emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. European Commission (DG ENV).

HAUK, E. & SCHADAUER, K. (2009): Instruktionen für die Feldarbeit der Österreichischen Waldinventur 2007–2009. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at:, http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf

HAUSBERGER, S. & KELLER, M. et al. (1998): Handbuch der Emissionsfaktoren des Straßenverkehrs in Österreich. Im Auftrag des Umweltbundesamtes; BMLFUW und BMVIT. Wien.

HAUSBERGER, S. (2000): Emissionen des Off-Road-Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz. Not published.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015a): NEMO Methodenbericht im Rahmen des Projekts NEMO4U. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015. Not yet published.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015b): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2014. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

HÄUSLER, J. (2009): Das Leistungspotenzial von Fleckviehmutterkühen – Versuchsergebnisse des LFZ Raumberg-Gumpenstein. Fachtag „Erfolgreiche Mutterkuhhaltung" Fachschule Warth.

HEIM, P. (2005): Fütterung von Kuh und Kalb. [Feeding of mother cow and calve]. Article in UFA-Revue 3/05, an agricultural journal of Switzerland.

HOCHBICHLER, E.; BELLOS, P. & LICK, E. (2006): Biomass functions and expansion factors for spruce, pine, beech and oak in Austria. Austrian Journal on Forest Science, Special Issue on Austrian biomassfunctions. 123. Jg., Heft 1/2, 35–46.

Hörtenhuber, S. (2022): Update of data on livestock feeding in the Austrian Air Pollutant Inventory (OLI) for poultry, horses, sheep, goats and other animals & revision of the calculations for biogas. Final project report. Dezember 2021. (Unpublished).

Hörtenhuber, S.; Größbacher, V.; Schanz, L. (2022a): Update of data on livestock feeding in the Austrian Air Pollutant Inventory (OLI) for cattle and pigs. Final project report. Dezember 2021. (Unpublished).

Hörtenhuber, S.; Größbacher, V.; Weissensteiner, R.; Zollitsch, W. (2022b): Minderungspotenziale zu Treibhausgas- und Luftschadstoff-Emissionen aus der Nutztierhaltung unter besonderer Berücksichtigung ernährungsbezogener Faktoren (MiNutE). Universität für Bodenkultur. Wien 2022

Hörtenhuber, S.; Größbacher, V.; Schanz, L.; Zollitsch, W.J. (2023): Implementing IPCC 2019 Guidelines into a National Inventory: Impacts of Key Changes in Austrian Cattle and Pig Farming. Sustainability 2023, 15, 4814. https://doi.org/10.3390/su15064814

Iea – International Energy Agency (2022): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2022). Submitted years 1990-2021. Statistik Austria, Wien.

Ifeu – Institut für Energie- und Umweltforschung Heidelberg GmbH (2008): Optimierungen für einen nachhaltigen Ausbau der Biogaserzeugung und -nutzung in Deutschland

Infras (2022): Notter, B.;Cox, B;/Hausberger, S.; Matzer, C.; Weller, K.; Dippold, M.; Politschnig, N.; Lipp, S.; Allekotte, M.; Knörr, W.; André, M.; Gagnepain, L.; Hult, C.; Jerkskö, M.: HBEFA V4.2 Documentation of updates. Bern/Graz/Heidelberg/Lyon/Göteborg, February 23, 2022.

International Association of Oil & Gas Producers (2011): Petroleum industry guidelines for reporting greenhouse gas emissions, 2nd Edition, OGP Report Number 446, International Association of Oil & Gas Producers.

International Iron and Steel Institute (IISI) (2004): Steel statistical yearbook 2004. Brussels.

Ipcc – Intergovernmental Panel on Climate Change (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 1: Reporting Instructions, Vol. 2: Workbook, Vol. 3: Reference Manual. Intergovernmental Panel on Climate Change, Edited by J.T. Houghton, L.G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander, Genf.

Ipcc – Intergovernmental Panel on Climate Change (2000): Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Report). Japan. [also referenced as "IPCC GPG" in the NIR]

Ipcc – Intergovernmental Panel on Climate Change (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry. Edited by J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner.

Ipcc – Intergovernmental Panel on Climate Change (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and anabe K. (eds). Published: IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/

Ipcc – Intergovernmental Panel on Climate Change (2007): Climate Change 2007 – Impacts, Adaptation and Vulnerability. 4th Assessment Report. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

IPCC – Intergovernmental Panel on Climate Change (2007). Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf

IPCC – Intergovernmental Panel on Climate Change (2013). Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA Chapter 8 - Anthropogenic and Natural Radiative Forcing. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

IPCC – Intergovernmental Panel on Climate Change (2014): 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. HIRAISHI, T., KRUG, T., TANABE, K., SRIVASTAVA, N., BAASANSUREN, J., FUKUDA, M. AND TROXLER, T.G. (EDS), Published: IPCC, Switzerland.

IPCC – Intergovernmental Panel on Climate Change (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team: R.K Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.).

IPCC – Intergovernmental Panel on Climate Change (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the Task Force on National Greenhouse Gas Inventories (TFI) in accordance with the decision taken at the 44th Session of IPCC in Bangkok, Thailand, in October 2016. Published: May 2019. https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

JÄGER, F.(2003): Forstrecht. 3rd Edition, Verlag Österreich, Wien.

JFSQ – JOINT FOREST SECTOR QUESTIONNAIRE FOR 2020, provided by the BML. Vienna, 2021. unpublished.

JFSQ – JOINT FOREST SECTOR QUESTIONNAIRE for 2021, provided by the BML. Vienna, 2022. unpublished.

JOURNAL OF ENVIRONMENTAL MANAGEMENT 279 (2021): Valkova, T.; Parravicini, V.; Saracevic, E.; Tauber, J.; Svardal, K.; Krampe, J.: A method to estimate the direct nitrous oxide emissions of municipal wastewater treatment plants based on the degree of nitrogen removal. Research article. https://www.sciencedirect.com/science/article/pii/S0301479720314882?via%3Dihub

KALIVODA, M./KUDRNA, M. (1997): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium, Perchtoldsdorf/Vienna, 1997.

KALIVODA, M./KUDRNA, M. (2002): Air Traffic Emission Calculation for Austria 1990–2000, study commissioned by Umweltbundesamt GmbH, Perchtoldsdorf, 2002. Study has not been published, but can be made available upon request.

KAUSEL, A. (1998): Ein halbes Jahrhundert des Erfolges, Der ökonomische Aufstieg Österreichs im OECD-Raum seit 1950. Österreichische Nationalbank, Wien.

KFG (KRAFTFAHRGESETZ 1967 – KFG. 1967) in der geltenden Fassung BGBl. I Nr. 190/2021.KIRNER, L. & SCHNEEBERGER, W. (1999): Strukturanalyse der Betriebe mit der ÖPUL-Maßnahme „Verzicht auf bestimmte ertragssteigernde Betriebsmittel (Betrieb)". Der Förderungsdienst 47(6).

KRANERT M. & CORD-LANDWEHR K., (2010): Einführung in die Abfallwirtschaft; 4 vollständig aktualisierte und erweiterte Auflage; S. 226.

KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht, WUV Universitätsverlag, Wien.

KÖRNER, C.; SCHILCHER, B. & PELAEZ-RIEDL, S. (1993): Bestandsaufsaufnahme anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – Mögliche Maßnahmen. Dokumentation, Kapitel 6.1. Österreichische Akademie der Wissenschaften. Wien.

KORTELAINEN, P.; PAJUNEN, H.; RANTAKARI, M. & SAARNISTO, M. (2004): A large carbon pool and small sink in boreal Holocene lake sediments. Global Change Biology 10/10, 1648–1653.

KTBL – Kuratorium für Technik und Bauwesen in der Landwirtschaft; German Association for Technology and Structures in Agriculture (2005): Gasausbeute in Landwirtschaftlichen Biogasanlagen. KTBL-Heft 50.Darmstadt, Germany.

LANDESBETRIEB LANDWIRTSCHAFT HESSEN (2013): Nährstoffgehalte pflanzlicher Produkte zum Nährstoffvergleich. http://www.llh-hessen.de/pflanzenproduktion/duengung-boden/n-duengung/155-landwirtschaft/pflanzenproduktion/duengung-boden/567-naehrstoffgehalte-pflanzlicher-produkte-zum-naehrstoffvergleich.html (accessed 4.6.2014)

LANG, G.; LEUTGÖB, K. & LUTTER, E. (2003): Abschätzung der Entwicklung der NMVOC-Emissionen im Bereich der Kleinverbraucher. Energieverwertungsagentur, Wien.

LEDERMANN, T. & NEUMANN, M. (2006): Biomass equations from data of old long-term experimental plots. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 47–64.

LEISEWITZ, A. & SCHWARZ, W. (2010): Assessment of the Consumption and the Real Emissions of Fluorinated Greenhouse Gases in Austria 2000-2008. Ökorecherche, Frankfurt am Main.

LEISEWITZ, A. (2012): Überprüfung von Vereinfachungsmöglichkeiten bei der Datenerhebung und -berechnung für die österreichische F-Gas-Berichterstattung im Bereich der stationären Kälte und Klimatisierung im Anschluss an den Bericht von Ökorecherche 2010. Ökorecherche, Frankfurt am Main.

LFL – Bayerische Landesanstalt für Landwirtschaft (2017): online database on biogas potential of various substrates http://www.lfl.bayern.de/iba/energie/049711/?sel_list=1%2Cb&anker0=substratanker#substratanker

LFU – Landesanstalt für Umweltschutz Baden-Württemberg (1992): Der Deponiegashaushalt in Altablagerungen – Leitfaden Deponiegas. Materialien zur Altlastenbearbeitung. Handbuch Altlasten und Grundwasserschadensfälle. Baden-Württemberg.

LÖHR, L. (1990): Faustzahlen für den Landwirt.

MATHÄ, M. & ELLINGER, R. (2011): CO_2 Bilanz der Österreichischen Zivilflughäfen, Bilanzjahr 2010.

MATZER C., WELLER K., DIPPOLD M., LIPP S., RÖCK M., REXEIS M., HAUSBERGER S.(2019): Update of emission factors for HBEFA Version 4.1; Final report, I-05/19/CM EM-I-16/26/679 from 09.09.2019, TU Graz https://www.hbefa.net/d/documents/HBEFA41_Report_TUG_09092019.pdf

MAUSCHITZ, G. (2004): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2008): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2010): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2009. TU Wien. http://www.zement.at/downloads/emissionen_2004_2009.pdf

MAUSCHITZ, G. (2011): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2010. TU Wien. http://www.zement.at/downloads/emissionen_2010.pdf

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2011. TU Wien. http://www.zement.at/downloads/emissionen_2011.pdf

MAUSCHITZ, G. (2013): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2012. TU Wien. http://www.zement.at/downloads/emissionen_2012.pdf

MAUSCHITZ, G. (2014): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2013. TU Wien. http://www.zement.at/downloads/emissionen_2013.pdf

MAUSCHITZ, G. (2015): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2014. TU Wien. http://www.zement.at/downloads/emissionen_2014.pdf

MAUSCHITZ, G. (2016): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2014. TU Wien. http://www.zement.at/downloads/emissionen_2015.pdf

MAUSCHITZ, G. (2017): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2016. TU Wien. http://www.zement.at/downloads/downloads_2017/Emissionen_2016.pdf

MAUSCHITZ, G. (2018): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2018. TU Wien. http://www.zement.at/downloads/downloads_2018/Emissionen_2018.pdf

MAUSCHITZ, G. (2020): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2019. TU Wien. https://www.zement.at/downloads/downloads_2020/Emissionen_2019.pdf

MAUSCHITZ, G. (2021): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2020. TU Wien. https://www.zement.at/downloads/downloads_2021/Emissionen_2020.pdf

MAUSCHITZ, G. (2022): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2021. TU Wien. https://www.zement.at/downloads/downloads_2022/Emissionen_aus_Anlagen_der_oesterr._Zementindustrie_Berichtsjahr_2021_1.pdf

MCPFE LIAISON UNIT and UNECE/FAO (2007): "State of Europe's Forest 2007". Ministerial Conference on the Protection of Forests in Europe, Liaison Unit Warsaw, ISBN 10-83-922396-8-7.

MEET (1999): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium.

MENZI, H.; RUETTIMANN, L. & REIDY, B. (2003): DYNAMO: A new calculation model for dynamic emission inventories for ammonia. Proc. International Symposium 'Gaseous and odour emissions from animal production facilities', Horsens, Denmark, June 1–4.

MOLITOR, R., S. HAUSBERGER, G. BENKE et al. (2004) Abschätzung der Auswirkungen des Tanktourismus auf den Kraftstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich, Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Trafico, Wien 2004.

MOLITOR, R.; SCHÖNFELDER, S.; HAUSBERGER, S. & BENKE, G. et al. (2009) Abschätzung der Auswirkungen des Kraftstoffexports im Tank auf den Kraftstoffabsatz und die Entwicklung der CO_2- und Luftschadstoffemissionen in Österreich - Aktualisierung 2007 und Prognose 2030. Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und Bundesministerium für Verkehr, Innovation und Technologie. Wien 2009.

MONNI, S. & SYRI, S. (2003): Uncertainties in the Finnish 2001 Greenhouse Gas Emission Inventory. VTT RESEARCH NOTES 2209, Espoo.

NASA (2020): Evidence / Facts – Climate Change: Vital Signs of the Planet (nasa.gov), online access January 2021

NESTROY, O.; DANNEBERG, O. H. & ENGLISCH, M. (2000): Systematische Gliederung der Böden Österreichs (Österreichische Bodensystematik 2000). Mitt. d. Österr. Bodenkundl. Ges., H. 60, Wien 2000.

NEUMAYR, C. (2012): Treibhausgasemissionen von Systemen der Rind- und Lammfleischerzeugung. Diplomarbeit / Masterarbeit - Institut für Nutztierwissenschaften (NUWI), BOKU-Universität für Bodenkultur, pp 97.

OBERNOSTERER, R.; SMUTNY, R. & JÄGER, E. (2004): HFKW Gase in Dämmschäumen des Bauwesens. Umweltbundesamt, Internal Report. Study has not been published, but can be made available upon request.

OFFENTHALER, I. & HOCHBICHLER, E. (2006): Estimation of root biomass for Austrian forest tree species. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 65–86.

ÖIGV – Österreichischer Industriegaseverband (2013): N_2O use in medical and industrial field (personal communication), Schwechat.

ÖKOINSTITUT (2002): Öko Institut e.V., Institut für angewandte Ökologie, April 2002, Freiburg, Darmstadt, Berlin.

ORTHOFER, R. (1991): Abschätzung der Methan-Emissionen in Österreich, OEFZS-4586, Seibersdorf, Austria.

ORTHOFER, R.; KNOFLACHER, H.M. & ZÜGER, J. (1995): N_2O-Emissionen in Österreich. Seibersdorf Research Report OEFZS-A-3256, Seibersdorf.

ÖWAV – Österreichischer Wasser- und Abfallwirtschaftsverband (2003): ÖWAV ArbeitsbehelfEPER. Arbeitsbehelf zur Abschätzung von Emissionen in Luft und Wasser. Reststoff- und Massenabfalldeponie gemäß EPER-V (BGBl. II Nr. 300/2002). Wien 2003.

PARRAVICINI V.; SVARDAL K. (2015). Klimarelevante Emissionen aus der Abwasserreinigung. ÖWAV-TU-Seminar 2015, NEW: Nährstoffe – Energie – Wasser; Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der technischen Universität Wien, Wiener Mitteilungen, Band 232, 183-204 sowie Parravicini V., Valkova T. (2014). Lachgasemissionen aus kommunalen Kläranlagen. Vortrag: ÖWAV-Seminar „Abwasserreinigung - Werte erhalten, Effizienz steigern und Ressourcen schonen", Wien; 24.-25.2.2014; in: „Wiener Mitteilungen", Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft, Band 230, 125 - 156.

PARRAVICINI, V., SVARDAL, K., KRAMPE, J. (2016). Greenhouse Gas Emissions from Wastewater Treatment Plants. Energy Procedia, 97 (2016), S. 246 – 253.

PHILIPPITSCH, R.; GRATH, J.; SCHIMON, W.; GMEINER, C.; DEUTSCH, K.; GRUBER, D.; TOMEK, H.; BONANI, M. & LASSNIG, M. (2001): Wassergüte in Österreich. Jahresbericht 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBl. Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.

PÖLLINGER, A. (2008): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution 1990-2008 carried out in June 2008. Vienna.

PÖLLINGER, A. (2018): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution carried out within (AMON & HÖRTENHUBER 2019). Vienna.

PÖLLINGER et al. (2018): Erhebung zum Wirtschaftsdüngermanagement aus der landwirtschaftlichen Tierhaltung in Österreich. Surveys on manure management from agricultural livstock farmings in Austria. Abschlussbericht TIHALO II. Projekt Nr./Wissenschaftliche Tätigkeit Nr. 3662. PÖLLINGER, A.; BRETTSCHUH, S.; LACKNER, L.; STICKLER, Y.; ZENTNER, A.; HBLFA Raumberg Gumpenstein & Bundesanstalt für Agrarwirtschaft, Wien. Bundesministerium für Nachhaltigkeit und Tourismus (BMNT), Wien 2018.

PÖLLINGER, A. (2021): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Investigation of data on slurry application stemming from the ÖPUL promotion database of the Federal Ministry for Agriculture, Regions and Tourism (BMLRT).

PÖTSCH, E.M.; GRUBER, L. & STEINWIDDER, A. (2005): Answers and comments on the additional questions, following the meeting in Bruxelles. Internal statement, HBLFA Raumberg-Gumpenstein.

PÖTSCHER, K. (2008): Die österreichische Luftraumüberwachung. TU Wien, Heft 4/2008. https://oes.tuwien.ac.at/article/id/229/; 5.12.2021.

PRILLER, H. (2004): Berechnung der N-Ausscheidung für Schweine. Dokument zur Fütterungsberatung an den Landwirtschaftskammern. 10 p.

RAMIREZ RAMIREZ, A.; DE KEIZER, C. & VAN DER SLUIJS, J. P. (2006): Monte Carlo Analysis of Uncertainties in the Netherlands Greenhouse Gas Emission Inventory for 1990 – 2004. Report NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht.

REIDY, B. & MENZI, H. (2005): Ammoniakemissionen in der Schweiz: Neues Emissionsinventar 1990 bis 2000 mit Hochrechungen bis 2003 Technischer Schlussbericht Schweizerische Hochschule für Zollikofen.

REIDY, B.; DÄMMGEN, U.; DÖHLER, H.; EURICH-MENDEN, B.; EVERT, F. K. VAN; HUTCHINGS, N. J.; LUESINK, H. H.; MENZI, H.; MISSELBROOK, T. H.; MONTENY, G.J. & WEBB, J. (2008): Comparison of models used for national agricultural ammonia emission inventories in Europe : liquid manure systems. Atmospheric environment, Band 42, Heft 14, Seite 3452-3464, englisch. ISSN: 0004-6981.

REIDY, B.; RIHM, B. & MENZI, H. (2007): A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations, Reference: AEA7495, IN Journal: Atmospheric Environment.

REIDY et al. (2008, 2009): Comparisons of models used for national agricultural ammonia emission inventories in Europe. Atmospheric Environment, Band 42 and Band 43.

REIDY, B.; WEBB, J.; MISSELBROOK, T.H.; MENZI, H.; LUESINK, H.H.; HUTCHINGS, N.J.; EURICH-MENDEN, B.; DÖHLER, H. & DÄMMGEN, U. (2009): Comparison of models used for national agricultural ammonia emission inventories in Europe: Litter-based manure systems. Atmospheric environment, Band 43, Heft 9, Seite 1632–1640, englisch. ISSN: 0004-6981

RESCH, R., GUGGENBERGER,T., WIEDNER, G., KASAL, A., WURM, K., GRUBER, L., RINGDORFER, F. & BUCHGRABER, K. (2006): Futterwerttabellen im Jahr 2006 für das Grundfutter im Alpenraum. Available from Website http://www.gumpenstein.at

REXEIS, M. et al. (2013): Emissionen aus Kalt- und Kühlstarts sowie aus AdBlue-Verwendung in SCR-Katalysatoren von Lkw, LNF, 2-Rädern sowie von mobilen Maschinen. Erstellt im Auftrag des Umweltbundesamtes GmbH. Graz, 2013.

RINDERZUCHT AUSTRIA (2022): Annual Breeding data reports (Zucht Data Jahresberichte). Available from Website https://www.zar.at/Downloads/Jahresberichte/ZuchtData-Jahresberichte.html

RÖMPP LEXIKON CHEMIE (1996-1999): 10. Auflage, Band 3: H – L

RUBATSCHER, D.; MUNK, K.; STÖHR, D.; BAHN, M.; MADER-OBERHAMMER, M. & CERNUSCA, A. (2006): Biomass expansion functions for Larix decidua: a contribution to the estimation of forest carbon stocks. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 86–101.

RUSS, W. (2004): Mehr Wald – ein positiver Trend? BFW Praxis Information 3/2004, pp. 4-7, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at: http://bfw.ac.at/700/pdf/BFW_praxis2004_kl.pdf

RWA (2006–2013): Expert judgements based on annual sales data of urea. Personal communication, Raiffeisen Ware Austria AG, Wien.

RYPDAL, K. & WINIWARTER, W. (2001): Uncertainties in Greenhouse Gas Inventories – Evaluation, comparability and implications. Environmental Science.

SBV – Swiss Farmers Union (2007): Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2006. Swiss Farmers Union, Brugg.

SBV – Swiss Farmers Union (2021): Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2019. Swiss Farmers Union, Brugg.

SCHÄFER, R. (2002): Neues Konzept zum Düngemitteleinsatz. In: VKS News 65. Ausgabe 08/2002.

SCHECHTNER (1991): Wirtschaftsdünger – Richtige Gewinnung und Anwendung, Sonderausgabe des Förderungsdienst 1991, BMLF, Wien.

SCHIELER, K. & HAUK, E. (2001): Instruktion für die Feldarbeit – Österreichische Waldinventur 2000/2002, Fassung 2001. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna. Download at: http://bfw.ac.at/700/pdf/da_ges_neu.pdf

SCHIELER, K.; BÜCHSENMEISTER, R. & SCHADAUER, K. (1995): Österreichische Forstinventur – Ergebnisse 1986/90. Bericht 92, Federal Office and Research Centre for Forests, Wien.

SCHMIDT, A.; VITOVEC, W.; PUXBAUM, H. & KNIERIDER, R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien.

SCHOLZ, H.; KOVACS, A. Z.; STEFLER, J.; FAHR, R-D.; VON LENGERKERN, G. (2001): Milchleistung und -qualität von Fleischrindkühen während der Säugeperiode. Archiv für Tierzucht. 44(6), 611–620.

SCHWARZ, W. & GSCHREY, B. (2009): Service contract to assess the feasibility of options to reduce emissions of SF_6 from the EU non-ferrous metal industry and analyse their potential impacts. Prepared for European Commission, DG Environment. Final Report, Frankfurt am Main.

SCHWARZ, W. (2004): Emissionen, Aktivitätsraten und Emissionsfaktoren von fluorierten Treibhausgasen (F-Gasen) in Deutschland für die Jahre 1995-2002. Anpassung an die Erfordernisse der internationalen Berichterstattung und Implementierung der Daten in das Zentrale System Emissionen (ZES), Umweltbundesamt, Dessau.

SCHWINGSHACKL, M. & REXEIS, M. (2022): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2021. IVT – Institut für Verbrennungskraftmaschinen und Thermodynamik. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2022.

SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020): Update der Emissionsfaktoren und Aktivitätsdaten von NRMM für die Inventur OLI2020. Erstellt im Auftrag der Umweltbundesamt GmbH. Bericht Nr. I-18/20/Schwings EM 20/05/679 VOM 09.12.2020.

SEMPOS (2018): Note on fossil carbon content in biofuels. Final draft – result of the expert group within the ESD-review project in 2018. Not published yet.

SJARDIN, M. (2003): CO_2 emission factors for non-energy use in the non-ferrous metal, ferroalloys and inorganics industry. Copernicus Institute, Department of Science, Technology and Society, University of Utrecht.

SPLECHTNA, B. & GLATZEL, G. (2005): Optionen der Bereitstellung von Biomasse aus Wäldern und Energieholzplantagen für die energetische Nutzung. Berlin-Brandenburgische Akademie der Wissenschaften, Berlin, Materialien Nr. 1.

STANZEL, G.; JUNGMEIER, J. & SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research, Graz.

STATCUBE (2014a): Neue Gebäude mit Wohnungen 1970 - 1979; ohne An-, Auf-, Umbautätigkeit (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2014b): Neue Gebäude mit Wohnungen 1980 - 2002; ohne An-, Auf-, Umbautätigkeit (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2014c): Neue Wohnungen 1980 - 2002 (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2022a): Bevölkerung zu Jahresbeginn ab 1982 (Bevölkerungsstatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2022b): Mikrozensus; Hauptwohnsitzwohnungen (HWS) ab 2004. Statistische Datenbank von Statistik, Wien.

STATISTIK AUSTRIA – please refer to section „Data Sources by Sector"

STEINER, G., M. & REITER, K. (1992): Österreichischer Moorschutzkatalog-Datenbank. Styria Medien Service. Wien.

STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J. & WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemissionen. Report des Joanneum Research: Institut für Umweltgeologie und Ökosystemforschung.

STEINWENDER, R. & GOLD, H. (1989): Produktionstechnik und Gebrauchskreuzungen in der Mutterkuhhaltung. Versuchsbericht. Agricultural Research Center for Alpine Regions, Gumpenstein.

STEINWIDDER, A. (2003): Qualitäts-Rindermast im Grünland. Mutterkuhhaltung und Jungrinder. Ochsen-, Kalbinnen- und Bullenmast. Leopold Stocker Verlag. Graz, Stuttgart

STEINWIDDER, A. & GUGGENBERGER, T. (2003): Erhebungen zur Futteraufnahme und Nährstoffversorgung von Milchkühen sowie Nährstoffbilanzierung auf Grünlandbetrieben in Österreich. Die Bodenkultur 54 (1), 49–66.

STEINWIDDER, A; HÄUSLER, J.; SCHAUER, A.; MAIERHOFER, G.; GRUBER, L.; GASTEINER, J. & PODSTATZKY, L. (2006): Einfluss des Absetztermins auf die Milchleistung und Körpermasse von Mutterkühen sowie die Zuwachsleistung von Mutterkuh-Jungrindern. Versuchsbericht. Extensively managed beef cows – Effects on animal health, reproductive success, performance of calves and economics. Experiment 2004 to 2008. Interim report. Agricultural Research and Education Centre, HBLFA Raumberg-Gumpenstein.

STREBL, F.; GEBETSROITHER, E. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Agricultural Soils in Austria; ARC Seibersdorf research, revised version, February 2003.

SÜD-TREBER GMBH (2021): Nährstoffe zu Rübenkleinteilen.Rübenkleinteile | Süd-Treber GmbH (suedtreber.de) accessed November 2021

TABERAUX, A. (1996): Relationship between Operating Parameters and Emissions, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

THE OIL INDUSTRY INTERNATIONAL EXPLORATION AND PRODUCTION FORUM (1994): Methods for estimating atmospheric emissions from E&P operations, Report No. 2.59/197, London 1994. http://www.ogp.org.uk/pubs/197.pdf

TU – Technische Universität Wien: Schwarzböck, T. (2015): Bestimmung der fossilen Kohlendioxidemissionen aus Österreichischen Müllverbrennungsanlagen (BEFKÖM). Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft; im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien. https://www.wien.gv.at/umweltschutz/nachhaltigkeit/pdf/schwarzboeck-2015.pdf

UBA BERLIN (1999): MBA Bericht: Ökologische Vertretbarkeit mechanisch-biologischer Vorbehandlung von Restabfällen.

UMWELTBUNDESAMT (1995): Boos, R.; Neubacher, F.; Reiter, B.; Schindlbauer, H. & Twrdik, F.: Zusammensetzung und Behandlung von Altölen in Österreich. Monographien, Bd. M-054. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1997): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998a): Götz, B.: Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Berichte, Bd. BE-087a, Umweltbundesamt, Wien, July 1998.

UMWELTBUNDESAMT (1998b): Lahl, U.; Zeschmar-Lahl, B. & Scheidl, K. (1998): Abluftemissionen aus der mechanisch-biologischen Abfallbehandlung in Österreich. Monographien, Bd. M-104, Umweltbundesamt, Klagenfurt.

UMWELTBUNDESAMT (2000a): Weiss, P.; Schieler, K.; Schadauer, K.; Radunsky, K. & Englisch, M.: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Monographien, Bd. M-106, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2000b): Lahl, U.; Zeschmar-Lahl, B. & Angerer, T.: Entwicklungspotentiale der mechanisch-biologischen Abfallbehandlung. Eine ökologische Analyse. Monographien, Bd. M-125, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999. Interner Bericht, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001b): Bichler, B.; Werenskiold, W. & Unterberger, S.: Abschätzung der tatsächlichen und potentiellen treibhauswirksamen Emissionen von H-FKW, P-FKW und SF_6 für Österreich. Internal Report. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2001c): Häusler, G.: Emissionen aus Abfalldeponien 1980–1998, Interner Bericht, Bd. IB-623. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001d): Perz, K.: Materialien zum Bundesabfallwirtschaftsplan 2001, Monographien, Bd. M-138, Umweltbundesamt, Klagenfurt.

UMWELTBUNDESAMT (2001e): Grech, H. & Rolland, C.: Stand der Abfallbehandlung in Österreich im Hinblick auf das Jahr 2004. Berichte, Bd. BE-182. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001f): WIESENBERGER, W.: State-of-the-art for the Production of Nitric Acid with Regard to the IPPC Directive. Monographien, Band 150. Wien. http://www.umweltbundesamt.at/fileadmin/site/publikationen/M150.pdf

UMWELTBUNDESAMT (2002): Erdgas-mix in Österreich, Elementaranalyse. Auszug aus der GEMIS-Datenbank des Umweltbundesamt.

UMWELTBUNDESAMT (2003): Rolland, C. & Scheibengraf, M.: Biologisch abbaubarer Kohlenstoff im Restmüll. Berichte, Bd. BE-236. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004): SCHINDLER I., KUTSCHERA U., WIESENBERGER H.: Medienübergreifende Umweltkontrolle in ausgewählten Gebieten. Wien.

UMWELTBUNDESAMT (2004a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 2003. Berichte, Bd. BE-254. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004b): Pilot study on statistics on waste management in agriculture, forestry and fishing – Agriwaste. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004c): Rolland, C. & Oliva, J.: Erfassung von Deponiegas – Statusbericht von österreichischen Deponien. Berichte, Bd. BE-238. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2005): Schachermayer, E.: Vergleich und Evaluierung verschiedener Modelle zur Berechnung der Methanemissionen aus Deponien. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2006a): Salchenegger, S.: Biokraftstoffe im Verkehrssektor in Österreich 2006, Zusammenfassung der Daten der Republik Österreich gemäß Art. 4, Abs. 1 der Richtlinie 2003/30/EG für das Berichtsjahr 2005. Reports, Bd. REP-0068. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2006b): Neubauer, C. & Öhlinger, A.: Ist-Stand der mechanisch biologischen Abfallbehandlung (MBA) in Österreich, Zustandsbericht 2006. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007b): Dampfkesseldatenbank, Stand Oktober 2007. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007c): Lenz, K. & Kampel, E.: Nitrous Oxide emissions from industrial wastewater, Interne Studie, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008a): Schachermayer, E. & Lampert, C.: Erfasste Deponiegasmengen auf Österreichischen Deponien – Zeitreihe für die Jahre 2002 bis 2007. Reports, Bd. REP-0100. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008b): Neubauer, C. & Walter, B.: Behandlung von gemischten Siedlungs- und Gewerbeabfällen in Österreich – Betrachtungszeitraum 2003–2008. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010, 2014 & 2018): External review of the Agricultural calculation model by Austrian Agricultural experts within the framework of stakeholder meetings held in 2010, 2014 & 2018. Discussion and validation of applied values, parameters and time series by the national experts. Vienna.

UMWELTBUNDESAMT (2010a): Anderl, M.; Freudenschuß, A.; Friedrich, A.; Köther, T.; Kriech, M.; Kuschel, V.; Muik, B.; Pazdernik, K.; Poupa, S.; Schodl, B.; Stranner, G.; Schwaiger, E.; Seuss, K.; Weiss, P.; Wieser, M. & Zethner, G.: Austria's National Inventory Report 2010. Reports, Bd. REP-0265. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010b): Freudenschuß, A.; Sedy, K.; Spiegel, H. et al.: Arbeiten zur Evaluierung von ÖPUL-Maßnahmen hinsichtlich ihrer Klimawirksamkeit. REP-290. Umweltbundeamt, Wien. http://www.umweltbundesamt.at/aktuell/publikationen/publikationssuche/publikationsdetail/?&pub_id=1875

UMWELTBUNDESAMT (2011a): Query of data from the National Austrian Waste Water Database. Vienna 2011.

UMWELTBUNDESAMT (2011b): Lampert, C.; Tesar, M. & Thaler, P.: Klimarelevanz und Energieeffizienz der Verwertung biogener Abfälle. Report. REP-0353. Vienna

UMWELTBUNDESAMT (2013): Data on sewage sludge application provided by the provincial governments. Vienna 2013.

UMWELTBUNDESAMT (2014a): Data on sewage sludge application provided by the provincial governments. Vienna 2014.

UMWELTBUNDESAMT (2014b): Lampert, C.: Stand der temporären Abdeckung von Deponien und Deponiegaserfassung. Report. REP-0484. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2014c): Stakeholder Workshop on the revision of the agricultural model according to the IPCC 2006 GL.16th September 2014. Vienna.

UMWELTBUNDESAMT (2015): Data on sewage sludge application provided by the provincial governments. Vienna 2015.

UMWELTBUNDESAMT (2016a): Data on sewage sludge application provided by the provincial governments. Vienna 2016.

UMWELTBUNDESAMT (2016b): Lampert, C.; Neubauer, M. & Bernhardt A.: Kommunale Grünabfälle (KoGa). Report. unpublished. Vienna.

UMWELTBUNDESAMT (2017): Data on sewage sludge application provided by the provincial governments. Vienna 2017.

UMWELTBUNDESAMT (2018): Data on sewage sludge application provided by the provincial governments. Vienna 2018.

UMWELTBUNDESAMT (2019a): Data on sewage sludge application provided by the provincial governments. Vienna 2019.

UMWELTBUNDESAMT (2019b): Lampert, C.; Thaler, P.: Deponiegaserfassung 2013-2017. REP-0679. Wien

UMWELTBUNDESAMT (2019c) Lampert, C., Perl, D., Lenz, K. THG Emissionen industrielle Abwasserreinigung, unveröffentlicht

UMWELTBUNDESAMT (2020): Data on sewage sludge application provided by the provincial governments. Vienna 2020.

UMWELTBUNDESAMT (2021): Data on sewage sludge application provided by the provincial governments. Vienna 2021.

UMWELTBUNDESAMT (2022a): Emissionshandelsregister Österreich. „Stand der Einhaltung" für die Jahre 2005-2021 im österreichischen Teil des Unionsregisters. Geprüfte Emissionen, zurückgegebene Zertifikate und Einhaltungsstatus. https://www.emissionshandelsregister.at/oeffentlicheberichte/standdereinhaltung

UMWELTBUNDESAMT (2022b): Data on sewage sludge application provided by the provincial governments. Vienna 2022.

UMWELTBUNDESAMT (2023a): Anderl, M.; Colson, J.; Gangl, M.; Kuschel, V.; Makoschitz, L.; Matthews, B.; Mayer, M.; Mayer, S.; Moldaschl, E.; Pazdernik, K.; Poupa, S.; Purzner, M.; Roll, M.; Rockenschaub A.K.; Schieder, W.; Schmidt, G.; Schodl, B.; Schwaiger, E.; Schwarzl, B.; Stranner, G.; Weiss, P.; Wieser, M. & Zechmeister, A.: Austria's Annual Greenhouse Gas Inventory 1990-2021. Submission under Regulation (EU) No 2018/1999. „Short-NIR 2023". Wien

UMWELTBUNDESAMT (2023b): Anderl, M.; Brendle, C.; Colson, J.; Gangl, M.; Makoschitz, L.; Mayer, S.; Pazdernik, K.; Poupa, S.; Purzner, M.; Reiterer, D.; Roll, M.; Schieder, W.; Schmidt, G.; Stranner, G.; Wieser, M.; Wankmüller & Zechmeister, A.: Austria's Informative Inventory Report 2023. Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Reports, DRAFT, Wien.

UNECE (2015): Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. United Nations Economic Commission for Europe, 2015. http://www.unece.org/environmental-policy/conventions/envlrtapwelcome/publications.html

UNFCCC (2011a): Submission of information on forest management reference levels by Austria in accordance with Decision 2/CMP.6. https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_austria_2011.pdf

UNFCCC (2011b): Report of the technical assessment of the forest management reference level submission of Austria submitted in 2011. http://unfccc.int/resource/docs/2011/tar/aut01.pdf

UNFCCC (2012): Decision 2/CMP.7 Land use, land use change and forestry, The seventh session of the Conference of the Parties serving as the meeting of the Parities to the Kyoto Protocol, 2011 in Durban, South Africa. http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf

UNFCCC (2019): Report on the individual review of the annual submission of Austria submitted in 2018. FCCC/ARR/2018/AUT. https://unfccc.int/sites/default/files/resource/aut.pdf

UNTERARBEITSGRUPPE N-ADHOC (2004): Überprüfung und Überarbeitung der N-Anfallswerte für einzelne Tierkategorien. Unterlagen ausgearbeitet vom Fachbeirat für Bodenfruchtbarkeit und Bodenschutz des BMLFUW.

VIA DONAU (2022): Jahresbericht Donauschifffahrt in Österreich. Via Donau – Österreichische Wasserstraßen-Gesellschaft mbH, Hrsg. BMK Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.

VITOVEC, W. (1991): N_2O-Emissionen anthropogener Quellen in Österreich. Dissertation, TU Vienna, Austria.

WARTHA, C. (2005): Life Cycle Inventory Austria 2000 - Review, Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2005.

WARTHA, C. (2011): Life Cycle Inventory „Erdgasbereitstellung Austria – Update 2010", Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2011.

WASNER, J. (2009): Einfluss einer Carbokalkdüngung bei kalkhältigen Böden auf das Ertragsverhalten sowie auf ausgewählte bodenchemische und -physikalische Parameter. PhD Thesis, Universität für Bodenkultur, Wien.

WERF – Water Environment Research Foundation (2010): Leverenz, H.L.; Tchobanoglous, G.; Darby, J.L.: Evaluation of Greenhouse Gas Emissions from septic systems. University of California.

WEST, T.O. (2008): Country-level estimates for Carbon distribution in U.S. croplands, 1990–2005. Environmental Science Division, Oak Ridge National Laboratory. http://cdiac.ornl.gov/carbonmanagement/cropcarbon/

WINDSPERGER, A. & HINTERMEIER, G. (2002): Entschwefelungstechnologien – Die Situation in Österreich. Eine Studie im Auftrag des Umweltbundesamt.

WINDSPERGER, S. & SCHMIDT-STEJSKAL, H. (2008): Austria's Emission Inventroy from solvent use 2009. Institut für Industrielle Ökologie (IIÖ). Studie im Auftrag des Umweltbundesamt. Wien. Study has not been published, but can be made available upon request.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt. Wien.

WINDSPERGER, A.; STEJSKAL, H.; PURZNER, M.; TITZ, M. & BURGSTALLER, J. (2018): Dokumentation der methodischen Arbeiten zur VOC-Inventur in Österreich. Internal Report. Vienna 2018.

WINIWARTER, W. & ORTHOFER, R. (2000): Unsicherheit der Emissionsinventur für Treibhausgase in Österreich, Seibersdorf Research Report, OEFZS--S-0072, Seibersdorf.

WINIWARTER, W. & RYPDAL, K. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria. Atmospheric Environment 35: 5 425–5 440.

WINIWARTER, W. (2007): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, ARC (Austrian Research Centers) Seibersdorf. Research Report ARC-sys-0154. Final report contracted by Umweltbundesamt.

WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports – Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5–74.

WINKLER, N. (2003): Walderschließung Österreichs im Detail. Federal Office and Research Centre for Forests, Wien, http://bfw.ac.at/700/2109.html

WIRTH, C.; SCHUMACHER, J. & SCHULZE, E.D. (2004): Generic biomass functions for Norway spruce in Central Europe – a meta-analysis approach toward prediction and uncertainty estimation. Tree Physiology 24, 121–139.

WKÖ – Wirtschaftskammer Österreich (2005): Bergbau-Stahl Jahresbericht, Fachverband der Bergwerke und Eisen erzeugenden Industrie, Wien 2005.

WKÖ – Wirtschaftskammer Österreich (2006): Bergbau-Stahl Jahresbericht, Fachverband Bergbau-Stahl, Wien 2006.

ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Jahrbuch 2004. Data query 2007. http://www.zamg.ac.at/fix/klima/jb2004/Web/index.html

ZENTRALE ARBEITSGEMEINSCHAFT ÖSTERREICHISCHER RINDERZÜCHTER (2004): Cattle Breeding in Austria, 148 pp.

ZESSNER, M. (1999): Bedeutung und Steuerung von Nährstoff- und Schwermetallflüssen des Abwassers. Wiener Mitteilung Band 157. Wien, 1999.

ZESSNER, M. & LINDTNER, S. (2005): Estimations of municipal point source pollution in the context of river basin management. Institute for Water Quality and Waste Management, Vienna University of Technology Published in Water Science & Technology. Vol. 52, No 9 pp 175-182. IWA Publishing 2005

13 DATA SOURCES BY SECTOR

All Sectors

APCC – Austrian Panel on Climate Change (2014):Österreichischer Sachstandsbericht – Klimawandel 2014. Verlag der Österreichischen Akademie der Wissenschaften, Wien, Österreich. 1 096 Seiten. ISBN 978-3-7001-7699-2

EEA – European Environment Agency (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013. EEA Technical report No. 12/2013. http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

EEA – European Environment Agency (2016): EMEP/EEA air pollutant emission inventory guidebook – 2016. EEA Technical report No. 21/2016. Copenhagen.

EEA – European Environment Agency (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019. EEA Technical report No. 19/2019. https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

EEA (2020): 2020 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 4(3) of Regulation (EU) No 2018/842 and to Article 3 of Decision No 406/2009/EC – Austria. Final Review Report. August 2020.

IPCC – Intergovernmental Panel on Climate Change (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and anabe K. (eds). Published: IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/

IPCC – Intergovernmental Panel on Climate Change (2007). Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf

IPCC – Intergovernmental Panel on Climate Change (2013). Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA Chapter 8 - Anthropogenic and Natural Radiative Forcing. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

IPCC – Intergovernmental Panel on Climate Change (2014): Climate Change 2014: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Appendix 8.A. https://www.ipcc.ch/assessment-report/ar5/.

IPCC – Intergovernmental Panel on Climate Change (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team: R.K Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.).

IPCC – Intergovernmental Panel on Climate Change (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the Task Force on National Greenhouse Gas Inventories (TFI) in accordance with the decision taken at the 44th Session of IPCC in Bangkok, Thailand, in October 2016. Published: May 2019. https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

NASA (2020): Evidence / Facts – Climate Change: Vital Signs of the Planet (nasa.gov), online access January 2021

UMWELTBUNDESAMT (2023a): Anderl, M.; Colson, J.; Gangl, M.; Kuschel, V.; Makoschitz, L.; Matthews, B.; Mayer, M.; Mayer, S.; Moldaschl, E.; Pazdernik, K.; Poupa, S.; Purzner, M.; Roll, M.; Rockenschaub A.K.; Schieder, W.; Schmidt, G.; Schodl, B.; Schwaiger, E.; Schwarzl, B.; Stranner, G.; Weiss, P.; Wieser, M. & Zechmeister, A.: Austria's Annual Greenhouse Gas Inventory 1990-2021. Submission under Regulation (EU) No 2018/1999. „Short-NIR 2023". Wien

UMWELTBUNDESAMT (2023b): Anderl, M.; Brendle, C.; Colson, J.; Gangl, M.; Makoschitz, L.; Mayer, S.; Pazdernik, K.; Poupa, S.; Purzner, M.; Reiterer, D.; Roll, M.; Schieder, W.; Schmidt, G.; Stranner, G.; Wieser, M.; Wankmüller & Zechmeister, A.: Austria's Informative Inventory Report 2023. Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Reports, DRAFT, Wien.

Uncertainties

CHARLES, D., JONES, B.M.R., SALWAY, A.G., EGGLESTON, H.S., MILNE, R. (1998): Treatment of uncertainties for national estimates of greenhouse gas emissions. AEAT-2688-1, AEA Technology, Culham, UK.

GEBETSROITHER, E.; STREBL, F. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; Seibersdorf research report ARC--S-0175, Seibersdorf.

HAUSBERGER, S. (2005): Scenarios for the Transport Sector in Austria 1990 to 2020. Report No. FVT-68/05/ Haus Em 24/04-6790. Forschungsinstitut für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz.

MONNI, S. & S. SYRI (2003): Uncertainties in the Finnish 2001 Greenhouse Gas Emission Inventory. VTT RESEARCH NOTES 2209, Espoo.

ORTHOFER, R. (1991): Abschätzung der Methan-Emissionen in Österreich, OEFZS-4586, Seibersdorf, Austria.

ORTHOFER, R.; KNOFLACHER, H.M. & ZÜGER, J. (1995): N_2O-Emissionen in Österreich. Seibersdorf Research Report OEFZS-A-3256, Seibersdorf.

RAMIREZ RAMIREZ, A.; DE KEIZER, C. & VAN DER SLUIJS, J. P. (2006): Monte Carlo Analysis of Uncertainties in the Netherlands Greenhouse Gas Emission Inventory for 1990 – 2004. Report NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht.

RYPDAL, K. & WINIWARTER, W. (2001): Uncertainties in Greenhouse Gas Inventories – Evaluation, comparability and implications. Environmental Science.

STANZEL, G.; JUNGMEIER, J. & SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research, Graz.

VITOVEC, W. (1991): N_2O-Emissionen anthropogener Quellen in Österreich. Dissertation, TU Vienna, Austria.

WINIWARTER, W. & ORTHOFER, R. (2000): Unsicherheit der Emissionsinventur für Treibhausgase in Österreich, Seibersdorf Research Report, OEFZS--S-0072, Seibersdorf.

WINIWARTER, W. & RYPDAL, K. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria. Atmospheric Environment 35: 5 425–5 440.

WINIWARTER, W. (2007): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, ARC (Austrian Research Centers) Seibersdorf. Research Report ARC-sys-0154. Final report contracted by Umweltbundesamt.

Energy – Energy demand model for space heating

AEA – AUSTRIAN ENERGY AGENCY (2015): Eine Typologie österreichischer Wohngebäude. Ein Nachschlagewerk mit charakteristischen, energierelevanten Merkmalen von 32 Modellgebäuden – im Bestand und für jeweils zwei Sanierungsvarianten. 2. Auflage. Wien, März 2015.

AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG (2021): Sonderauswertung der Heizungs-Datenbank. Abteilung 15 Energie, Wohnbau, Technik FA Energie und Wohnbau. Stand: 1.Quartal 2021.

AMT DER VORARLBERGER LANDESREGIERUNG (2021): Sonderauswertung der Altersverteilung von Öl- und Gaskesseln aus Messperiode 2016-2018. Abteilung Allgemeine Wirtschaftsangelegenheiten (VIa), Fachbereich Energie und Klimaschutz. Stand: 01.03.2021.

BEKAT – BURGENLÄNDISCHER EMISSIONS- UND ENERGIEKATASTER (2021): Auswertung der Anzahl der Haushalte nach Enerigeträger der Beheizung. Amt der Burgenländischen Landesregierung, Abteilung 4 - Ländliche Entwicklung, Agrarwesen, Natur- und Klimaschutz, Referat Luftreinhaltung und Luftgüte, Stand: Februar 2021.

BML – Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft (2022a): Geodatenkatalog des BMLRT. Übersicht über Geodatensätze in der GDI GDS R17, Oktober 2021. Vorabzug. BML Abteilung II/1. Projektbezogene Nutzung des Gebäude- und Wohnungsregister (GWR), Wien.

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2019a) Standardfaktoren für Brennstoffe aus der nationalen Treibhausgasinventur zur Anwendung für die Ebene 2a in Österreich, gültig 2019-2021. https://www.bmk.gv.at/dam/jcr:81f399e8-e965-4a16-b118-9402e05778f3/Standardfaktoren_Ebene2a_ua.pdf

BMWFW – Bundesministerium für Wirtschaft und Arbeit (2014): NEEAP 2014. Erster Nationaler Energieeffizienzaktionsplan der Republik Österreich 2014 gemäß Energieeffizienzrichtlinie 2012/27/EU. Anhang B: Gebäuderenovierungsstrategie Österreich. Österreichische Energieagentur – AEA / Monitoringstelle im Auftrag des Bundesministeriums für Wissenschaft, Forschung und Wirtschaft. Wien, April 2014.

E7 ENERGIE MARKT ANALYSE GMBH (2009): Jahresendenergieeinsatz nach Brennstoff, Technologie und Sektor. Analyse des Raumwärmeenergiebedarfs in Abhängigkeit der Heizungstechnologie (Bestandsdaten 2004). Endbericht. Wien, November 2009.

E7 ENERGIE MARKT ANALYSE GMBH (2017): Jahresendenergieeinsatz nach Brennstoff, Technologie und Sektor. Analyse des Raumwärmeenergiebedarfs in Abhängigkeit der Heizungstechnologie. Endbericht. Wien, Februar 2017.

IEA – International Energy Agency (2022): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2022). Submitted years 1990-2021. Statistik Austria, Wien.

LAND SALZBURG (2021): Sonderauswertungen aus dem Gebäudemodell nach Nutzungsart, Energieträger, Heizsystem, Leistungsklasse, Versorgung, Bauperiode und Eigentümer. Land Salzburg, Referat Energiewirtschaft und -beratung. Stand: 10.03.2021.

LANG, G.; LEUTGÖB, K. & LUTTER, E. (2003): Abschätzung der Entwicklung der NMVOC-Emissionen im Bereich der Kleinverbraucher. Energieverwertungsagentur, Wien

STADT WIEN (2017): Gasetagenheizungen im Licht der Dekarbonisierung des Energiesystems – Kurzstudie. Der Bereich der Gasetagenheizungen wird under dem Gesichtspunkt der Dekarboniserung des Energiesystems beleuchtet. Studie von e7 Markt-Analyse-GmbH im Auftrag der MA 20 – Energieplanung. Dezember 2017.

STATCUBE (2014a): Neue Gebäude mit Wohnungen 1970 - 1979; ohne An-, Auf-, Umbautätigkeit (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2014b): Neue Gebäude mit Wohnungen 1980 - 2002; ohne An-, Auf-, Umbautätigkeit (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2014c): Neue Wohnungen 1980 - 2002 (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2022a): Bevölkerung zu Jahresbeginn ab 1982 (Bevölkerungsstatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2022b): Mikrozensus; Hauptwohnsitzwohnungen (HWS) ab 2004. Statistische Datenbank von Statistik, Wien.

STATISTIK AUSTRIA (1973): Häuser- und Wohnungszählung 1971. Österreichisches Statistisches Zentralamt, Wien.

STATISTIK AUSTRIA (1982): Häuser- und Wohnungszählung 1981. Österreichisches Statistisches Zentralamt, Wien.

STATISTIK AUSTRIA (1990): Mikrozensus Energieeinsatz der Haushalte 1990. Statistik Austria. Wien.

STATISTIK AUSTRIA (1992a): Häuser- und Wohnungszählung 1991. Österreichisches Statistisches Zentralamt, Wien.

STATISTIK AUSTRIA (1992b): Mikrozensus Energieeinsatz der Haushalte 1992. Statistik Austria. Wien.

STATISTIK AUSTRIA (2002): Mikrozensus Energieeinsatz der Haushalte 1999/2000. Statistik Austria. Wien.

STATISTIK AUSTRIA (2004): Gebäude- und Wohnungszählung 2001. Hauptergebnisse Österreich. Statistik Austria, Wien.

STATISTIK AUSTRIA (2013): Census 2011 Gebäude- und Wohnungszählung. Ergebnisse zu Gebäuden und Wohnungen aus der Registerzählung. Statistik Austria, Wien.

STATISTIK AUSTRIA (2019): Sonderauswertung des Mikrozensus Energieeinsatz der Haushalte 2003/04-2017/18 (MZ 2004-2018). Statistik Austria im Auftrag durch das Umweltbundesamt. Wien.

STATISTIK AUSTRIA (2021): Sonderauswertung des Mikrozensus Energieeinsatz der Haushalte 2019/20 (MZ 2020). Statistik Austria im Auftrag durch das Umweltbundesamt. Wien.

STATISTIK AUSTRIA (2022a): Paket Gebäude- und Wohnungsregister ab 2014 - Gemeinden, Politische Bezirke und Bundesländer. Statistik Austria, Wien.

STATISTIK AUSTRIA (2022b): Paket GWR-Baumaßnahmen. Statistik Austria, Wien.

STATISTIK AUSTRIA (2022c): Energiebilanz Österreich 1970 – 2021. Im Auftrag des Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.

UMWELTBUNDESAMT (2002): Erdgasmix in Österreich, Elementaranalyse. Auszug aus der GEMIS-Datenbank des Umweltbundesamt.

UMWELTBUNDESAMT (2014d): Schieder, W.; Storch, A..; Thielen, P.; Wampl, S. & Zechmeister, A.: Entwicklung eines Raumwärme-Emissionsmodells. Endbericht *(unveröffentlicht).* Erstellung im Auftrag des BMLFUW, Umweltbundesamt, Wien, Dezember 2014.

ZAMG – Zentralanstalt für Meteorologie und Geodynamik & Statistik Austria (2022): Auswertung der Heizgradtagsummen, Stand Dezember 2022. Wien.

Energy – Other energy data sources

ABFALLWIRTSCHAFT (2003): Artikel „Situation der Monoverbrenner, E.H.Reil, Fernwärme Wien" aus „Abfallwirtschaft und Klimaschutz, Umweltbundesamt, Oktober 2003, Wien".

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2019a) Standardfaktoren für Brennstoffe aus der nationalen Treibhausgasinventur zur Anwendung für die Ebene 2a in Österreich, gültig 2019-2021. https://www.bmk.gv.at/dam/jcr:81f399e8-e965-4a16-b118-9402e05778f3/Standardfaktoren_Ebene2a_ua.pdf

BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung 1990. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung 1996. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1999): Energiebericht der Österreichischen Bundesregierung 1999. Bundesministerium für wirtschaftliche Angelegenheiten, Wien. Anhang Emissionsfaktoren. Wien, 1999.

HACKL, A. & MAUSCHITZ, G. (1996): Methangas und Kohlendioxid aus der Bereitstellung in Österreich genutzter Energieträger, TU-Wien, Wien, 1996.

IEA – International Energy Agency (2022): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2022). Submitted years 1990-2021. Statistik Austria, Wien.

IPCC – Intergovernmental Panel on Climate Change, UNEP – United Nations Environment Programme, OECD –Organisation for Economic Co-Operation and Development & IEA – International Energy Agency (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

IPCC – Intergovernmental Panel on Climate Change (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the Task Force on National Greenhouse Gas Inventories (TFI) in accordance with the decision taken at the 44th Session of IPCC in Bangkok, Thailand, in October 2016. Published: May 2019. Publications - IPCC-TFI (iges.or.jp)LANG, G.; LEUTGÖB, K. & LUTTER, E. (2003): Abschätzung der Entwicklung Der NMVOC-Emissionen Im Bereich Der Kleinverbraucher. Energieverwertungsagentur, Wien.

MAUSCHITZ, G. (2004, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien. Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften. Wien.

ÖKOINSTITUT (2002): Öko Institut e.V., Institut für angewandte Ökologie, April 2002, Freiburg, Darmstadt, Berlin.

STANZEL, G.; JUNGMEIER, J. & SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research Graz.

TU – Technische Universität Wien: Schwarzböck, T. (2015): Bestimmung der fossilen Kohlendioxidemissionen aus Österreichischen Müllverbrennungsanlagen (BEFKÖM). Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft; im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien. https://www.wien.gv.at/umweltschutz/nachhaltigkeit/pdf/schwarzboeck-2015.pdf

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999. Interner Bericht, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2002): Erdgasmix in Österreich, Elementaranalyse. Auszug aus der GEMIS-Datenbank des Umweltbundesamt.

UMWELTBUNDESAMT (2004a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 2003. Berichte, Bd. BE-254. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007b): Dampfkesseldatenbank, Stand Oktober 2007. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2014d): Schieder, W.; Storch, A..; Thielen, P.; Wampl, S. & Zechmeister, A.: Entwicklung eines Raumwärme-Emissionsmodells. Endbericht *(unveröffentlicht).* Erstellung im Auftrag des BMLFUW, Umweltbundesamt, Wien, Dezember 2014.

UMWELTBUNDESAMT (2022a): Emissionshandelsregister Österreich. „Stand der Einhaltung" für die Jahre 2005-2021 im österreichischen Teil des Unionsregisters. Geprüfte Emissionen, zurückgegebene Zertifikate und Einhaltungsstatus. https://www.emissionshandelsregister.at/oeffentlicheberichte/standdereinhaltung

ZAMG – Zentralanstalt für Meteorologie und Geodynamik & Statistik Austria (2022): Auswertung der Heizgradtagsummen, Stand Dezember 2022. Wien.

Transport

ASFINAG. Yearly analysis of mileage on Austrian highways. Yearly nonstandard analysis (not published). ASFINAG data edited by Austrian Federal Ministry of Transport (bmvit), Wien.

AUSTRO CONTROL. Flight movements Austria – yearly nonstandard analysis (not published). Austro Control.

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie. Winter, R.; Biokraftstoffe im Verkehrssektor.

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022a). ZBD: Zentrale Beguchtachtungsdatenbank (periodically updated specific mileage).

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022b): Schodl, B.: CO_2-Monitoring der Neuzulassungen von Leichten Nutzfahrzeugen 2021. im Auftrag des BMK, Wien 2022. https://www.bmk.gv.at/themen/klima_umwelt/luft/luft/co2_monitoring/lnf.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022c): Schodl, B.: Statusbericht zu den CO_2-Emissionen neu zugelassener Pkw in Österreich 2021; im Auftrag des BMNT, Wien 2022. https://www.bmk.gv.at/themen/klima_umwelt/luft/luft/co2_monitoring/pkw.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022d): Yearly growth rates on Austrian road network for 2021; nonstandard analysis (not published). Wien, 2022.

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2023a): Winter, R.; Erneuerbare Kraftstoffe und Energieträger im Verkehrssektor in Österreich 2022 (für 2021), BMK, Wien 2023. https://www.bmk.gv.at/themen/energie/energieversorgung/biomasse/alternative-kraftstoffe/biokraftstoffbericht.html

DIPPOLD, M., HAUSBERGER, S. (2021): Ermittlung von Emissionsfaktoren für Diesel-Pkw mit Softwareupdate (EFA-SU). UBA (Umweltbundesamt) Deutschland, Dessau-Roßlau. https://www.umweltbundesamt.de/publikationen/ermittlung-von-emissionsfaktoren-fuer-diesel-pkw

ELLINGER, R. & KRACHER, M. (2020). CO_2-Bilanz für den Flughafen Wien. Bilanzjahr 2019. Wien: Auftraggeber Flughafen Wien AG. Wien, 2021.

INFRAS (2022): Notter, B.;Cox, B;/Hausberger, S.; Matzer, C.; Weller, K.; Dippold, M.; Politschnig, N.; Lipp, S.; Allekotte, M.; Knörr, W.; André, M.; Gagnepain, L.; Hult, C.; Jerkskö, M.: HBEFA V4.2 Documentation of updates. Bern/Graz/Heidelberg/Lyon/Göteborg, February 23, 2022.

SCHWINGSHACKL, M. & REXEIS, M. (2022): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2021. IVT – Institut für Verbrennungskraftmaschinen und Thermodynamik. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2022.

STATISTIK AUSTRIA. Flight movements per aircraft type and airport (national and international) – yearly nonstandard analysis (not published). Statistik Austria. Wien.

STATISTIK AUSTRIA. Yearly new vehicle registrations from Statistik Austria. Wien.

VIA DONAU (2022): Jahresbericht Donauschifffahrt in Österreich. Via Donau – Österreichische Wasserstraßen-Gesellschaft mbH, Hrsg. BMK Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.

Fugitives

BMWA – Bundesministerium für Wirtschaft und Arbeit (2008): Die österreichischen Bergbauproduktion 2008, Wien 2008.

E-CONTROL (2022a): Speicherbewirtschaftung. https://www.e-control.at/statistik/g-statistik/archiv/marktstatistik/speicherbewirtschaftung, accessed in 24.11.2022

FVGW – Fachverband der Gas- und Wärmeversorgungsunternehmungen (2022): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2022 – Auswertung Rohrleitungsnetz GAS in Österreich für die Jahre 2002 bis 2021 (personal communication; Email 07.11.2022).

FVMI – Fachverband der Mineralölindustrie (1999-2021): Jahresberichte des Fachverbandes der Mineralölindustrie Österreichs. Jeweilige Jahresberichte für die Jahre 1999 bis 2021. Wien. https://www.wko.at/Content.Node/branchen/oe/Mineraloelindustrie/Jahresberichte.html

FVMI – Fachverband der Mineralölindustrie (2022): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2022 – Emissionen der Mineralölkette (personal communication; Email 24.10.2022).

INTERNATIONAL ASSOCIATION OF OIL & GAS PRODUCERS (2011): Petroleum industry guidelines for reporting greenhouse gas emissions, 2nd Edition, OGP Report Number 446, International Association of Oil & Gas Producers.

THE OIL INDUSTRY INTERNATIONAL EXPLORATION AND PRODUCTION FORUM (1994): Methods for estimating atmospheric emissions from E&P operations, Report No. 2.59/197, London 1994. http://www.ogp.org.uk/pubs/197.pdf

WARTHA, C. (2005): Life Cycle Inventory Austria 2000 - Review, Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2005.

WARTHA, C. (2011): Life Cycle Inventory „Erdgasbereitstellung Austria – Update 2010“, Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2011.

WKÖ – WIRTSCHAFTSKAMMER ÖSTERREICH (2005): Bergbau-Stahl Jahresbericht, Fachverband der Bergwerke und Eisen erzeugenden Industrie, Wien 2005.

WKÖ – WIRTSCHAFTSKAMMER ÖSTERREICH (2006): Bergbau-Stahl Jahresbericht, Fachverband Bergbau-Stahl, Wien 2006.

Industrial Processes

BARBER, M.A.; (1996): (Alcan International Limited) Alcans's P-FKW Emission Reduction Program. A Case Study, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

BARNERT, H. (1998): Österreichisches Lackinstitut: Möglichkeiten und Grenzen umweltverträglicher Beschichtung (Lacke, Klebstoffe, Bautenschutzmittel, Holzschutzmittel), Wien.

BIERMAYR, P. et al. (2013): Innovative Energietechnologien in Österreich. Marktentwicklung 2012. Bundesministerium für Verkehr, Wirtschaft und Technologie, Wien.

BMWFW – Bundesministerium für Wirtschaft und Arbeit (2010-2017): Österreichisches Montan-Handbuch 2010-2017. Bergbau – Rohstoffe – Grundstoffe – Energie, Wien 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017.

BRITISH GEOLOGICAL SURVEY (2001): World Mineral Statistics 1995–1999. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2005): World mineral production 1999–2003. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2006): World mineral production 2000–2004. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2007): World mineral production 2001–2005. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2008): World mineral production 2002–2006. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2009): World mineral production 2003–2007. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2010): World mineral production 2004–2008. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2011): World mineral production 2005–2009. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2012): World mineral production 2006–2010. Keyworth, Nottingham: British Geological Survey. http://www.bgs.ac.uk/mineralsuk/statistics/worldStatistics.html

BRITISH GEOLOGICAL SURVEY (2021): Data for 2012 to 2020 were obtained by personal communication

ECOFYS, FRAUNHOFER INSTITUTE FOR SYSTEMS AND INNOVATION RESEARCH, ÖKO-INSTITUT (Eds.) (2009): Methodology for the free allocation of emission allowances in the EU ETS post 2012 - Sector report for the chemical industry. By order of the European Commission. Study Contract: 07.0307/2008/515770/ETU/C2. Ecofys project Number: PECSNL082164. http://www.ecofys.com/files/files/091102_chemicals.pdf

ENTEC UK LIMITED (2006): European Commission, Support for the Development and Adoption of Monitoring and Reporting Guidelines as Harmonized Benchmarks for N_2O activities for unilateral inclusion in the EU ETS for 2008-12, final report.

EUROPEAN COMMISSION (2007): Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers. BAT Reference Document LVIC-AAF August 2007. Brussels. http://eippcb.jrc.es/reference/BREF/lvic_aaf.pdf

EUROSTAT (2008): Structural business statistics (NACE Rev.1.1) – online statistics. Luxembourg. http://epp.eurostat.ec.europa.eu

GIBBS, M. (ICF Inc.) & JACOBS, C. (US EPA) (1996): Reducing P-FKW Emissions from Primary Aluminium Production in the USA, from: Light Metal Age, February 1996.

HACKL, A. & MAUSCHITZ, G. (1995, 1997, 2001, 2003, 2007): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

HARNISCH, J. & SCHWARZ, W. (2003): Final Report on the Costs and the impact on emissions of potential regulatory framework for reducing emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. European Commission (DG ENV).

INTERNATIONAL IRON AND STEEL INSTITUTE (IISI) (2004): Steel statistical yearbook 2004. Brussels.

LEISEWITZ, A. & SCHWARZ, W. (2010): Assessment of the Consumption and the Real Emissions of Fluorinated Greenhouse Gases in Austria 2000-2008. Ökorecherche, Frankfurt am Main.

LEISEWITZ, A. (2012): Überprüfung von Vereinfachungsmöglichkeiten bei der Datenerhebung und -berechnung für die österreichische F-Gas-Berichterstattung im Bereich der stationären Kälte und Klimatisierung im Anschluss an den Bericht von Ökorecherche 2010. Ökorecherche, Frankfurt am Main.

MAUSCHITZ, G. (2004): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2008): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2010): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2009. TU Wien. http://www.zement.at/downloads/emissionen_2004_2009.pdf

MAUSCHITZ, G. (2011): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2010. TU Wien. http://www.zement.at/downloads/emissionen_2010.pdf

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2011. TU Wien. http://www.zement.at/downloads/emissionen_2011.pdf

MAUSCHITZ, G. (2013): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2012. TU Wien. http://www.zement.at/downloads/emissionen_2012.pdf

MAUSCHITZ, G. (2014): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2013. TU Wien. http://www.zement.at/downloads/emissionen_2013.pdf

MAUSCHITZ, G. (2015): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2014. TU Wien. http://www.zement.at/downloads/emissionen_2014.pdf

MAUSCHITZ, G. (2016): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2014. TU Wien. http://www.zement.at/downloads/emissionen_2015.pdf

MAUSCHITZ, G. (2017): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2016. TU Wien. http://www.zement.at/downloads/downloads_2017/Emissionen_2016.pdf

MAUSCHITZ, G. (2018): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2018. TU Wien. http://www.zement.at/downloads/downloads_2018/Emissionen_2018.pdf

MAUSCHITZ, G. (2020): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2019. TU Wien. https://www.zement.at/downloads/downloads_2020/Emissionen_2019.pdf

MAUSCHITZ, G. (2021): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2020. TU Wien. https://www.zement.at/downloads/downloads_2021/Emissionen_2020.pdf

MAUSCHITZ, G. (2022): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2021. TU Wien. https://www.zement.at/downloads/downloads_2022/Emissionen_aus_Anlagen_der_oesterr._Zementindustrie_Berichtsjahr_2021_1.pdf

OBERNOSTERER, R.; SMUTNY, R. & JÄGER, E. (2004): HFKW Gase in Dämmschäumen des Bauwesens. Umweltbundesamt, Internal Report. Study has not been published, but can be made available upon request.

ÖIGV – Österreichischer Industriegaseverband (2013): N_2O use in medical and industrial field (personal communication), Schwechat.

SCHMIDT, A.; VITOVEC, W.; PUXBAUM, H. & KNIERIDER, R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien.

SCHWARZ, W. & GSCHREY, B. (2009): Service contract to assess the feasibility of options to reduce emissions of SF_6 from the EU non-ferrous metal industry and analyse their potential impacts. Prepared for European Commission, DG Environment. Final Report, Frankfurt am Main

SCHWARZ, W. (2004): Emissionen, Aktivitätsraten und Emissionsfaktoren von fluorierten Treibhausgasen (F-Gasen) in Deutschland für die Jahre 1995-2002. Anpassung an die Erfordernisse der internationalen Berichterstattung und Implementierung der Daten in das Zentrale System Emissionen (ZES), Umweltbundesamt, Dessau.

SJARDIN, M. (2003): CO_2 emission factors for non-energy use in the non-ferrous metal, ferroalloys and inorganics industry. Copernicus Institute, Department of Science, Technology and Society, University of Utrecht.

STATISTIK AUSTRIA: National statistics. Wien.
- Statistisches Jahrbuch Österreich 1992–2012;
- Industrie und Gewerbestatistik (1. Teil) 1990–1995;
- Konjunkturerhebung im Produzierenden Bereich (Band 3) 1997–2012;
- Außenhandelsstatistik 1996–2019;
- Konjunkturstatistik im Produzierenden Bereich ab 2008 – online, 2008-2019

TABERAUX, A. (1996): Relationship between Operating Parameters and Emissions, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8^{th}–9^{th} 1996.

UMWELTBUNDESAMT (2001b): Bichler, B.; Werenskiold, W. & Unterberger, S.: Abschätzung der tatsächlichen und potentiellen treibhauswirksamen Emissionen von H-FKW, P-FKW und SF_6 für Österreich. Internal Report. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2001f): WIESENBERGER, W.: State-of-the-art for the Production of Nitric Acid with Regard to the IPPC Directive. Monographien, Band 150. Wien. http://www.umweltbundesamt.at/fileadmin/site/publikationen/M150.pdf

WASNER, J. (2009): Einfluss einer Carbokalkdüngung bei kalkhältigen Böden auf das Ertragsverhalten sowie auf ausgewählte bodenchemische und -physikalische Parameter. PhD Thesis, Universität für Bodenkultur, Wien.

WINDSPERGER, A. & HINTERMEIER, G. (2002): Entschwefelungstechnologien – Die Situation in Österreich. Eine Studie im Auftrag des Umweltbundesamt.

Other Product Use

BARNERT, H. (1998): Österreichisches Lackinstitut: Möglichkeiten und Grenzen umweltverträglicher Beschichtung (Lacke, Klebstoffe, Bautenschutzmittel, Holzschutzmittel), Wien.

EUROSTAT (2008): Structural business statistics (NACE Rev.1.1) – online statistics. Luxembourg. http://epp.eurostat.ec.europa.eu

ÖIGV – Österreichischer Industriegaseverband (2013): N_2O use in medical and industrial field (personal communication), Schwechat.

RAMIREZ, A.; DE KEIZER, C.; & VAN DER SLUIJS, J. P. (2006): Monte Carlo Analysis of Uncertainties in the Netherlands Greenhouse Gas Emission Inventory for 1990–2004. Report NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht.

SCHMIDT, A.; VITOVEC, W.; PUXBAUM, H. & KNIERIDER, R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien.

STATISTIK AUSTRIA: Statistisches Jahrbuch Österreich 1992–2011;
- Industrie und Gewerbestatistik (1. Teil) 1990–1995; 2000–2007
- Konjunkturerhebung im Produzierenden Bereich (Band 2 bzw. 3) 1997–2011;
- Der Außenhandel Österreichs 1. bis 4. Vierteljahr 1980–2011, Spezialhandel nach Waren und Ländern. Statistik Austria, Wien.
- Außenhandelsstatistik 2008–2019, online, https://portal.statistik.at/
- -Konjunkturstatistik im Produzierenden Bereich (2008–2019): online, https://portal.statistik.at/

WINDSPERGER, S. & SCHMIDT-STEJSKAL, H. (2008): Austria's Emission Inventroy from solvent use 2009. Institut für Industrielle Ökologie (IIÖ). Studie im Auftrag des Umweltbundesamt. Wien. Study has not been published, but can be made available upon request.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt. Wien.

WINDSPERGER, A.; STEJSKAL, H.; PURZNER, M.; TITZ, M. & BURGSTALLER, J. (2018): Dokumentation der methodischen Arbeiten zur VOC-Inventur in Österreich. Internal Report. Vienna 2018.

Agriculture

Emission estimation for *3.A*, *3.B* and *3.D* were carried out by scientific institutes, results were provided as in the following studies:

AGENCY FOR RENEWABLE RESOURCES (2021): https://biogas.fnr.de/daten-und-fakten/faustzahlen accessed in November 2021

AMA (2021): Fettgehalt und Eiweißgehalt der Anlieferungsmilch ab 1991: https://www.ama.at/marktinformationen/milch-und-milchprodukte/rohmilchqualitaet, accessed in November 2022.

AMA (2022): Auswertung zum Mineraldüngerverbrauch in Österreich für 2015, 2016, 2017, 2018, 2019, 2020 und 2021. Agrarmarkt Austria. September 2022.

AMON, B.; HOPFNER- SIXT, K. & AMON, T. (2002): Emission Inventory for the Agricultural Sector in Austria – Manure Management, Institute of Agricultural, Environmental and Energy Engineering (BOKU – University of Agriculture, Vienna), July 2002.

AMON, B. & HÖRTENHUBER, S. (2010): Revision of Austria's National Greenhouse Gas Inventory, Sector Agriculture. Final Report. Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU), study on behalf of Umweltbundesamt GmbH. Wien. (unpublished)

AMON, B. & HÖRTENHUBER, S. (2014):Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien 2014 (unveröffentlicht).

AMON, B. & HÖRTENHUBER, S. (2019): Implementierung der TIHALO II Ergebnisse sowie des EMEP/EEA Guidebooks 2016 in das Landwirtschafts-Emissionsmodell für die OLI 2018. Endbericht. Priv. Doz. Dr. nat. techn. Barbara Amon und Dr. nat. techn. Stefan Hörtenhuber (Forschungsinstitut für Biologischen Landbau FiBL) im Auftrag vom Umweltbundesamt. Wien 2019 (unveröffentlicht).

GEBETSROITHER, E.; STREBL, F. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; Report ARC-S-0175, ARC Seibersdorf research, July 2002.

STREBL, F.; GEBETSROITHER, E. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Agricultural Soils in Austria; ARC Seibersdorf research, revised version, February 2003.

UNECE (2015): Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. United Nations Economic Commission for Europe, 2015. http://www.unece.org/environmental-policy/conventions/envlrtapwelcome/publications.html

As these studies are not published, a detailed description of the applied methods is given in the NIR. In the following data sources used in the studies mentioned above are summarized.

AMLINGER, F.; PEYR, S.; HILDEBRANDT, U.; MÜSKEN, J. & CUHLS, C. (2005): Stand der Technik der Kompostierung, Grundlagenstudie.

AMON, B. & HÖRTENHUBER, S. (2008): Revision der österreichischen Luftschadstoff-Inventur (OLI) für NH_3, NMVOC und NO_x; Sektor 4, Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien. (unpublished)

AMON, B.; FRÖHLICH, M.; WEIßENSTEINER, R; ZABLATNIK, B. & AMON, T. (2007): Tierhaltung und Wirtschaftsdüngermanagement in Österreich. Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft, Wien.

AMON, B.; KRYVORUCHKO, V. & AMON, T. (2006): Influence of different levels of covering on greenhouse gas and ammonia emissions from slurry stores. International Congress Series (ICS) No 1293 "2nd International Conference on Greenhouse Gases and Animal Agriculture.

AMON, B.; KRYVORUCHKO, V.; FRÖHLICH, M.; AMON, T.; PÖLLINGER, A.; MÖSENBACHER, I. & HAUSLEITNER, A. (2007a). Ammonia and greenhouse gas emissions from a straw flow system for fattening pigs: Housing and manure storage. Livestock Science 112, 199–207.

AMON, B.; MOITZI, G.; SCHIMPL, M.; KRYVORUCHKO, V. & WAGNER-ALT, C. (2002a): Methane, Nitrous Oxide and Ammonia Emissions from Management of Liquid Manures. Final Report November 2002. Research project no. 1107, BMLF GZ 24.002/24-IIA1a/98 and extension GZ 24.002/33-IIA1a/00. On behalf of Federal Ministry of Agriculture, Forestry, Environment and Water Management, and Federal Ministry for Education, Science and Culture. Vienna.

AMON, B. et al. (2002, 2008 & 2010): not published final reports on the revision of Austria's Air Emissions Inventory, Sector Agriculture. Vienna.

AMON, B. (2010): expert judgement, personal communication. Vienna.

AMON, T. (2011): expert judgement, personal communication. Vienna.

AUSTRIAN CHAMBER OF AGRICULTURE (2012): Statistical data of burning straw. Mag. Längauer (email), November 2012.

AUSTRIAN CHAMBER OF AGRICULTURE (2022): Statistical data of burning straw. Mag. Längauer (email), November 2022.

BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT (LFL) (2020): Gruber Tabelle zur Fütterung in der Rindermast. Freising-Weihenstephan: Institut für Tierernährung und Futterwirtschaft.

BERNHAUSER, O. (2014): Personal Communication. Expert of the Regional Chamber of Agriculture in Lower Austria.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2002): Gewässerschutzbericht gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2007): Sonderrichtlinie des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW) für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft. Anlage I, Anhänge zum Agrarumweltprogramm und zur Tierschutzmaßnahme (ÖPUL 2007). http://www.ama.at/Portal.Node/ama/public?gentics.rm=PCP&gentics.pm=gti_full&p.contentid=10008.47092&SRL_O4_20071126.pdf

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2017): Richtlinien für die sachgerechte Düngung. 7. Auflage Fachbeirat für Bodenfruchtbarkeit und Bodenschutz. Wien.

BML – Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft (2022b): Grüner Bericht 1999, 2000, 2002, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Grüner Bericht gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. www.gruenerbericht.at . In 2022, the Federal Ministry of Agriculture, Regions and Tourism (BMLRT) has become the BML.

BRUNSTERMANN, R. (2007): Übung Biologische Abfallbehandlung Teil 1; Universität Essen. https://www.uni-due.de/imperia/md/content/abfall/__bungbiologie1bsc2007.pdf

BUCHGRABER, K.; AMLINGER, F.; TULNIK, R. (2003) Produktion und Einsatz von Kompost in der Landwirtschaft und im Gemüsebau; Landwirt Heft 12/2003 Sonderbeilage

BUNDESANSTALT FÜR AGRARWIRTSCHAFT UND BERGBAUERNFRAGEN (2022): Federal Institute of Agricultural Economics. Download from data pool. https://bab.gv.at/index.php?lang=de.

DETZEL, A; VOGT, R; FEHRENBACH, H. et al. (2003): Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationalen Richtlinien. Institut für angewandte Ökologie (IFEU). Institute for Applied Ecology.

DLG – Deutsche Landwirtschafts-Gesellschaft (1997): DLG-Futterwerttabelle für Wiederkäuer. 7. erweiterte und überarbeitete Auflage. DLG-Verlag, Frankfurt/Main, Germany.

EAGER – European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER).

E-CONTROL (2008): Ökostrombericht 2008. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Oktober 2008. Wien.

E-CONTROL (2010): Ökostrombericht 2010. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Juli 2009. Wien.

E-CONTROL (2011): Ökostrombericht 2011. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2011. Wien.

E-CONTROL (2013): Ökostrombericht 2013. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2013. Wien.

E-CONTROL (2013): Rohstoffbilanzen für 2011. Personal communication by DI Michael Sorger, 18.09.2013.

E-CONTROL (2014): http://www.e-control.at/portal/page/portal/medienbibliothek/publikationen/dokumente/pdfs/Oekostrombericht2014_final.pdf accessed October 2014

E-CONTROL (2015): http://www.e-control.at/documents/20903/388512/Oekostrombericht-2015.pdf/592ed7a3-4913-401d-a6d4-d57780c2776d accessed in January 2016

E-CONTROL (2016): https://www.e-control.at/documents/20903/388512/e-control-oekostrombericht-2016.pdf/bbd26620-e1a3-4243-aed7-33c95e317d7a accessed in December 2016

E-CONTROL (2017): https://www.e-control.at/documents/20903/388512/e-control-oekostrombericht-2017.pdf/ce32088b-b8dc-85d3-2585-c6af224b3113 accessed in November 2017

E-CONTROL (2018): https://www.e-control.at/documents/20903/388512/%C3%96kostrombericht_2018.pdf/6d5a9de6-7b65-5c72-740e-3a8d16282368 accessed in November 2018

E-CONTROL (2019): https://www.e-control.at/documents/1785851/1811582/%C3%96kostrombericht_FINAL.pdf/f689b909-2088-77b0-0c9e-eeb260effe7b?t=1569999423109 accessed in October 2019.

E-CONTROL (2020): EC_Ökobericht20_08.09_NEU.indd (e-control.at) accessed in October 2020.

E-CONTROL (2021): EC_Ökobericht21_18.10.indd (e-control.at) accessed in October 2021.

E-CONTROL (2022b): EC_EAG_Monitoringb_15.09_DRUCK.indd (e-control.at) accessed in November 2022.

EDER, A., FEICHTINGER, F., STRAUSS, P. & BLÖSCHL G. (2013): Calculation of nitrogen leaching values for the annual greenhouse gas inventory of Austria – Evaluation of long term lysimeter time series. Federal Agency for Water Management, Institute for Land and Water Management Research, Petzen-kirchen,and Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria.

EDER, A., BLÖSCHL G.,FEICHTINGER, F.; HERNDL, M., KLAMMLER, G.; HÖSCH, J., ERHART, E. & STRAUSS, P.(2014): Indirect nitrogen losses of managed soils contributing to greenhouse emissions of agricultural areas in Austria: results from lysimeter studies. Article in Nutr Cycl Agroecosyst. DOI 10.1007/s10705-015-9682-9. 2015.

EEA – European Environment Agency (2009): EMEP/EEA air pollutant emission inventory guidebook – 2009. Technical report No 6/2009. Copenhagen.

EEA – European Environment Agency (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013. EEA Technical report No. 12/2013. Copenhagen.

EEA – European Environment Agency (2016): EMEP/EEA air pollutant emission inventory guidebook – 2016. EEA Technical report No. 21/2016. Copenhagen.

EEA – European Environment Agency (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019. EEA Technical report No. 19/2019. https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

EEA – European Environment Agency (2020): 2020 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 4(3) of Regulation (EU) No 2018/842 and to Article 3 of Decision No 406/2009/EC – Austria. Final Review Report. August 2020.

Egger-Danner, C.; Fürst-Waltl, B.; Fürst, C.; Gruber, L.; Hörtenhuber, S.; Koeck, A.; Ledinek, M.; Pfeiffer, C.; Steininger, F.; Weißensteiner, R.; Willam, A.; Zollitsch, W.; Zottl, K. (2016): EFFICIENT COW. Analyse und Optimierung der Produktionseffizienz und der Umweltwirkung in der österreichischen Rinderwirtschaft. Wien: Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter ZAR.

EGLE, L., RECHBERGER, H., ZESSNER, M., (2014) Phosphorbilanz Österreich Grundlage für ein nachhaltiges Phosphormanagement – gegenwärtige Situation und zukünftige Entwicklung; Hrsg. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Sektion VII Wasser

FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V. (FNR, 2010): Leitfaden Biogas. Von der Gewinnung zur Nutzung. Herausgegeben von der Fachagentur Nachwachsende Rohstoffe mit Förderung des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz aufgrund eines Beschlusses des Deutschen Bundestages 5., vollständig überarbeitete Auflage, Gülzow, 2010.

FAO AGR. STATISTICAL SYSTEM (2001): FAO Agricultural Statistical System. http://faostat.fao.org/site/339/default.aspx

FNR (FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V.; 2006): Handreichung - Biogasgewinnung und -nutzung. 3. überarbeitete Auflage. Gülzow, Germany.

FOEN – FEDERAL OFFICE FOR THE ENVIRONMENT (2021): Switzerland's Greenhouse Gas Inventory 1990–2019. National Inventory Report including reporting elements under the Kyoto Protocol. Submission of April 2021 under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Bern, 2021.

FRANKHAUSER, J. (2007): Personal Communication, Austrian Chamber of Agriculture, May. Vienna.

FREIBAUER, A. & KALTSCHMITT, M. (2001): Biogenic greenhouse gas emissions from agriculture in Europe. European Summary Report (Project Report Task 3) of the EU-Concerted Action FAIR3-CT96-1877 "Biogenic Emissions of Greenhouse Gases Caused by Arable and Animal Agriculture".

GRABNER, R.; KLATZER, R.; MEIER, W.; STEINWIDDER, A.; STÖGER, E. & TOIFL, G. (2004): Mutterkuh- und Ochsenhaltung 2003. Ergebnisse und Konsequenzen der Betriebszweigauswertung aus den Arbeitskreisen Mutterkuh und Ochsenhaltung [Husbandry of mother cows and bullocks 2003]. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien.

GRUBER, L. & STEINWIDDER, A. (1996): Einfluß der Fütterung auf die Stickstoff- und Phosphorausscheidung landwirtschaftlicher Nutztiere – Modellkalkulationen auf Basis einer Literaturübersicht in: Die Bodenkultur – Austrian Journal of Agricultural Research, 47. Band/Heft 4/Dezember 1996/ISBN 0006-5471, WUV-Universitätsverlag, Wien.

GRUBER, L.; PÖTSCH, E. M. (2006): Calculation of nitrogen excretion of dairy cows in Austria. Die Bodenkultur, 2006, Vol. 57, Heft 1–4, Vienna.

GRUBER, L.; ETTLE, T.; SCHWARZ, F. J.; SUSENBETH, A.; ROYER, M.; PRIES, M.; FISCHER, B.; JILG, T.; KOCH, C.; TERLER, G.; MEYER, U.; HAMMON, H. M.; KUNZ, H.-J. & GUGGENBERGER T. (2021): Untersuchungen zur Futteraufnahme und zum Energieaufwand von Aufzuchtrindern der Rasse Fleckvieh und Holstein von der Geburt bis 220 kg Lebendmasse. 48. Viehwirtschaftliche Fachtagung, 1–26.

HADORN, R. & WENK, C. (1996): Effect of different sources of dietary fibre on nutrient and energy utilization in broilers. 2. Energy and N-balance as well as whole body composition. Archiv für Geflügelkunde.

HÄUSLER, J. (2009): Das Leistungspotenzial von Fleckviehmutterkühen – Versuchsergebnisse des LFZ Raumberg-Gumpenstein. Fachtag „Erfolgreiche Mutterkuhhaltung" Fachschule Warth.

HEIM, P. (2005): Fütterung von Kuh und Kalb. [Feeding of mother cow and calve]. Article in UFA-Revue 3/05, an agricultural journal of Switzerland.

HÖRTENHUBER, S. (2022): Update of data on livestock feeding in the Austrian Air Pollutant Inventory (OLI) for poultry, horses, sheep, goats and other animals & revision of the calculations for biogas. Final project report. Dezember 2021. (Unpublished).

HÖRTENHUBER, S.; GRÖßBACHER, V.; SCHANZ, L. (2022a): Update of data on livestock feeding in the Austrian Air Pollutant Inventory (OLI) for cattle and pigs. Final project report. Dezember 2021. (Unpublished).

HÖRTENHUBER, S.; GRÖßBACHER, V.; WEISSENSTEINER, R.; ZOLLITSCH, W. (2022b): Minderungspotenziale zu Treibhausgas- und Luftschadstoff-Emissionen aus der Nutztierhaltung unter besonderer Berücksichtigung ernährungsbezogener Faktoren (MiNutE). Universität für Bodenkultur. Wien 2022.

HÖRTENHUBER, S.; GRÖßBACHER, V.; SCHANZ, L.; ZOLLITSCH, W.J. (2023): Implementing IPCC 2019 Guidelines into a National Inventory: Impacts of Key Changes in Austrian Cattle and Pig Farming. Sustainability 2023, 15, 4814. https://doi.org/10.3390/su15064814

IPCC – Intergovernmental Panel on Climate Change (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the Task Force on National Greenhouse Gas Inventories (TFI) in accordance with the decision taken at the 44th Session of IPCC in Bangkok, Thailand, in October 2016. Published: May 2019. Publications - IPCC-TFI (iges.or.jp)

KIRNER, L. & SCHNEEBERGER, W. (1999): Strukturanalyse der Betriebe mit der ÖPUL-Maßnahme „Verzicht auf bestimmte ertragssteigernde Betriebsmittel (Betrieb)". Der Förderungsdienst 47(6).

KRANERT M., CORD-LANDWEHR K., (2010): Einführung in die Abfallwirtschaft; 4 vollständig aktualisierte und erweiterte Auflage; S. 226.

KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht, WUV Universitätsverlag, Wien.

KTBL – Kuratorium für Technik und Bauwesen in der Landwirtschaft; German Association for Technology and Structures in Agriculture (2005): Gasausbeute in Landwirtschaftlichen Biogasanlagen. KTBL-Heft 50.Darmstadt, Germany.

LANDESBETRIEB LANDWIRTSCHAFT HESSEN (2013): Nährstoffgehalte pflanzlicher Produkte zum Nährstoffvergleich. http://www.llh-hessen.de/pflanzenproduktion/duengung-boden/n-duengung/155-landwirtschaft/pflanzenproduktion/duengung-boden/567-naehrstoffgehalte-pflanzlicher-produkte-zum-naehrstoffvergleich.html (accessed 4.6.2014)

LÖHR, L. (1990): Faustzahlen für den Landwirt.

MENZI, H.; RUETTIMANN, L. & REIDY, B. (2003): DYNAMO: A new calculation model for dynamic emission inventories for ammonia. Proc. International Symposium 'Gaseous and odour emissions from animal production facilities', Horsens, Denmark, June 1–4.

NEUMAYR, C. (2012): Treibhausgasemissionen von Systemen der Rind- und Lammfleischerzeugung. Diplomarbeit / Masterarbeit - Institut für Nutztierwissenschaften (NUWI), BOKU-Universität für Bodenkultur, pp 97.

PHILIPPITSCH, R.; GRATH, J.; SCHIMON, W.; GMEINER, C.; DEUTSCH, K.; GRUBER, D.; TOMEK, H.; BONANI, M. & LASSNIG, M. (2001): Wassergüte in Österreich. Jahresbericht 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBl. Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.

PÖLLINGER, A. (2008): national expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution 1990-2008 carried out in June 2008. Vienna.

PÖLLINGER, A. (2018): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution carried out within (AMON & HÖRTENHUBER 2019). Vienna.

PÖLLINGER et al. (2018): Erhebung zum Wirtschaftsdüngermanagement aus der landwirtschaftlichen Tierhaltung in Österreich. Surveys on manure management from agricultural livstock farmings in Austria. Abschlussbericht TIHALO II. Projekt Nr./Wissenschaftliche Tätigkeit Nr. 3662. PÖLLINGER, A.; BRETTSCHUH, S.; LACKNER, L.; STICKLER, Y.; ZENTNER, A.; HBLFA Raumberg Gumpenstein & Bundesanstalt für Agrarwirtschaft, Wien. Bundesministerium für Nachhaltigkeit und Tourismus (BMNT), Wien 2018.

PÖLLINGER, A. (2021): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Investigation of data on slurry application stemming from the ÖPUL promotion database of the Federal Ministry for Agriculture, Regions and Tourism (BMLRT). Vienna 2021.

PÖTSCH, E.M.; GRUBER, L. & STEINWIDDER, A. (2005): Answers and comments on the additional questions, following the meeting in Bruxelles. Internal statement, HBLFA Raumberg-Gumpenstein.

PRILLER, H. (2004): Berechnung der N-Ausscheidung für Schweine. Dokument zur Fütterungsberatung an den Landwirtschaftskammern. 10 p.

REIDY, B. & MENZI, H. (2005): Ammoniakemissionen in der Schweiz: Neues Emissionsinventar 1990 bis 2000 mit Hochrechungen bis 2003 Technischer Schlussbericht Schweizerische Hochschule für Zollikofen.

Reidy, B.; Dämmgen, U.; Döhler, H.; Eurich-Menden, B.; Evert, F. K. van; Hutchings, N. J.; Luesink, H. H.; Menzi, H.; Misselbrook, T. H.; Monteny, G.J. & Webb, J. (2008): Comparison of models used for national agricultural ammonia emission inventories in Europe : liquid manure systems. Atmospheric environment, Band 42, Heft 14, Seite 3452–3464, englisch. ISSN: 0004-6981.

REIDY, B.; RIHM, B. & MENZI, H. (2007): A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations, Reference: AEA7495, IN Journal: Atmospheric Environment.

Reidy, B.; Webb, J.; Misselbrook, T.H.; Menzi, H.; Luesink, H.H.; Hutchings, N.J.; Eurich-Menden, B.; Döhler, H. & Dämmgen, U. (2009): Comparison of models used for national agricultural ammonia emission inventories in Europe: Litter-based manure systems. Atmospheric environment, Band 43, Heft 9, Seite 1632–1640, englisch. ISSN: 0004-6981.

REIDY et al. (2008, 2009): Comparisons of models used for national agricultural ammonia emission inventories in Europe. Atmospheric Environment, Band 42 and Band 43.

RESCH, R., GUGGENBERGER,T., WIEDNER, G., KASAL, A., WURM, K., GRUBER, L., RINGDORFER, F. & BUCHGRABER, K. (2006): Futterwerttabellen im Jahr 2006 für das Grundfutter im Alpenraum. Available from Website http://www.gumpenstein.at

RINDERZUCHT AUSTRIA (2022): Annual Breeding data reports (Zucht Data Jahresberichte). Available from Website https://www.zar.at/Downloads/Jahresberichte/ZuchtData-Jahresberichte.html

RÖMPP LEXIKON CHEMIE (1996-1999): 10. Auflage, Band 3: H – L

RWA (2006–2013): Expert judgements based on annual sales data of urea. Personal communication, Raiffeisen Ware Austria AG, Wien.

SBV – Swiss Farmers Union (2007): Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2006. Swiss Farmers Union, Brugg.

SBV – Swiss Farmers Union (2021): Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2019. Swiss Farmers Union, Brugg.

SCHÄFER, R. (2002): Neues Konzept zum Düngemitteleinsatz. In: VKS News 65. Ausgabe 08/2002.

SCHECHTNER (1991): Wirtschaftsdünger – Richtige Gewinnung und Anwendung, Sonderausgabe des Förderungsdienst 1991, BMLF, Wien.

SCHOLZ, H.; KOVACS, A. Z.; STEFLER, J.; FAHR, R-D.; VON LENGERKERN, G. (2001): Milchleistung und -qualität von Fleischrindkühen während der Säugeperiode. Archiv für Tierzucht. 44(6), 611–620.

STANZEL, W.; JUNGMEIER, G. & SPITZER, J. (1995): Emissionsfaktoren und energietechnische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research, Institut für Energieforschung.

STATISTIK AUSTRIA (1960–2020): Statistik der Landwirtschaft. Statistik Austria, Wien.

STATSTIK AUSTRIA (1990–2022): Agrarstrukturerhebungen 1990–2020. Schnellberichte. Statistik Austria. Wien 2022 http://www.statistik.at/web_de/services/publikationen/8/index.html

STATISTIK AUSTRIA (2015): Richtlinien für die Ernteerhebung 2015. Feldfrüchte und Dauerwiesen. Statistik Austria. Wien.

STATISTIK AUSTRIA (2018): Agrarstrukturerhebung: Stichprobenerhebung 2016. Schnellbericht 1.17, Wien.

STATISTIK AUSTRIA (2022a): Allgemeine Viehzählung am 1. Dezember 2021. National livestock counting December 2021 published in: BML 2022.

STATISTIK AUSTRIA (2022B): Final results of the farm structure survey 2020. Agrarstrukturerhebung_2020_20221117 (statistik.at)

STEINWENDER, R. & GOLD, H. (1989): Produktionstechnik und Gebrauchskreuzungen in der Mutterkuhhaltung. Versuchsbericht. Agricultural Research Center for Alpine Regions, Gumpenstein.

STEINWIDDER, A. (2003): Qualitäts-Rindermast im Grünland. Mutterkuhhaltung und Jungrinder. Ochsen-, Kalbinnen- und Bullenmast. Leopold Stocker Verlag. Graz, Stuttgart

STEINWIDDER, A. & GUGGENBERGER, T. (2003): Erhebungen zur Futteraufnahme und Nährstoffversorgung von Milchkühen sowie Nährstoffbilanzierung auf Grünlandbetrieben in Österreich. Die Bodenkultur 54 (1), 49–66.

STEINWIDDER, A; HÄUSLER, J.; SCHAUER, A.; MAIERHOFER, G.; GRUBER, L.; GASTEINER, J. & PODSTATZKY, L. (2006): Einfluss des Absetztermins auf die Milchleistung und Körpermasse von Mutterkühen sowie die Zuwachsleistung von Mutterkuh-Jungrindern. Versuchsbericht. Extensively managed beef cows – Effects on animal health, reproductive success, performance of calves and economics. Experiment 2004 to 2008. Interim report. Agricultural Research and Education Centre, HBLFA Raumberg-Gumpenstein.

SÜD-TREBER GMBH (2021): Nährstoffe zu Rübenkleinteilen. https://suedtreber.de/produkte/rubenkleinteile/ accessed November 2021

UMWELTBUNDESAMT (1997): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998): Götz, B.: Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Berichte, Bd. BE-087a, Umweltbundesamt, Wien, July 1998.

UMWELTBUNDESAMT (2011a): Query of data from the National Austrian Waste Water Database. Vienna 2011.

UMWELTBUNDESAMT (2013): Data on sewage sludge application provided by the provincial governments. Vienna 2013.

UMWELTBUNDESAMT (2014a): Data on sewage sludge application provided by the provincial governments. Vienna 2014.

UMWELTBUNDESAMT (2014c): Stakeholder Workshop on the revision of the agricultural model according to the IPCC 2006 GL.16th September 2014. Vienna.

UMWELTBUNDESAMT (2015): Data on sewage sludge application provided by the provincial governments. Vienna 2015.

UMWELTBUNDESAMT (2016a): Data on sewage sludge application provided by the provincial governments. Vienna 2016.

UMWELTBUNDESAMT (2017): Data on sewage sludge application provided by the provincial governments. Vienna 2017.

UMWELTBUNDESAMT (2018): Data on sewage sludge application provided by the provincial governments. Vienna 2018.

UMWELTBUNDESAMT (2019a): Data on sewage sludge application provided by the provincial governments. Vienna 2019.

UMWELTBUNDESAMT (2020): Data on sewage sludge application provided by the provincial governments. Vienna 2020.

UMWELTBUNDESAMT (2021): Data on sewage sludge application provided by the provincial governments. Vienna 2021.

UMWELTBUNDESAMT (2022b): Data on sewage sludge application provided by the provincial governments. Vienna 2022.

UMWELTBUNDESAMT (2023b): Anderl, M.; Brendle, C.; Colson, J.; Gangl, M.; Makoschitz, L.; Mayer, S.; Pazdernik, K.; Poupa, S.; Purzner, M.; Reiterer, D.; Roll, M.; Schieder, W.; Schmidt, G.; Stranner, G.; Wieser, M.; Wankmüller & Zechmeister, A.: Austria's Informative Inventory Report 2023. Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Reports, DRAFT, Wien.

UNECE (2015): Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. United Nations Economic Commission for Europe, 2015. http://www.unece.org/environmental-policy/conventions/envlrtapwelcome/publications.html

UNTERARBEITSGRUPPE N-ADHOC (2004): Überprüfung und Überarbeitung der N-Anfallswerte für einzelne Tierkategorien. Unterlagen ausgearbeitet vom Fachbeirat für Bodenfruchtbarkeit und Bodenschutz des BMLFUW.

ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Jahrbuch 2004. Data query 2007. http://www.zamg.ac.at/fix/klima/jb2004/Web/index.html

Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter (2004): Cattle Breeding in Austria, 148 pp.

ZESSNER, M. (1999): Bedeutung und Steuerung von Nährstoff- und Schwermetallflüssen des Abwassers. Wiener Mitteilung Band 157. Wien, 1999.

LULUCF

AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG 1996: Bodenzustandsinventur Burgenland. Amt der Burgenländischen Landesregierung, Eisenstadt.

AMT DER KÄRNTNER LANDESREGIERUNG 1999: Kärntner Bodenzustandsinventur. Amt der Kärntner Landesregierung, Klagenfurt.

AMT DER NIEDERÖSTERREICHISCHEN LANDESREGIERUNG 1994: Bodenzustandsinventur Niederösterreich. Amt der Niederösterreichischen Landesregierung, St. Pölten.

AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG 1993: Oberösterreichischer Bodenkataster – Bodenzustandsinventur 1993. Amt der Oberösterreichischen Landesregierung, Linz.

AMT DER SALZBURGER LANDESREGIERUNG 1993: Salzburger Bodenzustandsinventur. Amt der Salzburger Landesregierung, Salzburg.

AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 1988–1996: Steiermärkische Bodenschutzberichte 1988–1996. Amt der Steiermärkischen Landesregierung, Graz.

AMT DER TIROLER LANDESREGIERUNG 1988: Bericht über den Zustand der Tiroler Böden. Amt der Tiroler Landesregierung, Innsbruck.

AUSTRIAN STANDARD ÖNORM B 3012 (2003): Holzarten – Kennwerte zu den Benennungen und Kurzzeichen der ÖNORM EN 13556 (Wood species – Characteristic values to terms and symbols of ÖNORM EN 13556). Austrian Standard, Wien.

BEV – Bundesamt für Eich- und Vermessungswesen (2022): Regional Information derived from the Austrian real estate database BEV – Austrian Federal Office of Metrology and Surveying, Wien.

BFW (1992): Österreichische Waldbodenzustandsinventur. Mitteilungen der Forstlichen Bundesversuchsanstalt Wien, Vol. 168/I, Vol. 168/II, Federal Office and Research Centre for Forests, Wien.

BFW (2005): Erhebungsnetz der österreichischen Waldinventur. http://www.bfw.ac.at/rz/bfwcms.web?dok=2384

BFW (2009): BioSoil - das europäische Waldboden-Monitoring. In: BFW-Praxisinformation Nr. 20 p. 13-15. Federal Office and Research Centre for Forests, Wien.

BFW (2022): Waldinventurergebnisse der Perioden 1992/96, 2000/02, 2007/09, 2016/2022. Federal Office and Research Centre for Forests, Wien. http://bfw.ac.at/rz/wi.home

BFW (2022a pers. comm.): Annual growth indices. Personal communication, Federal Office and Research Centre for Forests, Wien.

BFW (2011b pers. comm.): Figures on needle, branch and root biomasses for the Austrian forests for the individual NFI periods. Personal communication, Federal Office and Research Centre for Forests, Wien.

BFW (2019): Holzvorrat auf neuem Höchststand. In: BFW-Praxisinformation Nr. 50 p. 8-12. Federal Office and Research Centre for Forests, Wien.

BGBL. Nr. 440/1975: Forest Act of the Republic of Austria. Federal Ministry of Agriculture, Forestry, Environment and Water Management – Vienna/Austria.

BMK (2021): Holzströme in Österreich. Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna/Austria. https://www.klimaaktiv.at/erneuerbare/energieholz/holzstr_oesterr.html

BMLFUW (2000): Empfehlungen für die sachgerechte Düngung von Christbaumkulturen. Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006c): Richtlinien für die Sachgerechte Düngung. 6. Auflage. Fachbeirat für Bodenfruchtbarkeit und Bodenschutz, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2016): Sonderrichtlinie des BMLFUW für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft (ÖPUL 2015). https://www.bmnt.gv.at/english/agriculture/Rural-development/-pul2015until2020.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2017): Richtlinien für die sachgerechte Dünung im Ackerbau und Grünland, 7. Auflage, Kapitel 5.2.1, Tab.70. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1985-2017): Grüner Bericht. Bericht über die Lage der österreichischen Land- und Forstwirtschaft. Wien. Federal Ministry for Agriculture, Forestry, Environment and Water Management.

BMLRT (1964–2021): Holzeinschlag in Österreich. Edited annually by the Federal Ministry for Agriculture, Regions and Tourism, Wien. https://info.bmlrt.gv.at/themen/wald/wald-in-oesterreich/wald-und-zahlen/Holzeinschlag.html

BMLRT (Bundesministerium für Landwirtschaft, Regionen und Tourismus) (2020-2021): Grüner Bericht. Bericht über die Situation der österreichischen Land- und Forstwirtschaft gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. www.gruenerbericht.at. Federal Ministry of Agriculture, Regions and Tourism.

BMNT (Bundesministerium für Nachhaltigkeit und Tourismus) (2018-2019): Grüner Bericht. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Wien. Federal Ministry for Sustainability and Tourism.

BORIS – Bodeninformationssystem des Umweltbundesamtes: http://www.borisdaten.at

DÖRFLINGER, A.; HIETZ, P.; MAIER, R.; PUNZ, W.; FUSSENEGGER, K. (1995): Ökosystem Großstadt Wien – Quantifizierung ökologischer Parameter unter besonderer Berücksichtigung der Vegetation; Bundesministerium für Wissenschaft und Forschung und MA 22.

ECKMÜLLNER, O. (2006): Allometric relations to estimate needle and branch mass of Norway spruce and Scots pine in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions. 123. Jg., Heft 1/2, 7–16.

EDER, A., FEICHTINGER, F., STRAUSS, P. & BLÖSCHL G. (2013): Calculation of nitrogen leaching values for the annual greenhouse gas inventory of Austria – Evaluation of long term lysimeter time series. Federal Agency for Water Management, Institute for Land and Water Management Research, Petzen-kirchen,and Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria.

FINNISH ENVIRONMENT INSTITUTE (2011): Soil Carbon Model Yasso. Finnish Environment Institute, Helsinki, http://www.ymparisto.fi/default.asp?contentid=250208&lan=en&clan=en

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2003). Quantification of carbon pools in agriculturally used soils of Austria by use of a soil information system as basis for the Austrian carbon balance model. OECD Expert Meeting: Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analyses., C. A. S. Smith (ed., 14–18 October 2002, Ottawa, Canada, Agriculture and Agri-Food Canada, Ottawa, CA & Organisation of Economic Co-operation and Development, Paris, FR.

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2005). Quantification of organic carbon pools for Austria's agricultural soils using a soil information system. Can. J. Soil Sci. 85: 491–498.

GSCHWANTNER, TH. & SCHADAUER, K. (2006): Branch biomass functions for broadleaved tree species in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions, 123 Jg.; Heft 1/2, 17–34.

GSCHWANTNER, TH., GABLER, K., SCHADAUER, K. & WEISS, P. (2010): National Forest Inventory Reports, Chapter 1: Austria. In: Tomppo, E.; Gschwantner, Th.; Lawrence, M. & McRoberts, R.E. (Eds.): National Forest Inventories: pathways for common reporting. Springer, Heidelberg, Dordrecht, London, New York, 57–71.

HAUK, E. & SCHADAUER, K. (2009): Instruktionen für die Feldarbeit der Österreichischen Waldinventur 2007–2009. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at:, http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf

HOCHBICHLER, E.; BELLOS, P. & LICK, E. (2006): Biomass functions and expansion factors for spruce, pine, beech and oak in Austria. Austrian Journal on Forest Science, Special Issue on Austrian biomassfunctions. 123. Jg., Heft 1/2, 35–46.

IPCC (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry. Edited by J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner.

JÄGER, F. (2003): Forstrecht. 3rd Edition, Verlag Österreich, Wien.

JFSQ – JOINT FOREST SECTOR QUESTIONNAIRE FOR 2020, provided by the BML. Vienna, 2021. unpublished.

JFSQ – JOINT FOREST SECTOR QUESTIONNAIRE for 2021, provided by the BML. Vienna, 2022. unpublished.

JUHOS, K.& TÖKEL, L. (2012): Carbon content of the biomass of vineyards and orchards in Hungary An assessment based on large-scale field measurements, case studies and expert judgement. Corvinus University of Budapest, Budapest

KÖRNER, C.; SCHILCHER, B. & PELAEZ-RIEDL, S. (1993): Bestandsaufsaufnahme anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – Mögliche Maßnahmen. Dokumentation, Kapitel 6.1. Österreichische Akademie der Wissenschaften. Wien.

KORTELAINEN, P.; PAJUNEN, H.; RANTAKARI, M. & SAARNISTO, M. (2004): A large carbon pool and small sink in boreal Holocene lake sediments. Global Change Biology 10/10, 1648–1653.

LEDERMANN, T. & NEUMANN, M. (2006): Biomass equations from data of old long-term experimental plots. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 47–64.

NESTROY, O.; DANNEBERG, O. H. & ENGLISCH, M. (2000): Systematische Gliederung der Böden Österreichs (Österreichische Bodensystematik 2000). Mitt. d. Österr. Bodenkundl. Ges., H. 60, Wien 2000.

OFFENTHALER, I. & HOCHBICHLER, E. (2006): Estimation of root biomass for Austrian forest tree species. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 65–86.

ÖSTAT (Österreichisches Statistisches Zentralamt) (1991): Land- und Forstwirtschaftliche Betriebszählung 1990. Hauptergebnisse Österreich. Heft 1.060/12. Wien.

ÖSTAT (Österreichisches Statistisches Zentralamt) (1994): Agrarstrukturerhebung 1993. Schnellbericht 1.17. Wien.

ÖSTAT (Österreichisches Statistisches Zentralamt) (1998): Agrarstrukturerhebung 1997. Schnellbericht 1.17. Wien.

RUBATSCHER, D.; MUNK, K.; STÖHR, D.; BAHN, M.; MADER-OBERHAMMER, M. & CERNUSCA, A. (2006): Biomass expansion functions for Larix decidua: a contribution to the estimation of forest carbon stocks. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 86–101.

RUSS, W. (2004): Mehr Wald – ein positiver Trend? BFW Praxis Information 3/2004, pp. 4-7, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at: http://bfw.ac.at/700/pdf/BFW_praxis2004_kl.pdf

SCHIELER, K. & HAUK, E. (2001): Instruktion für die Feldarbeit – Österreichische Waldinventur 2000/2002, Fassung 2001. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna. Download at: http://bfw.ac.at/700/pdf/da_ges_neu.pdf

SCHIELER, K.; BÜCHSENMEISTER, R. & SCHADAUER, K. (1995): Österreichische Forstinventur – Ergebnisse 1986/90. Bericht 92, Federal Office and Research Centre for Forests, Wien.

SPIEGEL, H., DERSCH, G., HÖSCH, J. & BAUMGARTEN, A. (2007): Tillage effects on soil organic carbon and nutrient availability in a long-term field experiment in Austria. Die Bodenkultur 58 (1-4).

SPLECHTNA, B. & GLATZEL, G. (2005): Optionen der Bereitstellung von Biomasse aus Wäldern und Energieholzplantagen für die energetische Nutzung. Berlin-Brandenburgische Akademie der Wissenschaften, Berlin, Materialien Nr. 1.

STATISTIK AUSTRIA (2001): Agrarstrukturerhebung 1999. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2005): Agrarstrukturerhebung 2003. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2006): Agrarstrukturerhebung 2005. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2008): Agrarstrukturerhebung 2007. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2010): Weingartengrunderhebung 2009. Schnellbericht 1.19. Wien.

STATISTIK AUSTRIA (2011): Der Weinbau in Österreich 2009. Wien.

STATISTIK AUSTRIA (2013): Agrarstrukturerhebung 2010. Gesamtergebnisse. Wien.

STATISTIK AUSTRIA (2014): Agrarstrukturerhebung 2013. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2016): Der Weinbau in Österreich 2015. Wien.

STATISTIK AUSTRIA (2018): Agrarstrukturerhebung: Stichprobenerhebung 2016. Schnellbericht 1.17, Wien.

STATISTIK AUSTRIA (2021a): Anbau auf dem Ackerland. Kalenderjahr 2020. Endgültige Ergebnisse. Schnellbericht 1.16. Wien.

STATISTIK AUSTRIA (2021b): Weingartengrunderhebung 2020. Endgültige Ergebnisse.Teil 1. Schnellbericht 1.19. Wien.

STATISTIK AUSTRIA (2022a): Agrarstrukturerhebung 2020. Statistik im Fokus 1.17, Wien.

STATISTIK AUSTRIA (2022b): Anbau auf dem Ackerland. Kalenderjahr 2021. Endgültige Ergebnisse. Schnellbericht 1.16. Wien.

STATISTIK AUSTRIA (1960-2020): Statistik der Landwirtschaft. Wien.

STEINER, G., M. & REITER, K. (1992): Österreichischer Moorschutzkatalog-Datenbank. Styria Medien Service. Wien.

STREBL, F.; GEBETSROITHER, E. & ORTHOFER, R. (2003): Greenhouse Gas Emission from Cropland & Grassland Management in Austria. ARC-S-0221. Austrian Research Centre, Seibersdorf.

UMWELTBUNDESAMT (2000a): Weiss, P.; Schieler, K.; Schadauer, K.; Radunsky, K. & Englisch, M.: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Monographien, Bd. M-106, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004b): Pilot study on statistics on waste management in agriculture, forestry and fishing – Agriwaste. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010a): Anderl, M.; Freudenschuß, A.; Friedrich, A.; Köther, T.; Kriech, M.; Kuschel, V.; Muik, B.; Pazdernik, K.; Poupa, S.; Schodl, B.; Stranner, G.; Schwaiger, E.; Seuss, K.; Weiss, P.; Wieser, M. & Zethner, G.: Austria's National Inventory Report 2010. Reports, Bd. REP-0265. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010b): Freudenschuß, A.; Sedy, K.; Spiegel, H. et al.: Arbeiten zur Evaluierung von ÖPUL-Maßnahmen hinsichtlich ihrer Klimawirksamkeit. REP-290. Umweltbundeamt, Wien. http://www.umweltbundesamt.at/aktuell/publikationen/publikationssuche/publikationsdetail/?&pub_id=1875

UMWELTBUNDESAMT (2014): Anderl, M.; Freudenschuß, A.; Haider, S.; Jobstmann,H.; Kohlbach, M.; Köther, T.; Kriech, M.; Lampert, Ch.; Moosmann, L.; Pazdernik, K.; Pinterits, M.; Poupa, S.; Schmid, C.; Stranner, G.; Schwaiger, E.; Schwarzl, B.; Weiss, P.; Zechmeister, A.: Austria's National Inventory Report 2014 – Submission under the United Nations Framework Convention of Climate Change and the Kyoto Protocol. Report REP-475; Umweltbundesamt, Vienna.

UNFCCC (2011): Report of the technical assessment of the forest management reference level submission of Austria submitted in 2011. http://unfccc.int/resource/docs/2011/tar/aut01.pdf

UNFCCC (2012): Decision 2/CMP.7 Land use, land use change and forestry, The seventh session of the Conference of the Parties serving as the meeting of the Parities to the Kyoto Protocol, 2011 in Durban, South Africa. http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf

WEST, T.O. (2008): Country-level estimates for Carbon distribution in U.S. croplands, 1990–2005. Environmental Science Division, Oak Ridge National Laboratory. http://cdiac.ornl.gov/carbonmanagement/cropcarbon/

WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports – Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5–74.

WINKLER, N. (2003): Walderschließung Österreichs im Detail. Federal Office and Research Centre for Forests, Wien, http://bfw.ac.at/700/2109.html

WIRTH, C.; SCHUMACHER, J. & SCHULZE, E.D. (2004): Generic biomass functions for Norway spruce in Central Europe – a meta-analysis approach toward prediction and uncertainty estimation. Tree Physiology 24, 121–139.

Waste

AMLINGER (2003): information from Dipl.Ing. Florian Amlinger – Compost Consulting & Development, Hochbergstrasse A-2380 Perchtoldsdorf.

AMLINGER, F.; PEYR, S.; HILDEBRANDT, U.; MÜSKEN, J.; CUHLS, C. & CLEMENS, J. (2005): Stand der Technik der Kompostierung. Grundlagenstudie. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. http://www.umweltnet.at/article/articleview/30919/1/6954

ANGERER, T. & FRÖHLICH, M. (2002): Thermisch Regenerative Oxidation als Verfahren der Abluftreinigung bei mechanisch-biologischen Anlagen zur Behandlung von Abfällen. Schriftenreihe des BMLFUW. Study is not published but can be made available to the ERT upon request.

ANGERER, T. (1997): Stand der Mechanisch-Biologischen Restabfallbehandlung vor der Deponierung (MBRVD) in Österreich – November 1997 – MUL Leoben.

AUSTROPAPIER (2022). Vereinigung der Österreichischen Papierindustrie. Statistik Papier & Zellstoff. https://austropapier.at/website2020/wp-content/uploads/2022/04/zellstoff21.pdf

BAUMELER, A.; BRUNNER, P. H.; FEHRINGER, R.; KISLIAKOVA, A. & SCHACHERMAYER, E. (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft (CH_4). Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs. Wien.

BAYARD, R., BENBELKACEM, H., GOURDON, R., BUFFI, P. (2018): Characterization of selected municipal solid waste components to estimate their biodegradability; Journal of Environmental Management 216

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2023b). Bundesabfallwirtschaftsplan 2023. Wien. https://www.bmk.gv.at/themen/klima_umwelt/abfall/aws/bundes_awp/bawp2023.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1993, 1996, 1999, 2002): Gewässerschutzberichte gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Umwelt (1995): Bundes-Abfallwirtschaftsplan Bundesabfallbericht 1995, Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2001): Bundesabfallbericht 2001, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006a): Bundes-Abfallwirtschaftsplan 2006 (BAWP 2006), Wien. www.bundesabfallwirtschaftsplan.at

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006b): Kommunale Abwasserrichtlinie der EU – 91/271 EWG, Österreichischer Bericht 2006. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008a): Statusbericht 2008 zum Bundesabfallwirtschaftsplan 2006. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2008. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2009): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2009 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2010. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011a): Bundes-Abfallwirtschaftsplan 2011 (BAWP 2011). Wien. http://www.bundesabfallwirtschaftsplan.at/

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2011 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien http://www.lebensministerium.at/publikationen/wasser/abwasser/05012011.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2012): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2012. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2013): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2012. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014a): Stork, C.; Windhofer, G. & Zieritz, I.: Kommunales Abwasser: Österreichischer Bericht 2014. Kombinierter Bericht gemäß Artikel 15 und Artikel 16 der Richtlinie 91/271/EWG für den Zeitraum 2011 – 2012. Wien, Juni 2014. http://www.bmlfuw.gv.at/wasser/wasserqualitaet/abwasserreinigung/Lagebericht2014.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014b): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2013. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015a): Parravicini, V.; Valkova, T.; Haslinger, J.; Saracevic, E.; Winkelbauer, A.; Tauber, J.; Svardal, K.; Hohenblum, P.; Clara, M.; Windhofer, G.; Pazdernik, K. & Lampert, C.: ReLaKO – Reduktionspotential bei den Lachgasemissionen aus Kläranlagen durch Optimierung des Betriebes. Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der TU Wien & Umweltbundesamt GmbH. Wien. https://www.bmlfuw.gv.at/service/publikationen/wasser/Lachgasemissionen---Kl-ranlagen.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015b): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2014. Wien, Dezember 2015. http://www.bundesabfallwirtschaftsplan.at/dms/bawp/AW_Statusbericht_2015_final.pdf

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015c): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2015. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2016b): Kommunales Abwasser. Österreichischer Bericht 2016. Wien. https://www.bmlfuw.gv.at/wasser/wasser-eu-international/europaeische_wasserpolitik/Lagebericht-2016.html

BMLRT – Bundesministerium für Landwirtschaft, Regionen und Tourismus (2020): Kommunales Abwasser. Österreichischer Bericht 2020. Wien. https://www.bmlrt.gv.at/dam/jcr:40608892-831f-40d1-bc22-106972fb1ef4/Lagebericht_2020.pdf

BML – Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft (2022c): Kommunales Abwasser. Österreichischer Bericht 2022. Wien. https://info.bml.gv.at/dam/jcr:ee735108-3eec-47d2-a1b6-ebb478b964af/UWWTD_Lagebericht_2022_2022-06-22.pdf

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2018a): Bundes-Abfallwirtschaftsplan 2017. Wien. https://www.bmnt.gv.at/umwelt/abfall-ressourcen/bundes-abfallwirtschaftsplan/BAWP2017-Final.html

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2018b): Kommunales Abwasser Österreichischer Bericht 2018. Wien

BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung 1990. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung 1996. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

DOEDENS, H.; CUHLS, C.; MÖNKEBERG, F.; LEVSEN, K.; KRUPPA, J.; SÄNGER, U. & KOCK, H. (1999): Bilanzierung von Umweltchemikalien bei der biologischen Vorbehandlung von Restabfällen, Phase 2: Emissionen, Schadstoffbilanzen und Abluftbehandlung. BMB+F Verbundvorhaben: Mechanisch-biologische Vorbehandlung von zu deponierenden Abfällen.

EEA – European Environment Agency (2020): 2020 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 4(3) of Regulation (EU) No 2018/842 and to Article 3 of Decision No 406/2009/EC – Austria. Final Review Report. August 2020.

ENVIRONMENTAL SCIENCE & TECHNOLOGY (2011): Diaz-Valbuena, L.; Leverenz, H.L.; Cappa, C.D.; Tchobanoglous, G.; Horwath, W.R., and Darby, J.L.; Methane, carbon dioxide, and nitrous oxide emissions from septic tank systems. Department of Civil and Environmental Engineering, Department of Land, Air, and Water Resources, University of California.

FLÖGL, W. (2002): Klimarelevanz der Deponien in Oberösterreich. Hydro Consulting Engineers. Erstellt im Auftrag für das Amt der OÖ Landesregierung. Abteilung Umweltschutz, UA Abfallwirtschaft. Linz.

GILBERG, U. et al. (2005): Waste management in Europe and the Landfill Directive, Background paper from the ETC/RWM to the ETC/ACC workshop "Inventories and Projections of Greenhouse Gas Emissions from Waste"; European Environment Agency.

HACKL, A. & MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.

IFEU – Institut für Energie- und Umweltforschung Heidelberg GmbH (2008) Optimierungen für einen nachhaltigen Ausbau der Biogaserzeugung und -nutzung in Deutschland

JOURNAL OF ENVIRONMENTAL MANAGEMENT 279 (2021): Valkova, T.; Parravicini, V.; Saracevic, E.; Tauber, J.; Svardal, K.; Krampe, J.: A method to estimate the direct nitrous oxide emissions of municipal wastewater treatment plants based on the degree of nitrogen removal. Research article. https://www.sciencedirect.com/science/article/pii/S0301479720314882?via%3Dihub

KAUSEL, A. (1998): Ein halbes Jahrhundert des Erfolges, Der ökonomische Aufstieg Österreichs im OECD-Raum seit 1950. Österreichische Nationalbank, Wien.

LFL – Bayerische Landesanstalt für Landwirtschaft (2017): online database on biogas potential of various substrates http://www.lfl.bayern.de/iba/energie/049711/?sel_list=1%2Cb&anker0=substratanker#substratanker

LFU – Landesanstalt für Umweltschutz Baden-Württemberg (1992): Der Deponiegashaushalt in Altablagerungen – Leitfaden Deponiegas. Materialien zur Altlastenbearbeitung. Handbuch Altlasten und Grundwasserschadensfälle. Baden-Württemberg.

ORTHOFER, R., H.M. KNOFLACHER, J. ZÜGER (1995): N_2O-Emissionen in Österreich. Seibersdorf Research Report OEFZS-A-3256, Seibersdorf.

ÖWAV – Österreichischer Wasser- und Abfallwirtschaftsverband (2003): ÖWAV Arbeitsbehelf EPER. Arbeitsbehelf zur Abschätzung von Emissionen in Luft und Wasser. Reststoff- und Massenabfalldeponie gemäß EPER-V (BGBl. II Nr. 300/2002). Wien 2003.

PARRAVICINI V.; SVARDAL K. (2015). Klimarelevante Emissionen aus der Abwasserreinigung. ÖWAV-TU-Seminar 2015, NEW: Nährstoffe – Energie – Wasser; Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der technischen Universität Wien, Wiener Mitteilungen, Band 232, 183-204 sowie Parravicini V., Valkova T. (2014). Lachgasemissionen aus kommunalen Kläranlagen. Vortrag: ÖWAV-Seminar „Abwasserreinigung - Werte erhalten, Effizienz steigern und Ressourcen schonen", Wien; 24.-25.2.2014; in: „Wiener Mitteilungen", Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft, Band 230, 125 – 156.

PARRAVICINI V., SVARDAL K., KRAMPE J. (2016). Greenhouse Gas Emissions from Wastewater Treatment Plants. Energy Procedia, 97 (2016), S. 246 – 253.

RETTENBERGER G., MEZGER, H. (1992): Der Deponiegashaushalt in Altablagerungen - Leitfaden Deponiegas

STATISTIK AUSTRIA (2022): Statistik des Bevölkerungsstandes. Erstellt am 27.05.2021. Update am 31.05.2022. Wien, 2022. https://www.statistik.at/statistiken/bevoelkerung-und-soziales/bevoelkerung/bevoelkerungsstand/bevoelkerung-im-jahresdurchschnitt

STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J. & WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemissionen. Report des Joanneum Research: Institut für Umweltgeologie und Ökosystemforschung.

UBA BERLIN (1999): MBA Bericht: Ökologische Vertretbarkeit mechanisch-biologischer Vorbehandlung von Restabfällen.

UMWELTBUNDESAMT (1995): Boos, R.; Neubacher, F.; Reiter, B.; Schindlbauer, H. & Twrdik, F.: Zusammensetzung und Behandlung von Altölen in Österreich. Monographien, Bd. M-054. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998b): Lahl, U.; Zeschmar-Lahl, B. & Scheidl, K. (1998): Abluftemissionen aus der mechanisch-biologischen Abfallbehandlung in Österreich. Monographien, Bd. M-104, Umweltbundesamt, Klagenfurt.

UMWELTBUNDESAMT (2000b): Lahl, U.; Zeschmar-Lahl, B. & Angerer, T.: Entwicklungspotentiale der mechanisch-biologischen Abfallbehandlung. Eine ökologische Analyse. Monographien, Bd. M-125, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999. Interne Berichte, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001c): Häusler, G.: Emissionen aus Abfalldeponien 1980–1998, Interner Bericht, Bd. IB-623. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001d): Perz, K.: Materialien zum Bundesabfallwirtschaftsplan 2001, Monographien, Bd. M-138, Umweltbundesamt, Klagenfurt.

UMWELTBUNDESAMT (2001e): Grech, H. & Rolland, C.: Stand der Abfallbehandlung in Österreich im Hinblick auf das Jahr 2004. Berichte, Bd. BE-182. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2003): Rolland, C. & Scheibengraf, M.: Biologisch abbaubarer Kohlenstoff im Restmüll. Berichte, Bd. BE-236. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004c): Rolland, C. & Oliva, J.: Erfassung von Deponiegas – Statusbericht von österreichischen Deponien. Berichte, Bd. BE-238. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2005): Schachermayer, E.: Vergleich und Evaluierung verschiedener Modelle zur Berechnung der Methanemissionen aus Deponien. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2006b): Neubauer, C. & Öhlinger, A.: Ist-Stand der mechanisch biologischen Abfallbehandlung (MBA) in Österreich, Zustandsbericht 2006. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007c): Lenz, K. & Kampel, E.: Nitrous Oxide emissions from industrial wastewater, Interne Studie, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008a): Schachermayer, E. & Lampert, C.: Erfasste Deponiegasmengen auf Österreichischen Deponien – Zeitreihe für die Jahre 2002 bis 2007. Reports, Bd. REP-0100. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008b): Neubauer, C. & Walter, B.: Behandlung von gemischten Siedlungs- und Gewerbeabfällen in Österreich – Betrachtungszeitraum 2003–2008. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2011a): Query of data from the National Austrian Waste Water Database. Vienna 2011.

UMWELTBUNDESAMT (2011b): Lampert, C.; Tesar, M. & Thaler, P.: Klimarelevanz und Energieeffizienz der Verwertung biogener Abfälle. Report. REP-0353. Vienna.

UMWELTBUNDESAMT (2014b): Lampert, C.: Stand der temporären Abdeckung von Deponien und Deponiegaserfassung. Report. REP-0484. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2016b): Lampert, C.; Neubauer, M. & Bernhardt, A.: Kommunale Grünabfälle (KoGa). Report. unpublished. Vienna.

UMWELTBUNDESAMT (2019b): Lampert, C.; Thaler, P.: Deponiegaserfassung 2013-2017. REP-0679. Wien

UMWELTBUNDESAMT (2019c): Lampert, C., Perl, D., Lenz, K. THG Emissionen industrielle Abwasserreinigung, unpublished. Vienna

UMWELTBUNDESAMT (2022d): Query of data from the Electronic Emission Register of Surface Water Bodies. Vienna 2022.

WEILAND, P. (2001): Grundlagen der Methangärung – Biologie und Substrate. VDI-Berichte, Nr. 1620 „Biogas als regenerative Energie – Stand und Perspektiven"; VDI-Verlag).

WERF – WATER ENVIRONMENT RESEARCH FOUNDATION (2010): Leverenz, H.L.; Tchobanoglous, G.; Darby, J.L.: Evaluation of Greenhouse Gas Emissions from septic systems. University of California.

WINIWARTER, W. & RYPDAL, K. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria. Atmospheric Environment 35: 5 425–5 440.

WINIWARTER, W. (2007): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, ARC (Austrian Research Centers) Seibersdorf. Research Report ARC-sys-0154. Final report contracted by Umweltbundesamt.

ZESSNER, M. & LINDTNER, S. (2005): Estimations of municipal point source pollution in the context of river basin management. Institute for Water Quality and Waste Management, Vienna University of Technology Published in Water Science & Technology. Vol. 52, No 9 pp 175-182. IWA Publishing 2005.

umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

AUSTRIA'S NATIONAL INVENTORY REPORT 2023 – ANNEX

Submission under the United Nations Framework Convention on Climate Change

ANNEX
REP-0852

VIENNA 2023

Since 23 December 2005 the Umweltbundesamt has been accredited as Inspection Body for emission inventories, Type A (ID No. 241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG), by decree of Accreditation Austria (first decree, No. BMWA-92.715/0036-I/12/2005, issued by Accreditation Austria / Federal Ministry of Economics and Labour on 19 January 2006).

The information covered refers to the following accreditation scope of the IBE: 2006 IPCC GL for National Greenhouse Gas Inventories, 2006 GL Revised Supplementary KP and 2006 GL Supplement Wetlands (akkreditierung-austria.gv.at/overview)

ANNEX 1: KEY CATEGORIES

Annex 1.1 – Description of methodology for identification of key categories

The method used to identify key source categories follows the Approach 1 method – quantitative approach described in the IPCC 2006 GL (Volume 1), Chapter 4 *Methodological Choice and Identification of Key Categories.* In addition, the Approach 2 method was applied.

The analysis includes all greenhouse gases reported under the UNFCCC: CO_2, CH_4, N_2O, HFC, PFC, SF_6 and NF_3. All IPCC categories are included.

Key categories were first identified for the inventory excluding LULUCF and then the key category analysis was repeated for the full inventory including LULUCF categories.

The identification of key categories consists of six steps:

- Identifying categories
- Level Assessment excluding LULUCF (Approach 1 and Approach 2)
- Trend Assessment excluding LULUCF (Approach 1 and Approach 2)
- Level Assessment including LULUCF (Approach 1 and Approach 2)
- Trend Assessment including LULUCF (Approach 1 and Approach 2)
- Qualitative considerations

Annex 1.2 – Information on the level of disaggregation

Level of disaggregation and identification of key categories

To identify key categories total emissions were split into those categories that have been estimated using the same methodology and the same emission factor. Table A 17 presents the 310 source/sink categories (incl. LULUCF) considered in the Austrian key category analysis, and their greenhouse gas emissions expressed in CO_2 equivalent emissions for the years 1990 to 2021.

Further details and a list of the source/sink categories and key categories for each sector are given in the corresponding subchapters *3 Energy – 8 Waste* in the NIR.

Level Assessment excluding LULUCF

For the Level Assessment the contribution of GHG emissions (expressed in CO_2 equivalent emissions) of each category to national total emissions was calculated. The calculation was performed for the years 1990 and 2021 according to Equation 4.1 of the IPCC 2006 GL. Then the sources were ranked in descending order of magnitude according to the results of the level assessment and finally a cumulative total was calculated.

For the year 2021 41 source categories comprised > 95% of the cumulative total and were thus rated as key categories. For the year 1990 49 source categories were identified as key categories in the level assessment (Approach 1). The result of each level assessment is presented in Tables A 1 and A 2.

Trend Assessment excluding LULUCF

The Trend Assessment identifies source categories that have a different trend from the trend of the overall inventory. As differences in trends are more significant at the overall inventory level for larger source categories, the result of the trend difference (i.e. the source category trend minus total trend) is weighted according to the sources' level assessment.

For the Trend Assessment, emissions of the year 2021 were compared with 1990.

The calculation was performed according to Equation 4.2 of the IPCC 2006 GL. For sources with zero current year emissions Equation 4.3 of the IPCC 2006 GL was used to calculate the trend. The results were ranked in descending order of magnitude and a cumulative total was calculated. Those sources that make up > 95% of the total trend were rated key categories. 23 sources were identified as key categories in the trend assessment according to Approach 1. Results are presented in Table A 3.

Level Assessment including LULUCF

The level assessment was repeated for the full inventory including the LULUCF categories for the years 1990 and 2021 according to Equation 5.4.1 of the GPG-LULUCF. The result of each level assessment is presented in Tables A 4 and A 5.

Trend Assessment including LULUCF

Also the trend assessment was repeated for the full inventory including the LULUCF categories for the years 1990 and 2021 according to Equation 5.4.2 of the GPG-LULUCF (Equation 5.4.3 for zero current year emissions). The result of the trend assessment Approach 1 is presented in Table A 6.

Qualitative criteria

Qualitative criteria considered were:

- categories that are close to the 95% criteria, but are not included in all years, e.g. due to fluctuating emissions/removals
- mitigation techniques,
- high expected growth of emissions/removals
- unexpected low or high emissions/removals.

No additional key source categories were identified applying these qualitative criteria.

Identification of key categories

Any category meeting the 95% (Approach 1) respectively 90% (Approach 2) threshold in any year of the Level Assessment or in the Trend Assessment and meeting the qualitative criteria as described above is considered a key category. The key categories are presented in descending order of magnitude of contribution to total national GHG emissions.

Consequences of key category selection

Whenever a method used for the estimation of emissions/removals of a key category is not consistent with the requirements of the IPCC 2006 Guidelines, the method will have to be improved in order to reduce uncertainty, which is considered in the emission inventory improvement programme.

Annex 1.3 – Results of the Key Category Analysis

Results are presented for the level assessments for the years 1990 and 2021, and for the trend assessment 1990-2021, both for the key category analysis excluding and including LULUCF. Furthermore, key categories identified including their ranking in the level and trend assessments and emission sources and removal sinks in the level of aggregation as used for the key category analysis together with emissions/removals from 1990 to 2021 for these categories are included.

Table A 1: Approach 1 – Level Assessment of the KCA excluding LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate $E_{x,t}$ [t CO_2-e units]	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b gasoline	Road Transportation	CO_2	7 896	10.0%	10.0%
2 C 1	Iron and Steel Production	CO_2	6 840	8.7%	18.6%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	6 247	7.9%	26.5%
1 A 4 b liquid	Residential	CO_2	5 633	7.1%	33.7%
1 A 3 b diesel oil	Road Transportation	CO_2	5 360	6.8%	40.5%
3 A 1	Cattle	CH_4	4 854	6.1%	46.6%
5 A	Solid Waste Disposal	CH_4	4 081	5.2%	51.8%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	3 294	4.2%	55.9%
1 A 4 b solid	Residential	CO_2	2 511	3.2%	59.1%
2 A 1	Cement Production	CO_2	2 033	2.6%	61.7%
1 A 1 b liquid	Petroleum Refining	CO_2	1 958	2.5%	64.1%
1 A 4 b gaseous	Residential	CO_2	1 856	2.3%	66.5%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 776	2.2%	68.7%
1 A 4 a liquid	Commercial/Institutional	CO_2	1 420	1.8%	70.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	1 229	1.6%	72.1%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	1 180	1.5%	73.6%
1 A 2 a solid	Iron and Steel	CO_2	1 107	1.4%	75.0%
2 C 3	Aluminium Production	PFC	1 032	1.3%	76.3%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	1 014	1.3%	77.6%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	943	1.2%	78.8%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	853	1.1%	79.8%
2 B 2	Nitric Acid Production	N_2O	780	1.0%	80.8%
1 A 4 a gaseous	Commercial/Institutional	CO_2	698	0.9%	81.7%
1 A 2 a gaseous	Iron and Steel	CO_2	650	0.8%	82.5%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	610	0.8%	83.3%
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	559	0.7%	84.0%
1 A 2 f solid	Non-Metallic Minerals	CO_2	535	0.7%	84.7%
1 A 2 c gaseous	Chemicals	CO_2	519	0.7%	85.3%
1 A 2 f liquid	Non-Metallic Minerals	CO_2	508	0.6%	86.0%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	507	0.6%	86.6%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO_2	506	0.6%	87.3%
2 A 4 c	Non-metallurgical Magnesium	CO_2	481	0.6%	87.9%
3 B 1 1	Cattle	CH_4	467	0.6%	88.5%

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate $E_{x,t}$ [t CO_2-e units]	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2 B 1	Ammonia Production	CO_2	467	0.6%	89.1%
2 A 2	Lime Production	CO_2	439	0.6%	89.6%
1 A 1 b gaseous	Petroleum Refining	CO_2	437	0.6%	90.2%
1 A 2 d solid	Pulp, Paper and Print	CO_2	398	0.5%	90.7%
1 B 1 a	Oil	CH_4	373	0.5%	91.1%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	349	0.4%	91.6%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	345	0.4%	92.0%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	341	0.4%	92.5%
3 B 1 1	Cattle	N_2O	294	0.4%	92.8%
1 B 2 b	Natural Gas	CH_4	290	0.4%	93.2%
1 A 1 a other	Public Electricity and Heat Production	CO_2	286	0.4%	93.6%
1 A 4 b biomass	Residential	CH_4	264	0.3%	93.9%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	256	0.3%	94.2%
2 C 4	Magnesium Production	SF_6	235	0.3%	94.5%
1 A 3 e gaseous	Other Transportation	CO_2	224	0.3%	94.8%
1 A 4 b solid	Residential	CH_4	224	0.3%	95.1%

Table A 2: Approach 1 – Level Assessment of the KCA excluding LULUCF for 2021

IPCC Category Code	IPCC Category	GHG	Year 2021 Estimate Ex,t [t CO_2-e units]	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b diesel oil	Road Transportation	CO_2	16 839	21.7%	21.7%
2 C 1	Iron and Steel Production	CO_2	11 002	14.2%	35.9%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	4 467	5.8%	41.7%
1 A 3 b gasoline	Road Transportation	CO_2	4 213	5.4%	47.1%
3 A 1	Cattle	CH_4	3 938	5.1%	52.2%
1 A 4 b gaseous	Residential	CO_2	3 791	4.9%	57.1%
1 A 4 b liquid	Residential	CO_2	3 332	4.3%	61.4%
1 A 1 b liquid	Petroleum Refining	CO_2	2 217	2.9%	64.2%
2 A 1	Cement Production	CO_2	1 889	2.4%	66.7%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	1 580	2.0%	68.7%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 500	1.9%	70.6%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 431	1.8%	72.5%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	1 345	1.7%	74.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	1 323	1.7%	75.9%
1 A 2 c gaseous	Chemicals	CO_2	1 220	1.6%	77.5%
1 A 1 a other	Public Electricity and Heat Production	CO_2	1 049	1.4%	78.9%
1 A 2 a gaseous	Iron and Steel	CO_2	994	1.3%	80.1%
1 A 4 a gaseous	Commercial/Institutional	CO_2	923	1.2%	81.3%
5 A	Solid Waste Disposal	CH_4	878	1.1%	82.5%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	808	1.0%	83.5%
1 A 2 a solid	Iron and Steel	CO_2	760	1.0%	84.5%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	743	1.0%	85.4%
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	665	0.9%	86.3%
2 A 2	Lime Production	CO_2	663	0.9%	87.1%
1 A 4 a liquid	Commercial/Institutional	CO_2	631	0.8%	88.0%
1 A 2 f other	Non-Metallic Minerals	CO_2	616	0.8%	88.8%
1 A 1 b gaseous	Petroleum Refining	CO_2	533	0.7%	89.4%
3 B 1 1	Cattle	CH_4	508	0.7%	90.1%

IPCC Category Code	IPCC Category	GHG	Year 2021 Estimate Ex,t [t CO_2-e units]	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2 B 1	Ammonia Production	CO_2	500	0.6%	90.7%
1 A 3 e gaseous	Other Transportation	CO_2	374	0.5%	91.2%
2 A 4 c	Non-metallurgical Magnesium	CO_2	357	0.5%	91.7%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO_2	354	0.5%	92.1%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6	304	0.4%	92.5%
1 A 2 c other	Chemicals	CO_2	294	0.4%	92.9%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	286	0.4%	93.3%
3 B 1 1	Cattle	N_2O	280	0.4%	93.6%
1 A 2 b gaseous	Non-Ferrous Metals	CO_2	275	0.4%	94.0%
1 A 2 f solid	Non-Metallic Minerals	CO_2	253	0.3%	94.3%
1 B 2 b	Natural Gas	CH_4	238	0.3%	94.6%
1 A 4 b biomass	Residential	CH_4	236	0.3%	94.9%
1 A 2 d solid	Pulp, Paper and Print	CO_2	210	0.3%	95.2%

Table A 3: Approach 1 – Trend Assessment of the KCA excluding LULUCF for the trend 1990–2021.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Trend Assessment $T_{x,t}$	% Contribution to Trend	Cumulative Total of $L_{x,t}$
1 A 4 b solid	Residential	CO_2	2 511	61	1.276	37.7%	37.7%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	853	20	0.456	13.5%	51.1%
1 A 4 a other	Commercial/Institutional	CO_2	83	0	0.208	6.1%	57.3%
5 A	Solid Waste Disposal	CH_4	4 081	878	0.188	5.6%	62.8%
2 B 2	Nitric Acid Production	N_2O	780	41	0.176	5.2%	68.0%
2 C 4	Magnesium Production	SF_6	235	5	0.145	4.3%	72.3%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	1 229	120	0.144	4.3%	76.5%
1 A 4 b solid	Residential	CH_4	224	5	0.114	3.4%	79.9%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	4 213	0.087	2.6%	82.5%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2	91	1	0.087	2.6%	85.1%
1 A 4 b liquid	Residential	CO_2	5 633	3 332	0.049	1.5%	86.5%
1 A 3 b diesel oil	Road Transportation	CO_2	5 360	16 839	0.046	1.4%	87.9%
2 C 3	Aluminium Production	CO_2	150	6	0.044	1.3%	89.2%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	345	38	0.036	1.1%	90.2%
2 C 1	Iron and Steel Production	CO_2	6 840	11 002	0.033	1.0%	91.2%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	610	149	0.024	0.7%	91.9%
1 A 4 a liquid	Commercial/Institutional	CO_2	1 420	631	0.022	0.7%	92.6%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2	51	2	0.019	0.6%	93.1%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 431	0.018	0.5%	93.7%
1 A 2 f liquid	Non-Metallic Minerals	CO_2	508	147	0.016	0.5%	94.1%
3 A 1	Cattle	CH_4	4 854	3 938	0.014	0.4%	94.5%
1 A 3 b gasoline	Road Transportation	N_2O	83	7	0.012	0.4%	94.9%
1 A 4 b gaseous	Residential	CO_2	1 856	3 791	0.012	0.4%	95.3%

Table A 4: Approach 1 – Level Assessment of the KCA including LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate $E_{x,t}$ [t CO_2-e units]	Absolute Value of Year 1990 Estimate $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
4 A 1	Forest land remaining forest land	CO_2	-8 122	8 122	8.5%	8.5%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	7 896	8.3%	16.8%
2 C 1	Iron and Steel Production	CO_2	6 840	6 840	7.2%	24.0%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	6 247	6 247	6.6%	30.5%
1 A 4 b liquid	Residential	CO_2	5 633	5 633	5.9%	36.5%
1 A 3 b diesel oil	Road Transportation	CO_2	5 360	5 360	5.6%	42.1%
3 A 1	Cattle	CH_4	4 854	4 854	5.1%	47.2%
5 A	Solid Waste Disposal	CH_4	4 081	4 081	4.3%	51.5%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	3 294	3 294	3.5%	54.9%
4 G	HWP	CO_2	-3 122	3 122	3.3%	58.2%
4 A 2	Land converted to forest land	CO_2	-2 957	2 957	3.1%	61.3%
1 A 4 b solid	Residential	CO_2	2 511	2 511	2.6%	63.9%
2 A 1	Cement Production	CO_2	2 033	2 033	2.1%	66.1%
1 A 1 b liquid	Petroleum Refining	CO_2	1 958	1 958	2.1%	68.1%
1 A 4 b gaseous	Residential	CO_2	1 856	1 856	1.9%	70.1%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 776	1.9%	71.9%
1 A 4 a liquid	Commercial/Institutional	CO_2	1 420	1 420	1.5%	73.4%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	1 229	1 229	1.3%	74.7%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	1 180	1 180	1.2%	76.0%
1 A 2 a solid	Iron and Steel	CO_2	1 107	1 107	1.2%	77.1%
2 C 3	Aluminium Production	PFC	1 032	1 032	1.1%	78.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	1 014	1 014	1.1%	79.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	943	943	1.0%	80.3%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	853	853	0.9%	81.1%
2 B 2	Nitric Acid Production	N_2O	780	780	0.8%	82.0%
1 A 4 a gaseous	Commercial/Institutional	CO_2	698	698	0.7%	82.7%
1 A 2 a gaseous	Iron and Steel	CO_2	650	650	0.7%	83.4%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	610	610	0.6%	84.0%
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	559	559	0.6%	84.6%
1 A 2 f solid	Non-Metallic Minerals	CO_2	535	535	0.6%	85.2%
1 A 2 c gaseous	Chemicals	CO_2	519	519	0.5%	85.7%
1 A 2 f liquid	Non-Metallic Minerals	CO_2	508	508	0.5%	86.2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	507	507	0.5%	86.8%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO_2	506	506	0.5%	87.3%
4 F 2	Land converted to Other land	CO_2	502	502	0.5%	87.8%
2 A 4 c	Non-metallurgical Magnesium	CO_2	481	481	0.5%	88.3%
3 B 1 1	Cattle	CH_4	467	467	0.5%	88.8%
2 B 1	Ammonia Production	CO_2	467	467	0.5%	89.3%
4 E 2	Land converted to Settlements	CO_2	448	448	0.5%	89.8%
2 A 2	Lime Production	CO_2	439	439	0.5%	90.3%
1 A 1 b gaseous	Petroleum Refining	CO_2	437	437	0.5%	90.7%
1 A 2 d solid	Pulp, Paper and Print	CO_2	398	398	0.4%	91.1%
4 C 2	Land converted to grassland	CO_2	391	391	0.4%	91.5%
1 B 1 a	Oil	CH_4	373	373	0.4%	91.9%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	349	349	0.4%	92.3%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	345	345	0.4%	92.7%
3 D 2	Indirect N2O emissions from Managed Soils	N_2O	341	341	0.4%	93.0%

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate $E_{x,t}$ [t CO_2-e units]	Absolute Value of Year 1990 Estimate $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
4 C 1	Grassland remaining grassland	CO_2	294	294	0.3%	93.3%
3 B 1 1	Cattle	N_2O	294	294	0.3%	93.6%
1 B 2 b	Natural Gas	CH_4	290	290	0.3%	93.9%
1 A 1 a other	Public Electricity and Heat Production	CO_2	286	286	0.3%	94.2%
1 A 4 b biomass	Residential	CH_4	264	264	0.3%	94.5%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	256	256	0.3%	94.8%
2 C 4	Magnesium Production	SF_6	235	235	0.2%	95.0%

Table A 5: Approach 1 – Level Assessment of the KCA including LULUCF for 2021.

IPCC Category Code	IPCC Category	GHG	Year 2021 Estimate Ex,t [t CO_2-e units]	Absolute Value of Year 2021 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b diesel oil	Road Transportation	CO_2	16 839	16 839	18.4%	18.4%
2 C 1	Iron and Steel Production	CO_2	11 002	11 002	12.0%	30.4%
4 A 1	Forest land remaining forest land	CO_2	-8 938	8 938	9.8%	40.1%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	4 467	4 467	4.9%	45.0%
1 A 3 b gasoline	Road Transportation	CO_2	4 213	4 213	4.6%	49.6%
3 A 1	Cattle	CH_4	3 938	3 938	4.3%	53.9%
1 A 4 b gaseous	Residential	CO_2	3 791	3 791	4.1%	58.0%
1 A 4 b liquid	Residential	CO_2	3 332	3 332	3.6%	61.7%
1 A 1 b liquid	Petroleum Refining	CO_2	2 217	2 217	2.4%	64.1%
4 G	HWP	CO_2	-1 889	1 889	2.1%	66.1%
2 A 1	Cement Production	CO_2	1 889	1 889	2.1%	68.2%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	1 580	1 580	1.7%	69.9%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 500	1 500	1.6%	71.6%
4 A 2	Land converted to forest land	CO_2	-1 437	1 437	1.6%	73.1%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 431	1 431	1.6%	74.7%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	1 345	1 345	1.5%	76.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	1 323	1 323	1.4%	77.6%
1 A 2 c gaseous	Chemicals	CO_2	1 220	1 220	1.3%	78.9%
1 A 1 a other	Public Electricity and Heat Production	CO_2	1 049	1 049	1.1%	80.1%
1 A 2 a gaseous	Iron and Steel	CO_2	994	994	1.1%	81.2%
1 A 4 a gaseous	Commercial/Institutional	CO_2	923	923	1.0%	82.2%
5 A	Solid Waste Disposal	CH_4	878	878	1.0%	83.1%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	808	808	0.9%	84.0%
1 A 2 a solid	Iron and Steel	CO_2	760	760	0.8%	84.8%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	743	743	0.8%	85.6%
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	665	665	0.7%	86.4%
2 A 2	Lime Production	CO_2	663	663	0.7%	87.1%
1 A 4 a liquid	Commercial/Institutional	CO_2	631	631	0.7%	87.8%
1 A 2 f other	Non-Metallic Minerals	CO_2	616	616	0.7%	88.5%
1 A 1 b gaseous	Petroleum Refining	CO_2	533	533	0.6%	89.0%
4 F 2	Land converted to Other land	CO_2	514	514	0.6%	89.6%
3 B 1 1	Cattle	CH_4	508	508	0.6%	90.2%
2 B 1	Ammonia Production	CO_2	500	500	0.5%	90.7%
4 E 2	Land converted to Settlements	CO_2	441	441	0.5%	91.2%
1 A 3 e gaseous	Other Transportation	CO_2	374	374	0.4%	91.6%
2 A 4 c	Non-metallurgical Magnesium	CO_2	357	357	0.4%	92.0%

IPCC Category Code	IPCC Category	GHG	Year 2021 Estimate Ex,t [t CO_2-e units]	Absolute Value of Year 2021 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO_2	354	354	0.4%	92.4%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6	304	304	0.3%	92.7%
4 C 1	Grassland remaining grassland	CO_2	296	296	0.3%	93.0%
1 A 2 c other	Chemicals	CO_2	294	294	0.3%	93.3%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	286	286	0.3%	93.7%
3 B 1 1	Cattle	N_2O	280	280	0.3%	94.0%
1 A 2 b gaseous	Non-Ferrous Metals	CO_2	275	275	0.3%	94.3%
1 A 2 f solid	Non-Metallic Minerals	CO_2	253	253	0.3%	94.5%
1 B 2 b	Natural Gas	CH_4	238	238	0.3%	94.8%
1 A 4 b biomass	Residential	CH_4	236	236	0.3%	95.1%

Table A 6: Approach 1 – Trend Assessment of the KCA including LULUCF for the trend 1990–2021.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Trend Assessment $T_{x,t}$	% Contribution to Trend	Cumulative Total of $L_{x,t}$
1 A 4 b solid	Residential	CO_2	2 511	61	1.058	36.9%	36.9%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	853	20	0.378	13.2%	50.0%
1 A 4 a other	Commercial/Institutional	CO_2	83	0	0.165	5.8%	55.8%
5 A	Solid Waste Disposal	CH_4	4 081	878	0.156	5.4%	61.2%
2 B 2	Nitric Acid Production	N_2O	780	41	0.146	5.1%	66.3%
2 C 4	Magnesium Production	SF_6	235	5	0.120	4.2%	70.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	1 229	120	0.120	4.2%	74.7%
1 A 4 b solid	Residential	CH_4	224	5	0.094	3.3%	78.0%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	4 213	0.072	2.5%	80.5%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2	91	1	0.071	2.5%	83.0%
1 A 4 b liquid	Residential	CO_2	5 633	3 332	0.041	1.4%	84.4%
1 A 3 b diesel oil	Road Transportation	CO_2	5 360	16 839	0.038	1.3%	85.7%
2 C 3	Aluminium Production	CO_2	150	6	0.036	1.3%	87.0%
4 A 2	Land converted to forest land	CO_2	2 957	1 437	0.033	1.1%	88.1%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	345	38	0.030	1.0%	89.2%
2 C 1	Iron and Steel Production	CO_2	6 840	11 002	0.027	0.9%	90.1%
4 G	HWP	CO_2	3 122	1 889	0.021	0.7%	90.8%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	610	149	0.020	0.7%	91.5%
1 A 4 a liquid	Commercial/Institutional	CO_2	1 420	631	0.019	0.6%	92.2%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2	51	2	0.016	0.6%	92.7%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 431	0.015	0.5%	93.3%
1 A 2 f liquid	Non-Metallic Minerals	CO_2	508	147	0.013	0.5%	93.7%
3 A 1	Cattle	CH_4	4 854	3 938	0.012	0.4%	94.1%
1 A 4 b gaseous	Residential	CO_2	1 856	3 791	0.010	0.3%	94.5%
1 A 3 b gasoline	Road Transportation	N_2O	83	7	0.010	0.3%	94.8%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	3 294	4 467	0.009	0.3%	95.1%

Table A 7: Approach 1 – Key categories identified including their ranking in the level and trend assessment for the KCA excluding LULUCF.

			Approach 1	Approach 1	Approach 1			
IPCC Category Code	**IPCC Category**	**GHG**	**Level Assessment 1990**	**Level Assessment 2021**	**Trend Assessment 1990-2021**	**Base Year (1990) Estimate $E_{x,0}$**	**Latest Year (2021) Estimate Ex,t**	**Share Latest Year (2021)**
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	8	3		3 294	4 467	5.8%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	15		7	1 229	120	0.2%
1 A 1 a other	Public Electricity and Heat Production	CO_2	44	16		286	1 049	1.4%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	3			6 247	0	0.0%
1 A 1 b gaseous	Petroleum refining	CO_2	36	27		437	533	0.7%
1 A 1 b liquid	Petroleum refining	CO_2	11	8		1 958	2 217	2.9%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO_2	31	32		506	354	0.5%
1 A 2 a gaseous	Iron and Steel	CO_2	24	17		650	994	1.3%
1 A 2 a solid	Iron and Steel	CO_2	17	21		1 107	760	1.0%
1 A 2 b gaseous	Non-ferrous Metals	CO_2		37		75	275	0.4%
1 A 2 c gaseous	Chemicals	CO_2	28	15		519	1 220	1.6%
1 A 2 c other	Chemicals	CO_2		34		125	294	0.4%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	20	10		943	1 580	2.0%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	21		2	853	20	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO_2	37	41		398	210	0.3%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	30	22		507	743	1.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	40		14	345	38	0.0%
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	26	23		559	665	0.9%
1 A 2 f liquid	Non-Metallic Minerals	CO_2	29		20	508	147	0.2%
1 A 2 f other	Non-Metallic Minerals	CO_2		26		67	616	0.8%
1 A 2 f solid	Non-Metallic Minerals	CO_2	27	38		535	253	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	46	13		256	1 345	1.7%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	19	14		1 014	1 323	1.7%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	25		16	610	149	0.2%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2			10	91	1	0.0%
1 A 3 b diesel oil	Road Transportation	CO_2	5	1	12	5 360	16 839	21.7%
1 A 3 b gasoline	Road Transportation	N_2O			22	83	7	0.0%
1 A 3 b gasoline	Road Transportation	CO_2	1	4	9	7 896	4 213	5.4%
1 A 3 e gaseous	Other Transportation	CO_2	48	30		224	374	0.5%
1 A 4 a gaseous	Commercial/Institutional	CO_2	23	18		698	923	1.2%
1 A 4 a liquid	Commercial/Institutional	CO_2	14	25	17	1 420	631	0.8%
1 A 4 a other	Commercial/Institutional	CO_2			3	83	0	0.0%
1 A 4 b biomass	Residential	CH_4	45	40		264	236	0.3%
1 A 4 b gaseous	Residential	CO_2	12	6	23	1 856	3 791	4.9%
1 A 4 b liquid	Residential	CO_2	4	7	11	5 633	3 332	4.3%
1 A 4 b solid	Residential	CO_2	9		1	2 511	61	0.1%
1 A 4 b solid	Residential	CH_4	49		8	224	5	0.0%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2			18	51	2	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	16	20		1 180	808	1.0%
1 B 1 a	Coal Mining and Handling	CH_4	38			373	NA	
1 B 2 b	Natural Gas	CH_4	43	39		290	238	0.3%
2 A 1	Cement Production	CO_2	10	9		2 033	1 889	2.4%
2 A 2	Lime Production	CO_2	35	24		439	663	0.9%
2 A 4 c	Non-metallurgical Magnesium	CO_2	32	31		481	357	0.5%
2 B 1	Ammonia Production	CO_2	34	29		467	500	0.6%

IPCC Category Code	IPCC Category	GHG	Approach 1 Level Assessment 1990	Approach 1 Level Assesment 2021	Approach 1 Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Share Latest Year (2021)
2 B 2	Nitric Acid Production	N_2O	22		5	780	41	0.1%
2 C 1	Iron and Steel Production	CO_2	2	2	15	6 840	11 002	14.2%
2 C 3	Aluminium Production	PFC	18			1 032	0	0.0%
2 C 3	Aluminium Production	CO_2			13	150	6	0.0%
2 C 4	SF_6 used in Mg Foundries	SF_6	47		6	235	5	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	39			349	165	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		12	19	0	1 431	1.8%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6		33		124	304	0.4%
3 A 1	Cattle	CH_4	6	5	21	4 854	3 938	5.1%
3 B 1 1	Cattle	CH_4	33	28		467	508	0.7%
3 B 1 1	Cattle	N_2O	42	36		294	280	0.4%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	13	11		1 776	1 500	1.9%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	41	35		341	286	0.4%
5 A	Solid Waste Disposal	CH_4	7	19	4	4 081	878	1.1%

Table A 8: Approach 1 – Key categories identified including their ranking in the level and trend assessment for the KCA including LULUCF.

IPCC Category Code	IPCC Category	GHG	Approach 1 Level Assessment 1990	Approach 1 Level Assesment 2021	Approach 1 Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	9	4	26	3 294	4 467
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	18		7	1 229	120
1 A 1 a other	Public Electricity and Heat Production	CO_2	51	19		286	1 049
1 A 1 a solid	Public Electricity and Heat Production	CO_2	4			6 247	0
1 A 1 b gaseous	Petroleum Refining	CO_2	41	30		437	533
1 A 1 b liquid	Petroleum Refining	CO_2	14	9		1 958	2 217
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO_2	34	37		506	354
1 A 2 a gaseous	Iron and Steel	CO_2	27	20		650	994
1 A 2 a solid	Iron and Steel	CO_2	20	24		1 107	760
1 A 2 b gaseous	Non-Ferrous Metals	CO_2		43		75	275
1 A 2 c gaseous	Chemicals	CO_2	31	18		519	1 220
1 A 2 c other	Chemicals	CO_2		40		125	294
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	23	12		943	1 580
1 A 2 d liquid	Pulp, Paper and Print	CO_2	24		2	853	20
1 A 2 d solid	Pulp, Paper and Print	CO_2	42			398	210
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	33	25		507	743
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	46		15	345	38
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	29	26		559	665
1 A 2 f liquid	Non-Metallic Minerals	CO_2	32		22	508	147
1 A 2 f other	Non-Metallic Minerals	CO_2		29		67	616
1 A 2 f solid	Non-Metallic Minerals	CO_2	30	44		535	253
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	53	16		256	1 345
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	22	17		1 014	1 323

IPCC Category Code	IPCC Category	GHG	Approach 1 Level Assessment 1990	Approach 1 Level Assesment 2021	Approach 1 Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	28		18	610	149
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2			10	91	1
1 A 3 b diesel oil	Road Transportation	CO_2	6	1	12	5 360	16 839
1 A 3 b gasoline	Road Transportation	N_2O			25	83	7
1 A 3 b gasoline	Road Transportation	CO_2	2	5	9	7 896	4 213
1 A 3 e gaseous	Other Transportation	CO_2		35		224	374
1 A 4 a gaseous	Commercial/Institutional	CO_2	26	21		698	923
1 A 4 a liquid	Commercial/Institutional	CO_2	17	28	19	1 420	631
1 A 4 a other	Commercial/Institutional	CO_2			3	83	0
1 A 4 b biomass	Residential	CH_4	52	46		264	236
1 A 4 b gaseous	Residential	CO_2	15	7	24	1 856	3 791
1 A 4 b liquid	Residential	CO_2	5	8	11	5 633	3 332
1 A 4 b solid	Residential	CO_2	12		1	2 511	61
1 A 4 b solid	Residential	CH_4			8	224	5
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2			20	51	2
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	19	23		1 180	808
1 B 1 a	Coal Mining and Handling	CH_4	44			373	NA
1 B 2 b	Natural Gas	CH_4	50	45		290	238
2 A 1	Cement Production	CO_2	13	11		2 033	1 889
2 A 2	Lime Production	CO_2	40	27		439	663
2 A 4 c	Non-metallurgical Magnesium	CO_2	36	36		481	357
2 B 1	Ammonia Production	CO_2	38	33		467	500
2 B 2	Nitric Acid Production	N_2O	25		5	780	41
2 C 1	Iron and Steel Production	CO_2	3	2	16	6 840	11 002
2 C 3	Aluminium Production	PFC	21			1 032	0
2 C 3	Aluminium Production	CO_2			13	150	6
2 C 4	Magnesium Production	SF_6	54		6	235	5
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	45			349	165
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		15	21	0	1 431
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6		38		124	304
3 A 1	Cattle	CH_4	7	6	23	4 854	3 938
3 B 1 1	Cattle	CH_4	37	32		467	508
3 B 1 1	Cattle	N_2O	49	42		294	280
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	16	13		1 776	1 500
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	47	41		341	286
4 A 1	Forest land remaining forest land	CO_2	1	3		-8 122	-8 938
4 A 2	Land converted to forest land	CO_2	11	14	14	-2 957	-1 437
4 C 1	Grassland remaining grassland	CO_2	48	39		294	296
4 C 2	Land converted to grassland	CO_2	43			391	138
4 E 2	Land converted to Settlements	CO_2	39	34		448	441
4 F 2	Land converted to Other land	CO_2	35	31		502	514
4 G	HWP	CO_2	10	10	17	-3 122	-1 889
5 A	Solid Waste Disposal	CH_4	8	22	4	4 081	878

Table A 9: Approach 2 – Level Assessment of the KCA excluding LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Latest Year (1990) Estimate $E_{x,t}$	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 776	0.330	33.0%
5 A	Solid Waste Disposal	CH_4	4 081	0.105	43.5%
3 A 1	Cattle	CH_4	4 854	0.101	53.5%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	341	0.063	59.9%
2 C 3	Aluminium Production	PFC	1 032	0.048	64.6%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	0.031	67.8%
3 B 1 1	Cattle	N_2O	294	0.027	70.5%
1 A 3 b diesel oil	Road Transportation	CO_2	5 360	0.021	72.6%
3 B 2 5	Indirect N_2O Emissions	N_2O	103	0.019	74.5%
1 B 1 a	Oil	CH_4	373	0.017	76.2%
1 A 4 b biomass	Residential	CH_4	264	0.012	77.5%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	349	0.012	78.7%
1 A 4 b solid	Residential	CH_4	224	0.010	79.7%
2 A 1	Cement Production	CO_2	2 033	0.010	80.7%
3 B 1 1	Cattle	CH_4	467	0.010	81.7%
3 B 1 3	Swine	N_2O	99	0.009	82.6%
1 A 4 b gaseous	Residential	CO_2	1 856	0.009	83.5%
2 A 2	Lime Production	CO_2	439	0.008	84.3%
5 D	Waste Water Treatment and Discharge	N_2O	86	0.008	85.1%
5 D	Waste Water Treatment and Discharge	CH_4	137	0.007	85.8%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF_6	124	0.006	86.4%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	3 294	0.006	87.1%
1 A 4 b liquid	Residential	CO_2	5 633	0.006	87.6%
1 A 3 b gasoline	Road Transportation	N_2O	83	0.005	88.2%
1 A 1 a other	Public Electricity and Heat Production	CO_2	286	0.005	88.7%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	1 014	0.005	89.1%
2 C 1	Iron and Steel Production	CO_2	6 840	0.004	89.6%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	943	0.004	90.0%

Table A 10: Approach 2 – Level Assessment of the KCA excluding LULUCF for 2021.

IPCC Category Code	IPCC Category	GHG	Latest Year (2021) Estimate Ex,t	Level Assessment with Uncertainty $LU_{x,t}$	Cumulative Total of $L_{x,t}$
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 500	0.316	31.6%
3 A 1	Cattle	CH_4	3 938	0.083	39.8%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 431	0.081	48.0%
1 A 3 b diesel oil	Road Transportation	CO_2	16 839	0.075	55.5%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	286	0.060	61.5%
3 B 1 1	Cattle	N_2O	280	0.029	64.4%
5 A	Solid Waste Disposal	CH_4	878	0.026	67.0%
3 B 2 5	Indirect N_2O Emissions	N_2O	111	0.023	69.3%
1 A 4 b gaseous	Residential	CO_2	3 791	0.020	71.3%
1 A 3 b gasoline	Road Transportation	CO_2	4 213	0.019	73.2%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6	304	0.018	75.0%
1 A 1 a other	Public Electricity and Heat Production	CO_2	1 049	0.017	76.7%
5 D	Waste Water Treatment and Discharge	N_2O	152	0.016	78.4%

IPCC Category Code	IPCC Category	GHG	Latest Year (2021) Estimate Ex,t	Level Assessment with Uncertainty $LU_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b biomass	Residential	CH_4	236	0.013	79.6%
1 A 2 f other	Non-Metallic Minerals	CO_2	616	0.012	80.8%
3 B 1 1	Cattle	CH_4	508	0.011	81.9%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	1 580	0.008	82.7%
2 C 1	Iron and Steel Production	CO_2	11 002	0.008	83.5%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	1 323	0.007	84.2%
1 A 2 c gaseous	Chemicals	CO_2	1 220	0.006	84.8%
1 A 3 b diesel oil	Road Transportation	N_2O	199	0.006	85.5%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	165	0.006	86.1%
3 B 1 3	Swine	N_2O	57	0.006	86.7%
1 A 2 c other	Chemicals	CO_2	294	0.006	87.3%
3 G	Liming	CO_2	99	0.005	87.8%
1 A 2 a gaseous	Iron and Steel	CO_2	994	0.005	88.3%
1 A 4 a gaseous	Commercial/Institutional	CO_2	923	0.005	88.8%
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	4 467	0.005	89.3%
2 A 1	Cement Production	CO_2	1 889	0.005	89.7%
1 A 4 b biomass	Residential	N_2O	85	0.005	90.2%

Table A 11: Approach 2 – Trend Assessment of the KCA excluding LULUCF for the trend 1990–2021.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Trend Assessment with Uncertainty $TU_{x,t}$	% Contributi on to Trend	Cumulative Total of $TU_{x,t}$
1 A 4 b solid	Residential	CH_4	224	5	5.703	22.5%	22.5%
5 A	Solid Waste Disposal	CH_4	4 081	878	5.221	20.6%	43.1%
1 A 4 a other	Commercial/Institutional	CO_2	83	0	3.751	14.8%	57.9%
1 A 4 b solid	Residential	CO_2	2 511	61	1.427	5.6%	63.5%
2 C 4	Magnesium Production	SF_6	235	5	1.026	4.0%	67.5%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 431	0.975	3.8%	71.4%
2 B 2	Nitric Acid Production	N_2O	780	41	0.948	3.7%	75.1%
1 A 3 b gasoline	Road Transportation	N_2O	83	7	0.842	3.3%	78.4%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 500	0.829	3.3%	81.7%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	853	20	0.510	2.0%	83.7%
5 D	Waste Water Treatment and Discharge	CH_4	137	25	0.416	1.6%	85.4%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	4 213	0.370	1.5%	86.8%
3 A 1	Cattle	CH_4	4 854	3 938	0.286	1.1%	87.9%
1 A 3 b gasoline	Road Transportation	CH_4	77	7	0.277	1.1%	89.0%
1 A 4 b solid	Residential	N_2O	11	0	0.252	1.0%	90.0%

Table A 12: Approach 2 – Level Assessment of the KCA including LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Latest Year (1990) Estimate $E_{x,t}$	Absolute Value of Year 1990 Estimate $E_{x,t}$	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
4 A 1	Forest land remaining forest land	CO_2	-8 122	8 122	0.213	21.3%
3 D 1	Direct N2O Emissions from Managed Soils	N_2O	1 776	1 776	0.185	39.8%
4 G	HWP	CO_2	-3 122	3 122	0.080	47.7%

IPCC Category Code	IPCC Category	GHG	Latest Year (1990) Estimate $E_{x,t}$	Absolute Value of Year 1990 Estimate $E_{x,t}$	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
5 A	Solid Waste Disposal	CH_4	4 081	4 081	0.059	53.6%
3 A 1	Cattle	CH_4	4 854	4 854	0.056	59.2%
4 A 2	Land converted to forest land	CO_2	-2 957	2 957	0.055	64.7%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	341	341	0.035	68.3%
4 C 1	Grassland remaining grassland	CO_2	294	294	0.035	71.8%
2 C 3	Aluminium Production	PFC	1 032	1 032	0.027	74.5%
4 F 2	Land converted to Other land	CO_2	502	502	0.020	76.5%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	7 896	0.017	78.2%
3 B 1 1	Cattle	N_2O	294	294	0.015	79.8%
1 A 3 b diesel oil	Road Transportation	CO_2	5 360	5 360	0.012	80.9%
4 C 2	Land converted to grassland	CO_2	391	391	0.011	82.0%
3 B 2 5	Indirect N_2O Emissions	N_2O	103	103	0.011	83.1%
1 B 1 a	Oil	CH_4	373	373	0.010	84.0%
4 E 2	Land converted to Settlements	CO_2	448	448	0.008	84.8%
1 A 4 b biomass	Residential	CH_4	264	264	0.007	85.5%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	349	349	0.007	86.2%
4	Total land use categories	N_2O	113	113	0.006	86.8%
4 B 2	Land converted to cropland	CO_2	190	190	0.006	87.4%
1 A 4 b solid	Residential	CH_4	224	224	0.006	88.0%
2 A 1	Cement Production	CO_2	2 033	2 033	0.006	88.6%
3 B 1 1	Cattle	CH_4	467	467	0.005	89.1%
3 B 1 3	Swine	N_2O	99	99	0.005	89.6%
1 A 4 b gaseous	Residential	CO_2	1 856	1 856	0.005	90.1%

Table A 13: Approach 2 – Level Assessment of the KCA including LULUCF for 2021.

IPCC Category Code	IPCC Category	GHG	Latest Year (2021) Estimate Ex,t	Absolute Value of Year 2021 Estimate Ex,t	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
4 A 1	Forest land remaining forest land	CO_2	-8 938	8 938	0.197	19.7%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 500	1 500	0.171	36.8%
4 A 2	Land converted to forest land	CO_2	-1 437	1 437	0.093	46.0%
4 G	HWP	CO_2	-1 889	1 889	0.053	51.3%
3 A 1	Cattle	CH_4	3 938	3 938	0.045	55.8%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 431	1 431	0.044	60.2%
1 A 3 b diesel oil	Road Transportation	CO_2	16 839	16 839	0.041	64.2%
4 C 1	Grassland remaining grassland	CO_2	296	296	0.039	68.1%
4 F 2	Land converted to Other land	CO_2	514	514	0.036	71.7%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	286	286	0.033	75.0%
3 B 1 1	Cattle	N_2O	280	280	0.016	76.6%
5 A	Solid Waste Disposal	CH_4	878	878	0.014	77.9%
4 C 2	Land converted to grassland	CO_2	138	138	0.013	79.2%
3 B 2 5	Indirect N_2O Emissions	N_2O	111	111	0.013	80.5%
1 A 4 b gaseous	Residential	CO_2	3 791	3 791	0.011	81.6%
1 A 3 b gasoline	Road Transportation	CO_2	4 213	4 213	0.010	82.6%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6	304	304	0.010	83.6%
1 A 1 a other	Public Electricity and Heat Production	CO_2	1 049	1 049	0.009	84.5%
5 D	Waste Water Treatment and Discharge	N_2O	152	152	0.009	85.4%

IPCC Category Code	IPCC Category	GHG	Latest Year (2021) Estimate Ex,t	Absolute Value of Year 2021 Estimate Ex,t	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
4	Total land use categories	N_2O	112	112	0.008	86.2%
4 E 2	Land converted to Settlements	CO_2	441	441	0.008	86.9%
1 A 4 b biomass	Residential	CH_4	236	236	0.007	87.6%
1 A 2 f other	Non-Metallic Minerals	CO_2	616	616	0.006	88.2%
4 B 2	Land converted to cropland	CO_2	211	211	0.006	88.8%
3 B 1 1	Cattle	CH_4	508	508	0.006	89.4%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	1 580	1 580	0.004	89.9%
2 C 1	Iron and Steel Production	CO_2	11 002	11 002	0.004	90.3%

Table A 14: Approach 2 – Trend Assessment of the KCA including LULUCF for the trend 1990–2021.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Trend Assessment with Uncertainty $TU_{x,t}$	% Contribution to Trend	Cumulative Total of $TU_{x,t}$
1 A 4 b solid	Residential	CH_4	224	5	4.715	17.3%	17.3%
5 A	Solid Waste Disposal	CH_4	4 081	878	4.332	15.9%	33.3%
4 A 2	Land converted to forest land	CO_2	2 957	1 437	3.719	13.7%	46.9%
1 A 4 a other	Commercial/Institutional	CO_2	83	0	2.979	10.9%	57.9%
4 C 2	Land converted to grassland	CO_2	391	138	1.258	4.6%	62.5%
1 A 4 b solid	Residential	CO_2	2 511	61	1.183	4.3%	66.8%
4 G	HWP	CO_2	3 122	1 889	1.048	3.9%	70.7%
2 C 4	Magnesium Production	SF_6	235	5	0.848	3.1%	73.8%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 431	0.809	3.0%	76.8%
2 B 2	Nitric Acid Production	N_2O	780	41	0.786	2.9%	79.7%
1 A 3 b gasoline	Road Transportation	N_2O	83	7	0.696	2.6%	82.2%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 500	0.688	2.5%	84.8%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	853	20	0.422	1.6%	86.3%
5 D	Waste Water Treatment and Discharge	CH_4	137	25	0.345	1.3%	87.6%
1 A 3 b gasoline	Road Transportation	CO_2	7 896	4 213	0.307	1.1%	88.7%
4 A 1	Forest land remaining forest land	CO_2	8 122	8 938	0.302	1.1%	89.8%
3 A 1	Cattle	CH_4	4 854	3 938	0.237	0.9%	90.7%

Table A 15: Approach 2 – Key categories identified including their ranking in the level and trend assessment for the KCA excluding LULUCF.

			Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2			
IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assessment 2021	Trend Assessment 1990-2021	Level Assessment 1990	Level Assessment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Share Latest Year (2021)
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	8	3		7	3		3 294	4 467	5.8%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	15		7				1 229	120	0.2%
1 A 1 a other	Public Electricity and Heat Production	CO_2	44	16		20	13		286	1 049	1.4%

			Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2			
IPCC Category Code	**IPCC Category**	**GHG**	**Level Assessment 1990**	**Level Assesment 2021**	**Trend Assessment 1990-2021**	**Level Assessment 1990**	**Level Assesment 2021**	**Trend Assessment 1990-2021**	**Base Year (1990) Estimate $E_{x,0}$**	**Latest Year (2021) Estimate Ex,t**	**Share Latest Year (2021)**
1 A 1 a solid	Public Electricity and Heat Production	CO_2	3						6 247	0	0.0%
1 A 1 b gaseous	Petroleum refining	CO_2	36	27					437	533	0.7%
1 A 1 b liquid	Petroleum refining	CO_2	11	8					1 958	2 217	2.9%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO_2	31	32					506	354	0.5%
1 A 2 a gaseous	Iron and Steel	CO_2	24	17			14		650	994	1.3%
1 A 2 a solid	Iron and Steel	CO_2	17	21					1 107	760	1.0%
1 A 2 b gaseous	Non-ferrous Metals	CO_2		37					75	275	0.4%
1 A 2 c gaseous	Chemicals	CO_2	28	15			12		519	1 220	1.6%
1 A 2 c other	Chemicals	CO_2		34			20		125	294	0.4%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	20	10		13	8		943	1 580	2.0%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	21		2			10	853	20	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO_2	37	41					398	210	0.3%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	30	22					507	743	1.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	40		14				345	38	0.0%
1 A 2 f gaseous	Other	CO_2	26	23					559	665	0.9%
1 A 2 f liquid	Other	CO_2	29		20				508	147	0.2%
1 A 2 f other	Other	CO_2		26			17		67	616	0.8%
1 A 2 f solid	Other	CO_2	27	38					535	253	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	46	13					256	1 345	1.7%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	19	14		12	11		1 014	1 323	1.7%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	25		16				610	149	0.2%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2			10				91	1	0.0%
1 A 3 b diesel oil	Road Transportation	CO_2	5	1	12	4	1		5 360	16 839	21.7%
1 A 3 b diesel oil	Road Transportation	N_2O					24		11	199	0.3%
1 A 3 b gasoline	Road Transportation	CO_2	1	4	9	1	4	12	7 896	4 213	5.4%
1 A 3 b gasoline	Road Transportation	CH_4						14	77	7	0.0%
1 A 3 b gasoline	Road Transportation	N_2O			22	28		8	83	7	0.0%
1 A 3 e gaseous	Other	CO_2	48	30					224	374	0.5%
1 A 4 a gaseous	Commercial/Institutional	CO_2	23	18			15		698	923	1.2%

			Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2			
IPCC Category Code	**IPCC Category**	**GHG**	**Level Assessment 1990**	**Level Assesment 2021**	**Trend Assessment 1990-2021**	**Level Assessment 1990**	**Level Assesment 2021**	**Trend Assessment 1990-2021**	**Base Year (1990) Estimate $E_{x,0}$**	**Latest Year (2021) Estimate Ex,t**	**Share Latest Year (2021)**
1 A 4 a liquid	Commercial/Institutional	CO_2	14	25	17				1 420	631	0.8%
1 A 4 a other	Commercial/Institutional	CO_2			3			3	83	0	0.0%
1 A 4 b biomass	Residential	CH_4	45	40		21	23		264	236	0.3%
1 A 4 b biomass	Residential	N_2O					29		62	85	0.1%
1 A 4 b gaseous	Residential	CO_2	12	6	23	9	6		1 856	3 791	4.9%
1 A 4 b liquid	Residential	CO_2	4	7	11	3			5 633	3 332	4.3%
1 A 4 b solid	Residential	CO_2	9		1			4	2 511	61	0.1%
1 A 4 b solid	Residential	CH_4	49		8	22		1	224	5	0.0%
1 A 4 b solid	Residential	N_2O						15	11	0	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO_2	16	20					1 180	808	1.0%
1 A 4 c solid	Agriculture/Forestry/Fisheries	CO_2			18				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH_4	38			16			373	NA	-
1 B 2 b	Natural Gas	CH_4	43	39					290	238	0.3%
2 A 1	Cement Production	CO_2	10	9		8	7		2 033	1 889	2.4%
2 A 2	Lime Production	CO_2	35	24		15			439	663	0.9%
2 A 4 c	Non-metallurgical Magnesium	CO_2	32	31					481	357	0.5%
2 B 1	Ammonia Production	CO_2	34	29					467	500	0.6%
2 B 2	Nitric Acid Production	N_2O	22		5			7	780	41	0.1%
2 C 1	Iron and Steel Production	CO_2	2	2	15	2	2		6 840	11 002	14.2%
2 C 3	Aluminium Production	PFC	18			11			1 032	0	0.0%
2 C 3	Aluminium Production	CO_2			13				150	6	0.0%
2 C 4	SF_6 used in Al and Mg Foundries	SF_6	47		6			5	235	5	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	39			17	25		349	165	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		12	19		10	6	0	1 431	1.8%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6		33		24	19		124	304	0.4%
3 A 1	Cattle	CH_4	6	5	21	5	5	13	4 854	3 938	5.1%
3 B 1 1	Cattle	CH_4	33	28		14	18		467	508	0.7%
3 B 1 1	Cattle	N_2O	42	36		19	22		294	280	0.4%
3 B 1 3	Swine	N_2O				26	30		99	57	0.1%
3 B 2 5	Indirect N_2O Emissions	N_2O				25	27		103	111	0.1%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	13	11		10	9	9	1 776	1 500	1.9%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	41	35		18	21		341	286	0.4%
3 G	Liming	CO_2					28		46	99	0.1%
5 A	Solid Waste Disposal	CH_4	7	19	4	6	16	2	4 081	878	1.1%
5 D	Waste Water Treatment and Discharge	N_2O				27	26		86	152	0.2%

			Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2			
IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Share Latest Year (2021)
5 D	Waste Water Treatment and Discharge	CH_4				23		11	137	25	0.0%

Table A 16: Approach 2 – Key categories identified including their ranking in the level and trend assessment for the KCA including LULUCF.

			Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2			
IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Share Latest Year (2021)
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	9	3	26				3 294	4 467	4.9%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	18		7				1 229	120	0.1%
1 A 1 a other	Public Electricity and Heat Production	CO_2	51	16			12		286	1 049	1.1%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	4						6 247	0	0.0%
1 A 1 b gaseous	Petroleum refining	CO_2	41	27					437	533	0.6%
1 A 1 b liquid	Petroleum refining	CO_2	14	8					1 958	2 217	2.4%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO_2	34	34					506	354	0.4%
1 A 2 a gaseous	Iron and Steel	CO_2	27	17					650	994	1.1%
1 A 2 a solid	Iron and Steel	CO_2	20	21					1 107	760	0.8%
1 A 2 b gaseous	Non-ferrous Metals	CO_2		40					75	275	0.3%
1 A 2 c gaseous	Chemicals	CO_2	31	15					519	1 220	1.3%
1 A 2 c other	Chemicals	CO_2		37					125	294	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	23	10			8		943	1 580	1.7%
1 A 2 d liquid	Pulp, Paper and Print	CO_2	24		2			13	853	20	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO_2	42						398	210	0.2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	33	22					507	743	0.8%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	46		15				345	38	0.0%
1 A 2 f gaseous	Other	CO_2	29	23					559	665	0.7%
1 A 2 f liquid	Other	CO_2	32		22				508	147	0.2%
1 A 2 f other	Other	CO_2		26			14		67	616	0.7%
1 A 2 f solid	Other	CO_2	30	41					535	253	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	53	13					256	1 345	1.5%

			Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2			
IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assessment 2021	Trend Assessment 1990-2021	Level Assessment 1990	Level Assessment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate Ex,t	Share Latest Year (2021)
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	22	14					1 014	1 323	1.4%
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2			10				91	1	0.0%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	28		18				610	149	0.2%
1 A 3 b diesel oil	Road Transportation	CO_2	6	1	12	3	1		5 360	16 839	18.4%
1 A 3 b gasoline	Road Transportation	CO_2	2	4	9	2	4	15	7 896	4 213	4.6%
1 A 3 b gasoline	Road Transportation	N_2O			25			11	83	7	0.0%
1 A 3 e gaseous	Other	CO_2		32					224	374	0.4%
1 A 4 a gaseous	Commercial/Institutional	CO_2	26	18					698	923	1.0%
1 A 4 a liquid	Commercial/Institutional	CO_2	17	25	19				1 420	631	0.7%
1 A 4 a other	Commercial/Institutional	CO_2			3			4	83	0	0.0%
1 A 4 b biomass	Residential	CH_4	52	43		21	22		264	236	0.3%
1 A 4 b gaseous	Residential	CO_2	15	6	24	9	6		1 856	3 791	4.1%
1 A 4 b liquid	Residential	CO_2	5	7	11				5 633	3 332	3.6%
1 A 4 b solid	Residential	CO_2	12		1			6	2 511	61	0.1%
1 A 4 b solid	Residential	CH_4			8	22		1	224	5	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO_2	19	20					1 180	808	0.9%
1 A 4 c solid	Agriculture/Forestry/Fisheries	CO_2			20				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH_4	44			16			373	NA	0.0%
1 B 2 b	Natural Gas	CH_4	50	42					290	238	0.3%
2 A 1	Cement Production	CO_2	13	9		8			2 033	1 889	2.1%
2 A 2	Lime Production	CO_2	40	24					439	663	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO_2	36	33					481	357	0.4%
2 B 1	Ammonia Production	CO_2	38	30					467	500	0.5%
2 B 2	Nitric Acid Production	N_2O	25		5			10	780	41	0.0%
2 C 1	Iron and Steel Production	CO_2	3	2	16		2		6 840	11 002	12.0%
2 C 3	Aluminium Production	PFC	21			11			1 032	0	0.0%
2 C 3	Aluminium Production	CO_2			13				150	6	0.0%
2 C 4	SF_6 used in Al and Mg Foundries	SF_6	54		6			8	235	5	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	45			17			349	165	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		12	21		11	9	0	1 431	1.6%
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6		35			18		124	304	0.3%
3 A 1	Cattle	CH_4	7	5	23	4	5	17	4 854	3 938	4.3%
3 B 1 1	Cattle	CH_4	37	29		13	16		467	508	0.6%
3 B 1 1	Cattle	N_2O	49	39		20	21		294	280	0.3%

			Approach 1	**Approach 1**	**Approach 1**	**Approach 2**	**Approach 2**	**Approach 2**			
IPCC Category Code	**IPCC Category**	**GHG**	**Level Assessment 1990**	**Level Assessment 2021**	**Trend Assessment 1990-2021**	**Level Assessment 1990**	**Level Assessment 2021**	**Trend Assessment 1990-2021**	**Base Year (1990) Estimate $E_{x,0}$**	**Latest Year (2021) Estimate Ex,t**	**Share Latest Year (2021)**
3 B 1 3	Swine	N_2O				26			99	57	0.1%
3 B 2 5	Indirect N_2O Emissions	N_2O				25	27		103	111	0.1%
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	16	11		10	9	12	1 776	1 500	1.6%
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	47	38		18	20		341	286	0.3%
4	Total land use categories	N_2O				24	26		113	112	0.1%
4 A 1	Forest land remaining forest land	CO_2	1	46		1	3	16	-8 122	-8 938	9.8%
4 A 2	Land converted to forest land	CO_2	11	44	14	7	10	3	-2 957	-1 437	1.6%
4 B 2	Land converted to cropland	CO_2				23	23		190	211	0.2%
4 C 1	Grassland remaining grassland	CO_2	48	36		19	19		294	296	0.3%
4 C 2	Land converted to grassland	CO_2	43			15	25	5	391	138	0.2%
4 E 2	Land converted to Settlements	CO_2	39	31		14	17		448	441	0.5%
4 F 2	Land converted to Other land	CO_2	35	28		12	15		502	514	0.6%
4 G	HWP	CO_2	10	45	17	6	7	7	-3 122	-1 889	2.1%
5 A	Solid Waste Disposal	CH_4	8	19	4	5	13	2	4 081	878	1.0%
5 D	Waste Water Treatment and Discharge	N_2O					24		86	152	0.2%
5 D	Waste Water Treatment and Discharge	CH_4						14	137	25	0.0%

Table A 17: Source/sink categories and emissions/removals for key category analysis.

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	Gg	1 229	1 561	1 184	1 111	672	255	353	222	90	42	65	120
1 A 1 a solid	Public Electricity and Heat Production	CO_2	Gg	6 247	4 529	4 824	5 844	3 870	2 335	1 587	1 344	1 367	1 160	356	0
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	Gg	3 294	3 439	3 472	5 277	5 233	3 626	4 014	5 129	4 379	4 719	4 227	4 467
1 A 1 a other	Public Electricity and Heat Production	CO_2	Gg	286	282	288	495	886	1 083	1 156	1 089	1 036	1 031	1 016	1 049
1 A 1 b liquid	Petroleum Refining	CO_2	Gg	1 958	2 169	1 852	2 311	2 226	2 463	2 458	2 344	2 348	2 287	2 235	2 217
1 A 1 b gaseous	Petroleum Refining	CO_2	Gg	437	421	362	516	499	341	327	395	476	504	497	533
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CO_2	Gg	4	0	0	0	0	0	0	0	0	0	0	0
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO_2	Gg	506	611	281	394	238	275	273	259	240	312	289	354
1 A 2 a liquid	Iron and Steel	CO_2	Gg	76	83	73	59	32	6	8	7	7	5	7	20
1 A 2 a solid	Iron and Steel	CO_2	Gg	1 107	497	180	695	142	284	500	551	586	653	715	760
1 A 2 a gaseous	Iron and Steel	CO_2	Gg	650	757	1 022	1 090	1 101	1 116	1 069	1 100	1 178	1 147	1 081	994
1 A 2 b liquid	Non-Ferrous Metals	CO_2	Gg	35	41	47	33	20	29	21	18	7	8	8	9
1 A 2 b solid	Non-Ferrous Metals	CO_2	Gg	22	10	18	13	7	14	14	11	9	13	13	10
1 A 2 b gaseous	Non-Ferrous Metals	CO_2	Gg	75	205	128	172	209	252	269	266	309	278	246	275
1 A 2 b other	Non-Ferrous Metals	CO_2	Gg	0	0	0	0	0	1	1	1	1	1	1	0
1 A 2 c liquid	Pulp, Paper and Print	CO_2	Gg	97	102	64	74	142	57	60	56	39	42	75	39
1 A 2 c solid	Chemicals	CO_2	Gg	106	150	250	149	76	103	105	207	120	58	38	30
1 A 2 c gaseous	Chemicals	CO_2	Gg	519	572	874	1 019	1 014	1 013	1 131	1 139	1 106	1 182	1 131	1 220
1 A 2 c other	Chemicals	CO_2	Gg	125	161	153	106	315	222	254	226	205	181	181	294
1 A 2 d liquid	Pulp, Paper and Print	CO_2	Gg	853	523	171	139	72	42	30	17	17	17	13	20
1 A 2 d solid	Pulp, Paper and Print	CO_2	Gg	398	381	446	438	326	384	365	387	371	366	298	210
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	Gg	943	1 361	1 763	1 709	1 906	1 378	1 358	1 349	1 473	1 580	1 480	1 580
1 A 2 d other	Pulp, Paper and Print	CO_2	Gg	15	36	0	7	8	25	20	22	21	7	9	2
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	Gg	345	342	166	242	201	68	57	48	35	35	29	38
1 A 2 e solid	Food Processing, Beverages and Tobacco	CO_2	Gg	18	6	22	13	15	23	16	18	14	13	12	13
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	Gg	507	583	694	704	749	888	742	737	719	712	749	743

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1 A 2 e other	Food Processing, Beverages and Tobacco	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f liquid	Non-Metallic Minerals	CO_2	Gg	508	348	198	296	195	159	165	136	132	106	79	147
1 A 2 f solid	Non-Metallic Minerals	CO_2	Gg	535	435	503	373	312	266	221	211	230	234	311	253
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	Gg	559	615	641	659	602	625	645	667	670	701	699	665
1 A 2 f other	Non-Metallic Minerals	CO_2	Gg	67	122	197	327	419	555	600	622	662	623	566	616
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	Gg	256	358	551	809	1 074	1 064	1 079	1 139	1 218	1 285	1 234	1 345
1 A 2 g 7 other	Off-road vehicles and other machinery	CO_2	Gg	0	0	0	0	4	4	4	4	4	4	4	4
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	Gg	610	791	605	713	506	259	252	224	165	210	150	149
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2	Gg	91	18	30	35	0	0	0	3	0	0	0	1
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	Gg	1 014	1 423	1 070	1 290	1 547	1 202	1 366	1 393	1 370	1 198	1 235	1 323
1 A 2 g 8 other	Other Manufacturing Industries	CO_2	Gg	3	50	33	44	45	28	29	29	31	30	32	32
1 A 3 a aviation gasoline	Domestic Aviation	CO_2	Gg	8	7	6	9	9	8	10	7	7	7	6	6
1 A 3 a jet kerosene	Domestic Aviation	CO_2	Gg	31	46	61	58	54	42	37	35	39	39	18	18
1 A 3 b gasoline	Road Transportation	CO_2	Gg	7 896	7 397	6 092	6 393	5 284	4 781	4 787	4 735	4 852	4 835	3 962	4 213
1 A 3 b diesel oil	Road Transportation	CO_2	Gg	5 360	7 757	11 897	17 625	16 214	16 738	17 587	18 327	18 366	18 471	16 243	16 839
1 A 3 b LPG	Road Transportation	CO_2	Gg	26	32	43	60	57	36	33	31	22	14	8	10
1 A 3 b other	Road Transportation	CO_2	Gg	0	0	0	13	69	85	70	64	70	66	56	58
1 A 3 b gaseous	Road Transportation	CO_2	Gg	0	0	0	1	25	40	39	39	38	42	44	43
1 A 3 c liquid	Railways	CO_2	Gg	171	143	133	160	142	86	111	96	92	92	80	80
1 A 3 c other	Railways	CO_2	Gg	0	0	0	0	1	0	0	0	0	0	0	0
1 A 3 c solid	Railways	CO_2	Gg	7	6	3	1	0	0	0	0	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	CO_2	Gg	18	25	33	46	47	58	61	65	68	77	17	29
1 A 3 d other	Domestic Navigation	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 d gasoline	Domestic Navigation	CO_2	Gg	10	9	9	9	8	7	7	7	7	7	7	7
1 A 3 e gaseous	Other Transportation	CO_2	Gg	224	227	338	359	459	586	562	635	588	542	472	374
1 A 3 e liquid	Other Transportation	CO_2	Gg	5	7	9	11	11	10	12	12	13	14	6	7
1 A 3 e other	Other Transportation	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 a liquid	Commercial/Institutional	CO_2	Gg	1 420	1 316	1 338	1 986	682	446	421	577	501	465	447	631
1 A 4 a solid	Commercial/Institutional	CO_2	Gg	91	60	105	68	21	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1 A 4 a gaseous	Commercial/Institutional	CO_2	Gg	698	1 623	1 311	1 283	952	845	796	836	855	896	842	923
1 A 4 a other	Commercial/Institutional	CO_2	Gg	83	39	42	81	4	6	6	6	7	7	0	0
1 A 4 b liquid	Residential	CO_2	Gg	5 633	5 844	5 602	4 934	4 311	3 347	3 317	3 351	2 990	3 007	3 076	3 332
1 A 4 b other	Residential	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 b solid	Residential	CO_2	Gg	2 511	1 651	851	372	246	86	82	90	77	79	55	61
1 A 4 b gaseous	Residential	CO_2	Gg	1 856	2 453	2 709	3 640	3 627	3 149	3 480	3 407	3 118	3 308	3 339	3 791
1 A 4 b peat	Residential	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	Gg	1 180	926	999	952	803	788	858	778	782	818	828	808
1 A 4 c other	Agriculture/Forestry/Fishing	CO_2	Gg	0	0	0	0	3	3	3	2	2	2	2	2
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2	Gg	51	37	17	12	5	2	2	3	2	2	2	2
1 A 4 c gaseous	Agriculture/Forestry/Fishing	CO_2	Gg	20	27	30	43	47	34	41	56	50	61	50	53
1 A 4 c biomass	Agriculture/Forestry/Fishing	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 5 other	Other	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 A 5 b liquid	Mobile combustion - Military	CO_2	Gg	35	33	41	44	43	38	37	36	35	34	33	30
1 B 2 a	Oil	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
1 B 2 b	Natural Gas	CO_2	Gg	102	127	165	160	184	162	131	138	127	118	109	84
2 A 1	Cement Production	CO_2	Gg	2 033	1 631	1 712	1 797	1 622	1 701	1 729	1 710	1 827	1 771	1 821	1 889
2 A 2	Lime Production	CO_2	Gg	439	435	550	623	610	617	617	617	581	616	588	663
2 A 3	Glass Production	CO_2	Gg	39	42	36	35	40	40	38	38	38	41	39	36
2 A 4 a	Ceramics	CO_2	Gg	116	149	116	128	81	91	91	95	105	104	106	96
2 A 4 b	Other uses of soda ash	CO_2	Gg	5	6	8	13	10	10	11	10	10	9	9	10
2 A 4 c	Non-metallurgical Magnesium	CO_2	Gg	481	410	339	310	314	301	318	345	365	293	282	357
2 A 4 d	Other	CO_2	Gg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 B 1	Ammonia Production	CO_2	Gg	467	509	491	462	475	501	522	467	357	520	491	500
2 B 2	Nitric Acid Production	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0
2 B 5	Carbide Production	CO_2	Gg	38	32	43	38	37	46	43	41	43	42	40	44
2 B-10	Other (please specify)	CO_2	Gg	138	134	135	145	157	135	148	145	137	148	146	143
2 C 1	Iron and Steel Production	CO_2	Gg	6 840	7 564	8 420	9 764	10 388	10 787	10 352	11 109	9 431	10 339	9 482	11 002
2 C 2	Ferroalloys Production	CO_2	Gg	21	21	19	19	20	20	20	20	18	18	17	17
2 C 3	Aluminium Production	CO_2	Gg	150	1	2	1	4	5	5	5	5	5	5	6

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2 C 5	Lead Production	CO_2	Gg	5	4	4	5	5	5	5	5	5	5	5	5
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	Gg	349	234	198	174	169	132	134	142	145	147	154	165
2 G	Other Product Manufacture and Use	CO_2	Gg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3 G	Liming	CO_2	Gg	46	36	43	54	69	83	84	86	97	99	99	99
3 H	Urea application	CO_2	Gg	10	20	19	22	29	35	39	38	32	27	25	23
3 I	Other (please specify)	CO_2	Gg	31	29	27	20	15	27	29	26	26	25	25	27
5 C	Incineration and Open Burning of Waste	CO_2	Gg	28	11	12	12	2	2	2	2	2	2	2	2
1 A 1 a liquid	Public Electricity and Heat Production	CH_4	Gg CO_2 e	1	2	1	1	1	0	0	0	0	0	0	0
1 A 1 a solid	Public Electricity and Heat Production	CH_4	Gg CO_2 e	2	1	1	2	1	1	0	0	0	0	0	0
1 A 1 a gaseous	Public Electricity and Heat Production	CH_4	Gg CO_2 e	2	2	2	3	3	2	2	3	2	2	2	2
1 A 1 a biomass	Public Electricity and Heat Production	CH_4	Gg CO_2 e	0	1	2	5	14	15	14	15	14	14	15	15
1 A 1 a other	Public Electricity and Heat Production	CH_4	Gg CO_2 e	2	2	2	3	6	8	8	8	7	7	8	8
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 1 c biomass	Manufacture of Solid Fuels and Other Energy Industries	CH_4	Gg CO_2 e	1	1	1	1	1	1	1	1	1	1	1	1
1 A 1 b gaseous	Petroleum Refining	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 1 b liquid	Petroleum Refining	CH_4	Gg CO_2 e	1	1	1	2	2	2	2	2	2	2	2	2
1 A 2 a liquid	Iron and Steel	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 a solid	Iron and Steel	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 a gaseous	Iron and Steel	CH_4	Gg CO_2 e	0	0	1	1	1	1	1	1	1	1	1	1
1 A 2 a biomass	Iron and Steel	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b liquid	Non-Ferrous Metals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b solid	Non-Ferrous Metals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b gaseous	Non-Ferrous Metals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b other	Non-Ferrous Metals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b biomass	Non-Ferrous Metals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 c liquid	Chemicals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 c solid	Chemicals	CH_4	Gg CO_2 e	0	0	1	0	0	0	0	1	0	0	0	0
1 A 2 c gaseous	Chemicals	CH_4	Gg CO_2 e	0	0	0	1	1	1	1	1	1	1	1	1

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1 A 2 c biomass	Chemicals	CH_4	Gg CO_2 e	1	0	1	1	1	1	1	1	1	1	1	1
1 A 2 c other	Chemicals	CH_4	Gg CO_2 e	1	1	1	0	1	1	1	1	1	1	1	1
1 A 2 d liquid	Pulp, Paper and Print	CH_4	Gg CO_2 e	1	1	0	0	0	0	0	0	0	0	0	0
1 A 2 d solid	Pulp, Paper and Print	CH_4	Gg CO_2 e	1	1	1	1	1	1	1	1	1	1	1	1
1 A 2 d gaseous	Pulp, Paper and Print	CH_4	Gg CO_2 e	0	1	1	1	1	1	1	1	1	1	1	1
1 A 2 d biomass	Pulp, Paper and Print	CH_4	Gg CO_2 e	3	5	3	5	4	4	4	4	4	5	5	4
1 A 2 d other	Pulp, Paper and Print	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e solid	Food Processing, Beverages and Tobacco	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e biomass	Food Processing, Beverages and Tobacco	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e other	Food Processing, Beverages and Tobacco	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f liquid	Non-Metallic Minerals	CH_4	Gg CO_2 e	1	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f solid	Non-Metallic Minerals	CH_4	Gg CO_2 e	2	1	1	1	1	1	1	1	1	1	1	1
1 A 2 f gaseous	Non-Metallic Minerals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f biomass	Non-Metallic Minerals	CH_4	Gg CO_2 e	0	0	0	0	1	1	1	1	1	1	1	1
1 A 2 f other	Non-Metallic Minerals	CH_4	Gg CO_2 e	0	1	1	2	2	2	3	3	3	3	2	3
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CH_4	Gg CO_2 e	0	0	1	1	0	0	0	0	0	0	0	0
1 A 2 g 7 biomass	Off-road vehicles and other machinery	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 g 8 liquid	Other Manufacturing Industries	CH_4	Gg CO_2 e	1	1	1	1	0	0	0	0	0	0	0	0
1 A 2 g 8 solid	Other Manufacturing Industries	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 g 8 gaseous	Other Manufacturing Industries	CH_4	Gg CO_2 e	1	1	1	1	1	1	1	1	1	1	1	1
1 A 2 g 8 biomass	Other Manufacturing Industries	CH_4	Gg CO_2 e	1	1	3	5	7	7	6	6	5	5	5	5
1 A 2 g 8 other	Other Manufacturing Industries	CH_4	Gg CO_2 e	0	0	0	1	1	0	0	0	0	0	1	0
1 A 3 a aviation gasoline	Domestic Aviation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 a jet kerosene	Domestic Aviation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 b gasoline	Road Transportation	CH_4	Gg CO_2 e	77	50	29	24	15	11	11	10	9	9	8	7
1 A 3 b diesel oil	Road Transportation	CH_4	Gg CO_2 e	4	4	4	5	4	6	8	10	11	12	11	12

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1 A 3 b LPG	Road Transportation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 b gaseous	Road Transportation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 b biomass	Road Transportation	CH_4	Gg CO_2 e	0	0	0	0	1	1	1	1	1	1	1	1
1 A 3 c liquid	Railways	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 c solid	Railways	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 c biomass	Railways	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 d gasoline	Domestic Navigation	CH_4	Gg CO_2 e	1	1	1	1	0	0	0	0	0	0	0	0
1 A 3 d biomass	Domestic Navigation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e gaseous	Other Transportation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e liquid	Other Transportation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e biomass	Other Transportation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e other	Other Transportation	CH_4	Gg CO_2 e	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1 A 4 a liquid	Commercial/Institutional	CH_4	Gg CO_2 e	5	4	3	3	1	1	1	1	1	1	1	1
1 A 4 a solid	Commercial/Institutional	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 a gaseous	Commercial/Institutional	CH_4	Gg CO_2 e	2	4	3	3	2	2	2	2	2	2	2	2
1 A 4 a biomass	Commercial/Institutional	CH_4	Gg CO_2 e	8	6	6	4	6	3	3	3	4	4	4	4
1 A 4 a other	Commercial/Institutional	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 b liquid	Residential	CH_4	Gg CO_2 e	21	18	16	13	8	6	6	5	5	5	5	5
1 A 4 b solid	Residential	CH_4	Gg CO_2 e	224	147	76	33	22	8	7	8	7	7	5	5
1 A 4 b gaseous	Residential	CH_4	Gg CO_2 e	5	6	7	9	9	8	9	9	8	8	8	10
1 A 4 b biomass	Residential	CH_4	Gg CO_2 e	264	272	241	220	260	227	232	232	210	212	211	236
1 A 4 b peat	Residential	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c liquid	Agriculture/Forestry/Fishing	CH_4	Gg CO_2 e	6	5	5	4	2	2	1	1	1	1	1	1
1 A 4 c solid	Agriculture/Forestry/Fishing	CH_4	Gg CO_2 e	5	3	1	1	0	0	0	0	0	0	0	0
1 A 4 c gaseous	Agriculture/Forestry/Fishing	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c biomass	Agriculture/Forestry/Fishing	CH_4	Gg CO_2 e	34	38	42	48	54	58	59	62	56	52	53	59
1 A 5 b liquid	Mobile combustion - Military	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 5 b biomass	Mobile combustion - Military	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 B 1 a	Oil	CH_4	Gg CO_2 e	373	41	30	0	NA	NA	NA	NA	NA	NA	NA	NA

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1 B 2 a	Oil	CH_4	Gg CO_2 e	8	9	9	9	8	10	9	9	10	10	9	9
1 B 2 b	Natural Gas	CH_4	Gg CO_2 e	290	327	332	301	310	285	283	315	263	246	237	238
2 B 1	Ammonia Production	CH_4	Gg CO_2 e	2	2	2	3	2	3	2	3	2	2	2	1
2 B 8	Petrochemical and Carbon Black Production	CH_4	Gg CO_2 e	29	29	29	29	42	42	42	42	42	42	42	42
2 B-10	Other (please specify)	CH_4	Gg CO_2 e	8	8	8	9	8	8	8	8	7	8	11	11
2 C 1	Iron and Steel Production	CH_4	Gg CO_2 e	6	7	7	7	3	4	4	4	4	4	4	4
3 A 1	Cattle	CH_4	Gg CO_2 e	4 854	4 774	4 477	4 191	4 149	4 083	4 087	4 081	4 024	3 962	3 931	3 938
3 A 2	Sheep	CH_4	Gg CO_2 e	69	82	76	73	80	79	85	90	91	90	88	90
3 A 3	Swine	CH_4	Gg CO_2 e	88	84	76	74	74	68	67	68	67	68	68	68
3 A 4	Other (please specify)	CH_4	Gg CO_2 e	44	58	63	69	80	87	88	94	94	94	95	96
3 B 1 1	Cattle	CH_4	Gg CO_2 e	467	444	409	376	434	502	514	528	518	510	505	508
3 B 1 2	Sheep	CH_4	Gg CO_2 e	3	3	3	3	3	3	3	3	3	3	3	3
3 B 1 3	Swine	CH_4	Gg CO_2 e	148	134	116	106	101	90	88	89	87	87	88	87
3 B 1 4	Other (please specify)	CH_4	Gg CO_2 e	14	16	16	17	19	22	22	23	23	24	24	24
3 F	Field Burning of Agricultural Residues	CH_4	Gg CO_2 e	1	1	1	1	1	0	0	0	0	0	0	NO
5 A	Solid Waste Disposal	CH_4	Gg CO_2 e	4 081	3 758	2 987	2 730	1 978	1 328	1 221	1 135	1 052	988	931	878
5 B	Biological Treatment of Solid Waste	CH_4	Gg CO_2 e	15	29	35	55	70	76	78	76	76	79	78	79
5 C	Incineration and Open Burning of Waste	CH_4	Gg CO_2 e	1	1	1	0	0	0	0	0	0	0	0	0
5 D	Waste Water Treatment and Discharge	CH_4	Gg CO_2 e	137	119	77	49	34	29	29	27	25	25	25	25
1 A 1 a liquid	Public Electricity and Heat Production	N_2O	Gg CO_2 e	2	3	2	2	1	1	1	0	0	0	0	0
1 A 1 a solid	Public Electricity and Heat Production	N_2O	Gg CO_2 e	24	18	20	24	16	10	7	6	6	5	2	0
1 A 1 a gaseous	Public Electricity and Heat Production	N_2O	Gg CO_2 e	2	2	2	3	3	2	2	2	2	2	2	2
1 A 1 a biomass	Public Electricity and Heat Production	N_2O	Gg CO_2 e	2	4	8	18	53	55	52	55	54	52	54	57
1 A 1 a other	Public Electricity and Heat Production	N_2O	Gg CO_2 e	5	5	6	11	19	24	26	24	23	23	24	24
1 A 1 b liquid	Petroleum Refining	N_2O	Gg CO_2 e	2	2	2	3	3	4	4	4	4	3	4	3
1 A 1 b gaseous	Petroleum Refining	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 a liquid	Iron and Steel	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0

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1 A 2 a solid	Iron and Steel	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 a gaseous	Iron and Steel	N_2O	Gg CO_2 e	0	0	0	1	1	1	1	1	1	1	1	0
1 A 2 a biomass	Iron and Steel	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b liquid	Non-Ferrous Metals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b solid	Non-Ferrous Metals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b gaseous	Non-Ferrous Metals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b other	Non-Ferrous Metals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 b biomass	Non-Ferrous Metals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 c liquid	Chemicals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 c solid	Chemicals	N_2O	Gg CO_2 e	0	1	1	1	0	0	0	1	1	0	0	0
1 A 2 c gaseous	Chemicals	N_2O	Gg CO_2 e	0	0	0	0	0	0	1	1	1	1	1	1
1 A 2 c biomass	Chemicals	N_2O	Gg CO_2 e	3	2	4	2	3	2	2	2	3	3	3	3
1 A 2 c other	Chemicals	N_2O	Gg CO_2 e	2	2	2	2	4	3	4	3	3	3	3	4
1 A 2 d liquid	Pulp, Paper and Print	N_2O	Gg CO_2 e	2	1	0	0	0	0	0	0	0	0	0	0
1 A 2 d solid	Pulp, Paper and Print	N_2O	Gg CO_2 e	2	2	2	2	1	2	2	2	2	2	1	1
1 A 2 d gaseous	Pulp, Paper and Print	N_2O	Gg CO_2 e	0	1	1	1	1	1	1	1	1	1	1	1
1 A 2 d biomass	Pulp, Paper and Print	N_2O	Gg CO_2 e	15	22	17	24	22	21	22	22	23	24	23	22
1 A 2 d other	Pulp, Paper and Print	N_2O	Gg CO_2 e	0	1	0	0	0	0	0	0	0	0	0	0
1 A 2 e liquid	Food Processing, Beverages and Tobacco	N_2O	Gg CO_2 e	1	1	0	0	0	0	0	0	0	0	0	0
1 A 2 e solid	Food Processing, Beverages and Tobacco	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 e biomass	Food Processing, Beverages and Tobacco	N_2O	Gg CO_2 e	0	0	0	0	1	0	0	0	0	0	0	0
1 A 2 e other	Food Processing, Beverages and Tobacco	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f liquid	Non-Metallic Minerals	N_2O	Gg CO_2 e	1	1	0	1	0	0	0	0	0	0	0	0
1 A 2 f solid	Non-Metallic Minerals	N_2O	Gg CO_2 e	2	2	2	2	1	1	1	1	1	1	1	1
1 A 2 f gaseous	Non-Metallic Minerals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f biomass	Non-Metallic Minerals	N_2O	Gg CO_2 e	0	0	0	2	3	4	4	4	4	4	4	4
1 A 2 f other	Non-Metallic Minerals	N_2O	Gg CO_2 e	1	2	4	5	5	8	8	8	9	8	8	8
1 A 2 g 7 liquid	Off-road vehicles and other machinery	N_2O	Gg CO_2 e	24	35	59	62	48	38	37	37	37	38	35	38

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1 A 2 g 7 biomass	Off-road vehicles and other machinery	N_2O	Gg CO_2 e	0	0	0	1	3	3	3	2	2	2	2	2
1 A 2 g 8 liquid	Other Manufacturing Industries	N_2O	Gg CO_2 e	1	1	1	1	1	0	0	0	0	0	0	0
1 A 2 g 8 solid	Manufacturing Industries and Construction	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 g 8 gaseous	Other Manufacturing Industries	N_2O	Gg CO_2 e	0	1	1	1	1	1	1	1	1	1	1	1
1 A 2 g 8 biomass	Other Manufacturing Industries	N_2O	Gg CO_2 e	4	2	9	18	24	28	23	23	20	18	19	20
1 A 2 g 8 other	Other Manufacturing Industries	N_2O	Gg CO_2 e	0	1	0	2	2	0	1	1	1	1	2	0
1 A 3 a aviation gasoline	Domestic Aviation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 a jet kerosene	Domestic Aviation	N_2O	Gg CO_2 e	0	1	1	1	1	1	0	0	0	0	0	0
1 A 3 b gasoline	Road Transportation	N_2O	Gg CO_2 e	83	96	70	53	25	11	10	9	9	8	7	7
1 A 3 b diesel oil	Road Transportation	N_2O	Gg CO_2 e	11	21	44	78	111	158	175	192	199	205	190	199
1 A 3 b LPG	Road Transportation	N_2O	Gg CO_2 e	0	0	1	1	0	0	0	0	0	0	0	0
1 A 3 b gaseous	Road Transportation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 b biomass	Road Transportation	N_2O	Gg CO_2 e	0	0	0	1	12	24	17	15	16	16	13	14
1 A 3 c liquid	Railways	N_2O	Gg CO_2 e	16	13	13	15	11	5	7	5	5	5	4	4
1 A 3 c solid	Railways	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 c biomass	Railways	N_2O	Gg CO_2 e	0	0	0	0	1	0	0	0	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	N_2O	Gg CO_2 e	2	3	4	5	5	5	5	5	6	6	1	2
1 A 3 d gasoline	Domestic Navigation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 d biomass	Domestic Navigation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e gaseous	Other Transportation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e liquid	Other Transportation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e biomass	Other Transportation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 3 e other	Other Transportation	N_2O	Gg CO_2 e	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1 A 4 a liquid	Commercial/Institutional	N_2O	Gg CO_2 e	3	2	3	4	1	1	1	1	1	1	1	1
1 A 4 a solid	Commercial/Institutional	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 a gaseous	Commercial/Institutional	N_2O	Gg CO_2 e	0	1	1	1	0	0	0	0	0	0	0	0
1 A 4 a biomass	Commercial/Institutional	N_2O	Gg CO_2 e	2	2	4	3	4	3	2	3	3	4	4	4
1 A 4 a other	Commercial/Institutional	N_2O	Gg CO_2 e	1	1	1	1	0	0	0	0	0	0	0	0
1 A 4 b liquid	Residential	N_2O	Gg CO_2 e	18	19	18	16	13	9	9	9	8	8	8	8

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1 A 4 b solid	Residential	N_2O	Gg CO_2 e	11	7	4	2	1	0	0	0	0	0	0	0
1 A 4 b gaseous	Residential	N_2O	Gg CO_2 e	1	1	1	2	2	2	2	2	1	2	2	2
1 A 4 b biomass	Residential	N_2O	Gg CO_2 e	62	66	64	62	80	77	79	79	73	75	75	85
1 A 4 b peat	Residential	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c liquid	Agriculture/Forestry/Fishing	N_2O	Gg CO_2 e	68	68	77	76	54	39	41	36	34	35	34	32
1 A 4 c solid	Agriculture/Forestry/Fishing	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c gaseous	Agriculture/Forestry/Fishing	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c biomass	Agriculture/Forestry/Fishing	N_2O	Gg CO_2 e	4	5	5	7	10	10	10	10	9	9	9	9
1 A 5 b liquid	Mobile combustion - Military	N_2O	Gg CO_2 e	1	1	1	1	1	1	1	1	1	1	1	1
1 A 5 b biomass	Mobile combustion - Military	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
2 B 2	Nitric Acid Production	N_2O	Gg CO_2 e	780	733	813	234	54	42	32	34	50	72	47	41
2 G	Other Product Manufacture and Use	N_2O	Gg CO_2 e	117	117	117	67	47	37	37	35	34	35	33	32
3 B 1 1	Cattle	N_2O	Gg CO_2 e	294	279	262	247	261	281	284	289	285	281	278	280
3 B 1 2	Sheep	N_2O	Gg CO_2 e	5	6	6	6	6	6	7	7	7	7	7	7
3 B 1 3	Swine	N_2O	Gg CO_2 e	99	88	74	66	63	57	57	58	56	56	57	57
3 B 1 4	Other (please specify)	N_2O	Gg CO_2 e	8	11	11	12	14	15	16	17	17	17	17	17
3 B 2 5	Indirect N_2O Emissions	N_2O	Gg CO_2 e	103	104	99	99	104	106	108	109	109	109	110	111
3 D 1	Direct N_2O Emissions from Managed Soils	N_2O	Gg CO_2 e	1 776	1 645	1 570	1 468	1 412	1 535	1 605	1 538	1 501	1 477	1 492	1 500
3 D 2	Indirect N_2O emissions from Managed Soils	N_2O	Gg CO_2 e	341	316	297	278	275	296	307	299	292	285	286	286
3 F	Field Burning of Agricultural Residues	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	NO
5 B	Biological Treatment of Solid Waste	N_2O	Gg CO_2 e	20	38	46	61	63	65	68	68	67	70	71	74
5 C	Incineration and Open Burning of Waste	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
5 D	Waste Water Treatment and Discharge	N_2O	Gg CO_2 e	86	99	120	133	141	145	148	149	149	151	151	152
2 C 3	Aluminium Production	PFC	Gg CO_2 e	1 032	0	0	0	0	0	0	0	0	0	0	0
2 C 4	Magnesium Production	SF_6	Gg CO_2 e	235	422	37	5	0	2	2	16	6	3	5	5
2 C 3	Aluminium Production	SF_6	Gg CO_2 e	14	14	0	0	0	0	0	0	0	0	0	0
2 E	Electronics Industry	HFC	Gg CO_2 e	2	9	4	4	2	2	2	4	4	3	3	3
2 E	Electronics Industry	PFC	Gg CO_2 e	31	75	79	145	71	45	46	40	29	35	27	23
2 E	Electronics Industry	SF_6	Gg CO_2 e	100	422	327	166	68	43	35	32	29	34	13	15
2 E	Electronics Industry	NF_3	Gg CO_2 e	0	6	10	26	4	13	6	11	15	13	11	12

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	Gg CO_2 e	0	36	380	908	1 358	1 844	1 831	1 836	1 877	1 744	1 651	1 431
2 F 2	Foam Blowing Agents	HFC	Gg CO_2 e	0	275	267	146	35	15	15	15	15	16	17	18
2 F 3	Fire Protection	HFC	Gg CO_2 e	0	0	0	6	11	12	11	12	24	12	11	11
2 F 4	Aerosols	HFC	Gg CO_2 e	0	4	25	38	20	24	25	25	26	26	24	23
2 F 5	Solvents	HFC	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
2 F 6	Other Applications	PFC	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
2 G 1	Other product manufacture and use - Electrical Equipment	SF_6	Gg CO_2 e	11	15	18	23	30	37	40	40	43	44	45	47
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	PFC	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
2 G 2	Other product manufacture and use - SF_6 and PFCs from other product use	SF_6	Gg CO_2 e	124	262	211	315	248	236	328	324	321	368	391	304
2 G 4 b	ORC	PFC	Gg CO_2 e	0	0	1	5	0	0	0	0	0	0	0	0
2 G 4 b	ORC	HFC	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0
4 A 1	Forest land remaining forest land	CO_2	Gg	-8 122	-15 891	-11 608	-14 683	-17 223	-5 476	-6 089	-1 810	6 566	3 239	-5 493	-8 938
4 A 2	Land converted to forest land	CO_2	Gg	-2 957	-2 975	-2 320	-2 086	-1 873	-1 581	-1 557	-1 534	-1 510	-1 486	-1 461	-1 437
4 B 1	Cropland remaining cropland	CO_2	Gg	-18	-37	-193	-305	-304	-222	-182	-139	-116	-88	-40	48
4 B 2	Land converted to cropland	CO_2	Gg	190	164	163	174	166	179	190	198	203	205	207	211
4 C 1	Grassland remaining grassland	CO_2	Gg	294	295	295	295	296	296	296	296	296	296	296	296
4 C 2	Land converted to grassland	CO_2	Gg	391	173	181	433	237	221	195	173	157	152	147	138
4 D 1	Wetlands remaining Wetlands	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	2	0
4 D 2	Land converted to Wetlands	CO_2	Gg	47	34	40	52	86	75	94	84	83	76	74	76
4 E 2	Land converted to Settlements	CO_2	Gg	448	473	498	662	663	558	554	555	563	549	516	441
4 F 2	Land converted to Other land	CO_2	Gg	502	413	406	353	495	494	497	500	503	507	510	514
4 G	HWP	CO_2	Gg	-3 122	-2 569	-1 889	-3 461	-2 452	-1 254	-1 137	-1 719	-1 969	-1 462	-122	-1 889
4	Total land use categories	CH_4	Gg CO_2 e	27	27	27	27	27	27	27	27	27	27	27	27
4	Total land use categories	N_2O	Gg CO_2 e	113	122	117	119	124	119	120	120	118	117	115	112

ANNEX 2: ASSESSMENT OF UNCERTAINTY

A consistent assessment of uncertainties of the Austrian greenhouse gas inventory requires a detailed understanding of the uncertainties of the respective input parameters. Since the first detailed uncertainty evaluation (WINIWARTER & ORTHOFER 2000, WINIWARTER & RYPDAL 2001), the Austrian inventory compilers have spent considerable effort to also obtain uncertainties from individual contributors to the inventory. This leads to a situation where national information or at least national expert knowledge directly from the stage of inventory development may flow into the assessment of uncertainties.

The respective sectoral uncertainties are documented in detail in the sectoral chapters of this report. Specific uncertainty estimates are e.g. available for agricultural soil, for enteric fermentation from animal husbandry, for F-gases, for transport, and for land-use change and forestry.

Annex 2.1 – Description of methodology used for identifying uncertainties

Theoretical background

The assessment and propagation of uncertainties in emission inventories has been described in detail by IPCC (IPCC 2000, IPCC 2006). Principally, two different pathways may be taken to arrive at a total uncertainty, and to develop an inventory uncertainty. The approach 1 is based on error propagation: assuming input information is available in form of normal distribution, and input uncertainties are statistically independent, the approach allows for reliable assessment of inventory uncertainty. More flexibility is possible in the method for approach 2. The Monte-Carlo approach allows any probability distribution of input parameters, and it also enables to define statistical dependencies between parameters. The most obvious dependency is a full dependency. This occurs when two values are based on the identical set of measurements. A variation or error in one value would then be fully reflected also in the other value. While "full dependency" theoretically can also be covered in error propagation, this is normally not done and only in a very limited way possible in the IPCC spreadsheets.

The general properties of error propagation allow to combine (add up) information in a way that the relative uncertainty (as percentage of the mean value) of the combination becomes lower than the relative uncertainty of any of the input parameters. This advantage of going into detail is often implicitly taken advantage of, when a problem is disassembled into sub-problems and the sub-results are being recombined. Nevertheless it is not always the most detailed level that yields results of lowest uncertainty. If measurements or assessments at the most detailed level are difficult, a more comprehensive level of information may provide the lower overall uncertainty.

As a consequence, optimizing the approach requires collecting input information at the most detailed level an inventory is prepared at. Attaching uncertainty data then may be done at a level where greatest confidence can be expected on the data. This may be the most detailed level, but more often uncertainty data will not be available, or a "balance" approach (energy balance, solvent balance) will allow more reliability at a more aggregated level.

Procedure

For the update of the uncertainty assessment of the Austrian greenhouse gas inventory, the most detailed level of the inventory system was used as the base level. This "base level" of the inventory facilitates compilation of emission data for different purposes. Reporting on air pollution (according to UN-ECE or European Commission requirements) is performed by agglomerating the details in basically the same way as it is done for the GHG inventory according to UNFCCC procedures.

This approach of starting at the most detailed level the inventory offers facilitated an assessment of emission uncertainty at any level that the most reasonable uncertainty data are available. Very detailed information can be entered directly, for aggregate information the same uncertainty (as a statistically dependent entity) is applied for all input entries concerned.

Uncertainty information was taken from national studies, from international information (as e.g. in the IPCC reports) from variation presented in literature, and by contacting national experts. Structured interviews were not held, but information collected previously in structured interviews still could be used.

In all input and output parameters, uncertainty has been expressed as normal or lognormal probability density function. In line with the IPCC requirements, the uncertainty range is presented as the range with 95% probability of a given value being within its boundaries. Thus the boundaries were given as the 2.5 and 97.5-percentiles of the respective distribution. For a normal distribution, this is +/- 2 standard deviations from the mean.

Random uncertainty vs. systematic uncertainty

In a previous study, random and systematic uncertainties were strictly separated. Systematic uncertainty was seen as composed of the errors contained and discovered in the national inventory during the analysis (WINIWARTER & RYPDAL 2001). As systematic uncertainty by the definition above is unknown at the time it occurs, its true magnitude can not be known. Previously, this magnitude of the errors still undiscovered was expected to be of similar magnitude as those identified. Such an assessment obviously refers to the inventory as a whole, and not to a single sector, as one should not expect an error always occurring in the same sector. Furthermore, it is highly questionable that the assumption, an error remaining relates to the error discovered already, can be sustained during all stages of inventory development.

Consequently here we did not perform a specific assessment of systematic uncertainty.

Data origin

Many of the uncertainties included in the calculations have already been covered in the previous submissions. Nevertheless it is worthwhile to consider some of the input uncertainties in detail – especially those that contribute more to the overall uncertainty.

Activities: According to information from the Austrian statistical agency, the Austrian energy balance is strongly affected by inexact reporting, reporting errors or omissions/double counting due to difficult attribution of responsibilities. Detailed statistics are therefore not very reliable, but on the total energy level a number of additional plausibility checks are performed. This procedure allows to expect high quality data of low uncertainty at a rather high level of detail, to be presented separately by the specified fuel types (coal/oil/gas, and also biomass but at a higher uncertainty). Consequently, separate (independent) assessment of energy data has been applied to power plants, other combustion including industry, and transport. Within each of these ranges of sectors the specific uncertainty has been applied, but is considered statistically dependent.

Some very special fuels are also treated separately (landfill gas, black liquor). Additionally, large industrial plants are considered separately, as long as they remain sufficiently separate of the energy input. Iron and steel industry is considered dependent of energy. Non-energy sectors are assessed using the specific Austrian studies already mentioned above. These studies contain specific information on agricultural soil, enteric fermentation from animal husbandry, F-gases, transport, and on land-use change and forestry.

Activity related uncertainties for base year and target year are considered to be the same in all cases, but statistically independent. There are reports, e.g. on the solvent sector, which assume lower uncertainty for more recent data. As the solvent balance is strongly dependent on the trade statistics, which suffered heavily from the relaxation of reporting requirements after Austria's accession to the EU in 1995, such improvement was not considered.

Carbon dioxide (CO_2): The emission factor of CO_2 is in most cases well contained due to the carbon content of fuels or of raw materials. Still it is basically one set of measurements that is applied uniformly. A large number of single data have been applied to arrive at a reliable carbon content and consequently emission factor, but this is already factored-in in the magnitude of the uncertainty. Consequently, all energy related carbon contents by fuel type are here considered identical for all energy related activities. We assume independence of uncertainties between fuel types only. Some more independent uncertainty figures are available for source categories like solvents, chemical industry, land use change.

Methane (CH_4): Methane emissions are derived from a large variety of individual measurements of total hydrocarbon (HC) or total volatile organic compound emissions. But only the smaller part of uncertainties derives from these measurements. The larger part is caused by assumptions on the fraction of CH_4 in the HC mix, which ranges from 10% (coal fired large plants) to 75% (gas combustion). Therefore statistically independent numbers are no more than the CH_4 fractions considered separately. Such separate data is available only in combustion generally, in power plants, and in transport. Consequently we have here a very similar pattern as in activities.

Agricultural methane (enteric fermentation and manure treatment) has been assessed for Austria in specific studies, which also reported the uncertainty involved in emission factors (AMON et al. 2002, GEBETSROITHER et al. 2002). This uncertainty estimate could be applied here.

Nitrous oxide (N_2O): Very limited measurement data are available on nitrous oxide emissions. When trying to trace emission factors back to their origin, the large Austrian data collection on emission factors from combustion (STANZEL et al. 1995) refers virtually all N_2O factors back to GEMIS. In line with an earlier assessment done in an Austrian N_2O balance (ORTHOFER et al. 1994), uncertainties by fuel in general and uncertainties in the domestic heating sector were considered independent. Also transport was considered independently, even separated between Diesel fuel and gasoline (as only the latter is equipped with catalysts, which are responsible for the larger share of emissions).

In addition to the definition of statistically independent parameters, some of the uncertainty attributions had to be adapted. Uncertainty figures in the energy sector refer to measurements done around 1990 (VITOVEC 1991). Changes in fuel quality or in combustion equipment are not at all reflected, leading to enhanced uncertainty which we here take from international data. Furthermore (and most importantly, see below), the uncertainty estimate on N_2O from soils used previously (NIR 2006) could not be sustained. A detailed investigation revealed that the source of the 48% uncertainty presented was a statement in an IPCC report (IPCC 2000) referring to a measurement uncertainty. Here we have to deal with an emission factor uncertainty, which is estimated much higher, at an order of magnitude in the latest IPCC emission inventory guidelines (IPCC 2006). This higher number which we adopt now is still much smaller than the two orders of magnitude recommended by IPCC previously (IPCC 2000), and also smaller than a previous estimate for Austria (WINIWARTER & RYPDAL 2001). The latter was considered in part systematic uncertainty, however (the random uncertainty was considered smaller than the range now used) – this is still in part true, but only reflects our lack of knowledge on soil processes. Choosing to apply a quasi-standardized value conforms to the claim of (WINIWARTER 2007) that application of similar parameters between countries allows for a smaller error in an inter-comparison, even if the difference to a "true value" might be larger.

Fluorinated gases: The uncertainties related to emissions of fluorinated gases (PFC, HFC and SF_6) have been investigated within the emission assessment (NIR 2006). Basically, emissions in areas where substances are specifically brought in, e.g. as solvents, are considered well understood, those that refer to release (refrigeration, electrodes during Al-production) are considered highly uncertain.

Annex 2.2 – Results of the Uncertainty Assessment

Table A 18: Approach 1 Uncertainty Analysis (Article 12(1) Regulation (EU) 2020/1208) for 1990 – excluding LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert \frac{D}{\sum C} \right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	312	327	5.0	50.0	50.2	0.0393	0.0003	0.0041	0.0137	0.0293	0.0010
1.A Stationary Combustion – Biomass	CO_2	0	0	5.0	1.0	5.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N_2O	92	207	5.0	50.0	50.2	0.0034	0.0015	0.0026	0.0743	0.0186	0.0059
1.A Stationary Combustion – Gaseous Fuels	CH_4	11	18	2.0	50.0	50.0	0.0000	0.0001	0.0002	0.0048	0.0006	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO_2	11 076	16 919	2.0	0.2	2.0	0.0793	0.0765	0.2140	0.0153	0.6054	0.3667
1.A Stationary Combustion – Gaseous Fuels	N_2O	5	8	2.0	50.0	50.0	0.0000	0.0000	0.0001	0.0018	0.0003	0.0000
1.A Stationary Combustion – Liquid Fuels	CH_4	38	10	0.5	50.0	50.0	0.0006	-0.0003	0.0001	-0.0172	0.0001	0.0003
1.A Stationary Combustion – Liquid Fuels	CO_2	14 203	8 875	0.5	0.5	0.7	0.0161	-0.0639	0.1123	-0.0319	0.0794	0.0073
1.A Stationary Combustion – Liquid Fuels	N_2O	122	83	0.5	50.0	50.0	0.0059	-0.0005	0.0011	-0.0229	0.0007	0.0005
1.A Stationary Combustion – Other fuels	CH_4	3	12	10.0	50.0	51.0	0.0000	0.0001	0.0001	0.0056	0.0021	0.0000
1.A Stationary Combustion – Other fuels	CO_2	580	2 001	10.0	15.0	18.0	0.0175	0.0181	0.0253	0.2717	0.3580	0.2019
1.A Stationary Combustion – Other fuels	N_2O	10	37	10.0	50.0	51.0	0.0000	0.0004	0.0005	0.0177	0.0067	0.0004
1.A Stationary Combustion – Solid Fuels	CH_4	234	7	0.5	50.0	50.0	0.0219	-0.0028	0.0001	-0.1405	0.0001	0.0197
1.A Stationary Combustion – Solid Fuels	CO_2	11 177	1 340	0.5	0.5	0.7	0.0100	-0.1216	0.0169	-0.0608	0.0120	0.0038
1.A Stationary Combustion – Solid Fuels	N_2O	41	3	0.5	50.0	50.0	0.0007	-0.0005	0.0000	-0.0236	0.0000	0.0006
1.A.3.a Transport – Civil Aviation	CH_4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO_2	38	24	3.0	3.0	4.2	0.0000	-0.0002	0.0003	-0.0005	0.0013	0.0000
1.A.3.a Transport – Civil Aviation	N_2O	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH_4	4	12	3.0	30.0	30.1	0.0000	0.0001	0.0002	0.0029	0.0006	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO_2	5 360	16 839	3.0	3.0	4.2	0.0828	0.1464	0.2130	0.4392	0.9038	1.0098
1.A.3.b Transport – Road Transportation – Diesel	N_2O	11	199	3.0	30.0	30.1	0.0000	0.0024	0.0025	0.0716	0.0107	0.0052
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	0	43	3.0	3.0	4.2	0.0000	0.0005	0.0005	0.0016	0.0023	0.0000

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		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	77	7	3.0	30.0	30.1	0.0009	-0.0009	0.0001	-0.0259	0.0004	0.0007
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	7 896	4 213	3.0	3.0	4.2	0.1796	-0.0446	0.0533	-0.1339	0.2261	0.0691
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	83	7	3.0	70.0	70.1	0.0054	-0.0009	0.0001	-0.0660	0.0004	0.0044
1.A.3.b Transport – Road Transportation – LPG	CO_2	26	10	3.0	3.0	4.2	0.0000	-0.0002	0.0001	-0.0006	0.0005	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH_4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N_2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH_4	0	1	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0006	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO_2	0	0	5.0	30.0	30.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N_2O	0	14	5.0	3.0	5.8	0.0000	0.0002	0.0002	0.0005	0.0012	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	0	0	5.0	70.0	70.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	0	58	5.0	3.0	5.8	0.0000	0.0007	0.0007	0.0022	0.0052	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	0	0	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH_4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO_2	178	81	3.0	3.0	4.2	0.0001	-0.0012	0.0010	-0.0036	0.0043	0.0000
1.A.3.c Transport – Railways	N_2O	16	4	3.0	30.0	30.1	0.0000	-0.0001	0.0001	-0.0043	0.0002	0.0000
1.A.3.d Transport – Navigation	CH_4	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.d Transport – Navigation	CO_2	28	35	3.0	3.0	4.2	0.0000	0.0001	0.0004	0.0003	0.0019	0.0000
1.A.3.d Transport – Navigation	N_2O	2	2	3.0	70.0	70.1	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000
1.A.3.e Transport – Other Transportation	CH_4	0	0	2.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO_2	229	382	2.0	0.2	2.0	0.0000	0.0020	0.0048	0.0004	0.0137	0.0002
1.A.3.e Transport – Other Transportation	N_2O	0	0	2.0	50.0	50.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH_4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO_2	35	30	1.0	0.5	1.1	0.0000	-0.0001	0.0004	0.0000	0.0005	0.0000
1.A.5.b Mobile	N_2O	1	1	1.0	50.0	50.0	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	373	0	5.0	50.0	50.2	0.0563	-0.0046	0.0000	-0.2315	0.0000	0.0536

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		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.B.2.a Fugitive Emission – Oil	CH_4	8	9	0.5	50.0	50.0	0.0000	0.0000	0.0001	0.0003	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO_2	0	0	0.5	0.5	0.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH_4	290	238	5.0	10.0	11.2	0.0017	-0.0006	0.0030	-0.0059	0.0213	0.0005
1.B.2.b Fugitive Emission – Natural Gas	CO_2	102	84	5.0	0.2	5.0	0.0000	-0.0002	0.0011	0.0000	0.0075	0.0001
2.A.1 Mineral Industry – Cement Production	CO_2	2 033	1 889	5.0	2.0	5.4	0.0192	-0.0013	0.0239	-0.0027	0.1690	0.0286
2.A.2 Mineral Industry – Lime Production	CO_2	439	663	20.0	5.0	20.6	0.0131	0.0029	0.0084	0.0147	0.2372	0.0565
2.A.3 Mineral Industry – Glass Production	CO_2	39	36	10.0	1.0	10.0	0.0000	0.0000	0.0005	0.0000	0.0064	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	116	96	2.0	5.0	5.4	0.0001	-0.0002	0.0012	-0.0012	0.0034	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	5	10	10.0	5.0	11.2	0.0000	0.0001	0.0001	0.0003	0.0018	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	481	357	2.0	5.0	5.4	0.0011	-0.0015	0.0045	-0.0073	0.0128	0.0002
2.A.4.d Other Process Uses of Carbonates – other	CO_2	0	0	20.0	2.0	20.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CH_4	2	1	2.0	5.0	5.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO_2	467	500	2.0	5.0	5.4	0.0010	0.0005	0.0063	0.0027	0.0179	0.0003
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	0	0	2.0	5.0	5.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	780	41	2.0	5.0	5.4	0.0028	-0.0091	0.0005	-0.0457	0.0015	0.0021
2.B.5 Chemical Industry – Carbide Production	CO_2	38	44	5.0	10.0	11.2	0.0000	0.0001	0.0006	0.0009	0.0040	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	29	42	10.0	10.0	14.1	0.0000	0.0002	0.0005	0.0017	0.0075	0.0001
2.B.10 Chemical Industry – Other	CH_4	8	11	2.0	5.0	5.4	0.0000	0.0000	0.0001	0.0002	0.0004	0.0000
2.B.10 Chemical Industry – Other	CO_2	138	143	2.0	5.0	5.4	0.0001	0.0001	0.0018	0.0005	0.0051	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO_2	6 840	11 002	0.5	0.5	0.7	0.0037	0.0543	0.1392	0.0271	0.0984	0.0104
2.C.1 Metal Industry – Iron and Steel Production	CH_4	6	4	0.5	0.0	0.5	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO_2	21	17	5.0	25.0	25.5	0.0000	0.0000	0.0002	-0.0011	0.0015	0.0000
2.C.3 Metal Industry – Aluminium Production	CO_2	150	6	2.0	0.5	2.1	0.0000	-0.0018	0.0001	-0.0009	0.0002	0.0000
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	2.0	50.0	50.0	0.4271	-0.0128	0.0000	-0.6404	0.0000	0.4101
2.C.3 Metal Industry – Aluminium Production	SF_6	14	0	2.0	50.0	50.0	0.0001	-0.0002	0.0000	-0.0087	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF_6	235	5	5.0	5.0	7.1	0.0004	-0.0029	0.0001	-0.0143	0.0004	0.0002

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		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.C.5 Metal Industry – Lead Production	CO_2	5	5	10.0	50.0	51.0	0.0000	0.0000	0.0001	0.0005	0.0010	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	349	165	20.0	30.0	36.1	0.0253	-0.0022	0.0021	-0.0672	0.0591	0.0080
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.2	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000
2.E Electronics Industry	PFC	31	23	5.0	10.0	11.2	0.0000	-0.0001	0.0003	-0.0008	0.0021	0.0000
2.E Electronics Industry	SF_6	100	15	5.0	10.0	11.2	0.0002	-0.0011	0.0002	-0.0106	0.0013	0.0001
2.E Electronics Industry	NF_3	0	12	5.0	10.0	11.2	0.0000	0.0002	0.0002	0.0015	0.0011	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 431	10.0	50.0	51.0	0.0000	0.0181	0.0181	0.9052	0.2560	0.8849
2.F.2 Foam Blowing	HFC	0	18	10.0	0.0	10.0	0.0000	0.0002	0.0002	0.0000	0.0032	0.0000
2.F.3 Fire Extinguishers	HFC	0	11	10.0	100.0	100.5	0.0000	0.0001	0.0001	0.0135	0.0019	0.0002
2.F.4 Aerosols	HFC	0	23	20.0	10.0	22.4	0.0000	0.0003	0.0003	0.0029	0.0083	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	47	5.0	100.0	100.1	0.0002	0.0005	0.0006	0.0452	0.0042	0.0021
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	0	0	25.0	50.0	55.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	124	304	25.0	50.0	55.9	0.0077	0.0023	0.0038	0.1152	0.1360	0.0318
2.G. Other Product Manufacture and Use	N_2O	117	32	20.0	0.0	20.0	0.0009	-0.0010	0.0004	0.0000	0.0116	0.0001
3.A.1 Enteric Fermentation – Cattle	CH_4	4 854	3 938	10.0	20.0	22.4	1.8852	-0.0104	0.0498	-0.2079	0.7046	0.5397
3.A.2 Enteric Fermentation – Sheep	CH_4	69	90	10.0	40.0	41.2	0.0013	0.0003	0.0011	0.0112	0.0161	0.0004
3.A.3 Enteric Fermentation – Swine	CH_4	88	68	10.0	20.0	22.4	0.0006	-0.0002	0.0009	-0.0047	0.0121	0.0002
3.A.4 Enteric Fermentation – Other	CH_4	44	96	10.0	40.0	41.2	0.0005	0.0007	0.0012	0.0268	0.0171	0.0010
3.B.1.1 Manure Management – Cattle	CH_4	467	508	10.0	20.0	22.4	0.0175	0.0006	0.0064	0.0125	0.0909	0.0084
3.B.1.1 Manure Management – Cattle	N_2O	294	280	10.0	100.0	100.5	0.1395	-0.0001	0.0035	-0.0105	0.0501	0.0026
3.B.1.2 Manure Management – Sheep	CH_4	3	3	10.0	30.0	31.6	0.0000	0.0000	0.0000	0.0003	0.0006	0.0000
3.B.1.2 Manure Management – Sheep	N_2O	5	7	10.0	100.0	100.5	0.0000	0.0000	0.0001	0.0022	0.0013	0.0000
3.B.1.3 Manure Management – Swine	CH_4	148	87	10.0	20.0	22.4	0.0018	-0.0007	0.0011	-0.0146	0.0156	0.0005
3.B.1.3 Manure Management – Swine	N_2O	99	57	10.0	100.0	100.5	0.0157	-0.0005	0.0007	-0.0508	0.0101	0.0027

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		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
3.B.1.4. Manure Management – Other	CH_4	14	24	10.0	30.0	31.6	0.0000	0.0001	0.0003	0.0038	0.0043	0.0000
3.B.1.4. Manure Management – Other	N_2O	8	17	10.0	100.0	100.5	0.0001	0.0001	0.0002	0.0114	0.0031	0.0001
3.B.2.5 Indirect N_2O Emissions	N_2O	103	111	5.0	200.0	200.1	0.0674	0.0001	0.0014	0.0255	0.0099	0.0008
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 500	5.0	200.0	200.1	20.2105	-0.0031	0.0190	-0.6137	0.1341	0.3946
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	341	286	5.0	200.0	200.1	0.7434	-0.0006	0.0036	-0.1213	0.0256	0.0154
3.F Field Burning of Agricultural Residues	CH_4	1	0	100.0	40.0	107.7	0.0000	0.0000	0.0000	-0.0005	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N_2O	0	0	100.0	50.0	111.8	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
3.G Liming	CO_2	46	99	5.0	50.0	50.2	0.0008	0.0007	0.0013	0.0344	0.0089	0.0013
3.H Urea application	CO_2	10	23	5.0	50.0	50.2	0.0000	0.0002	0.0003	0.0087	0.0021	0.0001
3.I Other	CO_2	31	27	5.0	50.0	50.2	0.0004	0.0000	0.0003	-0.0019	0.0024	0.0000
5.A Solid Waste Disposal	CH_4	4 081	878	12.0	25.0	27.7	2.0498	-0.0395	0.0111	-0.9877	0.1885	1.0112
5.B Biological Treatment of Solid Waste	CH_4	15	79	20.0	50.0	53.9	0.0001	0.0008	0.0010	0.0412	0.0284	0.0025
5.B Biological Treatment of Solid Waste	N_2O	20	74	20.0	50.0	53.9	0.0002	0.0007	0.0009	0.0341	0.0264	0.0019
5.C Incineration and Open Burning of Waste	CH_4	1	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
5.C Incineration and Open Burning of Waste	CO_2	28	2	7.0	20.0	21.2	0.0001	-0.0003	0.0000	-0.0064	0.0003	0.0000
5.C Incineration and Open Burning of Waste	N_2O	0	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH_4	137	25	20.0	50.0	53.9	0.0087	-0.0014	0.0003	-0.0690	0.0089	0.0048
5.D Waste Water Treatment and Discharge	N_2O	86	152	20.0	100.0	102.0	0.0123	0.0009	0.0019	0.0853	0.0542	0.0102
Total		**79 047**	**77 532**				**26.18**					**5.19**
Total Uncertainties						**Uncertainty in total inventory %:**	**5.12**				**Trend uncertainty %:**	**2.28**

Table A 19: Approach 1 Uncertainty Analysis (Article 12(1) Regulation (EU) 2020/1208) for 2021 – excluding LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	312	327	5.0	50.0	50.2	0.0450	0.0003	0.0041	0.0137	0.0293	0.0010
1.A Stationary Combustion – Biomass	CO_2	0	0	5.0	1.0	5.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N_2O	92	207	5.0	50.0	50.2	0.0181	0.0015	0.0026	0.0743	0.0186	0.0059
1.A Stationary Combustion – Gaseous Fuels	CH_4	11	18	1.0	50.0	50.0	0.0001	0.0001	0.0002	0.0048	0.0003	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO_2	11 076	16 919	1.0	0.2	1.0	0.0495	0.0765	0.2140	0.0153	0.3027	0.0919
1.A Stationary Combustion – Gaseous Fuels	N_2O	5	8	1.0	50.0	50.0	0.0000	0.0000	0.0001	0.0018	0.0001	0.0000
1.A Stationary Combustion – Liquid Fuels	CH_4	38	10	0.5	50.0	50.0	0.0000	-0.0003	0.0001	-0.0172	0.0001	0.0003
1.A Stationary Combustion – Liquid Fuels	CO_2	14 203	8 875	0.5	0.5	0.7	0.0066	-0.0639	0.1123	-0.0319	0.0794	0.0073
1.A Stationary Combustion – Liquid Fuels	N_2O	122	83	0.5	50.0	50.0	0.0029	-0.0005	0.0011	-0.0229	0.0007	0.0005
1.A Stationary Combustion – Other fuels	CH_4	3	12	5.0	50.0	50.2	0.0001	0.0001	0.0001	0.0056	0.0011	0.0000
1.A Stationary Combustion – Other fuels	CO_2	580	2 001	5.0	15.0	15.8	0.1665	0.0181	0.0253	0.2717	0.1790	0.1058
1.A Stationary Combustion – Other fuels	N_2O	10	37	5.0	50.0	50.2	0.0006	0.0004	0.0005	0.0177	0.0033	0.0003
1.A Stationary Combustion – Solid Fuels	CH_4	234	7	0.5	50.0	50.0	0.0000	-0.0028	0.0001	-0.1405	0.0001	0.0197
1.A Stationary Combustion – Solid Fuels	CO_2	11 177	1 340	0.5	0.5	0.7	0.0001	-0.1216	0.0169	-0.0608	0.0120	0.0038
1.A Stationary Combustion – Solid Fuels	N_2O	41	3	0.5	50.0	50.0	0.0000	-0.0005	0.0000	-0.0236	0.0000	0.0006
1.A.3.a Transport – Civil Aviation	CH_4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO_2	38	24	3.0	3.0	4.2	0.0000	-0.0002	0.0003	-0.0005	0.0013	0.0000
1.A.3.a Transport – Civil Aviation	N_2O	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH_4	4	12	3.0	30.0	30.1	0.0000	0.0001	0.0002	0.0029	0.0006	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO_2	5 360	16 839	3.0	3.0	4.2	0.8491	0.1464	0.2130	0.4392	0.9038	1.0098
1.A.3.b Transport – Road Transportation – Diesel	N_2O	11	199	3.0	30.0	30.1	0.0060	0.0024	0.0025	0.0716	0.0107	0.0052
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	0	43	3.0	3.0	4.2	0.0000	0.0005	0.0005	0.0016	0.0023	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	77	7	3.0	30.0	30.1	0.0000	-0.0009	0.0001	-0.0259	0.0004	0.0007

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	7 896	4 213	3.0	3.0	4.2	0.0531	-0.0446	0.0533	-0.1339	0.2261	0.0691
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	83	7	3.0	70.0	70.1	0.0000	-0.0009	0.0001	-0.0660	0.0004	0.0044
1.A.3.b Transport – Road Transportation – LPG	CO_2	26	10	3.0	3.0	4.2	0.0000	-0.0002	0.0001	-0.0006	0.0005	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH_4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N_2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH_4	0	1	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0006	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO_2	0	0	5.0	30.0	30.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N_2O	0	14	5.0	3.0	5.8	0.0000	0.0002	0.0002	0.0005	0.0012	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	0	0	5.0	70.0	70.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	0	58	5.0	3.0	5.8	0.0000	0.0007	0.0007	0.0022	0.0052	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	0	0	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH_4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO_2	178	81	3.0	3.0	4.2	0.0000	-0.0012	0.0010	-0.0036	0.0043	0.0000
1.A.3.c Transport – Railways	N_2O	16	4	3.0	30.0	30.1	0.0000	-0.0001	0.0001	-0.0043	0.0002	0.0000
1.A.3.d Transport – Navigation	CH_4	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.d Transport – Navigation	CO_2	28	35	3.0	3.0	4.2	0.0000	0.0001	0.0004	0.0003	0.0019	0.0000
1.A.3.d Transport – Navigation	N_2O	2	2	3.0	70.0	70.1	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000
1.A.3.e Transport – Other Transportation	CH_4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO_2	229	382	1.0	0.2	1.0	0.0000	0.0020	0.0048	0.0004	0.0068	0.0000
1.A.3.e Transport – Other Transportation	N_2O	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH_4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO_2	35	30	1.0	0.5	1.1	0.0000	-0.0001	0.0004	0.0000	0.0005	0.0000
1.A.5.b Mobile	N_2O	1	1	1.0	50.0	50.0	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	373	0	5.0	50.0	50.2	0.0000	-0.0046	0.0000	-0.2315	0.0000	0.0536
1.B.2.a Fugitive Emission – Oil	CH_4	8	9	0.5	50.0	50.0	0.0000	0.0000	0.0001	0.0003	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO_2	0	0	0.5	0.5	0.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH_4	290	238	5.0	10.0	11.2	0.0012	-0.0006	0.0030	-0.0059	0.0213	0.0005

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.B.2.b Fugitive Emission – Natural Gas	CO_2	102	84	5.0	0.2	5.0	0.0000	-0.0002	0.0011	0.0000	0.0075	0.0001
2.A.1 Mineral Industry – Cement Production	CO_2	2 033	1 889	1.1	2.0	2.3	0.0031	-0.0013	0.0239	-0.0027	0.0372	0.0014
2.A.2 Mineral Industry – Lime Production	CO_2	439	663	1.6	5.0	5.2	0.0020	0.0029	0.0084	0.0147	0.0190	0.0006
2.A.3 Mineral Industry – Glass Production	CO_2	39	36	10.0	1.0	10.0	0.0000	0.0000	0.0005	0.0000	0.0064	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	116	96	2.0	5.0	5.4	0.0000	-0.0002	0.0012	-0.0012	0.0034	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	5	10	10.0	5.0	11.2	0.0000	0.0001	0.0001	0.0003	0.0018	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	481	357	2.0	5.0	5.4	0.0006	-0.0015	0.0045	-0.0073	0.0128	0.0002
2.A.4.d Other Process Uses of Carbonates – other	CO_2	0	0	20.0	2.0	20.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CH_4	2	1	2.0	5.0	5.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO_2	467	500	2.0	5.0	5.4	0.0012	0.0005	0.0063	0.0027	0.0179	0.0003
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	0	0	2.0	5.0	5.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	780	41	2.0	5.0	5.4	0.0000	-0.0091	0.0005	-0.0457	0.0015	0.0021
2.B.5 Chemical Industry – Carbide Production	CO_2	38	44	5.0	10.0	11.2	0.0000	0.0001	0.0006	0.0009	0.0040	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	29	42	10.0	10.0	14.1	0.0001	0.0002	0.0005	0.0017	0.0075	0.0001
2.B.10 Chemical Industry – Other	CH_4	8	11	2.0	5.0	5.4	0.0000	0.0000	0.0001	0.0002	0.0004	0.0000
2.B.10 Chemical Industry – Other	CO_2	138	143	2.0	5.0	5.4	0.0001	0.0001	0.0018	0.0005	0.0051	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO_2	6 840	11 002	0.5	0.5	0.7	0.0101	0.0543	0.1392	0.0271	0.0984	0.0104
2.C.1 Metal Industry – Iron and Steel Production	CH_4	6	4	0.5	0.0	0.5	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO_2	21	17	5.0	25.0	25.5	0.0000	0.0000	0.0002	-0.0011	0.0015	0.0000
2.C.3 Metal Industry – Aluminium Production	CO_2	150	6	2.0	0.5	2.1	0.0000	-0.0018	0.0001	-0.0009	0.0002	0.0000
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	2.0	50.0	50.0	0.0000	-0.0128	0.0000	-0.6404	0.0000	0.4101
2.C.3 Metal Industry – Aluminium Production	SF_6	14	0	2.0	50.0	50.0	0.0000	-0.0002	0.0000	-0.0087	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF_6	235	5	5.0	5.0	7.1	0.0000	-0.0029	0.0001	-0.0143	0.0004	0.0002
2.C.5 Metal Industry – Lead Production	CO_2	5	5	10.0	50.0	51.0	0.0000	0.0000	0.0001	0.0005	0.0010	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	349	165	20.0	30.0	36.1	0.0059	-0.0022	0.0021	-0.0672	0.0591	0.0080
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.2	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000

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		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.E Electronics Industry	PFC	31	23	5.0	10.0	11.2	0.0000	-0.0001	0.0003	-0.0008	0.0021	0.0000
2.E Electronics Industry	SF_6	100	15	5.0	10.0	11.2	0.0000	-0.0011	0.0002	-0.0106	0.0013	0.0001
2.E Electronics Industry	NF_3	0	12	5.0	10.0	11.2	0.0000	0.0002	0.0002	0.0015	0.0011	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 431	10.0	50.0	51.0	0.8857	0.0181	0.0181	0.9052	0.2560	0.8849
2.F.2 Foam Blowing	HFC	0	18	10.0	0.0	10.0	0.0000	0.0002	0.0002	0.0000	0.0032	0.0000
2.F.3 Fire Extinguishers	HFC	0	11	10.0	100.0	100.5	0.0002	0.0001	0.0001	0.0135	0.0019	0.0002
2.F.4 Aerosols	HFC	0	23	20.0	10.0	22.4	0.0000	0.0003	0.0003	0.0029	0.0083	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	47	5.0	100.0	100.1	0.0036	0.0005	0.0006	0.0452	0.0042	0.0021
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	0	0	25.0	50.0	55.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	124	304	25.0	50.0	55.9	0.0481	0.0023	0.0038	0.1152	0.1360	0.0318
2.G. Other Product Manufacture and Use	N_2O	117	32	20.0	0.0	20.0	0.0001	-0.0010	0.0004	0.0000	0.0116	0.0001
3.A.1 Enteric Fermentation – Cattle	CH_4	4 854	3 938	1.0	20.0	20.0	1.0347	-0.0104	0.0498	-0.2079	0.0705	0.0482
3.A.2 Enteric Fermentation – Sheep	CH_4	69	90	10.0	40.0	41.2	0.0023	0.0003	0.0011	0.0112	0.0161	0.0004
3.A.3 Enteric Fermentation – Swine	CH_4	88	68	4.0	20.0	20.4	0.0003	-0.0002	0.0009	-0.0047	0.0048	0.0000
3.A.4 Enteric Fermentation – Other	CH_4	44	96	10.0	40.0	41.2	0.0026	0.0007	0.0012	0.0268	0.0171	0.0010
3.B.1.1 Manure Management – Cattle	CH_4	467	508	1.0	20.0	20.0	0.0172	0.0006	0.0064	0.0125	0.0091	0.0002
3.B.1.1 Manure Management – Cattle	N_2O	294	280	1.0	100.0	100.0	0.1303	-0.0001	0.0035	-0.0105	0.0050	0.0001
3.B.1.2 Manure Management – Sheep	CH_4	3	3	10.0	30.0	31.6	0.0000	0.0000	0.0000	0.0003	0.0006	0.0000
3.B.1.2 Manure Management – Sheep	N_2O	5	7	10.0	100.0	100.5	0.0001	0.0000	0.0001	0.0022	0.0013	0.0000
3.B.1.3 Manure Management – Swine	CH_4	148	87	4.0	20.0	20.4	0.0005	-0.0007	0.0011	-0.0146	0.0063	0.0003
3.B.1.3 Manure Management – Swine	N_2O	99	57	4.0	100.0	100.1	0.0053	-0.0005	0.0007	-0.0508	0.0040	0.0026
3.B.1.4. Manure Management – Other	CH_4	14	24	10.0	30.0	31.6	0.0001	0.0001	0.0003	0.0038	0.0043	0.0000
3.B.1.4. Manure Management – Other	N_2O	8	17	10.0	100.0	100.5	0.0005	0.0001	0.0002	0.0114	0.0031	0.0001
3.B.2.5 Indirect N_2O Emissions	N_2O	103	111	5.0	200.0	200.1	0.0816	0.0001	0.0014	0.0255	0.0099	0.0008

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		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G\bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 500	5.0	200.0	200.1	14.9736	-0.0031	0.0190	-0.6137	0.1341	0.3946
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	341	286	5.0	200.0	200.1	0.5454	-0.0006	0.0036	-0.1213	0.0256	0.0154
3.F Field Burning of Agricultural Residues	CH_4	1	0	100.0	40.0	107.7	0.0000	0.0000	0.0000	-0.0005	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N_2O	0	0	100.0	50.0	111.8	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
3.G Liming	CO_2	46	99	5.0	50.0	50.2	0.0041	0.0007	0.0013	0.0344	0.0089	0.0013
3.H Urea application	CO_2	10	23	5.0	50.0	50.2	0.0002	0.0002	0.0003	0.0087	0.0021	0.0001
3.I Other	CO_2	31	27	5.0	50.0	50.2	0.0003	0.0000	0.0003	-0.0019	0.0024	0.0000
5.A Solid Waste Disposal	CH_4	4 081	878	12.0	25.0	27.7	0.0987	-0.0395	0.0111	-0.9877	0.1885	1.0112
5.B Biological Treatment of Solid Waste	CH_4	15	79	20.0	50.0	53.9	0.0030	0.0008	0.0010	0.0412	0.0284	0.0025
5.B Biological Treatment of Solid Waste	N_2O	20	74	20.0	50.0	53.9	0.0026	0.0007	0.0009	0.0341	0.0264	0.0019
5.C Incineration and Open Burning of Waste	CH_4	1	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
5.C Incineration and Open Burning of Waste	CO_2	28	2	7.0	20.0	21.2	0.0000	-0.0003	0.0000	-0.0064	0.0003	0.0000
5.C Incineration and Open Burning of Waste	N_2O	0	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH_4	137	25	20.0	50.0	53.9	0.0003	-0.0014	0.0003	-0.0690	0.0089	0.0048
5.D Waste Water Treatment and Discharge	N_2O	86	152	20.0	100.0	102.0	0.0398	0.0009	0.0019	0.0853	0.0542	0.0102
Total		**79 047**	**77 532**				**19.10**					**4.23**
Total Uncertainties						**Uncertainty in total inventory %:**	**4.37**				**Trend uncertainty %:**	**2.06**

Table A 20: Approach 1 Uncertainty Analysis (Article 12(1) Regulation (EU) 2020/1208) for 1990 – including LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertaint	Emission factor / estimation parameter uncertaint	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitiv ity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	312	327	5.0	50.0	50.2	0.05	0.00	0.00	0.01	0.03	0.00
1.A Stationary Combustion – Biomass	CO_2	0	0	5.0	1.0	5.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A Stationary Combustion – Biomass	N_2O	92	207	5.0	50.0	50.2	0.00	0.00	0.00	0.09	0.02	0.01
1.A Stationary Combustion – Gaseous Fuels	CH_4	11	18	2.0	50.0	50.0	0.00	0.00	0.00	0.01	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	11 076	16 919	2.0	0.2	2.0	0.11	0.09	0.25	0.02	0.72	0.51
1.A Stationary Combustion – Gaseous Fuels	N_2O	5	8	2.0	50.0	50.0	0.00	0.00	0.00	0.00	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH_4	38	10	0.5	50.0	50.0	0.00	0.00	0.00	-0.02	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO_2	14 203	8 875	0.5	0.5	0.7	0.02	-0.08	0.13	-0.04	0.09	0.01
1.A Stationary Combustion – Liquid Fuels	N_2O	122	83	0.5	50.0	50.0	0.01	0.00	0.00	-0.03	0.00	0.00
1.A Stationary Combustion – Other fuels	CH_4	3	12	10.0	50.0	51.0	0.00	0.00	0.00	0.01	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	580	2 001	10.0	15.0	18.0	0.02	0.02	0.03	0.32	0.42	0.28
1.A Stationary Combustion – Other fuels	N_2O	10	37	10.0	50.0	51.0	0.00	0.00	0.00	0.02	0.01	0.00
1.A Stationary Combustion – Solid Fuels	CH_4	234	7	0.5	50.0	50.0	0.03	0.00	0.00	-0.17	0.00	0.03
1.A Stationary Combustion – Solid Fuels	CO_2	11 177	1 340	0.5	0.5	0.7	0.01	-0.15	0.02	-0.07	0.01	0.01
1.A Stationary Combustion – Solid Fuels	N_2O	41	3	0.5	50.0	50.0	0.00	0.00	0.00	-0.03	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH_4	0	0	3.0	30.0	30.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO_2	38	24	3.0	3.0	4.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a Transport – Civil Aviation	N_2O	1	0	3.0	30.0	30.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH_4	4	12	3.0	30.0	30.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO_2	5 360	16 839	3.0	3.0	4.2	0.12	0.17	0.25	0.51	1.07	1.41
1.A.3.b Transport – Road Transportation – Diesel	N_2O	11	199	3.0	30.0	30.1	0.00	0.00	0.00	0.08	0.01	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	0	43	3.0	3.0	4.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	0	0	3.0	50.0	50.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	0	0	3.0	50.0	50.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	77	7	3.0	30.0	30.1	0.00	0.00	0.00	-0.03	0.00	0.00

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertaint	Emission factor / estimation parameter uncertaint	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	7 896	4 213	3.0	3.0	4.2	0.25	-0.06	0.06	-0.17	0.27	0.10
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	83	7	3.0	70.0	70.1	0.01	0.00	0.00	-0.08	0.00	0.01
1.A.3.b Transport – Road Transportation – LPG	CO_2	26	10	3.0	3.0	4.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH_4	0	0	3.0	50.0	50.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N_2O	0	0	3.0	50.0	50.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH_4	0	1	5.0	50.0	50.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO_2	0	0	5.0	30.0	30.4	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N_2O	0	14	5.0	3.0	5.8	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	0	0	5.0	70.0	70.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	0	58	5.0	3.0	5.8	0.00	0.15	0.15	0.44	1.05	1.30
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	0	0	5.0	50.0	50.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.c Transport – Railways	CH_4	0	0	3.0	30.0	30.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.c Transport – Railways	CO_2	178	81	3.0	3.0	4.2	0.00	0.00	0.00	0.00	0.01	0.00
1.A.3.c Transport – Railways	N_2O	16	4	3.0	30.0	30.1	0.00	0.00	0.00	-0.01	0.00	0.00
1.A.3.d Transport – Navigation	CH_4	1	0	3.0	30.0	30.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d Transport – Navigation	CO_2	28	35	3.0	3.0	4.2	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.d Transport – Navigation	N_2O	2	2	3.0	70.0	70.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e Transport – Other Transportation	CH_4	0	0	2.0	50.0	50.0	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.e Transport – Other Transportation	CO_2	229	382	2.0	0.2	2.0	0.00	0.00	0.01	0.00	0.02	0.00
1.A.3.e Transport – Other Transportation	N_2O	0	0	2.0	50.0	50.0	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5.b Mobile	CH_4	0	0	1.0	50.0	50.0	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5.b Mobile	CO_2	35	30	1.0	0.5	1.1	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5.b Mobile	N_2O	1	1	1.0	50.0	50.0	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	373	0	5.0	50.0	50.2	0.08	-0.01	0.00	-0.28	0.00	0.08
1.B.2.a Fugitive Emission – Oil	CH_4	8	9	0.5	50.0	50.0	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO_2	0	0	0.5	0.5	0.7	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH_4	290	238	5.0	10.0	11.2	0.00	0.00	0.00	-0.01	0.03	0.00

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertaint	Emission factor / estimation parameter uncertaint	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.B.2.b Fugitive Emission – Natural Gas	CO_2	102	84	5.0	0.2	5.0	0.00	0.00	0.00	0.00	0.01	0.00
2.A.1 Mineral Industry – Cement Production	CO_2	2 033	1 889	5.0	2.0	5.4	0.03	0.00	0.03	0.00	0.20	0.04
2.A.2 Mineral Industry – Lime Production	CO_2	439	663	20.0	5.0	20.6	0.02	0.00	0.01	0.02	0.28	0.08
2.A.3 Mineral Industry – Glass Production	CO_2	39	36	10.0	1.0	10.0	0.00	0.00	0.00	0.00	0.01	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	116	96	2.0	5.0	5.4	0.00	0.00	0.00	0.00	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	5	10	10.0	5.0	11.2	0.00	0.00	0.00	0.00	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	481	357	2.0	5.0	5.4	0.00	0.00	0.01	-0.01	0.02	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO_2	0	0	20.0	2.0	20.1	0.00	0.00	0.00	0.00	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH_4	2	1	2.0	5.0	5.4	0.00	0.00	0.00	0.00	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO_2	467	500	2.0	5.0	5.4	0.0014	0.0005	0.0075	0.0023	0.0212	0.0005
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	0	0	2.0	5.0	5.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	780	41	2.0	5.0	5.4	0.0039	-0.0111	0.0006	-0.0555	0.0018	0.0031
2.B.5 Chemical Industry – Carbide Production	CO_2	38	44	5.0	10.0	11.2	0.0000	0.0001	0.0007	0.0009	0.0047	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	29	42	10.0	10.0	14.1	0.0000	0.0002	0.0006	0.0019	0.0089	0.0001
2.B.10 Chemical Industry – Other	CH_4	8	11	2.0	5.0	5.4	0.0000	0.0000	0.0002	0.0002	0.0005	0.0000
2.B.10 Chemical Industry – Other	CO_2	138	143	2.0	5.0	5.4	0.0001	0.0001	0.0021	0.0003	0.0061	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO_2	6 840	11 002	0.5	0.5	0.7	0.0052	0.0618	0.1646	0.0309	0.1164	0.0145
2.C.1 Metal Industry – Iron and Steel Production	CH_4	6	4	0.5	0.0	0.5	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO_2	21	17	5.0	25.0	25.5	0.0001	-0.0001	0.0003	-0.0015	0.0018	0.0000
2.C.3 Metal Industry – Aluminium Production	CO_2	150	6	2.0	0.5	2.1	0.0000	-0.0022	0.0001	-0.0011	0.0003	0.0000
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	2.0	50.0	50.0	0.5973	-0.0155	0.0000	-0.7755	0.0000	0.6014
2.C.3 Metal Industry – Aluminium Production	SF_6	14	0	2.0	50.0	50.0	0.0001	-0.0002	0.0000	-0.0106	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF_6	235	5	5.0	5.0	7.1	0.0006	-0.0035	0.0001	-0.0173	0.0005	0.0003
2.C.5 Metal Industry – Lead Production	CO_2	5	5	10.0	50.0	51.0	0.0000	0.0000	0.0001	0.0005	0.0011	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	349	165	20.0	30.0	36.1	0.0354	-0.0028	0.0025	-0.0831	0.0700	0.0118
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.2	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertaint	Emission factor / estimation parameter uncertaint	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.E Electronics Industry	PFC	31	23	5.0	10.0	11.2	0.0000	-0.0001	0.0004	-0.0011	0.0025	0.0000
2.E Electronics Industry	SF_6	100	15	5.0	10.0	11.2	0.0003	-0.0013	0.0002	-0.0128	0.0016	0.0002
2.E Electronics Industry	NF_3	0	12	5.0	10.0	11.2	0.0000	0.0002	0.0002	0.0018	0.0013	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 431	10.0	50.0	51.0	0.0000	0.0214	0.0214	1.0705	0.3028	1.2376
2.F.2 Foam Blowing	HFC	0	18	10.0	0.0	10.0	0.0000	0.0003	0.0003	0.0000	0.0038	0.0000
2.F.3 Fire Extinguishers	HFC	0	11	10.0	100.0	100.5	0.0000	0.0002	0.0002	0.0160	0.0023	0.0003
2.F.4 Aerosols	HFC	0	23	20.0	10.0	22.4	0.0000	0.0003	0.0003	0.0035	0.0098	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	47	5.0	100.0	100.1	0.0003	0.0005	0.0007	0.0531	0.0049	0.0028
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	0	0	25.0	50.0	55.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	124	304	25.0	50.0	55.9	0.0108	0.0027	0.0046	0.1340	0.1609	0.0438
2.G. Other Product Manufacture and Use	N_2O	117	32	20.0	0.0	20.0	0.0012	-0.0013	0.0005	0.0000	0.0137	0.0002
3.A.1 Enteric Fermentation – Cattle	CH_4	4 854	3 938	10.0	20.0	22.4	2.6368	-0.0140	0.0589	-0.2800	0.8333	0.7728
3.A.2 Enteric Fermentation – Sheep	CH_4	69	90	10.0	40.0	41.2	0.0018	0.0003	0.0013	0.0122	0.0191	0.0005
3.A.3 Enteric Fermentation – Swine	CH_4	88	68	10.0	20.0	22.4	0.0009	-0.0003	0.0010	-0.0061	0.0143	0.0002
3.A.4 Enteric Fermentation – Other	CH_4	44	96	10.0	40.0	41.2	0.0007	0.0008	0.0014	0.0311	0.0202	0.0014
3.B.1.1 Manure Management – Cattle	CH_4	467	508	10.0	20.0	22.4	0.0245	0.0006	0.0076	0.0115	0.1075	0.0117
3.B.1.1 Manure Management – Cattle	N_2O	294	280	10.0	100.0	100.5	0.1951	-0.0002	0.0042	-0.0228	0.0592	0.0040
3.B.1.2 Manure Management – Sheep	CH_4	3	3	10.0	30.0	31.6	0.0000	0.0000	0.0001	0.0004	0.0007	0.0000
3.B.1.2 Manure Management – Sheep	N_2O	5	7	10.0	100.0	100.5	0.0001	0.0000	0.0001	0.0024	0.0015	0.0000
3.B.1.3 Manure Management – Swine	CH_4	148	87	10.0	20.0	22.4	0.0024	-0.0009	0.0013	-0.0183	0.0185	0.0007
3.B.1.3 Manure Management – Swine	N_2O	99	57	10.0	100.0	100.5	0.0220	-0.0006	0.0008	-0.0636	0.0120	0.0042
3.B.1.4. Manure Management – Other	CH_4	14	24	10.0	30.0	31.6	0.0000	0.0001	0.0004	0.0043	0.0050	0.0000
3.B.1.4. Manure Management – Other	N_2O	8	17	10.0	100.0	100.5	0.0002	0.0001	0.0003	0.0132	0.0036	0.0002
3.B.2.5 Indirect N_2O Emissions	N_2O	103	111	5.0	200.0	200.1	0.0942	0.0001	0.0017	0.0230	0.0117	0.0007

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertaint	Emission factor / estimation parameter uncertaint	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 500	5.0	200.0	200.1	28.2671	-0.0043	0.0224	-0.8507	0.1586	0.7489
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	341	286	5.0	200.0	200.1	1.0398	-0.0008	0.0043	-0.1674	0.0303	0.0289
3.F Field Burning of Agricultural Residues	CH_4	1	0	100.0	40.0	107.7	0.0000	0.0000	0.0000	-0.0005	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N_2O	0	0	100.0	50.0	111.8	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
3.G Liming	CO_2	46	99	5.0	50.0	50.2	0.0012	0.0008	0.0015	0.0398	0.0105	0.0017
3.H Urea application	CO_2	10	23	5.0	50.0	50.2	0.0001	0.0002	0.0003	0.0101	0.0024	0.0001
3.I Other	CO_2	31	27	5.0	50.0	50.2	0.0005	-0.0001	0.0004	-0.0028	0.0029	0.0000
4 Total land use categories	CH_4	27	27			220.4	0.0080	0.0000	0.0004	0.0000	0.0000	0.0000
4 Total land use categories	N_2O	113	112			109.5	0.0341	0.0000	0.0017	0.0000	0.0000	0.0000
4.A.1 Forest land remaining forest land	CO_2	-8 122	-8 938			50.4	37.5402	-0.0117	0.1337	0.0000	0.0000	0.0000
4.A.2 Land converted to forest land	CO_2	-2 957	-1 437			35.7	2.5002	0.0229	0.0215	0.0000	0.0000	0.0000
4.B.1 Cropland remaining cropland	CO_2	-18	48			229.0	0.0039	0.0010	0.0007	0.0000	0.0000	0.0000
4.B.2 Land converted to cropland	CO_2	190	211			59.2	0.0282	0.0003	0.0032	0.0000	0.0000	0.0000
4.C.1 Grassland remaining grassland	CO_2	294	296			230.5	1.0306	0.0000	0.0044	0.0000	0.0000	0.0000
4.C.2 Land converted to grassland	CO_2	391	138			52.6	0.0946	-0.0038	0.0021	0.0000	0.0000	0.0000
4.D.1 Wetlands remaining Wetlands	CO_2	0	0			42.6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4.D.2 Land converted to Wetlands	CO_2	47	76			42.6	0.0009	0.0004	0.0011	0.0000	0.0000	0.0000
4.E.2 Land converted to Settlements	CO_2	448	441			34.0	0.0520	-0.0001	0.0066	0.0000	0.0000	0.0000
4.F.2 Land converted to Other land	CO_2	502	514			76.9	0.3328	0.0001	0.0077	0.0000	0.0000	0.0000
4.G HWP	CO_2	-3 122	-1 889			49.0	5.2391	0.0187	0.0283	0.0000	0.0000	0.0000
5.A Solid Waste Disposal	CH_4	4 081	878	12.0	25.0	27.7	2.8670	-0.0482	0.0131	-1.2039	0.2230	1.4991
5.B Biological Treatment of Solid Waste	CH_4	15	79	20.0	50.0	53.9	0.0001	0.0010	0.0012	0.0484	0.0336	0.0035
5.B Biological Treatment of Solid Waste	N_2O	20	74	20.0	50.0	53.9	0.0003	0.0008	0.0011	0.0400	0.0312	0.0026
5.C Incineration and Open Burning of Waste	CH_4	1	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
5.C Incineration and Open Burning of Waste	CO_2	28	2	7.0	20.0	21.2	0.0001	-0.0004	0.0000	-0.0078	0.0003	0.0001
5.C Incineration and Open Burning of Waste	N_2O	0	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH_4	137	25	20.0	50.0	53.9	0.0121	-0.0017	0.0004	-0.0840	0.0106	0.0072

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertaint	Emission factor / estimation parameter uncertaint	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
5.D Waste Water Treatment and Discharge	N_2O	86	152	20.0	100.0	102.0	0.0171	0.0010	0.0023	0.0979	0.0641	0.0137
Total		**66 840**	**67 131**				**83.48**					**8.89**
Total Uncertainties						**Uncertainty in total inventory %:**	**9.14**				**Trend uncertainty %:**	**2.98**

Table A 21: Approach 1 Uncertainty Analysis (Article 12(1) Regulation (EU) 2020/1208) for 2021 – including LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH_4	312	327	5.0	50.0	50.25	0.0601	0.0002	0.0049	0.0107	0.0346	0.0013
1.A Stationary Combustion – Biomass	CO_2	0	0	5.0	1.0	5.10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N_2O	92	207	5.0	50.0	50.25	0.0241	0.0017	0.0031	0.0863	0.0219	0.0079
1.A Stationary Combustion – Gaseous Fuels	CH_4	11	18	1.0	50.0	50.01	0.0002	0.0001	0.0003	0.0054	0.0004	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO_2	11 076	16 919	1.0	0.2	1.02	0.0661	0.0866	0.2531	0.0173	0.3580	0.1285
1.A Stationary Combustion – Gaseous Fuels	N_2O	5	8	1.0	50.0	50.01	0.0000	0.0000	0.0001	0.0021	0.0002	0.0000
1.A Stationary Combustion – Liquid Fuels	CH_4	38	10	0.5	50.0	50.00	0.0001	-0.0004	0.0001	-0.0210	0.0001	0.0004

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Liquid Fuels	CO_2	14 203	8 875	0.5	0.5	0.71	0.0087	-0.0805	0.1328	-0.0402	0.0939	0.0104
1.A Stationary Combustion – Liquid Fuels	N_2O	122	83	0.5	50.0	50.00	0.0039	-0.0006	0.0012	-0.0292	0.0009	0.0009
1.A Stationary Combustion – Other fuels	CH_4	3	12	5.0	50.0	50.25	0.0001	0.0001	0.0002	0.0066	0.0013	0.0000
1.A Stationary Combustion – Other fuels	CO_2	580	2 001	5.0	15.0	15.81	0.2221	0.0212	0.0299	0.3182	0.2117	0.1461
1.A Stationary Combustion – Other fuels	N_2O	10	37	5.0	50.0	50.25	0.0008	0.0004	0.0006	0.0208	0.0040	0.0004
1.A Stationary Combustion – Solid Fuels	CH_4	234	7	0.5	50.0	50.00	0.0000	-0.0034	0.0001	-0.1703	0.0001	0.0290
1.A Stationary Combustion – Solid Fuels	CO_2	11 177	1 340	0.5	0.5	0.71	0.0002	-0.1477	0.0200	-0.0738	0.0142	0.0057
1.A Stationary Combustion – Solid Fuels	N_2O	41	3	0.5	50.0	50.00	0.0000	-0.0006	0.0000	-0.0286	0.0000	0.0008
1.A.3.a Transport – Civil Aviation	CH_4	0	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO_2	38	24	3.0	3.0	4.24	0.0000	-0.0002	0.0004	-0.0007	0.0015	0.0000
1.A.3.a Transport – Civil Aviation	N_2O	1	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH_4	4	12	3.0	30.0	30.15	0.0000	0.0001	0.0002	0.0034	0.0008	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO_2	5 360	16 839	3.0	3.0	4.24	1.1326	0.1712	0.2519	0.5137	1.0689	1.4064
1.A.3.b Transport – Road Transportation – Diesel	N_2O	11	199	3.0	30.0	30.15	0.0080	0.0028	0.0030	0.0845	0.0126	0.0073
1.A.3.b Transport – Road Transportation – Gaseous	CO_2	0	43	3.0	3.0	4.24	0.0000	0.0006	0.0006	0.0019	0.0027	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH_4	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N_2O	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH_4	77	7	3.0	30.0	30.15	0.0000	-0.0010	0.0001	-0.0315	0.0005	0.0010
1.A.3.b Transport – Road Transportation – Gasoline	CO_2	7 896	4 213	3.0	3.0	4.24	0.0709	-0.0556	0.0630	-0.1667	0.2674	0.0993
1.A.3.b Transport – Road Transportation – Gasoline	N_2O	83	7	3.0	70.0	70.06	0.0000	-0.0011	0.0001	-0.0801	0.0004	0.0064
1.A.3.b Transport – Road Transportation – LPG	CO_2	26	10	3.0	3.0	4.24	0.0000	-0.0002	0.0002	-0.0007	0.0006	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH_4	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N_2O	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH_4	0	1	5.0	50.0	50.25	0.0000	0.0000	0.0000	0.0007	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO_2	0	0	5.0	30.0	30.41	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N_2O	0	14	5.0	3.0	5.83	0.0000	0.0002	0.0002	0.0006	0.0014	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH_4	0	0	5.0	70.0	70.18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Other Fuels	CO_2	0	58	5.0	3.0	5.83	0.0000	0.0009	0.0009	0.0026	0.0061	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	N_2O	0	0	5.0	50.0	50.25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH_4	0	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO_2	178	81	3.0	3.0	4.24	0.0000	-0.0015	0.0012	-0.0044	0.0051	0.0000
1.A.3.c Transport – Railways	N_2O	16	4	3.0	30.0	30.15	0.0000	-0.0002	0.0001	-0.0052	0.0003	0.0000
1.A.3.d Transport – Navigation	CH_4	1	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.d Transport – Navigation	CO_2	28	35	3.0	3.0	4.24	0.0000	0.0001	0.0005	0.0003	0.0022	0.0000
1.A.3.d Transport – Navigation	N_2O	2	2	3.0	70.0	70.06	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000
1.A.3.e Transport – Other Transportation	CH_4	0	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO_2	229	382	1.0	0.2	1.02	0.0000	0.0023	0.0057	0.0005	0.0081	0.0001
1.A.3.e Transport – Other Transportation	N_2O	0	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH_4	0	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO_2	35	30	1.0	0.5	1.12	0.0000	-0.0001	0.0004	0.0000	0.0006	0.0000
1.A.5.b Mobile	N_2O	1	1	1.0	50.0	50.01	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	373	0	5.0	50.0	50.25	0.0000	-0.0056	0.0000	-0.2804	0.0000	0.0786
1.B.2.a Fugitive Emission – Oil	CH_4	8	9	0.5	50.0	50.00	0.0000	0.0000	0.0001	0.0002	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO_2	0	0	0.5	0.5	0.71	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH_4	290	238	5.0	10.0	11.18	0.0016	-0.0008	0.0036	-0.0079	0.0252	0.0007
1.B.2.b Fugitive Emission – Natural Gas	CO_2	102	84	5.0	0.2	5.00	0.0000	-0.0003	0.0013	-0.0001	0.0089	0.0001
2.A.1 Mineral Industry – Cement Production	CO_2	2 033	1 889	1.1	2.0	2.28	0.0041	-0.0023	0.0283	-0.0046	0.0440	0.0020
2.A.2 Mineral Industry – Lime Production	CO_2	439	663	1.6	5.0	5.25	0.0027	0.0033	0.0099	0.0166	0.0224	0.0008
2.A.3 Mineral Industry – Glass Production	CO_2	39	36	10.0	1.0	10.05	0.0000	0.0000	0.0005	0.0000	0.0076	0.0001
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO_2	116	96	2.0	5.0	5.39	0.0001	-0.0003	0.0014	-0.0016	0.0041	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO_2	5	10	10.0	5.0	11.18	0.0000	0.0001	0.0002	0.0004	0.0022	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO_2	481	357	2.0	5.0	5.39	0.0008	-0.0019	0.0053	-0.0095	0.0151	0.0003
2.A.4.d Other Process Uses of Carbonates – other	CO_2	0	0	20.0	2.0	20.10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.B.1 Chemical Industry – Ammonia Production	CH_4	2	1	2.0	5.0	5.39	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO_2	467	500	2.0	5.0	5.39	0.0016	0.0005	0.0075	0.0023	0.0212	0.0005
2.B.2 Chemical Industry – Nitric Acid Production	CO_2	0	0	2.0	5.0	5.39	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N_2O	780	41	2.0	5.0	5.39	0.0000	-0.0111	0.0006	-0.0555	0.0018	0.0031
2.B.5 Chemical Industry – Carbide Production	CO_2	38	44	5.0	10.0	11.18	0.0001	0.0001	0.0007	0.0009	0.0047	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH_4	29	42	10.0	10.0	14.14	0.0001	0.0002	0.0006	0.0019	0.0089	0.0001
2.B.10 Chemical Industry – Other	CH_4	8	11	2.0	5.0	5.39	0.0000	0.0000	0.0002	0.0002	0.0005	0.0000
2.B.10 Chemical Industry – Other	CO_2	138	143	2.0	5.0	5.39	0.0001	0.0001	0.0021	0.0003	0.0061	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO_2	6 840	11 002	0.5	0.5	0.71	0.0134	0.0618	0.1646	0.0309	0.1164	0.0145
2.C.1 Metal Industry – Iron and Steel Production	CH_4	6	4	0.5	0.0	0.50	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO_2	21	17	5.0	25.0	25.50	0.0000	-0.0001	0.0003	-0.0015	0.0018	0.0000
2.C.3 Metal Industry – Aluminium Production	CO_2	150	6	2.0	0.5	2.06	0.0000	-0.0022	0.0001	-0.0011	0.0003	0.0000
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	2.0	50.0	50.04	0.0000	-0.0155	0.0000	-0.7755	0.0000	0.6014
2.C.3 Metal Industry – Aluminium Production	SF_6	14	0	2.0	50.0	50.04	0.0000	-0.0002	0.0000	-0.0106	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF_6	235	5	5.0	5.0	7.07	0.0000	-0.0035	0.0001	-0.0173	0.0005	0.0003
2.C.5 Metal Industry – Lead Production	CO_2	5	5	10.0	50.0	50.99	0.0000	0.0000	0.0001	0.0005	0.0011	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO_2	349	165	20.0	30.0	36.06	0.0079	-0.0028	0.0025	-0.0831	0.0700	0.0118
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.18	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000
2.E Electronics Industry	PFC	31	23	5.0	10.0	11.18	0.0000	-0.0001	0.0004	-0.0011	0.0025	0.0000
2.E Electronics Industry	SF_6	100	15	5.0	10.0	11.18	0.0000	-0.0013	0.0002	-0.0128	0.0016	0.0002
2.E Electronics Industry	NF_3	0	12	5.0	10.0	11.18	0.0000	0.0002	0.0002	0.0018	0.0013	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 431	10.0	50.0	50.99	1.1815	0.0214	0.0214	1.0705	0.3028	1.2376
2.F.2 Foam Blowing	HFC	0	18	10.0	0.0	10.00	0.0000	0.0003	0.0003	0.0000	0.0038	0.0000
2.F.3 Fire Extinguishers	HFC	0	11	10.0	100.0	100.50	0.0003	0.0002	0.0002	0.0160	0.0023	0.0003
2.F.4 Aerosols	HFC	0	23	20.0	10.0	22.36	0.0001	0.0003	0.0003	0.0035	0.0098	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	47	5.0	100.0	100.12	0.0048	0.0005	0.0007	0.0531	0.0049	0.0028
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	PFC	0	0	25.0	50.0	55.90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF_6 and PFCs from other product use	SF_6	124	304	25.0	50.0	55.90	0.0641	0.0027	0.0046	0.1340	0.1609	0.0438
2.G. Other Product Manufacture and Use	N_2O	117	32	20.0	0.0	20.00	0.0001	-0.0013	0.0005	0.0000	0.0137	0.0002
3.A.1 Enteric Fermentation – Cattle	CH_4	4 854	3 938	1.0	20.0	20.02	1.3803	-0.0140	0.0589	-0.2800	0.0833	0.0854
3.A.2 Enteric Fermentation – Sheep	CH_4	69	90	10.0	40.0	41.23	0.0031	0.0003	0.0013	0.0122	0.0191	0.0005
3.A.3 Enteric Fermentation – Swine	CH_4	88	68	4.0	20.0	20.40	0.0004	-0.0003	0.0010	-0.0061	0.0057	0.0001
3.A.4 Enteric Fermentation – Other	CH_4	44	96	10.0	40.0	41.23	0.0035	0.0008	0.0014	0.0311	0.0202	0.0014
3.B.1.1 Manure Management – Cattle	CH_4	467	508	1.0	20.0	20.02	0.0230	0.0006	0.0076	0.0115	0.0108	0.0002
3.B.1.1 Manure Management – Cattle	N_2O	294	280	1.0	100.0	100.00	0.1738	-0.0002	0.0042	-0.0228	0.0059	0.0006
3.B.1.2 Manure Management – Sheep	CH_4	3	3	10.0	30.0	31.62	0.0000	0.0000	0.0001	0.0004	0.0007	0.0000
3.B.1.2 Manure Management – Sheep	N_2O	5	7	10.0	100.0	100.50	0.0001	0.0000	0.0001	0.0024	0.0015	0.0000
3.B.1.3 Manure Management – Swine	CH_4	148	87	4.0	20.0	20.40	0.0007	-0.0009	0.0013	-0.0183	0.0074	0.0004
3.B.1.3 Manure Management – Swine	N_2O	99	57	4.0	100.0	100.08	0.0071	-0.0006	0.0008	-0.0636	0.0048	0.0041
3.B.1.4. Manure Management – Other	CH_4	14	24	10.0	30.0	31.62	0.0001	0.0001	0.0004	0.0043	0.0050	0.0000
3.B.1.4. Manure Management – Other	N_2O	8	17	10.0	100.0	100.50	0.0007	0.0001	0.0003	0.0132	0.0036	0.0002
3.B.2.5 Indirect N_2O Emissions	N_2O	103	111	5.0	200.0	200.06	0.1088	0.0001	0.0017	0.0230	0.0117	0.0007
3.D.1 Direct N_2O Emissions from Managed Soils	N_2O	1 776	1 500	5.0	200.0	200.06	19.9734	-0.0043	0.0224	-0.8507	0.1586	0.7489
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	341	286	5.0	200.0	200.06	0.7275	-0.0008	0.0043	-0.1674	0.0303	0.0289
3.F Field Burning of Agricultural Residues	CH_4	1	0	100.0	40.0	107.70	0.0000	0.0000	0.0000	-0.0005	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N_2O	0	0	100.0	50.0	111.80	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
3.G Liming	CO_2	46	99	5.0	50.0	50.25	0.0055	0.0008	0.0015	0.0398	0.0105	0.0017
3.H Urea application	CO_2	10	23	5.0	50.0	50.25	0.0003	0.0002	0.0003	0.0101	0.0024	0.0001
3.I Other	CO_2	31	27	5.0	50.0	50.25	0.0004	-0.0001	0.0004	-0.0028	0.0029	0.0000
4 Total land use categories	CH_4	27	27			218.82	0.0078	0.0000	0.0004	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
		input data	input data	input data Note A	input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G\bullet D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
4 Total land use categories	N_2O	113	112			121.48	0.0411	0.0000	0.0017	0.0000	0.0000	0.0000
4.A.1 Forest land remaining forest land	CO_2	-8 122	-8 938			38.77	26.6403	-0.0117	0.1337	0.0000	0.0000	0.0000
4.A.2 Land converted to forest land	CO_2	-2 957	-1 437			113.34	5.8877	0.0229	0.0215	0.0000	0.0000	0.0000
4.B.1 Cropland remaining cropland	CO_2	-18	48			55.88	0.0016	0.0010	0.0007	0.0000	0.0000	0.0000
4.B.2 Land converted to cropland	CO_2	190	211			50.80	0.0255	0.0003	0.0032	0.0000	0.0000	0.0000
4.C.1 Grassland remaining grassland	CO_2	294	296			228.90	1.0217	0.0000	0.0044	0.0000	0.0000	0.0000
4.C.2 Land converted to grassland	CO_2	391	138			166.99	0.1172	-0.0038	0.0021	0.0000	0.0000	0.0000
4.D.1 Wetlands remaining Wetlands	CO_2	0	0			63.59	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4.D.2 Land converted to Wetlands	CO_2	47	76			63.59	0.0052	0.0004	0.0011	0.0000	0.0000	0.0000
4.E.2 Land converted to Settlements	CO_2	448	441			30.14	0.0392	-0.0001	0.0066	0.0000	0.0000	0.0000
4.F.2 Land converted to Other land	CO_2	502	514			123.14	0.8876	0.0001	0.0077	0.0000	0.0000	0.0000
4.G HWP	CO_2	-3 122	-1 889			48.99	1.9014	0.0187	0.0283	0.0000	0.0000	0.0000
5.A Solid Waste Disposal	CH_4	4 081	878	12.0	25.0	27.73	0.1316	-0.0482	0.0131	-1.2039	0.2230	1.4991
5.B Biological Treatment of Solid Waste	CH_4	15	79	20.0	50.0	53.85	0.0041	0.0010	0.0012	0.0484	0.0336	0.0035
5.B Biological Treatment of Solid Waste	N_2O	20	74	20.0	50.0	53.85	0.0035	0.0008	0.0011	0.0400	0.0312	0.0026
5.C Incineration and Open Burning of Waste	CH_4	1	0	7.0	0.0	7.00	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
5.C Incineration and Open Burning of Waste	CO_2	28	2	7.0	20.0	21.19	0.0000	-0.0004	0.0000	-0.0078	0.0003	0.0001
5.C Incineration and Open Burning of Waste	N_2O	0	0	7.0	0.0	7.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH_4	137	25	20.0	50.0	53.85	0.0004	-0.0017	0.0004	-0.0840	0.0106	0.0072
5.D Waste Water Treatment and Discharge	N_2O	86	152	20.0	100.0	101.98	0.0530	0.0010	0.0023	0.0979	0.0641	0.0137
Total		**66 840**	**67 131**				**62.06**					**6.25**
Total Uncertainties						**Uncertainty in total inventory %:**	**7.88**				**Trend uncertainty %:**	**2.50**

ANNEX 3: DETAILED METHODOLOGICAL DESCRIPTIONS

Annex 3.1 – CRF 1.A Fuel Combustion

This Annex includes detailed information about category *1.A Fuel Combustion* (trend information by sub-category), a description of the national energy balance (including fuel and fuel categories) and a description of the methodology applied to extract activity data from the energy balance for the calculation of emissions for category *1.A Fuel Combustion* (e.g. correspondence of categories of the energy balance to IPCC categories). Activity data used for estimating emissions in the sectoral approach as taken from the energy balance is also presented.

Furthermore, the revision of the national energy balance as well as the implication of this revision on activity data are described.

Trend information by sub category

1.A.1.a Public Electricity and Heat Production

Table A 22: Greenhouse gas emissions from Category 1.A.1.a

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	11 056	0.24	0.13	11 098
1991	11 768	0.26	0.15	11 814
1992	8 599	0.25	0.11	8 636
1993	8 431	0.26	0.10	8 465
1994	8 712	0.26	0.10	8 747
1995	9 812	0.27	0.12	9 852
1996	11 073	0.33	0.14	11 121
1997	11 108	0.34	0.15	11 157
1998	10 103	0.33	0.13	10 146
1999	10 069	0.31	0.13	10 111
2000	9 768	0.30	0.14	9 815
2001	11 270	0.36	0.17	11 326
2002	10 529	0.37	0.18	10 586
2003	12 986	0.43	0.21	13 053
2004	12 685	0.46	0.22	12 757
2005	12 726	0.50	0.22	12 798
2006	11 639	0.58	0.25	11 723
2007	10 394	0.63	0.27	10 484
2008	10 301	0.70	0.29	10 397
2009	9 256	0.77	0.30	9 356
2010	10 661	0.88	0.35	10 778
2011	10 248	0.89	0.36	10 368
2012	8 805	0.90	0.36	8 925
2013	7 804	0.87	0.35	7 922
2014	6 309	0.84	0.33	6 419
2015	7 299	0.90	0.34	7 415
2016	7 109	0.90	0.33	7 221
2017	7 784	0.92	0.33	7 898
2018	6 872	0.88	0.32	6 982
2019	6 953	0.86	0.31	7 059
2020	5 665	0.87	0.31	5 771
2021	5 635	0.90	0.32	5 744
Trend 1990-2021	**-49.0%**	**274.9%**	**137.7%**	**-48.2%**

Solid fossil fuels and natural gas are dominant compared to other fuel types. Since 2007 liquid fossil fuels became less important. The share in CO_2 emissions from waste incineration in district heating plants which are reported as 'other fuels' increased from 3% in 1990 to 18% in 2020. Solid fuels 2020 decreased due to the phase-out of coal-fired power generation.

Table A 23: Share of fuel types on total CO_2 emissions from Category 1.A.1.a

	Liquid	Solid	Gaseous	Other
1990	11%	57%	30%	3%
1991	13%	58%	27%	2%
1992	17%	47%	32%	4%
1993	24%	37%	35%	4%
1994	22%	38%	37%	3%
1995	16%	46%	35%	3%
1996	14%	42%	40%	4%
1997	17%	45%	34%	3%
1998	22%	35%	40%	3%
1999	18%	38%	42%	3%
2000	12%	49%	36%	3%
2001	14%	52%	31%	3%
2002	8%	52%	36%	4%
2003	9%	53%	35%	3%
2004	9%	53%	34%	4%
2005	9%	46%	41%	4%
2006	9%	48%	38%	5%
2007	7%	49%	38%	6%
2008	7%	43%	44%	6%
2009	7%	33%	52%	9%
2010	6%	36%	49%	8%
2011	4%	41%	45%	9%
2012	3%	39%	47%	11%
2013	2%	42%	43%	13%
2014	2%	37%	44%	17%
2015	3%	32%	50%	15%
2016	5%	22%	56%	16%
2017	3%	17%	66%	14%
2018	1%	20%	64%	15%
2019	1%	17%	68%	15%
2020	1%	6%	75%	18%
2021	2%	0%	79%	19%

1.A.1.b Petroleum Refining

Table A 24: Greenhouse gas emissions from Category 1.A.1.b.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	2 394	0.05	0.01	2 398
1991	2 428	0.06	0.01	2 432
1992	2 389	0.05	0.01	2 393
1993	2 732	0.06	0.01	2 736
1994	2 709	0.06	0.01	2 714
1995	2 590	0.06	0.01	2 594
1996	2 647	0.07	0.01	2 651
1997	2 640	0.07	0.01	2 645
1998	2 633	0.07	0.01	2 638
1999	2 234	0.06	0.01	2 238
2000	2 214	0.06	0.01	2 218
2001	2 129	0.06	0.01	2 133

	CO_2 [kt]	**CH_4 [kt]**	**N_2O [kt]**	**CO_2 equiv. [kt]**
2002	2 565	0.07	0.01	2 570
2003	2 687	0.08	0.01	2 693
2004	2 844	0.08	0.01	2 850
2005	2 827	0.08	0.01	2 833
2006	2 830	0.08	0.01	2 836
2007	2 868	0.08	0.01	2 873
2008	2 806	0.07	0.01	2 811
2009	2 809	0.08	0.01	2 815
2010	2 724	0.07	0.01	2 730
2011	2 768	0.07	0.01	2 774
2012	2 836	0.08	0.01	2 842
2013	2 827	0.08	0.02	2 833
2014	2 713	0.08	0.01	2 719
2015	2 804	0.09	0.02	2 811
2016	2 784	0.09	0.02	2 791
2017	2 739	0.08	0.01	2 745
2018	2 824	0.08	0.02	2 831
2019	2 791	0.08	0.01	2 797
2020	2 732	0.08	0.01	2 738
2021	2 750	0.08	0.01	2 755
Trend 1990-2021	**14.8%**	**48.2%**	**73.4%**	**14.9%**

Table A 25 presents the share of CO_2 emissions on the different fuel types.

Table A 25: Share of fuel types on total CO_2 emissions from Category 1.A.1.b.

	Liquid	**Gaseous**
1990	82%	18%
1991	79%	21%
1992	80%	20%
1993	80%	20%
1994	86%	14%
1995	84%	16%
1996	82%	18%
1997	82%	18%
1998	82%	18%
1999	84%	16%
2000	84%	16%
2001	85%	15%
2002	89%	11%
2003	89%	11%
2004	84%	16%
2005	82%	18%
2006	83%	17%
2007	84%	16%
2008	82%	18%
2009	92%	8%
2010	82%	18%
2011	82%	18%
2012	85%	15%
2013	87%	13%
2014	88%	12%
2015	88%	12%
2016	88%	12%
2017	86%	14%
2018	83%	17%
2019	82%	18%
2020	82%	18%

	Liquid	Gaseous
2021	81%	19%

1.A.1.c Manufacture of Solid Fuels and Other Energy Industries

Table A 26: Greenhouse gas emissions from Category 1.A.1.c.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	510	0.04	0.0010	511
1991	549	0.04	0.0010	551
1992	522	0.04	0.0009	523
1993	424	0.04	0.0008	425
1994	453	0.04	0.0008	454
1995	611	0.04	0.0011	613
1996	261	0.04	0.0005	262
1997	277	0.04	0.0005	278
1998	352	0.04	0.0006	353
1999	284	0.04	0.0005	285
2000	281	0.04	0.0005	282
2001	245	0.04	0.0004	246
2002	212	0.03	0.0004	213
2003	168	0.03	0.0003	169
2004	245	0.04	0.0004	247
2005	394	0.04	0.0007	395
2006	262	0.04	0.0005	263
2007	264	0.04	0.0005	265
2008	237	0.04	0.0004	238
2009	264	0.05	0.0005	266
2010	238	0.04	0.0004	239
2011	266	0.04	0.0005	267
2012	206	0.05	0.0004	207
2013	250	0.04	0.0005	252
2014	248	0.04	0.0004	249
2015	275	0.05	0.0005	277
2016	273	0.05	0.0005	275
2017	259	0.04	0.0005	260
2018	240	0.04	0.0004	241
2019	312	0.05	0.0006	314
2020	289	0.05	0.0005	291
2021	354	0.05	0.0006	355
Trend 1990-2021	**510**	**0.04**	**0.0010**	**511**

Almost all emissions of category 1.A.1.c originate from natural gas combustion.

Table A 27: Share of fuel types on total CO_2 emissions from Category 1.A.1.c.

	Liquid	Gaseous
1990	1%	99%
1991	0%	100%
1992	0%	100%
1993	0%	100%
1994	0%	100%
1995	0%	100%
1996	NO	100%
1997	NO	100%
1998	NO	100%
1999	NO	100%
2000	NO	100%

	Liquid	Gaseous
2001	NO	100%
2002	NO	100%
2003	NO	100%
2004	NO	100%
2005	NO	100%
2006	NO	100%
2007	NO	100%
2008	NO	100%
2009	NO	100%
2010	NO	100%
2011	NO	100%
2012	NO	100%
2013	NO	100%
2014	NO	100%
2015	NO	100%
2016	NO	100%
2017	NO	100%
2018	NO	100%
2019	NO	100%
2020	NO	100%
2021	NO	100%

1.A.2.a Iron and Steel

Table A 28: Greenhouse gas emissions from Category 1.A.2.a.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	1 833	0.03	0.003	1 834
1991	1 441	0.02	0.003	1 442
1992	1 186	0.02	0.002	1 187
1993	1 366	0.02	0.003	1 367
1994	1 281	0.02	0.003	1 282
1995	1 338	0.02	0.003	1 339
1996	1 602	0.03	0.003	1 604
1997	1 862	0.03	0.003	1 864
1998	1 161	0.02	0.003	1 162
1999	1 330	0.02	0.003	1 331
2000	1 275	0.02	0.003	1 277
2001	1 439	0.03	0.003	1 440
2002	1 686	0.03	0.003	1 687
2003	1 734	0.03	0.003	1 735
2004	1 903	0.03	0.003	1 905
2005	1 845	0.03	0.003	1 846
2006	1 553	0.03	0.003	1 554
2007	1 216	0.02	0.002	1 217
2008	1 302	0.02	0.003	1 304
2009	1 020	0.02	0.002	1 021
2010	1 275	0.02	0.003	1 277
2011	1 446	0.03	0.003	1 447
2012	1 483	0.03	0.003	1 485
2013	1 606	0.03	0.003	1 608
2014	1 496	0.03	0.003	1 497
2015	1 406	0.02	0.002	1 407
2016	1 577	0.03	0.003	1 578
2017	1 658	0.03	0.003	1 660
2018	1 771	0.03	0.003	1 773
2019	1 805	0.03	0.003	1 806
2020	1 803	0.03	0.003	1 805
2021	1 774	0.03	0.003	1 776

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
Trend 1990-2021	**-3.2%**	**2.9%**	**-1.6%**	**-3.2%**

CO_2 emissions from category *1.A.2.a (without blast furnaces)* mainly arise from gaseous fuels.

Table A 29: Share of fuel types in total CO_2 emissions from Category 1.A.2.a.

	Liquid	Solid	Gaseous
1990	4.2%	60.4%	35.5%
1991	5.0%	48.4%	46.6%
1992	4.7%	41.4%	53.9%
1993	5.3%	49.9%	44.8%
1994	5.8%	41.2%	53.0%
1995	6.2%	37.1%	56.6%
1996	7.4%	34.5%	58.2%
1997	3.8%	38.0%	58.2%
1998	5.7%	2.5%	91.8%
1999	2.6%	18.1%	79.3%
2000	5.8%	14.1%	80.1%
2001	3.1%	16.0%	80.9%
2002	1.7%	28.1%	70.2%
2003	1.3%	29.7%	69.0%
2004	1.7%	29.4%	68.9%
2005	3.2%	37.7%	59.1%
2006	3.5%	28.2%	68.4%
2007	1.7%	13.0%	85.3%
2008	7.1%	14.7%	78.2%
2009	2.1%	8.6%	89.3%
2010	2.5%	11.2%	86.4%
2011	1.9%	12.4%	85.8%
2012	1.3%	13.0%	85.7%
2013	0.5%	17.4%	82.1%
2014	0.4%	9.8%	89.8%
2015	0.4%	20.2%	79.4%
2016	0.5%	31.7%	67.8%
2017	0.4%	33.2%	66.4%
2018	0.4%	33.1%	66.5%
2019	0.3%	36.2%	63.5%
2020	0.4%	39.7%	60.0%
2021	1.1%	42.8%	56.0%

1.A.2.b Non-Ferrous Metals

Table A 30: Greenhouse gas emissions from Category 1.A.2.b.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	132	0.004	0.001	132
1991	119	0.004	0.001	119
1992	127	0.003	0.000	127
1993	158	0.005	0.001	158
1994	261	0.006	0.001	261
1995	255	0.006	0.001	255
1996	177	0.005	0.001	177
1997	221	0.007	0.001	222
1998	205	0.006	0.001	206
1999	191	0.006	0.001	191
2000	193	0.006	0.001	193
2001	206	0.005	0.001	207

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2002	208	0.006	0.001	208
2003	213	0.006	0.001	213
2004	220	0.006	0.001	220
2005	218	0.005	0.001	218
2006	222	0.005	0.001	222
2007	251	0.006	0.001	251
2008	253	0.006	0.001	254
2009	235	0.006	0.001	235
2010	236	0.005	0.001	236
2011	248	0.005	0.001	249
2012	241	0.005	0.001	241
2013	271	0.012	0.003	272
2014	289	0.008	0.001	289
2015	295	0.007	0.001	296
2016	305	0.007	0.001	305
2017	297	0.007	0.001	297
2018	325	0.007	0.001	325
2019	301	0.007	0.001	301
2020	268	0.006	0.001	268
2021	294	0.006	0.001	294
Trend 1990-2021	**122.9%**	**50.9%**	**41.7%**	**122.7%**

CO_2 emissions from category *1.A.2.b* mainly arise from gaseous fuels.

Table A 31: Share of fuel types in total CO_2 emissions from Category 1.A.2.b

	Liquid	Solid	Gaseous	Other
1990	27%	17%	57%	0.0%
1991	29%	15%	56%	0.0%
1992	25%	6%	69%	0.0%
1993	21%	12%	67%	0.0%
1994	15%	6%	79%	0.0%
1995	16%	4%	80%	0.0%
1996	28%	9%	63%	0.0%
1997	32%	9%	59%	0.0%
1998	30%	8%	62%	0.0%
1999	25%	12%	63%	0.0%
2000	24%	9%	66%	0.0%
2001	26%	5%	70%	0.0%
2002	21%	8%	71%	0.0%
2003	19%	8%	74%	0.0%
2004	17%	7%	76%	0.0%
2005	15%	6%	79%	0.0%
2006	15%	6%	80%	0.0%
2007	12%	6%	83%	0.0%
2008	9%	6%	85%	0.0%
2009	8%	7%	85%	0.0%
2010	8%	3%	89%	0.0%
2011	9%	3%	88%	0.0%
2012	9%	3%	89%	0.0%
2013	13%	5%	81%	0.4%
2014	11%	6%	83%	0.3%
2015	10%	5%	85%	0.4%
2016	7%	5%	88%	0.4%
2017	6%	4%	90%	0.4%
2018	2%	3%	95%	0.2%
2019	3%	4%	93%	0.4%
2020	3%	5%	92%	0.3%

	Liquid	Solid	Gaseous	Other
2021	3%	3%	93%	0.1%

1.A.2.c Chemicals

Table A 32: Greenhouse gas emissions from Category 1.A.2.c.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	847	0.07	0.02	855
1991	858	0.08	0.02	866
1992	931	0.09	0.03	941
1993	1 001	0.08	0.02	1 008
1994	946	0.07	0.02	953
1995	986	0.07	0.02	993
1996	1 062	0.09	0.03	1 071
1997	1 155	0.10	0.03	1 164
1998	1 082	0.08	0.02	1 090
1999	1 327	0.11	0.03	1 339
2000	1 341	0.11	0.03	1 352
2001	1 374	0.09	0.02	1 383
2002	1 376	0.11	0.03	1 386
2003	1 454	0.13	0.04	1 468
2004	1 373	0.14	0.04	1 388
2005	1 348	0.07	0.02	1 355
2006	1 275	0.08	0.02	1 282
2007	1 167	0.07	0.02	1 174
2008	1 386	0.10	0.03	1 396
2009	1 418	0.09	0.03	1 428
2010	1 547	0.11	0.03	1 559
2011	1 487	0.10	0.03	1 498
2012	1 486	0.11	0.03	1 497
2013	1 384	0.09	0.03	1 394
2014	1 418	0.10	0.03	1 427
2015	1 394	0.09	0.02	1 403
2016	1 550	0.10	0.03	1 559
2017	1 627	0.10	0.03	1 637
2018	1 471	0.10	0.03	1 481
2019	1 462	0.09	0.03	1 472
2020	1 426	0.08	0.02	1 435
2021	1 582	0.10	0.03	1 593
Trend 1990-2021	**86.8%**	**39.7%**	**38.3%**	**86.4%**

In 2020, natural gas was still the main source of CO_2 emissions from category *1.A.2.c* while CO_2 emissions from solid and liquid fossil fuel combustion got less important.

Table A 33: Share of fuel types in total CO_2 emissions from Category 1.A.2.c

	Liquid	Solid	Gaseous	Other
1990	11%	13%	61%	15%
1991	12%	16%	54%	19%
1992	8%	20%	53%	20%
1993	9%	19%	60%	12%
1994	11%	16%	58%	14%
1995	10%	15%	58%	16%
1996	10%	17%	54%	19%
1997	13%	22%	52%	13%
1998	11%	23%	54%	12%
1999	7%	23%	62%	9%

	Liquid	Solid	Gaseous	Other
2000	5%	19%	65%	11%
2001	7%	18%	62%	13%
2002	5%	18%	60%	16%
2003	5%	17%	58%	20%
2004	6%	17%	62%	16%
2005	5%	11%	76%	8%
2006	6%	8%	74%	13%
2007	7%	7%	78%	9%
2008	6%	5%	69%	20%
2009	9%	5%	70%	17%
2010	9%	5%	66%	20%
2011	8%	5%	68%	19%
2012	7%	5%	69%	19%
2013	6%	6%	72%	16%
2014	4%	9%	71%	16%
2015	4%	7%	73%	16%
2016	4%	7%	73%	16%
2017	3%	13%	70%	14%
2018	3%	8%	75%	14%
2019	3%	4%	81%	12%
2020	5%	3%	79%	13%
2021	2%	2%	77%	19%

1.A.2.d Pulp, Paper and Print

Table A 34: Greenhouse gas emissions from Category 1.A.2.d.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv.[kt]
1990	2 208	0.20	0.07	2 233
1991	2 670	0.23	0.08	2 697
1992	2 159	0.21	0.08	2 186
1993	2 016	0.25	0.09	2 048
1994	2 546	0.26	0.10	2 579
1995	2 301	0.25	0.10	2 334
1996	2 392	0.23	0.08	2 421
1997	2 818	0.22	0.08	2 845
1998	2 631	0.21	0.08	2 658
1999	2 342	0.23	0.09	2 372
2000	2 379	0.20	0.08	2 405
2001	2 249	0.23	0.09	2 280
2002	2 256	0.20	0.08	2 282
2003	2 431	0.21	0.08	2 458
2004	2 288	0.21	0.08	2 315
2005	2 293	0.26	0.10	2 327
2006	2 195	0.26	0.10	2 229
2007	2 186	0.25	0.10	2 220
2008	2 191	0.23	0.10	2 223
2009	2 195	0.22	0.09	2 225
2010	2 312	0.23	0.09	2 343
2011	2 264	0.23	0.09	2 295
2012	2 023	0.23	0.10	2 055
2013	1 899	0.23	0.10	1 931
2014	1 741	0.22	0.09	1 772
2015	1 829	0.21	0.09	1 858
2016	1 774	0.22	0.09	1 805
2017	1 776	0.22	0.09	1 807
2018	1 883	0.23	0.10	1 915
2019	1 970	0.24	0.10	2 004
2020	1 800	0.22	0.09	1 831

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv.[kt]
2021	1 811	0.21	0.09	1 841
Trend 1990-2021	**-18.0%**	**6.7%**	**27.4%**	**-17.5%**

Natural gas combustion is the main source of CO_2 emissions from category *1.A.2.d*. liquid fuel consumption decreased since 1990 whereas the share of solid fuels in total CO_2 emissions is rather constant.

Table A 35: Share of fuel types in total CO_2 emissions from Category 1.A.2.d.

	Liquid	Solid	Gaseous	Other
1990	39%	18%	43%	1%
1991	42%	20%	38%	1%
1992	31%	21%	47%	1%
1993	34%	21%	44%	1%
1994	26%	14%	59%	1%
1995	23%	17%	59%	2%
1996	17%	15%	65%	3%
1997	18%	16%	66%	0%
1998	17%	17%	66%	0%
1999	10%	15%	74%	0%
2000	7%	19%	74%	0%
2001	8%	17%	75%	0%
2002	7%	20%	73%	0%
2003	7%	17%	75%	1%
2004	6%	19%	74%	1%
2005	6%	19%	75%	0%
2006	6%	21%	73%	0%
2007	4%	16%	79%	1%
2008	4%	15%	81%	0%
2009	5%	16%	79%	0%
2010	3%	14%	82%	0%
2011	2%	16%	82%	0%
2012	2%	17%	81%	0%
2013	3%	19%	76%	1%
2014	2%	21%	76%	1%
2015	2%	21%	75%	1%
2016	2%	21%	77%	1%
2017	1%	22%	76%	1%
2018	1%	20%	78%	1%
2019	1%	19%	80%	0%
2020	1%	17%	82%	1%
2021	1%	12%	87%	0%

1.A.2.e Food Processing, Beverages and Tobacco

Table A 36: Greenhouse gas emissions from Category 1.A.2.e.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	870	0.03	0.004	872
1991	933	0.03	0.005	935
1992	854	0.03	0.004	856
1993	886	0.03	0.005	888
1994	916	0.03	0.004	918
1995	931	0.03	0.004	933
1996	887	0.02	0.003	889
1997	1 041	0.03	0.004	1 043

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1998	943	0.02	0.003	944
1999	831	0.02	0.003	833
2000	882	0.02	0.004	884
2001	926	0.03	0.004	928
2002	1 100	0.03	0.004	1 102
2003	944	0.03	0.004	946
2004	947	0.03	0.004	949
2005	960	0.03	0.005	962
2006	934	0.03	0.005	937
2007	887	0.03	0.005	889
2008	878	0.03	0.005	880
2009	908	0.03	0.005	910
2010	966	0.03	0.005	968
2011	962	0.03	0.005	964
2012	942	0.03	0.005	944
2013	827	0.02	0.003	828
2014	922	0.02	0.003	924
2015	980	0.02	0.003	981
2016	816	0.02	0.003	817
2017	803	0.02	0.003	804
2018	769	0.02	0.003	771
2019	759	0.02	0.003	761
2020	790	0.02	0.003	791
2021	794	0.02	0.002	796
Trend 1990-2021	**-8.7%**	**-35.7%**	**-42.1%**	**-8.7%**

The share of natural gas consumption is increasing and is the main source of CO_2 emissions from category *1.A.2.e*. The share of liquid fossil fuel in total CO_2 emissions strongly decreased since 1990.

Table A 37: Share of fuel types in total CO_2 emissions from Category 1.A.2.e.

	Liquid	Solid	Gaseous	Other
1990	40%	2%	58%	0.00%
1991	42%	2%	55%	0.00%
1992	40%	1%	59%	0.00%
1993	44%	2%	54%	0.00%
1994	38%	2%	59%	0.00%
1995	37%	1%	63%	0.00%
1996	29%	1%	70%	0.05%
1997	30%	1%	69%	0.04%
1998	26%	1%	72%	0.05%
1999	20%	1%	79%	0.00%
2000	19%	2%	79%	0.00%
2001	26%	1%	73%	0.00%
2002	16%	1%	82%	0.00%
2003	24%	2%	75%	0.00%
2004	27%	1%	72%	0.00%
2005	25%	1%	73%	0.00%
2006	26%	1%	73%	0.00%
2007	24%	1%	75%	0.00%
2008	22%	1%	77%	0.00%
2009	23%	2%	76%	0.00%
2010	21%	2%	78%	0.03%
2011	21%	2%	78%	0.03%
2012	17%	2%	82%	0.03%
2013	9%	2%	89%	0.01%
2014	9%	2%	88%	0.00%
2015	7%	2%	91%	0.00%

	Liquid	Solid	Gaseous	Other
2016	7%	2%	91%	0.00%
2017	6%	2%	92%	0.00%
2018	5%	2%	94%	0.05%
2019	5%	2%	94%	0.00%
2020	4%	2%	95%	0.01%
2021	5%	2%	94%	0.00%

1.A.2.f Non-Metallic Minerals

Table A 38: Greenhouse gas emissions from Category 1.A.2.f.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	1 669	0.10	0.02	1 677
1991	1 668	0.10	0.02	1 675
1992	1 673	0.11	0.02	1 682
1993	1 621	0.10	0.02	1 629
1994	1 693	0.10	0.02	1 701
1995	1 520	0.09	0.02	1 528
1996	1 551	0.10	0.02	1 559
1997	1 698	0.11	0.02	1 707
1998	1 600	0.11	0.02	1 609
1999	1 472	0.09	0.02	1 480
2000	1 540	0.11	0.02	1 550
2001	1 508	0.12	0.03	1 518
2002	1 659	0.11	0.03	1 670
2003	1 687	0.11	0.02	1 697
2004	1 830	0.12	0.03	1 841
2005	1 656	0.14	0.04	1 669
2006	1 772	0.16	0.04	1 787
2007	1 895	0.17	0.04	1 912
2008	1 845	0.17	0.05	1 862
2009	1 554	0.15	0.04	1 569
2010	1 528	0.14	0.04	1 542
2011	1 546	0.14	0.04	1 560
2012	1 530	0.15	0.04	1 545
2013	1 552	0.15	0.04	1 567
2014	1 613	0.16	0.05	1 630
2015	1 605	0.17	0.05	1 623
2016	1 631	0.16	0.05	1 648
2017	1 636	0.17	0.05	1 654
2018	1 694	0.18	0.05	1 713
2019	1 664	0.17	0.05	1 682
2020	1 654	0.17	0.05	1 672
2021	1 682	0.18	0.05	1 701
Trend 1990-2021	**0.8%**	**77.1%**	**193.2%**	**1.4%**

Natural gas and other fossil fuel (Industrial waste) combustion is the main source of CO_2 emissions from category *1.A.2.f*. The share of other fossil fuel increased while liquid and solid fuels decreased.

Table A 39: Share of fuel types in total CO_2 emissions from category 1.A.2.f

	Liquid	Solid	Gaseous	Other
1990	30%	32%	33%	4%
1991	32%	28%	34%	5%
1992	28%	35%	31%	6%
1993	34%	29%	33%	3%
1994	36%	22%	33%	8%

	Liquid	Solid	Gaseous	Other
1995	23%	29%	40%	8%
1996	17%	34%	43%	7%
1997	16%	32%	43%	8%
1998	18%	33%	45%	5%
1999	22%	24%	42%	12%
2000	13%	33%	42%	13%
2001	11%	31%	44%	14%
2002	18%	21%	45%	16%
2003	18%	18%	46%	17%
2004	23%	16%	45%	17%
2005	18%	23%	40%	20%
2006	12%	31%	36%	21%
2007	12%	32%	35%	21%
2008	11%	31%	35%	23%
2009	11%	28%	34%	27%
2010	13%	20%	39%	27%
2011	13%	18%	40%	29%
2012	11%	19%	38%	32%
2013	11%	17%	41%	32%
2014	10%	17%	39%	34%
2015	10%	17%	39%	35%
2016	10%	14%	40%	37%
2017	8%	13%	41%	38%
2018	8%	14%	40%	39%
2019	6%	14%	42%	37%
2020	5%	19%	42%	34%
2021	9%	15%	40%	37%

1.A.2.g.7 Manufacturing Industries and Construction – Mobile sources

Table A 40: Greenhouse gas emissions from Category 1.A.2.g.7.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	256	0.01	0.09	280
1991	289	0.01	0.10	317
1992	306	0.02	0.11	335
1993	322	0.02	0.11	353
1994	338	0.02	0.12	370
1995	358	0.02	0.13	393
1996	446	0.02	0.17	491
1997	420	0.02	0.16	464
1998	494	0.02	0.19	546
1999	471	0.02	0.19	522
2000	551	0.02	0.22	610
2001	518	0.02	0.21	574
2002	504	0.02	0.20	558
2003	537	0.02	0.21	592
2004	591	0.02	0.20	645
2005	810	0.02	0.23	873
2006	979	0.02	0.24	1 044
2007	1 060	0.02	0.23	1 122
2008	1 166	0.01	0.23	1 228
2009	1 124	0.01	0.21	1 179
2010	1 077	0.01	0.19	1 129
2011	1 082	0.01	0.19	1 132
2012	1 119	0.01	0.18	1 167
2013	1 128	0.01	0.17	1 174
2014	1 102	0.01	0.16	1 146
2015	1 068	0.01	0.15	1 109

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2016	1 083	0.01	0.15	1 122
2017	1 142	0.01	0.15	1 182
2018	1 222	0.01	0.15	1 262
2019	1 289	0.01	0.15	1 329
2020	1 238	0.005	0.14	1 275
2021	1 349	0.005	0.15	1 389
Trend 1990-2021	**427.4%**	**-63.1%**	**67.5%**	**396.1%**

All emissions from mobile machinery of industry arise from liquid fuels (diesel, gasoline) and biofuels.

1.A.2.g.8 Manufacturing Industries and Construction - Other - stationary sources

Table A 41: Greenhouse gas emissions from Category 1.A.2.g.8.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	1 719	0.09	0.02	1 727
1991	1 853	0.10	0.02	1 863
1992	1 882	0.10	0.02	1 890
1993	1 997	0.10	0.02	2 006
1994	2 031	0.10	0.02	2 040
1995	2 282	0.10	0.02	2 290
1996	2 412	0.12	0.03	2 423
1997	2 508	0.13	0.03	2 520
1998	2 239	0.11	0.03	2 249
1999	1 680	0.19	0.05	1 698
2000	1 738	0.15	0.04	1 753
2001	1 705	0.16	0.04	1 721
2002	1 521	0.15	0.04	1 536
2003	1 721	0.17	0.05	1 739
2004	1 783	0.19	0.05	1 802
2005	2 082	0.26	0.08	2 111
2006	2 106	0.27	0.09	2 136
2007	1 928	0.31	0.10	1 964
2008	1 916	0.28	0.09	1 949
2009	1 964	0.30	0.10	2 000
2010	2 099	0.31	0.10	2 135
2011	1 913	0.32	0.11	1 952
2012	2 017	0.34	0.12	2 058
2013	1 920	0.31	0.11	1 958
2014	1 618	0.29	0.11	1 654
2015	1 489	0.30	0.11	1 526
2016	1 647	0.26	0.09	1 679
2017	1 649	0.26	0.09	1 681
2018	1 566	0.23	0.08	1 594
2019	1 438	0.21	0.07	1 463
2020	1 417	0.23	0.08	1 445
2021	1 505	0.23	0.08	1 533
Trend 1990-2021	**-12.4%**	**143.4%**	**293.0%**	**-11.2%**

Natural gas and liquid fossil fuel combustion is the main source of CO_2 emissions from category *1.A.2.g.8*.

Table A 42: Share of fuel types on total CO_2 emissions from Category 1.A.2.g.8

	Liquid	Solid	Gaseous	Other
1990	36%	5%	59%	0%
1991	36%	5%	57%	2%
1992	28%	2%	67%	3%
1993	40%	3%	54%	2%
1994	32%	2%	64%	3%
1995	35%	1%	62%	2%
1996	41%	1%	56%	2%
1997	56%	2%	37%	4%
1998	52%	2%	41%	5%
1999	37%	7%	52%	4%
2000	35%	2%	62%	2%
2001	40%	0%	56%	4%
2002	34%	1%	63%	3%
2003	38%	1%	59%	3%
2004	37%	1%	57%	5%
2005	34%	2%	62%	2%
2006	35%	2%	62%	2%
2007	30%	2%	66%	2%
2008	26%	2%	70%	2%
2009	25%	0%	73%	2%
2010	24%	0%	74%	2%
2011	27%	0%	71%	2%
2012	29%	0%	69%	2%
2013	16%	0%	82%	2%
2014	17%	0%	82%	1%
2015	17%	0%	81%	2%
2016	15%	0%	83%	2%
2017	14%	0%	84%	2%
2018	11%	0%	87%	2%
2019	15%	0%	83%	2%
2020	11%	0%	87%	2%
2021	10%	0%	88%	2%

1.A.3.e.i Other Transportation – Pipeline Compressors

Table A 43: Greenhouse gas emissions from Category 1.A.3.e.i

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	229	0.005	0.0005	229
1991	231	0.005	0.0005	231
1992	226	0.004	0.0005	226
1993	220	0.004	0.0005	221
1994	216	0.004	0.0004	216
1995	234	0.005	0.0005	234
1996	242	0.005	0.0005	242
1997	241	0.005	0.0005	241
1998	360	0.007	0.0007	361
1999	447	0.008	0.0009	447
2000	347	0.006	0.0007	348
2001	506	0.009	0.0010	507
2002	286	0.005	0.0006	287
2003	381	0.007	0.0008	381
2004	382	0.007	0.0008	383
2005	370	0.007	0.0007	370
2006	477	0.009	0.0009	477
2007	499	0.009	0.0010	500
2008	477	0.009	0.0010	477

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2009	447	0.008	0.0009	447
2010	470	0.009	0.0010	470
2011	580	0.011	0.0013	581
2012	470	0.009	0.0011	470
2013	618	0.011	0.0014	619
2014	516	0.009	0.0012	516
2015	596	0.011	0.0014	597
2016	574	0.010	0.0015	575
2017	647	0.012	0.0016	647
2018	601	0.011	0.0016	602
2019	556	0.010	0.0016	557
2020	479	0.009	0.0011	479
2021	382	0.007	0.0010	382
Trend 1990-2021	**66.6%**	**53.1%**	**117.4%**	**66.6%**

All emissions from pipeline compressors arise from gaseous fuels.

1.A.4 Other sectors

Table A 44: Greenhouse gas emissions from Category 1.A.4.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	13 543	20.46	0.64	14 286
1991	14 695	21.34	0.68	15 473
1992	14 166	19.44	0.66	14 884
1993	14 120	18.26	0.66	14 805
1994	12 842	16.61	0.63	13 474
1995	13 976	18.00	0.65	14 653
1996	14 956	17.86	0.70	15 641
1997	13 580	15.73	0.69	14 203
1998	13 629	14.84	0.68	14 224
1999	14 252	14.86	0.70	14 853
2000	13 005	14.31	0.67	13 583
2001	14 219	14.79	0.70	14 819
2002	13 488	13.44	0.67	14 042
2003	14 174	13.02	0.66	14 712
2004	13 667	12.61	0.64	14 190
2005	13 371	12.15	0.65	13 884
2006	13 182	12.38	0.65	13 701
2007	11 180	11.92	0.63	11 680
2008	11 553	12.09	0.64	12 062
2009	10 578	11.81	0.61	11 069
2010	10 702	13.04	0.62	11 232
2011	9 519	11.84	0.60	10 010
2012	9 079	12.30	0.58	9 578
2013	9 305	12.53	0.58	9 809
2014	8 369	10.95	0.54	8 818
2015	8 705	11.23	0.54	9 161
2016	9 007	11.44	0.54	9 471
2017	9 107	11.59	0.53	9 572
2018	8 385	10.52	0.49	8 810
2019	8 644	10.46	0.50	9 069
2020	8 642	10.37	0.50	9 064
2021	9 604	11.57	0.54	10 070
Trend 1990-2021	**-29.1%**	**-43.4%**	**-16.8%**	**-29.5%**

As can be seen from Table A 45 liquid fossil fuels are the main source of CO_2 emissions from category *1.A.4* with a quite constant share over time series. Since 1990 solid fossil fuels became less important whereas the share of CO_2 emissions from natural gas combustion more than doubled.

Table A 45: Share of fuel types on total CO_2 emissions from Category 1.A.4.

	Liquid	Solid	Gaseous	Other
1990	61%	20%	19%	1%
1991	59%	20%	21%	0%
1992	57%	18%	25%	0%
1993	57%	15%	28%	0%
1994	58%	14%	27%	0%
1995	58%	13%	29%	0%
1996	62%	11%	27%	0%
1997	62%	10%	29%	0%
1998	62%	8%	30%	0%
1999	62%	8%	31%	0%
2000	61%	7%	31%	0%
2001	59%	7%	35%	0%
2002	61%	5%	34%	0%
2003	61%	5%	34%	0%
2004	57%	4%	38%	0%
2005	59%	3%	37%	1%
2006	59%	3%	37%	0%
2007	58%	3%	39%	0%
2008	58%	3%	39%	0%
2009	57%	2%	41%	0%
2010	54%	3%	43%	0%
2011	55%	2%	43%	0%
2012	51%	2%	47%	0%
2013	52%	1%	46%	0%
2014	54%	1%	45%	0%
2015	53%	1%	46%	0%
2016	51%	1%	48%	0%
2017	52%	1%	47%	0%
2018	51%	1%	48%	0%
2019	50%	1%	49%	0%
2020	50%	1%	49%	0%
2021	50%	1%	50%	0%

1.A.4 Other sectors – stationary sources

Table A 46: Greenhouse gas emissions from Category 1.A.4 Other sectors – stationary sources.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	12 601	19.89	0.37	13 255
1991	13 756	20.80	0.40	14 317
1992	13 218	18.90	0.37	13 731
1993	13 168	17.72	0.37	13 656
1994	11 885	16.06	0.34	12 329
1995	13 054	17.48	0.37	13 535
1996	14 006	17.35	0.40	14 495
1997	12 593	15.24	0.37	13 028
1998	12 659	14.37	0.36	13 073
1999	13 275	14.40	0.38	13 695
2000	12 054	13.87	0.35	12 454
2001	13 244	14.36	0.37	13 661
2002	13 244	14.36	0.37	13 661
2003	13 236	12.59	0.35	13 610

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2004	12 708	12.20	0.34	13 070
2005	12 373	11.78	0.34	12 727
2006	12 217	12.03	0.35	12 579
2007	10 224	11.60	0.34	10 574
2008	10 539	11.80	0.35	10 896
2009	9 653	11.59	0.35	10 006
2010	9 801	12.84	0.39	10 192
2011	8 556	11.66	0.37	8 914
2012	8 185	12.14	0.38	8 557
2013	8 434	12.39	0.39	8 816
2014	7 426	10.81	0.34	7 760
2015	7 831	11.10	0.36	8 177
2016	8 074	11.32	0.37	8 427
2017	8 232	11.48	0.38	8 591
2018	7 507	10.41	0.35	7 834
2019	7 726	10.35	0.36	8 053
2020	7 717	10.27	0.36	8 043
2021	8 702	11.48	0.40	9 068
Trend 1990-2021	**-30.9%**	**-42.3%**	**10.1%**	**-31.6%**

Liquid fossil fuels are the main stationary source of CO_2 emissions from category *1.A.4* until 2011 with a quite constant share over time. Since 1990 solid fossil fuels became less important whereas the share of CO_2 emissions from natural gas combustion more than doubled.

Table A 47: Share of fuel types in total CO_2 emissions from Category 1.A.4 stationary sources.

	Liquid	Solid	Gaseous	Other
1990	58%	21%	20%	0.7%
1991	56%	21%	23%	0.5%
1992	54%	19%	27%	0.4%
1993	54%	16%	30%	0.2%
1994	55%	16%	29%	0.3%
1995	55%	13%	31%	0.3%
1996	59%	12%	29%	0.3%
1997	59%	10%	31%	0.3%
1998	59%	9%	32%	0.4%
1999	59%	8%	33%	0.3%
2000	58%	8%	34%	0.3%
2001	55%	7%	37%	0.4%
2002	54%	6%	34%	0.3%
2003	58%	5%	37%	0.4%
2004	54%	5%	41%	0.3%
2005	56%	4%	40%	0.7%
2006	56%	3%	40%	0.5%
2007	54%	3%	42%	0.3%
2008	54%	3%	43%	0.1%
2009	53%	3%	45%	0.1%
2010	50%	3%	47%	0.1%
2011	50%	2%	48%	0.1%
2012	46%	2%	52%	0.0%
2013	48%	2%	51%	0.1%
2014	48%	1%	50%	0.1%
2015	47%	1%	51%	0.1%
2016	45%	1%	53%	0.1%
2017	47%	1%	52%	0.1%
2018	45%	1%	54%	0.1%
2019	44%	1%	55%	0.1%

	Liquid	Solid	Gaseous	Other
2020	44%	1%	55%	0.0%
2021	44%	1%	55%	0.0%

1.A.4.a.1 Commercial/Institutional – stationary sources

Table A 48: Greenhouse gas emissions from Category 1.A.4.a.1 Commercial/Institutional- stationary sources.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	2 292	0.53	0.03	2 313
1991	2 392	0.51	0.03	2 413
1992	2 818	0.51	0.02	2 839
1993	2 992	0.51	0.02	3 012
1994	2 476	0.44	0.02	2 493
1995	3 038	0.51	0.02	3 059
1996	3 201	0.49	0.03	3 222
1997	3 288	0.42	0.03	3 308
1998	3 091	0.38	0.03	3 109
1999	3 608	0.50	0.04	3 631
2000	2 797	0.43	0.03	2 817
2001	3 794	0.51	0.03	3 817
2002	3 628	0.50	0.03	3 650
2003	4 220	0.55	0.04	4 246
2004	3 972	0.55	0.03	3 997
2005	3 418	0.40	0.03	3 437
2006	3 606	0.47	0.03	3 629
2007	2 607	0.39	0.03	2 626
2008	2 764	0.43	0.03	2 783
2009	2 206	0.35	0.02	2 222
2010	1 660	0.34	0.02	1 675
2011	1 487	0.28	0.02	1 499
2012	1 389	0.23	0.01	1 399
2013	1 387	0.23	0.01	1 398
2014	1 247	0.18	0.01	1 255
2015	1 296	0.22	0.01	1 306
2016	1 224	0.19	0.01	1 232
2017	1 420	0.23	0.02	1 431
2018	1 362	0.24	0.02	1 374
2019	1 367	0.24	0.02	1 379
2020	1 290	0.23	0.02	1 301
2021	1 554	0.27	0.02	1 568
Trend 1990-2021	**-32.2%**	**-49.6%**	**-12.7%**	**-32.2%**

1.A.4.b.1 Residential – stationary sources

Table A 49: Greenhouse gas emissions from Category 1.A.4.b.1 Residential – stationary sources.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	9 827	17.94	0.32	10 414
1991	10 921	18.71	0.35	11 539
1992	10 000	16.88	0.33	10 560
1993	9 888	15.72	0.33	10 415
1994	9 188	14.28	0.31	9 668
1995	9 776	15.48	0.33	10 295
1996	10 541	15.23	0.35	11 062
1997	9 040	13.24	0.32	9 496
1998	9 293	12.52	0.31	9 727
1999	9 372	12.27	0.32	9 801

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2000	8 999	11.87	0.30	9 411
2001	9 194	12.09	0.31	9 616
2002	8 674	10.85	0.29	9 055
2003	8 779	10.28	0.29	9 144
2004	8 510	9.79	0.28	8 858
2005	8 791	9.60	0.28	9 135
2006	8 460	9.81	0.29	8 813
2007	7 488	9.54	0.29	7 833
2008	7 643	9.66	0.30	7 993
2009	7 355	9.52	0.31	7 702
2010	8 051	10.56	0.34	8 438
2011	6 996	9.52	0.32	7 348
2012	6 736	9.90	0.34	7 102
2013	6 977	9.96	0.35	7 348
2014	6 105	8.60	0.30	6 426
2015	6 462	8.80	0.32	6 793
2016	6 763	9.00	0.33	7 102
2017	6 734	9.02	0.33	7 075
2018	6 075	8.16	0.30	6 384
2019	6 285	8.23	0.31	6 598
2020	6 364	8.15	0.31	6 675
2021	7 080	9.08	0.35	7 428
Trend 1990-2020	**-28.0%**	**-49.4%**	**10.0%**	**-28.7%**

1.A.4.c.1 Agriculture/Forestry/Fisheries – stationary sources

The following table presents greenhouse gas emissions from 1.A.4.c.1 Agriculture/Forestry/Fisheries – stationary sources.

Table A 50: Greenhouse gas emissions from Category 1.A.4.c.1 Agriculture/Forestry/Fisheries – stationary sources.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	482	1.42	0.02	527
1991	443	1.58	0.02	493
1992	400	1.50	0.02	447
1993	288	1.49	0.02	336
1994	222	1.34	0.02	264
1995	240	1.49	0.02	287
1996	263	1.62	0.02	314
1997	265	1.57	0.02	315
1998	275	1.47	0.02	322
1999	295	1.63	0.02	347
2000	258	1.57	0.02	308
2001	257	1.76	0.02	312
2002	216	1.67	0.02	269
2003	237	1.75	0.02	292
2004	226	1.86	0.03	285
2005	165	1.78	0.02	221
2006	151	1.75	0.02	206
2007	129	1.67	0.02	182
2008	132	1.72	0.02	186
2009	92	1.72	0.02	147
2010	91	1.94	0.03	152
2011	74	1.86	0.02	133
2012	60	2.01	0.03	124
2013	70	2.20	0.03	139
2014	75	2.03	0.03	138

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2015	73	2.08	0.03	139
2016	88	2.13	0.03	155
2017	78	2.23	0.03	148
2018	69	2.02	0.03	133
2019	73	1.87	0.02	132
2020	63	1.89	0.03	123
2021	67	2.12	0.03	134
Trend 1990-2021	**-86.1%**	**49.5%**	**41.2%**	**-74.5%**

Activity Data Recalculations

Updates of activity data and NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority Statistik Austria.

Table A 51: 1.A activity data recalculations by sub categories with respect to previous submission.

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference
1 A FUEL COMBUSTION ACTIVITIES	790.39	792.82	-2.43	1 016.09	1 016.68	-0.59	948.87	948.44	0.42
1 A liquid	368.39	368.39	-	427.52	427.42	0.11	383.23	383.09	0.14
1 A solid	113.46	115.89	-2.43	27.59	27.87	-0.28	19.21	20.07	-0.86
1 A gaseous	203.98	203.98	-	309.00	309.00	-	294.64	293.12	1.52
1 A other	8.99	8.99	-	34.13	34.25	-0.12	35.06	35.13	-0.06
1 A peat	0.00	0.00	-	-	-	-	-	-	-
1 A biomass	95.57	95.57	-	217.85	218.15	-0.30	216.73	217.04	-0.31
1 A 1 Energy Industries	187.35	187.35	-	220.72	220.72	-	205.03	205.03	-
1 A 1 liquid	43.15	43.15	-	31.10	31.10	-	30.40	30.40	-
1 A 1 solid	61.40	61.40	-	12.49	12.49	-	3.86	3.86	-
1 A 1 gaseous	76.48	76.48	-	99.56	99.56	-	90.17	90.17	-
1 A 1 other	4.66	4.66	-	22.08	22.08	-	22.63	22.63	-
1 A 1 peat	-	-	-	-	-	-	-	-	-
1 A 1 biomass	1.66	1.66	-	55.49	55.49	-	57.97	57.97	-
1 A 1 a Public Electricity and Heat Production	142.78	142.78	-	175.45	175.45	-	161.28	161.28	-
1 A 1 a liquid	15.63	15.63	-	0.55	0.55	-	0.83	0.83	-
1 A 1 a solid	61.40	61.40	-	12.49	12.49	-	3.86	3.86	-
1 A 1 a gaseous	59.46	59.46	-	84.88	84.88	-	76.03	76.03	-
1 A 1 a other	4.66	4.66	-	22.08	22.08	-	22.63	22.63	-
1 A 1 a peat	-	-	-	-	-	-	-	-	-
1 A 1 a biomass	1.63	1.63	-	55.45	55.45	-	57.93	57.93	-
1 A 1 b Petroleum refining	35.34	35.34	-	39.62	39.62	-	38.51	38.51	-
1 A 1 b liquid	27.46	27.46	-	30.56	30.56	-	29.57	29.57	-
1 A 1 b solid	-	-	-	-	-	-	-	-	-
1 A 1 b gaseous	7.88	7.88	-	9.06	9.06	-	8.94	8.94	-
1 A 1 b other	-	-	-	-	-	-	-	-	-
1 A 1 b peat	-	-	-	-	-	-	-	-	-
1 A 1 b biomass	-	-	-	-	-	-	-	-	-
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	9.23	9.23	-	5.66	5.66	-	5.24	5.24	-

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Differenc e	Subm, 2023	Subm, 2022	Differenc e	Subm, 2023	Subm, 2022	Differenc e
1 A 1 c liquid	0.06	0.06	-	-	-	-	-	-	-
1 A 1 c solid	-	-	-	-	-	-	-	-	-
1 A 1 c gaseous	9.13	9.13	-	5.61	5.61	-	5.20	5.20	-
1 A 1 c other	-	-	-	-	-	-	-	-	-
1 A 1 c peat	-	-	-	-	-	-	-	-	-
1 A 1 c biomass	0.03	0.03	-	0.04	0.04	-	0.04	0.04	-
1 A 1 c 1 Manufacture of Solid Fuels	-	-	-	-	-	-	-	-	-
1 A 1 c 1 liquid	-	-	-	-	-	-	-	-	-
1 A 1 c 1 solid	-	-	-	-	-	-	-	-	-
1 A 1 c 1 gaseous	-	-	-	-	-	-	-	-	-
1 A 1 c 1 other	-	-	-	-	-	-	-	-	-
1 A 1 c 1 peat	-	-	-	-	-	-	-	-	-
1 A 1 c 1 biomass	-	-	-	-	-	-	-	-	-
1 A 1 c 2 Oil and gas extraction	6.73	6.73	-	2.38	2.38	-	2.34	2.34	-
1 A 1 c 2 liquid	-	-	-	-	-	-	-	-	-
1 A 1 c 2 solid	-	-	-	-	-	-	-	-	-
1 A 1 c 2 gaseous	6.73	6.73	-	2.38	2.38	-	2.34	2.34	-
1 A 1 c 2 other	-	-	-	-	-	-	-	-	-
1 A 1 c 2 peat	-	-	-	-	-	-	-	-	-
1 A 1 c 2 biomass	-	-	-	-	-	-	-	-	-
1 A 1 c 3 Other Energy Industries	2.50	2.50	-	3.28	3.28	-	2.91	2.91	-
1 A 1 c 3 liquid	0.06	0.06	-	-	-	-	-	-	-
1 A 1 c 3 solid	-	-	-	-	-	-	-	-	-
1 A 1 c 3 gaseous	2.41	2.41	-	3.24	3.24	-	2.86	2.86	-
1 A 1 c 3 other	-	-	-	-	-	-	-	-	-
1 A 1 c 3 peat	-	-	-	-	-	-	-	-	-
1 A 1 c 3 biomass	0.03	0.03	-	0.04	0.04	-	0.04	0.04	-
1 A 2 Manufacturing Industries and Construction	169.63	172.06	-2.43	235.31	235.82	-0.50	229.93	230.12	-0.20
1 A 2 liquid	36.10	36.10	-	22.75	22.75	0.01	21.34	21.40	-0.06
1 A 2 solid	23.87	26.30	-2.43	13.33	14.52	-1.19	14.76	15.34	-0.58
1 A 2 gaseous	76.99	76.99	-	122.25	122.25	0.00	119.07	118.28	0.79
1 A 2 other	3.22	3.22	-	11.03	11.03	-0.01	11.64	11.64	0.00
1 A 2 peat	-	-	-	-	-	-	-	-	-
1 A 2 biomass	29.45	29.45	-	65.04	65.26	-0.23	63.11	63.46	-0.34
1 A 2 a Iron and Steel	24.44	26.87	-2.43	27.59	27.87	-0.28	27.10	27.49	-0.40
1 A 2 a liquid	1.01	1.01	-	0.07	0.07	-	0.09	0.09	-0.00
1 A 2 a solid	11.69	14.12	-2.43	6.89	7.16	-0.28	7.54	8.13	-0.58
1 A 2 a gaseous	11.73	11.73	-	20.62	20.62	-	19.45	19.26	0.19
1 A 2 a other	-	-	-	-	-	-	-	-	-
1 A 2 a peat	-	-	-	-	-	-	-	-	-
1 A 2 a biomass	-	-	-	0.01	0.01	-	0.01	0.01	-
1 A 2 b Non-Ferrous Metals	2.08	2.08	-	5.27	5.27	-	4.73	4.64	0.09
1 A 2 b liquid	0.51	0.51	-	0.12	0.12	-	0.13	0.13	-0.00
1 A 2 b solid	0.21	0.21	-	0.13	0.13	-	0.13	0.12	0.00

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference
1 A 2 b gaseous	1.35	1.35	-	5.01	5.01	-	4.42	4.33	0.09
1 A 2 b other	-	-	-	0.02	0.02	-	0.01	0.01	-
1 A 2 b peat	-	-	-	-	-	-	-	-	-
1 A 2 b biomass	-	-	-	0.00	0.00	-	0.04	0.04	-
1 A 2 c Chemicals	16.29	16.29	-	28.50	28.36	0.15	27.31	26.85	0.46
1 A 2 c liquid	1.27	1.27	-	0.57	0.57	-	0.99	1.00	-0.01
1 A 2 c solid	1.09	1.09	-	0.61	0.61	-	0.40	0.40	-
1 A 2 c gaseous	9.36	9.36	-	21.25	21.25	-	20.35	19.94	0.41
1 A 2 c other	1.67	1.67	-	2.48	2.48	-	2.40	2.40	-
1 A 2 c peat	-	-	-	-	-	-	-	-	-
1 A 2 c biomass	2.90	2.90	-	3.59	3.45	0.15	3.17	3.11	0.06
1 A 2 d Pulp, Paper and Print	55.31	55.31	-	71.89	72.26	-0.36	67.42	67.34	0.08
1 A 2 d liquid	10.94	10.94	-	0.23	0.23	-	0.18	0.18	-0.00
1 A 2 d solid	4.13	4.13	-	4.05	4.05	-	3.31	3.31	-
1 A 2 d gaseous	17.01	17.01	-	28.42	28.42	-	26.61	26.11	0.50
1 A 2 d other	0.19	0.19	-	0.07	0.07	-	0.09	0.09	-
1 A 2 d peat	-	-	-	-	-	-	-	-	-
1 A 2 d biomass	23.03	23.03	-	39.12	39.49	-0.36	37.23	37.65	-0.42
1 A 2 e Food Processing, Beverages and Tobacco	13.91	13.91	-	13.86	13.86	-	14.46	14.21	0.25
1 A 2 e liquid	4.45	4.45	-	0.48	0.48	-	0.41	0.41	-0.01
1 A 2 e solid	0.18	0.18	-	0.12	0.12	-	0.11	0.11	-
1 A 2 e gaseous	9.15	9.15	-	12.80	12.80	-	13.46	13.21	0.25
1 A 2 e other	-	-	-	-	-	-	0.00	0.00	-
1 A 2 e peat	-	-	-	-	-	-	-	-	-
1 A 2 e biomass	0.13	0.13	-	0.46	0.46	-	0.48	0.48	-0.00
1 A 2 f Non-Metallic Minerals	23.34	23.34	-	27.69	27.69	-	27.24	27.24	-
1 A 2 f liquid	6.26	6.26	-	1.15	1.15	-	0.88	0.88	-
1 A 2 f solid	5.69	5.69	-	2.46	2.46	-	3.27	3.27	-
1 A 2 f gaseous	10.09	10.09	-	12.61	12.61	-	12.57	12.57	-
1 A 2 f other	1.31	1.31	-	7.89	7.89	-	7.17	7.17	-
1 A 2 f peat	-	-	-	-	-	-	-	-	-
1 A 2 f biomass	-	-	-	3.59	3.59	-	3.35	3.35	-
1 A 2 g Other (please specify)	34.27	34.27	-	60.51	60.52	-0.01	61.68	62.36	-0.68
1 A 2 g liquid	11.65	11.65	-	20.14	20.13	0.01	18.67	18.71	-0.04
1 A 2 g solid	0.88	0.88	-	-	-	-	0.00	0.00	0.00
1 A 2 g gaseous	18.30	18.30	-	21.54	21.54	0.00	22.21	22.86	-0.65
1 A 2 g other	0.05	0.05	-	0.57	0.58	-0.01	1.97	1.97	0.00
1 A 2 g peat	-	-	-	-	-	-	-	-	-
1 A 2 g biomass	3.39	3.39	-	18.26	18.27	-0.01	18.83	18.82	0.01
1 A 2 g 7 Off-road vehicles and other machinery	3.45	3.45	-	18.26	18.27	-0.01	17.53	17.54	-0.00
1 A 2 g 7 liquid	3.45	3.45	-	17.26	17.26	0.01	16.58	16.57	0.00
1 A 2 g 7 solid	-	-	-	-	-	-	-	-	-
1 A 2 g 7 gaseous	-	-	-	-	-	-	-	-	-
1 A 2 g 7 other	-	-	-	0.05	0.06	-0.01	0.05	0.06	-0.00

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Differenc e	Subm, 2023	Subm, 2022	Differenc e	Subm, 2023	Subm, 2022	Differenc e
1 A 2 g 7 peat	-	-	-	-	-	-	-	-	-
1 A 2 g 7 biomass	-	-	-	0.95	0.95	-0.01	0.91	0.91	-0.00
1 A 2 g 8 Other Manufacturing Industries	30.82	30.82	-	42.25	42.25	0.00	44.14	44.82	-0.67
1 A 2 g 8 liquid	8.20	8.20	-	2.87	2.87	-	2.09	2.14	-0.05
1 A 2 g 8 solid	0.88	0.88	-	-	-	-	0.00	0.00	0.00
1 A 2 g 8 gaseous	18.30	18.30	-	21.54	21.54	0.00	22.21	22.86	-0.65
1 A 2 g 8 other	0.05	0.05	-	0.52	0.52	-	1.92	1.91	0.01
1 A 2 g 8 peat	-	-	-	-	-	-	-	-	-
1 A 2 g 8 biomass	3.39	3.39	-	17.31	17.31	-	17.92	17.91	0.02
1 A 3 Transport	183.62	183.62	-	343.01	343.09	-0.08	296.70	296.75	-0.05
1 A 3 liquid	179.50	179.50	-	315.67	315.58	0.09	272.68	272.63	0.05
1 A 3 solid	0.07	0.07	-	0.00	0.00	-	0.00	0.00	-
1 A 3 gaseous	4.05	4.05	-	10.50	10.50	-0.00	9.29	9.29	-0.00
1 A 3 other	-	-	-	0.89	0.99	-0.10	0.75	0.81	-0.06
1 A 3 biomass	-	-	-	15.95	16.02	-0.07	13.98	14.03	-0.04
1 A 3 a Domestic Aviation	0.52	0.52	-	0.63	0.63	-	0.32	0.32	-
1 A 3 a aviation gasoline	0.10	0.10	-	0.09	0.09	-	0.08	0.08	-
1 A 3 a jet kerosene	0.42	0.42	-	0.54	0.54	-	0.24	0.24	-
1 A 3 a biomass	-	-	-	-	-	-	-	-	-
1 A 3 b Road Transportation	176.22	176.22	-	329.93	330.01	-0.08	286.33	286.38	-0.05
1 A 3 b gasoline	103.53	103.53	-	64.06	64.06	-	52.49	52.49	-0.00
1 A 3 b diesel oil	72.28	72.28	-	248.21	248.12	0.09	218.27	218.21	0.06
1 A 3 b LPG	0.41	0.41	-	0.22	0.22	-	0.13	0.13	-
1 A 3 b other liquid	-	-	-	-	-	-	-	-	-
1 A 3 b gaseous	-	-	-	0.75	0.75	-0.00	0.80	0.79	0.00
1 A 3 b other	-	-	-	0.88	0.98	-0.10	0.74	0.81	-0.06
1 A 3 b biomass	-	-	-	15.81	15.88	-0.07	13.91	13.95	-0.04
1 A 3 b 1 Cars	116.97	116.97	-0.00	192.80	199.66	-6.86	157.95	163.83	-5.87
1 A 3 b 1 gasoline	97.36	97.36	-0.00	61.22	61.02	0.20	49.84	49.53	0.31
1 A 3 b 1 diesel oil	19.22	19.22	-0.00	122.03	128.09	-6.06	100.09	105.31	-5.22
1 A 3 b 1 LPG	0.39	0.39	-0.00	0.21	0.22	-0.00	0.12	0.13	-0.00
1 A 3 b 1 other liquid	-	-	-	-	-	-	-	-	-
1 A 3 b 1 gaseous	-	-	-	0.08	0.65	-0.58	0.07	0.72	-0.64
1 A 3 b 1 other	-	-	-	0.38	0.45	-0.07	0.31	0.35	-0.05
1 A 3 b 1 biomass	-	-	-	8.89	9.24	-0.35	7.51	7.79	-0.28
1 A 3 b 2 Light duty trucks	13.64	13.64	-	22.23	23.49	-1.26	22.40	19.44	2.96
1 A 3 b 2 gasoline	3.35	3.35	-	0.61	0.65	-0.04	0.62	0.54	0.08
1 A 3 b 2 diesel oil	10.28	10.28	-	20.45	21.61	-1.16	20.62	17.90	2.72
1 A 3 b 2 LPG	0.01	0.01	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 2 other liquid	-	-	-	-	-	-	-	-	-
1 A 3 b 2 gaseous	-	-	-	0.02	-	0.02	0.02	-	0.02
1 A 3 b 2 other	-	-	-	0.06	0.08	-0.01	0.06	0.06	0.00
1 A 3 b 2 biomass	-	-	-	1.08	1.15	-0.07	1.08	0.94	0.14
1 A 3 b 3 Heavy duty trucks and buses	44.78	44.78	0.00	112.57	104.36	8.21	103.84	100.56	3.28
1 A 3 b 3 gasoline	1.99	1.99	0.00	0.00	0.00	-	0.00	0.00	-
1 A 3 b 3 diesel oil	42.79	42.79	0.00	105.73	98.43	7.31	97.55	95.00	2.55

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference
1 A 3 b 3 LPG	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 3 other liquid	-	-	-	-	-	-	-	-	-
1 A 3 b 3 gaseous	-	-	-	0.65	0.09	0.56	0.71	0.08	0.63
1 A 3 b 3 other	-	-	-	0.44	0.46	-0.02	0.37	0.39	-0.02
1 A 3 b 3 biomass	-	-	-	5.74	5.38	0.36	5.21	5.09	0.12
1 A 3 b 4 Motorcycles	0.84	0.84	-	2.34	2.50	-0.16	2.15	2.56	-0.41
1 A 3 b 4 gasoline	0.84	0.84	-	2.23	2.38	-0.15	2.03	2.43	-0.39
1 A 3 b 4 diesel oil	-	-	-	-	-	-	-	-	-
1 A 3 b 4 LPG	-	-	-	-	-	-	-	-	-
1 A 3 b 4 other liquid	-	-	-	-	-	-	-	-	-
1 A 3 b 4 gaseous	-	-	-	-	-	-	-	-	-
1 A 3 b 4 other	-	-	-	-	-	-	-	-	-
1 A 3 b 4 biomass	-	-	-	0.11	0.11	-0.01	0.11	0.13	-0.02
1 A 3 b 5 Other (please specify)	-	-	-	-	-	-	-	-	-
1 A 3 b 5 gasoline	-	-	-	-	-	-	-	-	-
1 A 3 b 5 diesel oil	-	-	-	-	-	-	-	-	-
1 A 3 b 5 LPG	-	-	-	-	-	-	-	-	-
1 A 3 b 5 other liquid	-	-	-	-	-	-	-	-	-
1 A 3 b 5 gaseous	-	-	-	-	-	-	-	-	-
1 A 3 b 5 other	-	-	-	-	-	-	-	-	-
1 A 3 b 5 biomass	-	-	-	-	-	-	-	-	-
1 A 3 c Railways	2.38	2.38	-	1.31	1.31	-0.00	1.14	1.14	-0.00
1 A 3 c liquid	2.31	2.31	-	1.24	1.24	0.00	1.08	1.07	0.00
1 A 3 c solid	0.07	0.07	-	0.00	0.00	-	0.00	0.00	-
1 A 3 c gaseous	-	-	-	-	-	-	-	-	-
1 A 3 c other	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 3 c biomass	-	-	-	0.06	0.06	-0.00	0.05	0.05	-0.00
1 A 3 d Domestic Navigation	0.37	0.37	-	1.18	1.18	-0.00	0.33	0.33	-0.00
1 A 3 d residual oil	-	-	-	-	-	-	-	-	-
1 A 3 d gas/diesel oil	0.25	0.25	-	1.03	1.03	0.00	0.22	0.22	0.00
1 A 3 d gasoline	0.13	0.13	-	0.09	0.09	-	0.09	0.09	-
1 A 3 d other liquid	-	-	-	-	-	-	-	-	-
1 A 3 d gaseous	-	-	-	-	-	-	-	-	-
1 A 3 d other	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 3 d biomass	-	-	-	0.06	0.06	-0.00	0.02	0.02	-0.00
1 A 3 e Other Transportation	4.11	4.11	-	9.95	9.95	-	8.58	8.58	-0.00
1 A 3 e liquid	0.06	0.06	-	0.19	0.19	-	0.09	0.09	-0.00
1 A 3 e solid	-	-	-	-	-	-	-	-	-
1 A 3 e gaseous	4.05	4.05	-	9.75	9.75	-	8.49	8.49	-0.00
1 A 3 e other	-	-	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e biomass	-	-	-	0.01	0.01	-	0.00	0.00	-0.00
1 A 3 e 1 Pipeline Transport	4.05	4.05	-	9.74	9.74	-	8.49	8.49	-
1 A 3 e 1 liquid	-	-	-	-	-	-	-	-	-
1 A 3 e 1 solid	-	-	-	-	-	-	-	-	-
1 A 3 e 1 gaseous	4.05	4.05	-	9.74	9.74	-	8.49	8.49	-
1 A 3 e 1 other	-	-	-	-	-	-	-	-	-
1 A 3 e 1 biomass	-	-	-	-	-	-	-	-	-

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference
1 A 3 e 2 Other (please specify)	0.06	0.06	-	0.21	0.21	-	0.09	0.10	-0.00
1 A 3 e 2 liquid	0.06	0.06	-	0.19	0.19	-	0.09	0.09	-0.00
1 A 3 e 2 solid	-	-	-	-	-	-	-	-	-
1 A 3 e 2 gaseous	-	-	-	0.01	0.01	-	0.00	0.00	-0.00
1 A 3 e 2 other	-	-	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 biomass	-	-	-	0.01	0.01	-	0.00	0.00	-0.00
1 A 4 Other Sectors	249.32	249.32	-	216.58	216.58	-0.00	216.75	216.08	0.67
1 A 4 liquid	109.16	109.16	-	57.53	57.52	0.00	58.35	58.20	0.14
1 A 4 solid	28.12	28.12	-	0.85	0.85	-	0.60	0.87	-0.27
1 A 4 gaseous	46.46	46.46	-	76.69	76.69	-	76.11	75.38	0.73
1 A 4 other	1.11	1.11	-	0.13	0.14	-0.00	0.04	0.04	-0.00
1 A 4 peat	0.00	0.00	-	-	-	-	-	-	-
1 A 4 biomass	64.46	64.46	-	81.37	81.38	-0.00	81.66	81.59	0.07
1 A 4 a Commercial/Institutional	35.39	35.39	-	26.52	26.52	-	25.13	25.35	-0.23
1 A 4 a liquid	18.66	18.66	-	6.24	6.24	-	6.00	6.29	-0.29
1 A 4 a solid	0.96	0.96	-	-	-	-	-	-	-
1 A 4 a gaseous	12.60	12.60	-	16.11	16.11	-	15.15	15.07	0.08
1 A 4 a other	1.11	1.11	-	0.10	0.10	-	0.01	0.01	-
1 A 4 a peat	-	-	-	-	-	-	-	-	-
1 A 4 a biomass	2.06	2.06	-	4.07	4.07	-	3.97	3.98	-0.01
1 A 4 a 1 Stationary combustion	35.39	35.39	-	26.52	26.52	-	25.13	25.35	-0.23
1 A 4 a 1 liquid	18.66	18.66	-	6.24	6.24	-	6.00	6.29	-0.29
1 A 4 a 1 solid	0.96	0.96	-	-	-	-	-	-	-
1 A 4 a 1 gaseous	12.60	12.60	-	16.11	16.11	-	15.15	15.07	0.08
1 A 4 a 1 other	1.11	1.11	-	0.10	0.10	-	0.01	0.01	-
1 A 4 a 1 peat	-	-	-	-	-	-	-	-	-
1 A 4 a 1 biomass	2.06	2.06	-	4.07	4.07	-	3.97	3.98	-0.01
1 A 4 b Residential	193.30	193.30	-	171.13	171.14	-0.00	172.68	171.69	0.99
1 A 4 b liquid	74.79	74.79	-	40.28	40.28	0.00	41.20	40.77	0.43
1 A 4 b solid	26.62	26.62	-	0.83	0.83	-	0.58	0.85	-0.27
1 A 4 b gaseous	33.50	33.50	-	59.49	59.49	-	60.05	59.38	0.66
1 A 4 b other	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 4 b peat	0.00	0.00	-	-	-	-	-	-	-
1 A 4 b biomass	58.40	58.40	-	70.53	70.53	-0.00	70.85	70.69	0.17
1 A 4 b 1 Stationary combustion	191.02	191.02	-	169.63	169.63	-	171.20	170.21	0.99
1 A 4 b 1 liquid	72.50	72.50	-	38.84	38.84	-	39.80	39.36	0.43
1 A 4 b 1 solid	26.62	26.62	-	0.83	0.83	-	0.58	0.85	-0.27
1 A 4 b 1 gaseous	33.50	33.50	-	59.49	59.49	-	60.05	59.38	0.66
1 A 4 b 1 other	-	-	-	-	-	-	-	-	-
1 A 4 b 1 peat	0.00	0.00	-	-	-	-	-	-	-
1 A 4 b 1 biomass	58.40	58.40	-	70.46	70.46	-	70.78	70.61	0.17
1 A 4 b 2 Mobile combustion	2.29	2.29	-	1.51	1.51	-0.00	1.48	1.48	-0.00
1 A 4 b 2 liquid	2.29	2.29	-	1.44	1.44	0.00	1.41	1.41	0.00
1 A 4 b 2 biomass	-	-	-	0.07	0.07	-0.00	0.07	0.07	-0.00
1 A 4 b 2 other	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 4 c Agriculture/Forestry/Fishing	20.63	20.63	-	18.93	18.93	-0.00	18.94	19.04	-0.10
1 A 4 c liquid	15.71	15.71	-	11.01	11.00	0.00	11.14	11.14	0.00
1 A 4 c solid	0.55	0.55	-	0.02	0.02	-	0.02	0.02	-0.00

	Fuel Consumption [PJ]								
	1990			2019			2020		
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Differenc e	Subm, 2023	Subm, 2022	Differenc e	Subm, 2023	Subm, 2022	Differenc e
1 A 4 c gaseous	0.37	0.37	-	1.09	1.09	-	0.91	0.92	-0.01
1 A 4 c other	-	-	-	0.03	0.04	-0.00	0.03	0.04	-0.00
1 A 4 c peat	-	-	-	-	-	-	-	-	-
1 A 4 c biomass	4.01	4.01	-	6.78	6.78	-0.00	6.84	6.92	-0.08
1 A 4 c 1 Stationary combustion	10.26	10.26	-	7.47	7.47	-	7.35	7.45	-0.10
1 A 4 c 1 liquid	5.34	5.34	-	0.16	0.16	-	0.17	0.17	-0.00
1 A 4 c 1 solid	0.55	0.55	-	0.02	0.02	-	0.02	0.02	-0.00
1 A 4 c 1 gaseous	0.37	0.37	-	1.09	1.09	-	0.91	0.92	-0.01
1 A 4 c 1 other	-	-	-	-	-	-	-	-	-
1 A 4 c 1 peat	-	-	-	-	-	-	-	-	-
1 A 4 c 1 biomass	4.01	4.01	-	6.20	6.20	-	6.26	6.34	-0.08
1 A 4 c 2 Mobile combustion	10.37	10.37	-	11.46	11.46	-0.00	11.59	11.59	-0.00
1 A 4 c 2 gasoline	0.42	0.42	-	0.38	0.38	-	0.36	0.36	0.00
1 A 4 c 2 diesel oil	9.95	9.95	-	10.46	10.46	0.00	10.62	10.61	0.00
1 A 4 c 2 LPG	-	-	-	-	-	-	-	-	-
1 A 4 c 2 other liquid	-	-	-	-	-	-	-	-	-
1 A 4 c 2 gaseous	-	-	-	-	-	-	-	-	-
1 A 4 c 2 other	-	-	-	0.03	0.04	-0.00	0.03	0.04	-0.00
1 A 4 c 2 biomass	-	-	-	0.58	0.58	-0.00	0.58	0.59	-0.00
1 A 5 Other	0.48	0.48	-	0.47	0.47	-0.00	0.46	0.46	-
1 A 5 liquid	0.48	0.48	-	0.47	0.47	0.00	0.45	0.45	0.00
1 A 5 solid	-	-	-	-	-	-	-	-	-
1 A 5 gaseous	-	-	-	-	-	-	-	-	-
1 A 5 other	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 5 peat	-	-	-	-	-	-	-	-	-
1 A 5 biomass	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 5 a Stationary combustion	-	-	-	-	-	-	-	-	-
1 A 5 a liquid	-	-	-	-	-	-	-	-	-
1 A 5 a solid	-	-	-	-	-	-	-	-	-
1 A 5 a gaseous	-	-	-	-	-	-	-	-	-
1 A 5 a other	-	-	-	-	-	-	-	-	-
1 A 5 a peat	-	-	-	-	-	-	-	-	-
1 A 5 a biomass	-	-	-	-	-	-	-	-	-
1 A 5 b Mobile combustion - Military	0.48	0.48	-	0.47	0.47	-0.00	0.46	0.46	-
1 A 5 b liquid	0.48	0.48	-	0.47	0.47	0.00	0.45	0.45	0.00
1 A 5 b biomass	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 5 b other	-	-	-	0.00	0.00	-0.00	0.00	0.00	-0.00
Memo - International Aviation	12.10	12.10	-	40.03	40.03	-	14.38	14.38	-
aviation gasoline	-	-	-	-	-	-	-	-	-
jet kerosene	12.10	12.10	-	40.03	40.03	-	14.38	14.38	-
biomass	-	-	-	-	-	-	-	-	-
Memo - International Navigation	0.62	0.62	-	0.61	0.61	-	0.57	0.57	-
residual oil	-	-	-	-	-	-	-	-	-
gas/diesel oil	0.62	0.62	-	0.61	0.61	-	0.57	0.57	-
gasoline	-	-	-	-	-	-	-	-	-
other liquid	-	-	-	-	-	-	-	-	-
gaseous	-	-	-	-	-	-	-	-	-
other	-	-	-	-	-	-	-	-	-

	Fuel Consumption [PJ]								
		1990			2019			2020	
IPCC Category / Fuel Group	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference	Subm, 2023	Subm, 2022	Difference
biomass	-	-	-	-	-	-	-	-	-

A "-" indicates that no recalculations were carried out or recalculations are lower than ± 0.005 TJ (mostly due to rounding) .

Methodology

CO_2 emissions from *1.A Fuel Combustion* have been calculated using the IPCC Tier 2 methodology while for N_2O and CH_4 emissions the Tier 1 methodology has been applied. The fuel consumption based on the energy balance is multiplied with source specific emission factors for CO_2, CH_4 and N_2O. Sector specific considerations and emission factors are described in the related sub chapters of Chapter *3 Energy* of the NIR.

Activity data is taken from the national energy balance as described in the following sub chapters. Data of the national energy balance is presented in Annex 4.

The National Energy Balance

There are five different IEA questionnaires for each of: oil; natural gas; coal; renewable fuels; electricity and heat. Table A 52 shows the unified categories of the IEA questionnaires with ISIC codes and the corresponding SNAP and IPCC categories to which the fuel consumption is assigned to.

Data of the national energy balance is presented in Annex 4.

Table A 52: Categories of the national energy balance (JQ 2020) and their correspondence to IPCC categories.

IEA-Category and ISIC Codes[(2)]	Comments	SNAP	IPCC-Category
Production			Reference Approach: Production
Imports			Reference Approach: Import
Exports			Reference Approach: Export
Bunkers	No consumption [(1)]		
Stock Changes			Reference Approach: Stock Change
Refinery Fuel		0103	1 A 1 b Petroleum Refining
Transformation Sector, of which:			
Public Electricity plants	In the inventory plant specific data are considered.	0101 0102	1 A 1 a Public Electricity and Heat Production
Public CHP plants			
Public Heat plants			
Auto Producer Electricity plants	For autoproducers by sectors see table below.		
Auto Producer CHP plants			
Auto Producer Heat plants			
Coke Ovens	Transformation from *Coking Coal* to *Coke Oven Coke*.		
Blast furnaces	Coke Oven Coke.	030326	1 A 2 a Iron and Steel
Gas Works	Transformation of *Other Oil Products* to *Gas Works Gas*.		
Petrochemical Industry	No consumption [(1)]		
Patent Fuel Plants	No consumption [(1)]		
Not Elsewhere Specified	No consumption [(1)]		
Energy Sector, of which (ISIC 10, 11, 12, 23, 40):			
Coal Mines	No consumption [(1)]		
Oil and Gas Extraction		0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Inputs to oil refineries		0103	1 A 1 b Petroleum Refining
Coke Ovens	*Coke Oven Gas* and *Blast Furnace Gas*.	0301	1 A 2 a Iron and Steel

IEA-Category and ISIC Codes[2]	**Comments**	**SNAP**	**IPCC-Category**
Blast furnaces	*Coke Oven Coke*.	030326	1 A 2 a Iron and Steel
Gas Works	*Natural Gas. Other liquid fuels*.	0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Electricity, CHP and Heat Plants		0101	1 A 1 a Public Electricity and Heat Production
Liquefaction Plants	No consumption [1]		
Not Elsewhere Specified	No consumption [1]		
Distribution Losses	Includes statistical differences and therefore it may be less than zero.		
Final Energy Consumption			
Total Transport, of which (ISIC 60, 61, 62):			
Domestic Air Transport Road Rail Inland Waterways	Division to SNAP categories is performed by means of studies.	07 08 0201	1 A 2 f Manuf. Ind. and Constr. -Other 1 A 3 Transport 1 A 4 b Residential 1 A 4 c Agriculture/ Forestry/ Fisheries
Pipeline Transport	*Natural Gas*.	010506	1 A 3 e Transport-Other
Non Specified	*Other biofuels* and *Lubricants*.	0201	1 A 4 a Commercial/ Institutional
Total Industry, of which:			
Iron and Steel (ISIC 271, 2731)		0301 030301 030326	1 A 2 a Iron and Steel
Chemical incl.Petro-Chemical (ISIC 24)		0301	1 A 2 c Chemicals
Non ferrous Metals (ISIC 272, 2732)		0301	1 A 2 b Non-ferrous Metals
Non metallic Mineral Products (ISIC 26)		0301 030311 030317 030319	1 A 2 Non-metallic minerals
Transportation Equipment (ISIC 34, 35)		0301	1 A 2 g Manuf. Ind. and Constr. –Other
Machinery (ISIC 28, 29, 30, 31, 32)		0301	1 A 2 g Manuf. Ind. and Constr. –Other
Mining and Quarrying (ISIC 13, 14)		0105	1 A 2 g Manuf. Ind. and Constr. –Other
Food, Beverages and Tobacco (ISIC 15, 16)		0301	1 A 2 e Food Processing, Beverages and Tobacco
Pulp, Paper and Printing (ISIC 21, 22)		0301	1 A 2 d Pulp, Paper and Print
Wood and Wood Products (ISIC 20)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Construction (ISIC 45)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Textiles and Leather (ISIC 17, 18, 19)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Non Specified (ISIC 25, 33, 36, 37)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Total Other sectors, of which:			
Commercial and Public Services (ISIC 41, 50, 51, 52, 55, 63, 64, 65, 66, 67, 70, 71, 72, 73, 74, 75, 80, 85, 90, 91, 92, 93, 99)		0201	1 A 4 a Commercial/ Institutional
Residential (ISIC 95)		0202	1 A 4 b Residential
Agriculture (ISIC 01, 02, 05)		0203	1 A 4 c Agriculture/Forestry/ Fisheries
Non Specified	No consumption [1]		

(1) *Indicates that no fuel consumption is reported in the energy balance for the specific category. In some cases this may be interpreted as "included elsewhere" if the energy statistic has lack of detailed sectoral data.*

(2) *Sector names may differ to original IEA questionnaire naming convention. Note that the ISIC Revised 4 codes cited in this table are consistent with the NACE Revison 2 nomenclature.*

Table A 53: Categories of the national energy balance (since 2013) and their correspondence to IPCC categories: Autoproducers by sector.

Auto Producers (Electricity + CHP + Heat), of which:			
Energy Sector, of which:			
Coal Mines	No consumption (1)		
Oil and Gas Extraction		0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Inputs to oil refineries		0103	1 A 1 b Petroleum Refining
Coke Ovens	No consumption (1)		
Gas Works	No consumption (1)		
Liquefaction Plants	No consumption (1)		
Not Elsewhere Specified	No consumption (1)		
Industrie, of which:			
Iron and Steel		030326	1 A 2 a Iron and Steel
Chemical (incl.Petro-Chemical)		0301	1 A 2 c Chemicals
Non ferrous Metals		0301	1 A 2 b Non-ferrous Metals
Non metallic Mineral Products		0301	1 A 2 f Non-metallic minerals
Transportation Equipment		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Machinery		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Mining and Quarrying		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Food, Beverages and Tobacco		0301	1 A 2 e Food Processing, Beverages and Tobacco
Pulp, Paper and Printing		0301	1 A 2 d Pulp, Paper and Print
Wood and Wood Products		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Construction		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Textiles and Leather		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Non Specified (Industry)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Total Transport, of which			
Pipeline Transport	No consumption (1)		
Non Specified	No consumption (1)		
Other Sectors, of which			
Commercial and Public Services		0201	1 A 4 a Commercial/ Institutional
Residential	No consumption (1)		
Agriculture	No consumption (1)		
Non Specified	No consumption (1)		

(1) Indicates that no fuel consumption is reported in the energy balance for the specific category. In some cases this may be interpreted as "included elsewhere" if the energy statistic has lack of detailed sectoral data.

Fuels and Fuel Categories

The units used in the national fuel statistics are: *ton* for solid or liquid fuels and *cubic meter* for gaseous fuels. To convert these units into the caloric unit *Joule* the calorific value of each fuel category has to be quantified. These calorific values are specified in the unit *Joule per Mass or Volume Unit,* e.g. MJ/kg, MJ/m³ gas.

Each fuel has chemical and physical characteristics which influence its burning performance e.g. calorific value or carbon and sulphur content. Fuel categories are formed to pool fuels of the same characteristics in fuel groups. Limitations are given by the fuel categories of the energy balance. A list of the inventory fuel categories and their correspondence to IPCC-fuel categories is shown in Table A 54.

Table A 54: Fuel categories used for the inventory and correspondence to IPCC fuel categories.

	Inventory Fuel Category	**IEA Fuel Category**		**IPCC Fuel Category(3)**
Code (1)	**Category**	**Category**	**Average Net Calorific Value(2)**	
102 A	Hard Coal	Bituminous Coal and Anthracite	28.97	Solid (coal)
104 A	Hard Coal Briquettes	Patent Fuel	31.00	Solid (coal)
105 A	Brown Coal	Lignite/Brown Coal	21.33	Solid (coal)

	Inventory Fuel Category	IEA Fuel Category		IPCC Fuel Category[3]
Code [1]	Category	Category	Average Net Calorific Value[2]	
106 A	Brown Coal Briquettes	BKB/PB	19.80	Solid (coal)
107 A	Coke	Coke Oven Coke	28.48	Solid (coal)
113 A	Peat	Peat	0.00	Solid
304 A	Coke Oven Gas	Coke Oven Gas	17.01	Solid
305 A	Blast Furnace Gas	Blast Furnace Gas	3.65	Solid
110 A	Petrol Coke	Petrol Coke	31.56	Liquid
203 B	Light Fuel Oil Sulphur Content < 0,2 %			
203 C	Medium Fuel Oil Sulphur Content < 0,4%	Residual Fuel Oil	41.66	Liquid (residual oil)
203 D	Heavy Fuel Oil Sulphur Content >= 1%			
204 A	Gasoil	Heating and other Gasoil	42.70	Liquid (gas/diesel oil)
205 0	Diesel	Transport Diesel	42.37	Liquid (diesel oil; gas/diesel oil)
206 A	Petroleum	Other Kerosene	43.35	Liquid
206 B	Kerosene	Kerosene Type Jet Fuel	43.38	Liquid (jet kerosene)
207 A	Aviation Gasoline	Gasoline Type Jet Fuel	44.10	Liquid (aviation gasoline)
208 0	Motor Gasoline	Motor Gasoline	41.64	Liquid (gasoline)
224 A	Other Petroleum Products	Other Products	46.13	Liquid
303 A	Liquified Petroleum Gas (LPG)	LPG	46.12	Liquid
308 A	Refinery Gas	Refinery Gas	30.32	Liquid
301 A	Natural Gas	Natural Gas	36.64	Gaseous (natural gas)
114 B	Municipal Waste	Municipal Solid Waste- Renewable	[4]10.35	Other Fuels
		Municipal Solid Waste-Non Renewable	[4]10.35	Other Fuels
115 A	Industrial Waste	Industrial Wastes	17.22	Other Fuels
111 A	Fuel Wood	*Wood/Wood wastes/Other Solid Wastes, of which:* Wood	14.31	Biomass
112 A	Char Coal	Char coal	28.50	Biomass
116 A	Wood Wastes, Wood Chips, Pellets, Straw.	*Wood/Wood wastes/Other Solid Wastes, of which:* Other vegetal materials and waste (including straw, sawdust, wood chips)	6.40	Biomass
118 A	Sewage Sludge (dry substance)	*Wood/Wood wastes/Other Solid Wastes, of which:* Other vegetal materials and waste (including straw, sawdust, wood chips)	12.00	Biomass
215 A	Black Liquor	*Wood/Wood wastes/Other Solid Wastes, of which:* Black Liquor	[4]9.21	Biomass
309 A	Biogas	Biogas	[4]26.89	Biomass
309 B	Sewage Sludge Gas	Sewage Sludge Gas	[4]23.89	Biomass
310 A	Landfill Gas	Landfill Gas	[4]13.10	Biomass

(1) *First three digits are based on CORINAIR / NAPFUE 94–Code*

(2) *Units: [MJ / kg] or [MJ / m^3 Gas] respectively, for the Year 2020. Note that for some fuels sector specific calorific values are taken. The energy balance reports some fuels (e.g. renewables) in [TJ] so that unit conversion by means of calorific values is not necessary.*

(3) *Fuel subcategories are shown in parenthesis*

(4) *Heating value of transformation input.*

Energy Consumption and CO_2 Emissions by Sectors and Fuel Types

The following tables show detailed data on fuel consumption and CO_2 emissions for each fuel type and each sector of *1 A Fuel Combustion* are provided for the period from 1990 to 2020. For information on completeness, in particular on CO_2 emissions included elsewhere, please refer to the documentation boxes of the CRF and to Chapter 3.2.8 chapter *Completeness* of the NIR.

Table A 55: 2021 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans-port	Other Sectors	Total	Energy Ind.	Industry	Trans-port	Other Sectors	Total
	Total Solid		**13.53**	**0.00**	**0.66**	**14.19**		**1.28**	**0.00**	**0.06**	**1.34**
102A	Hard Coal		4.07	0.00	0.08	4.15		0.38	0.00	0.01	0.38
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal		1.22		0.04	1.26		0.12		0.00	0.12
106A	Brown Coal Briquettes				0.24	0.24				0.02	0.02
107A	Coke		0.30		0.26	0.56		0.03		0.02	0.06
113A	Peat										
304A	Coke Oven Gas		7.93			7.93		0.75			0.75
	Total Liquid	**31.06**	**23.48**	**284.62**	**63.97**	**403.13**	**2.34**	**1.77**	**21.24**	**4.77**	**30.11**
110A	Petrol Coke	2.34	1.40			3.74	0.24	0.13			0.37
203B	Light Fuel Oil	0.53	0.77		0.83	2.13	0.04	0.06		0.06	0.16
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil		0.35			0.35		0.03			0.03
204A	Gasoil	1.04	1.59		49.12	51.76	0.08	0.12		3.68	3.88
2050	Diesel	0.00	17.94	227.86	11.11	256.91	0.00	1.34	16.96	0.83	19.12
206A	Other Kerosene										
206B	Jet Kerosene			0.60		0.60			0.05		0.05
207A	Aviation Gasoline			0.08		0.08			0.01		0.01
2080	Motor Gasoline		0.13	55.92	0.97	57.02		0.01	4.22	0.07	4.30
224A	Other Petroleum Products	17.39	0.09			17.47	1.36	0.01			1.36
303A	Liquified Petroleum Gas (LPG)	0.80	1.22	0.16	1.94	4.11	0.05	0.08	0.01	0.12	0.26
308A	Refinery Gas	8.96				8.96	0.57				0.57
301A	**Total Gaseous (Natural Gas)**	**96.28**	**122.29**	**7.50**	**85.74**	**311.81**	**5.35**	**6.80**	**0.42**	**4.77**	**17.34**
	Total Other Fuel	**23.05**	**12.25**	**0.77**	**0.04**	**36.12**	**1.05**	**0.95**	**0.06**	**0.00**	**2.06**
114B	Municipal Waste	21.54				21.54	0.94				0.94
115A	Industrial Waste	1.51	12.19		0.01	13.71	0.11	0.94		0.00	1.06
225A	FAME		0.06	0.77	0.04	0.87		0.00	0.06	0.00	0.07
	Total Biomass(1)	**57.95**	**64.04**	**14.55**	**92.11**	**228.66**	**(6.23)**	**(6.57)**	**(1.03)**	**(10.26)**	**(24.09)**
111A	Fuel Wood				64.39	64.39				7.21	7.21
112A	Char Coal	0.04			0.46	0.50				0.05	0.05
116A	Wood Wastes	53.03	33.26		26.12	112.41	5.94	3.73		2.93	12.59
118A	Sewage Sludge	0.34	0.73			1.07	0.04	0.08			0.12
215A	Black Liquor		27.16			27.16		2.59			2.59
250A	Liquid Biofuels		1.02	14.55	0.65	16.22		0.07	1.03	0.05	1.15
309A	Biogas	4.43	0.66	0.01	0.28	5.39	0.24	0.04	0.00	0.02	0.29
309B	Sewage Sludge Gas	0.09	1.21		0.18	1.47	0.00	0.07		0.01	0.08
310A	Landfill Gas	0.02			0.03	0.04	0.00			0.00	0.00
	Total(1)		**13.53**	**0.00**	**0.66**	**14.19**		**1.28**	**0.00**	**0.06**	**1.34**

(1) *CO_2 emissions of Biomass are not included in Total.*

Table A 56: 2020 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	**Industry**	**Trans-port**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Trans-port**	**Other Sectors**	**Total**
	Total Solid	**3.86**	**14.76**	**0.00**	**0.60**	**19.21**	**0.36**	**1.39**	**0.00**	**0.06**	**1.80**
102A	Hard Coal	3.86	5.63	0.00	0.08	9.57	0.36	0.52	0.00	0.01	0.88
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal		1.35		0.03	1.38		0.13		0.00	0.13
106A	Brown Coal Briquettes				0.20	0.20				0.02	0.02
107A	Coke		0.32		0.25	0.58		0.03		0.02	0.06
113A	Peat										
304A	Coke Oven Gas		7.46			7.46		0.71			0.71
	Total Liquid	**30.40**	**21.34**	**273.13**	**58.35**	**383.23**	**2.30**	**1.60**	**20.38**	**4.35**	**28.62**
110A	Petrol Coke	2.25	0.63			2.88	0.23	0.06			0.29
203B	Light Fuel Oil	0.57	1.55		0.01	2.13	0.04	0.12		0.00	0.17
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	0.13	0.28			0.41	0.01	0.02			0.03
204A	Gasoil	0.14	1.08		44.23	45.45	0.01	0.08		3.32	3.41
2050	Diesel	0.00	16.46	219.67	11.41	247.54	0.00	1.23	16.35	0.85	18.42
206A	Other Kerosene										
206B	Jet Kerosene			0.67		0.67			0.05		0.05
207A	Aviation Gasoline			0.08		0.08			0.01		0.01
2080	Motor Gasoline		0.12	52.59	0.97	53.68		0.01	3.97	0.07	4.05
224A	Other Petroleum Products	18.48	0.09			18.57	1.44	0.01			1.45
303A	Liquified Petroleum Gas (LPG)	0.21	1.13	0.13	1.73	3.20	0.01	0.07	0.01	0.11	0.20
308A	Refinery Gas	8.61				8.61	0.55				0.55
301A	**Total Gaseous (Natural Gas)**	**90.17**	**119.07**	**9.29**	**76.11**	**294.64**	**5.01**	**6.62**	**0.52**	**4.23**	**16.38**
	Total Other Fuel	**22.63**	**11.64**	**0.75**	**0.04**	**35.06**	**1.02**	**0.79**	**0.06**	**0.00**	**1.87**
114B	Municipal Waste	21.58				21.58	0.94				0.94
115A	Industrial Waste	1.05	11.59		0.01	12.65	0.08	0.79		0.00	0.87
225A	FAME		0.05	0.75	0.04	0.83		0.00	0.06	0.00	0.06
	Total Biomass[(1)]	**57.97**	**63.11**	**13.99**	**81.66**	**216.73**	**(6.10)**	**(6.45)**	**(0.99)**	**(9.09)**	**(22.63)**
111A	Fuel Wood		0.01		57.52	57.54		0.00		6.44	6.44
112A	Char Coal	0.04			0.45	0.49				0.05	0.05
116A	Wood Wastes	50.49	30.61		22.55	103.65	5.65	3.43		2.53	11.61
118A	Sewage Sludge	0.59	0.81			1.40	0.07	0.09			0.16
215A	Black Liquor		29.20			29.20		2.78			2.78
250A	Liquid Biofuels		0.91	13.98	0.65	15.54		0.06	0.99	0.05	1.10
309A	Biogas	6.73	0.75	0.01	0.29	7.78	0.37	0.04	0.00	0.02	0.42
309B	Sewage Sludge Gas	0.08	0.84		0.17	1.09	0.00	0.05		0.01	0.06
310A	Landfill Gas	0.03			0.01	0.05	0.00			0.00	0.00
	Total[(1)]	**205.03**	**229.93**	**297.16**	**216.75**	**948.87**	**8.69**	**10.40**	**20.95**	**8.64**	**48.67**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 57: 2019 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	**Industry**	**Trans-port**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Trans-port**	**Other Sectors**	**Total**
	Total Solid	**12.49**	**14.24**	**0.00**	**0.85**	**27.59**	**1.16**	**1.34**	**0.00**	**0.08**	**2.58**
102A	Hard Coal	12.49	5.51	0.00	0.29	18.30	1.16	0.50	0.00	0.03	1.69
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal		1.60		0.03	1.63		0.15		0.00	0.16
106A	Brown Coal Briquettes				0.20	0.20				0.02	0.02
107A	Coke		0.33		0.30	0.63		0.04		0.03	0.06
113A	Peat										
304A	Coke Oven Gas		6.80			6.80		0.64			0.64
	Total Liquid	**31.10**	**22.75**	**316.14**	**57.53**	**427.52**	**2.33**	**1.71**	**23.59**	**4.29**	**31.92**
110A	Petrol Coke	2.09	0.95			3.04	0.21	0.09			0.30
203B	Light Fuel Oil	0.43	1.96		0.02	2.42	0.03	0.15		0.00	0.19
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	0.00	0.27			0.27	0.00	0.02			0.02
204A	Gasoil	0.26	1.05		43.52	44.83	0.02	0.08		3.26	3.36
2050	Diesel	0.00	17.14	250.68	11.26	279.08	0.00	1.28	18.65	0.84	20.77
206A	Other Kerosene										
206B	Jet Kerosene			0.98		0.98			0.07		0.07
207A	Aviation Gasoline			0.09		0.09			0.01		0.01
2080	Motor Gasoline		0.13	64.16	1.03	65.32		0.01	4.84	0.08	4.93
224A	Other Petroleum Products	18.06	0.12			18.18	1.41	0.01			1.42
303A	Liquified Petroleum Gas (LPG)	0.84	1.14	0.22	1.71	3.91	0.05	0.07	0.01	0.11	0.25
308A	Refinery Gas	9.42				9.42	0.60				0.60
301A	**Total Gaseous (Natural Gas)**	**99.56**	**122.25**	**10.50**	**76.69**	**309.00**	**5.54**	**6.80**	**0.58**	**4.26**	**17.18**
	Total Other Fuel	**22.08**	**11.03**	**0.89**	**0.13**	**34.13**	**1.03**	**0.84**	**0.07**	**0.01**	**1.95**
114B	Municipal Waste	19.80				19.80	0.86				0.86
115A	Industrial Waste	2.28	10.97		0.10	13.36	0.17	0.84		0.01	1.02
225A	FAME		0.05	0.89	0.03	0.98		0.00	0.07	0.00	0.07
	Total Biomass[(1)]	**55.49**	**65.04**	**15.95**	**81.37**	**217.85**	**(5.82)**	**(6.63)**	**(1.13)**	**(9.06)**	**(22.64)**
111A	Fuel Wood		0.01		57.43	57.44		0.00		6.43	6.43
112A	Char Coal	0.04			0.45	0.49				0.05	0.05
116A	Wood Wastes	47.99	31.05		22.39	101.43	5.38	3.48		2.51	11.36
118A	Sewage Sludge	0.63	1.11			1.74	0.07	0.12			0.20
215A	Black Liquor		29.96			29.96		2.85			2.85
250A	Liquid Biofuels		0.95	15.93	0.65	17.53		0.07	1.13	0.05	1.24
309A	Biogas	6.65	0.83	0.01	0.31	7.80	0.36	0.05	0.00	0.02	0.43
309B	Sewage Sludge Gas	0.14	1.13		0.14	1.41	0.01	0.06		0.01	0.08
310A	Landfill Gas	0.03			0.02	0.05	0.00			0.00	0.00
	Total[(1)]	**220.72**	**235.31**	**343.48**	**216.58**	**1 016.09**	**10.06**	**10.69**	**24.24**	**8.64**	**53.63**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 58: 2018 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	**Industry**	**Transport**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Transport**	**Other Sectors**	**Total**
	Total Solid	**14.78**	**14.23**	**0.00**	**0.84**	**29.86**	**1.37**	**1.33**	**0.00**	**0.08**	**2.78**
102A	Hard Coal	14.78	6.14	0.00	0.28	21.21	1.37	0.56	0.00	0.03	1.95
104A	Hard Coal Briquettes				0.05	0.05				0.00	0.00
105A	Brown Coal		1.69		0.03	1.72		0.16		0.00	0.17
106A	Brown Coal Briquettes				0.26	0.26				0.02	0.02
107A	Coke		0.30		0.23	0.53		0.03		0.02	0.05
113A	Peat										
304A	Coke Oven Gas		6.10			6.10		0.58			0.58
	Total Liquid	**32.21**	**21.51**	**315.09**	**57.28**	**426.08**	**2.44**	**1.62**	**23.50**	**4.27**	**31.83**
110A	Petrol Coke	2.16	1.22			3.38	0.22	0.12			0.33
203B	Light Fuel Oil	1.02	1.44		0.34	2.80	0.08	0.11		0.03	0.22
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil		0.27			0.27		0.02			0.02
204A	Gasoil	0.13	0.89		43.55	44.58	0.01	0.07		3.27	3.34
2050	Diesel	0.00	16.26	249.26	10.68	276.20	0.00	1.21	18.54	0.79	20.54
206A	Other Kerosene										
206B	Jet Kerosene			0.99		0.99			0.07		0.07
207A	Aviation Gasoline			0.10		0.10			0.01		0.01
2080	Motor Gasoline		0.12	64.40	1.07	65.59		0.01	4.86	0.08	4.95
224A	Other Petroleum Products	20.11	0.09			20.21	1.57	0.01			1.58
303A	Liquified Petroleum Gas (LPG)	0.26	1.20	0.34	1.65	3.45	0.02	0.08	0.02	0.11	0.22
308A	Refinery Gas	8.52				8.52	0.55				0.55
301A	**Total Gaseous (Natural Gas)**	**91.96**	**123.20**	**11.29**	**72.62**	**299.08**	**5.09**	**6.83**	**0.63**	**4.02**	**16.57**
	Total Other Fuel	**21.99**	**12.14**	**0.93**	**0.13**	**35.20**	**1.04**	**0.92**	**0.07**	**0.01**	**2.04**
114B	Municipal Waste	19.44				19.44	0.84				0.84
115A	Industrial Waste	2.55	12.09		0.09	14.74	0.19	0.92		0.01	1.12
225A	FAME		0.05	0.93	0.03	1.02		0.00	0.07	0.00	0.08
	Total Biomass(1)	**58.35**	**64.57**	**16.45**	**80.01**	**219.37**	**(6.09)**	**(6.60)**	**(1.16)**	**(8.91)**	**(22.77)**
111A	Fuel Wood		0.01		56.69	56.71		0.00		6.35	6.35
112A	Char Coal	0.04			0.43	0.47				0.05	0.05
116A	Wood Wastes	50.06	31.12		21.77	102.95	5.61	3.49		2.44	11.53
118A	Sewage Sludge	0.65	1.05			1.70	0.07	0.12			0.19
215A	Black Liquor		29.79			29.79		2.84			2.84
250A	Liquid Biofuels		0.92	16.43	0.63	17.98		0.06	1.16	0.04	1.27
309A	Biogas	7.38	0.91	0.01	0.34	8.64	0.40	0.05	0.00	0.02	0.47
309B	Sewage Sludge Gas	0.19	0.78		0.08	1.05	0.01	0.04		0.00	0.06
310A	Landfill Gas	0.03			0.05	0.08	0.00			0.00	0.00
	Total(1)	**219.29**	**235.65**	**343.76**	**210.88**	**1 009.59**	**9.94**	**10.70**	**24.20**	**8.38**	**53.22**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 59: 2017 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	**Industry**	**Trans-port**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Trans-port**	**Other Sectors**	**Total**
	Total Solid	**14.55**	**14.92**	**0.00**	**0.98**	**30.46**	**1.34**	**1.39**	**0.00**	**0.09**	**2.83**
102A	Hard Coal	14.55	7.29	0.00	0.23	22.08	1.34	0.66	0.00	0.02	2.02
104A	Hard Coal Briquettes				0.12	0.12				0.01	0.01
105A	Brown Coal		1.53		0.04	1.57		0.15		0.00	0.15
106A	Brown Coal Briquettes				0.27	0.27				0.03	0.03
107A	Coke		0.38		0.32	0.70		0.04		0.03	0.07
113A	Peat										
304A	Coke Oven Gas		5.72			5.72		0.54			0.54
	Total Liquid	**34.02**	**21.77**	**312.22**	**63.06**	**431.07**	**2.57**	**1.65**	**23.35**	**4.71**	**32.27**
110A	Petrol Coke	1.84	1.26			3.10	0.19	0.12			0.30
203B	Light Fuel Oil	0.12	2.26		0.70	3.08	0.01	0.18		0.05	0.24
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	2.57	1.15			3.71	0.20	0.09			0.29
204A	Gasoil	0.12	0.32		48.88	49.32	0.01	0.02		3.67	3.70
2050	Diesel	0.00	15.20	248.73	10.62	274.55	0.00	1.13	18.50	0.79	20.42
206A	Other Kerosene										
206B	Jet Kerosene			0.95		0.95			0.07		0.07
207A	Aviation Gasoline			0.10		0.10			0.01		0.01
2080	Motor Gasoline		0.11	61.96	1.08	63.16		0.01	4.74	0.08	4.84
224A	Other Petroleum Products	19.91	0.30			20.21	1.55	0.02			1.58
303A	Liquified Petroleum Gas (LPG)	0.96	1.17	0.48	1.77	4.39	0.06	0.08	0.03	0.11	0.28
308A	Refinery Gas	8.50				8.50	0.54				0.54
301A	**Total Gaseous (Natural Gas)**	**104.38**	**120.07**	**12.16**	**77.61**	**314.21**	**5.78**	**6.65**	**0.67**	**4.30**	**17.41**
	Total Other Fuel	**22.87**	**11.83**	**0.85**	**0.12**	**35.68**	**1.09**	**0.90**	**0.06**	**0.01**	**2.07**
114B	Municipal Waste	19.85				19.85	0.86				0.86
115A	Industrial Waste	3.02	11.79		0.08	14.89	0.23	0.90		0.01	1.13
225A	FAME		0.05	0.85	0.03	0.94		0.00	0.06	0.00	0.07
	Total Biomass[(1)]	**62.26**	**65.57**	**16.28**	**86.57**	**230.68**	**(6.36)**	**(6.70)**	**(1.15)**	**(9.64)**	**(23.85)**
111A	Fuel Wood		0.01		62.21	62.22		0.00		6.97	6.97
112A	Char Coal	0.03			0.38	0.42				0.04	0.04
116A	Wood Wastes	50.88	33.01		22.77	106.66	5.70	3.70		2.55	11.95
118A	Sewage Sludge	0.72	0.51			1.23	0.08	0.06			0.14
215A	Black Liquor		28.96			28.96		2.76			2.76
250A	Liquid Biofuels		0.84	16.28	0.62	17.74		0.06	1.15	0.04	1.26
309A	Biogas	10.40	0.81	0.01	0.41	11.63	0.57	0.04	0.00	0.02	0.63
309B	Sewage Sludge Gas	0.19	1.43		0.10	1.72	0.01	0.08		0.01	0.09
310A	Landfill Gas	0.04	0.00		0.07	0.10	0.00	0.00		0.00	0.01
	Total[(1)]	**238.08**	**234.16**	**341.53**	**228.33**	**1 042.10**	**10.78**	**10.59**	**24.09**	**9.11**	**54.57**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 60: 2016 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans-port	Other Sectors	Total	Energy Ind.	Industry	Trans-port	Other Sectors	Total
	Total Solid	**16.91**	**13.33**	**0.00**	**0.89**	**31.14**	**1.59**	**1.22**	**0.00**	**0.08**	**2.89**
102A	Hard Coal	16.91	6.12	0.00	0.13	23.17	1.59	0.53	0.00	0.01	2.13
104A	Hard Coal Briquettes				0.12	0.12				0.01	0.01
105A	Brown Coal		1.66		0.03	1.69		0.16		0.00	0.16
106A	Brown Coal Briquettes				0.19	0.19				0.02	0.02
107A	Coke		0.37		0.43	0.80		0.04		0.04	0.08
113A	Peat										
304A	Coke Oven Gas		5.18			5.18		0.49			0.49
	Total Liquid	**36.68**	**22.03**	**303.22**	**61.51**	**423.44**	**2.81**	**1.67**	**22.68**	**4.60**	**31.76**
110A	Petrol Coke	2.19	1.57			3.75	0.22	0.15			0.37
203B	Light Fuel Oil	0.16	2.78		1.58	4.51	0.01	0.22		0.12	0.35
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	4.26	1.48			5.74	0.34	0.12			0.45
204A	Gasoil	0.02	0.29		46.13	46.44	0.00	0.02		3.46	3.48
2050	Diesel	0.00	14.40	238.94	11.34	264.69	0.00	1.07	17.77	0.84	19.69
206A	Other Kerosene										
206B	Jet Kerosene			1.00		1.00			0.07		0.07
207A	Aviation Gasoline			0.13		0.13			0.01		0.01
2080	Motor Gasoline		0.11	62.64	1.13	63.87		0.01	4.80	0.09	4.89
224A	Other Petroleum Products	22.40	0.32			22.72	1.75	0.02			1.77
303A	Liquified Petroleum Gas (LPG)	1.14	1.10	0.51	1.34	4.09	0.07	0.07	0.03	0.09	0.26
308A	Refinery Gas	6.51				6.51	0.42				0.42
301A	**Total Gaseous (Natural Gas)**	**83.28**	**118.78**	**10.85**	**77.93**	**290.83**	**4.61**	**6.58**	**0.60**	**4.32**	**16.11**
	Total Other Fuel	**24.32**	**11.93**	**0.94**	**0.13**	**37.32**	**1.16**	**0.91**	**0.07**	**0.01**	**2.14**
114B	Municipal Waste	21.17				21.17	0.92				0.92
115A	Industrial Waste	3.15	11.88		0.09	15.12	0.24	0.90		0.01	1.15
225A	FAME		0.05	0.94	0.04	1.03		0.00	0.07	0.00	0.08
	Total Biomass(1)	**59.10**	**66.01**	**17.34**	**84.84**	**227.28**	**(6.03)**	**(6.74)**	**(1.23)**	**(9.44)**	**(23.44)**
111A	Fuel Wood	0.03	0.01		62.07	62.11	0.00	0.00		6.95	6.96
112A	Char Coal	0.04			0.46	0.50				0.05	0.05
116A	Wood Wastes	48.16	33.29		21.01	102.46	5.39	3.73		2.35	11.48
118A	Sewage Sludge	0.70	0.49			1.20	0.08	0.05			0.13
215A	Black Liquor		29.16			29.16		2.78			2.78
250A	Liquid Biofuels		0.87	17.33	0.73	18.93		0.06	1.23	0.05	1.34
309A	Biogas	9.85	0.84	0.01	0.35	11.06	0.54	0.05	0.00	0.02	0.60
309B	Sewage Sludge Gas	0.27	1.34		0.10	1.71	0.01	0.07		0.01	0.09
310A	Landfill Gas	0.04			0.11	0.16	0.00			0.01	0.01
	Total(1)	**220.29**	**232.08**	**332.35**	**225.30**	**1 010.02**	**10.17**	**10.38**	**23.36**	**9.01**	**52.91**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 61: 2015 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans-port	Other Sectors	Total	Energy Ind.	Industry	Trans-port	Other Sectors	Total
	Total Solid	**24.98**	**11.47**	**0.00**	**0.94**	**37.39**	**2.34**	**1.07**	**0.00**	**0.09**	**3.50**
102A	Hard Coal	24.98	6.25	0.00	0.06	31.29	2.34	0.57	0.00	0.01	2.91
104A	Hard Coal Briquettes				0.21	0.21				0.02	0.02
105A	Brown Coal		1.89		0.04	1.93		0.18		0.00	0.19
106A	Brown Coal Briquettes				0.20	0.20				0.02	0.02
107A	Coke		0.44		0.42	0.86		0.05		0.04	0.09
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		2.90			2.90		0.27			0.27
	Total Liquid	**35.91**	**22.16**	**292.20**	**61.32**	**411.59**	**2.72**	**1.68**	**21.80**	**4.58**	**30.79**
110A	Petrol Coke	1.86	1.48			3.34	0.19	0.14			0.33
203B	Light Fuel Oil	0.12	3.02		0.90	4.04	0.01	0.24		0.07	0.31
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	2.99	1.65			4.64	0.24	0.13			0.37
204A	Gasoil	0.12	0.29		47.38	47.79	0.01	0.02		3.55	3.58
2050	Diesel	0.00	14.20	227.17	10.49	251.86	0.00	1.06	16.89	0.78	18.73
206A	Other Kerosene										
206B	Jet Kerosene			1.07		1.07			0.08		0.08
207A	Aviation Gasoline			0.11		0.11			0.01		0.01
2080	Motor Gasoline		0.11	63.29	1.20	64.60		0.01	4.79	0.09	4.89
224A	Other Petroleum Products	21.64	0.30			21.94	1.69	0.02			1.71
303A	Liquified Petroleum Gas (LPG)	0.76	1.11	0.56	1.35	3.78	0.05	0.07	0.04	0.09	0.24
308A	Refinery Gas	8.42				8.42	0.54				0.54
301A	**Total Gaseous (Natural Gas)**	**76.58**	**116.85**	**11.29**	**72.71**	**277.43**	**4.24**	**6.47**	**0.63**	**4.03**	**15.37**
	Total Other Fuel	**22.57**	**10.97**	**1.13**	**0.12**	**34.80**	**1.08**	**0.83**	**0.09**	**0.01**	**2.01**
114B	Municipal Waste	19.35				19.35	0.84				0.84
115A	Industrial Waste	3.23	10.92		0.08	14.23	0.24	0.83		0.01	1.08
225A	FAME		0.05	1.13	0.04	1.22		0.00	0.09	0.00	0.09
	Total Biomass[(1)]	**61.39**	**68.48**	**18.36**	**83.15**	**231.38**	**(6.29)**	**(7.03)**	**(1.30)**	**(9.25)**	**(23.88)**
111A	Fuel Wood	0.03	0.00		60.59	60.63	0.00	0.00		6.79	6.79
112A	Char Coal	0.04			0.43	0.47				0.05	0.05
116A	Wood Wastes	50.44	36.46		20.90	107.80	5.65	4.08		2.34	12.07
118A	Sewage Sludge	0.72	0.53			1.25	0.08	0.06			0.14
215A	Black Liquor		28.40			28.40		2.71			2.71
250A	Liquid Biofuels		0.96	18.35	0.76	20.07		0.07	1.30	0.05	1.42
309A	Biogas	9.94	0.79	0.01	0.28	11.03	0.54	0.04	0.00	0.02	0.60
309B	Sewage Sludge Gas	0.11	1.34		0.09	1.54	0.01	0.07		0.00	0.08
310A	Landfill Gas	0.09			0.09	0.19	0.01			0.01	0.01
	Total[(1)]	**221.44**	**229.93**	**322.99**	**218.23**	**992.59**	**10.38**	**10.07**	**22.52**	**8.70**	**51.66**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 62: 2010 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	**Industry**	**Trans-port**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Trans-port**	**Other Sectors**	**Total**
	Total Solid	**41.47**	**9.39**	**0.00**	**2.90**	**53.77**	**3.87**	**0.88**	**0.00**	**0.27**	**5.02**
102A	Hard Coal	41.47	6.07	0.00	0.28	47.82	3.87	0.56	0.00	0.03	4.45
104A	Hard Coal Briquettes				0.40	0.40				0.04	0.04
105A	Brown Coal		1.57		0.12	1.69		0.15		0.01	0.17
106A	Brown Coal Briquettes				0.59	0.59				0.06	0.06
107A	Coke		0.35		1.51	1.86		0.04		0.14	0.18
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		1.40			1.40		0.13			0.13
	Total Liquid	**38.90**	**29.66**	**293.06**	**77.98**	**439.60**	**2.90**	**2.24**	**21.87**	**5.80**	**32.80**
110A	Petrol Coke	1.75	1.44			3.20	0.18	0.14			0.32
203B	Light Fuel Oil	0.15	4.91		1.79	6.86	0.01	0.38		0.14	0.53
203C	Medium Fuel Oil	1.79				1.79	0.14				0.14
203D	Heavy Fuel Oil	6.43	3.03			9.46	0.51	0.24			0.75
204A	Gasoil	0.11	3.21		59.67	62.98	0.01	0.24		4.47	4.72
2050	Diesel	0.00	14.37	221.34	10.70	246.40	0.00	1.07	16.41	0.79	18.27
206A	Other Kerosene		0.01			0.01		0.00			0.00
206B	Jet Kerosene			1.31		1.31			0.10		0.10
207A	Aviation Gasoline			0.12		0.12			0.01		0.01
2080	Motor Gasoline		0.11	69.40	1.38	70.88		0.01	5.29	0.11	5.41
224A	Other Petroleum Products	15.34	0.52			15.85	1.20	0.04			1.23
303A	Liquified Petroleum Gas (LPG)	1.30	2.07	0.89	4.45	8.71	0.08	0.13	0.06	0.28	0.56
308A	Refinery Gas	12.02				12.02	0.77				0.77
301A	**Total Gaseous (Natural Gas)**	**107.76**	**128.68**	**8.74**	**83.50**	**328.68**	**5.97**	**7.13**	**0.48**	**4.63**	**18.21**
	Total Other Fuel	**17.86**	**11.21**	**0.92**	**0.10**	**30.09**	**0.89**	**0.79**	**0.07**	**0.01**	**1.75**
114B	Municipal Waste	14.38				14.38	0.62				0.62
115A	Industrial Waste	3.48	11.16		0.06	14.70	0.26	0.79		0.00	1.05
225A	FAME		0.05	0.92	0.04	1.01		0.00	0.07	0.00	0.08
	Total Biomass(1)	**55.34**	**66.51**	**15.78**	**86.53**	**224.16**	**(5.89)**	**(6.88)**	**(1.12)**	**(9.64)**	**(23.53)**
111A	Fuel Wood	0.04	0.65		69.13	69.82	0.00	0.07		7.74	7.82
112A	Char Coal	0.04			0.37	0.41				0.04	0.04
116A	Wood Wastes	49.83	34.77		15.93	100.53	5.58	3.89		1.78	11.26
118A	Sewage Sludge	0.22	0.69			0.92	0.03	0.08			0.10
215A	Black Liquor		28.53			28.53		2.72			2.72
250A	Liquid Biofuels		0.80	15.78	0.66	17.24		0.06	1.12	0.05	1.22
309A	Biogas	4.78	0.51	0.00	0.10	5.39	0.26	0.03	0.00	0.01	0.29
309B	Sewage Sludge Gas	0.32	0.55		0.27	1.13	0.02	0.03		0.01	0.06
310A	Landfill Gas	0.12			0.07	0.19	0.01			0.00	0.01
	Total(1)	**261.32**	**245.46**	**318.50**	**251.02**	**1 076.30**	**13.62**	**11.04**	**22.42**	**10.70**	**57.79**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 63: 2005 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans-port	Other Sectors	Total	Energy Ind.	Industry	Trans-port	Other Sectors	Total
	Total Solid	**61.63**	**18.43**	**0.01**	**4.81**	**84.88**	**5.84**	**1.72**	**0.00**	**0.45**	**8.01**
102A	Hard Coal	51.51	7.65	0.01	1.37	60.54	4.81	0.71	0.00	0.13	5.64
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal	10.12	2.54		0.16	12.82	1.04	0.22		0.02	1.27
106A	Brown Coal Briquettes		0.00		1.01	1.01		0.00		0.10	0.10
107A	Coke		1.15		2.23	3.38		0.12		0.21	0.32
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		7.09			7.09		0.67			0.67
	Total Liquid	**45.18**	**30.94**	**326.96**	**105.60**	**508.67**	**3.42**	**2.37**	**24.41**	**7.87**	**38.07**
110A	Petrol Coke	2.07	2.05			4.12	0.21	0.19			0.40
203B	Light Fuel Oil	0.17	7.14		9.23	16.53	0.01	0.56		0.71	1.28
203C	Medium Fuel Oil	2.29	0.00			2.29	0.18	0.00			0.18
203D	Heavy Fuel Oil	11.39	4.14			15.53	0.90	0.32			1.23
204A	Gasoil	0.19	4.94		77.61	82.73	0.01	0.37		5.82	6.21
2050	Diesel	0.01	10.80	240.59	11.74	263.14	0.00	0.80	17.84	0.87	19.52
206A	Other Kerosene		0.02			0.02		0.00			0.00
206B	Jet Kerosene			1.37		1.37			0.10		0.10
207A	Aviation Gasoline			0.12		0.12			0.01		0.01
2080	Motor Gasoline		0.11	83.96	1.65	85.72		0.01	6.40	0.13	6.54
224A	Other Petroleum Products	17.28	0.17			17.45	1.35	0.01			1.36
303A	Liquified Petroleum Gas (LPG)	2.29	1.56	0.93	5.37	10.15	0.15	0.10	0.06	0.34	0.65
308A	Refinery Gas	9.49				9.49	0.61				0.61
301A	**Total Gaseous (Natural Gas)**	**111.68**	**119.92**	**6.49**	**89.65**	**327.73**	**6.19**	**6.64**	**0.36**	**4.97**	**18.16**
	Total Other Fuel	**10.33**	**7.89**	**0.17**	**1.08**	**19.47**	**0.49**	**0.48**	**0.01**	**0.08**	**1.07**
114B	Municipal Waste	8.88				8.88	0.39				0.39
115A	Industrial Waste	1.45	7.88		1.07	10.41	0.11	0.48		0.08	0.67
225A	FAME		0.01	0.17	0.01	0.18		0.00	0.01	0.00	0.01
	Total Biomass[(1)]	**20.46**	**58.24**	**2.20**	**67.64**	**148.53**	**(2.08)**	**(6.00)**	**(0.16)**	**(7.55)**	**(15.79)**
111A	Fuel Wood	0.04	1.14		57.69	58.87	0.00	0.13		6.46	6.59
112A	Char Coal	0.03			0.36	0.39				0.04	0.04
116A	Wood Wastes	16.55	29.10		9.09	54.74	1.85	3.26		1.02	6.13
118A	Sewage Sludge	0.25	0.04			0.29	0.03	0.00			0.03
215A	Black Liquor		26.65			26.65		2.54			2.54
250A	Liquid Biofuels		0.10	2.20	0.11	2.40		0.01	0.16	0.01	0.17
309A	Biogas	2.85	0.43		0.14	3.42	0.16	0.02		0.01	0.19
309B	Sewage Sludge Gas	0.69	0.64		0.06	1.39	0.04	0.04		0.00	0.08
310A	Landfill Gas	0.04	0.15		0.19	0.38	0.00	0.01		0.01	0.02
	Total[(1)]	**249.28**	**235.41**	**335.83**	**268.77**	**1 089.29**	**15.95**	**11.21**	**24.79**	**13.37**	**65.31**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 64: 2000 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans-port	Other Sectors	Total	Energy Ind.	Industry	Trans-port	Other Sectors	Total
	Total Solid	**49.16**	**15.21**	**0.03**	**10.33**	**74.72**	**4.82**	**1.45**	**0.00**	**0.97**	**7.25**
102A	Hard Coal	37.36	10.31	0.03	2.16	49.85	3.53	0.97	0.00	0.20	4.70
104A	Hard Coal Briquettes				0.12	0.12				0.01	0.01
105A	Brown Coal	11.80	1.90		0.64	14.34	1.29	0.18		0.07	1.55
106A	Brown Coal Briquettes		0.00		2.06	2.06		0.00		0.20	0.20
107A	Coke		1.19		5.35	6.54		0.12		0.49	0.62
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		1.81			1.81		0.17			0.17
	Total Liquid	**41.55**	**24.71**	**244.94**	**106.01**	**417.21**	**3.04**	**1.88**	**18.32**	**7.94**	**31.18**
110A	Petrol Coke	1.63	0.81			2.44	0.16	0.08			0.25
203B	Light Fuel Oil	1.81	5.52		15.69	23.02	0.14	0.43		1.21	1.78
203C	Medium Fuel Oil				1.47	1.47				0.11	0.11
203D	Heavy Fuel Oil	13.04	6.59		0.14	19.77	1.04	0.51		0.01	1.56
204A	Gasoil	0.01	1.61		71.98	73.59	0.00	0.12		5.40	5.52
2050	Diesel	0.04	7.32	162.80	11.06	181.22	0.00	0.54	12.07	0.82	13.44
206A	Other Kerosene				0.26	0.26				0.02	0.02
206B	Jet Kerosene			1.37		1.37			0.10		0.10
207A	Aviation Gasoline			0.08		0.08			0.01		0.01
2080	Motor Gasoline		0.11	80.02	1.72	81.84		0.01	6.10	0.13	6.24
224A	Other Petroleum Products	9.74	0.21			9.96	0.76	0.01			0.77
303A	Liquified Petroleum Gas (LPG)	0.94	2.54	0.67	3.70	7.85	0.06	0.16	0.04	0.24	0.50
308A	Refinery Gas	14.33				14.33	0.87				0.87
301A	**Total Gaseous (Natural Gas)**	**74.27**	**111.77**	**6.10**	**73.11**	**265.25**	**4.11**	**6.19**	**0.34**	**4.05**	**14.69**
	Total Other Fuel	**5.46**	**6.25**		**0.56**	**12.27**	**0.29**	**0.38**		**0.04**	**0.71**
114B	Municipal Waste	4.64				4.64	0.23				0.23
115A	Industrial Waste	0.82	6.25		0.56	7.63	0.06	0.38		0.04	0.49
225A	FAME										
	Total Biomass(1)	**8.08**	**40.83**		**69.27**	**118.18**	**(0.90)**	**(4.13)**		**(7.73)**	**(12.76)**
111A	Fuel Wood		0.95		59.22	60.17		0.11		6.63	6.74
112A	Char Coal	0.03			0.31	0.34				0.03	0.03
116A	Wood Wastes	7.67	15.15		9.24	32.05	0.86	1.70		1.03	3.59
118A	Sewage Sludge	0.28				0.28	0.03				0.03
215A	Black Liquor		24.06			24.06		2.29			2.29
250A	Liquid Biofuels										
309A	Biogas	0.00	0.31		0.05	0.36	0.00	0.02		0.00	0.02
309B	Sewage Sludge Gas	0.08	0.36		0.03	0.47	0.00	0.02		0.00	0.03
310A	Landfill Gas	0.01			0.43	0.44	0.00			0.02	0.02
	Total(1)	**178.52**	**198.78**	**251.06**	**259.28**	**887.64**	**12.26**	**9.90**	**18.66**	**13.01**	**53.83**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 65: 1995 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	**Industry**	**Trans-port**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Trans-port**	**Other Sectors**	**Total**
	Total Solid	**45.49**	**15.72**	**0.06**	**18.59**	**79.86**	**4.53**	**1.50**	**0.01**	**1.75**	**7.78**
102A	Hard Coal	29.90	7.45	0.06	4.11	41.52	2.82	0.70	0.01	0.38	3.91
104A	Hard Coal Briquettes										
105A	Brown Coal	15.58	2.29		1.14	19.00	1.71	0.22		0.12	2.05
106A	Brown Coal Briquettes		0.28		3.05	3.32		0.03		0.30	0.32
107A	Coke		0.78		10.30	11.08		0.08		0.95	1.03
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		4.93			4.93		0.47			0.47
	Total Liquid	**46.34**	**33.87**	**205.75**	**107.92**	**393.87**	**3.73**	**2.59**	**15.46**	**8.09**	**29.86**
110A	Petrol Coke	1.87	0.37			2.24	0.19	0.04			0.23
203B	Light Fuel Oil	1.39	11.55		17.79	30.73	0.11	0.90		1.37	2.38
203C	Medium Fuel Oil	0.11	0.00		2.32	2.43	0.01	0.00		0.18	0.19
203D	Heavy Fuel Oil	17.70	13.77		0.46	31.93	1.41	1.07		0.04	2.52
204A	Gasoil	0.09	0.20		70.50	70.80	0.01	0.02		5.29	5.31
2050	Diesel	0.28	4.82	106.98	10.61	122.69	0.02	0.36	7.93	0.79	9.10
206A	Other Kerosene				0.26	0.26				0.02	0.02
206B	Jet Kerosene			1.05		1.05			0.08		0.08
207A	Aviation Gasoline			0.09		0.09			0.01		0.01
2080	Motor Gasoline		0.07	97.13	1.80	99.00		0.01	7.41	0.14	7.55
224A	Other Petroleum Products	8.88	0.21		0.01	9.10	0.69	0.01		0.00	0.71
303A	Liquified Petroleum Gas (LPG)	1.06	2.88	0.49	4.18	8.61	0.07	0.18	0.03	0.27	0.55
308A	Refinery Gas	14.95				14.95	1.23				1.23
301A	**Total Gaseous (Natural Gas)**	**80.70**	**99.58**	**4.09**	**74.06**	**258.43**	**4.47**	**5.52**	**0.23**	**4.10**	**14.32**
	Total Other Fuel	**5.13**	**5.27**		**0.52**	**10.92**	**0.28**	**0.37**		**0.04**	**0.69**
114B	Municipal Waste	3.91				3.91	0.19				0.19
115A	Industrial Waste	1.22	5.27		0.52	7.01	0.09	0.37		0.04	0.50
225A	FAME										
	Total Biomass[(1)]	**4.05**	**35.65**		**69.85**	**109.55**	**(0.45)**	**(3.63)**		**(7.79)**	**(11.86)**
111A	Fuel Wood		1.07		66.28	67.35		0.12		7.42	7.54
112A	Char Coal	0.03			0.28	0.31				0.03	0.03
116A	Wood Wastes	3.77	13.04		2.63	19.44	0.42	1.46		0.29	2.18
118A	Sewage Sludge	0.21				0.21	0.02				0.02
215A	Black Liquor		21.39			21.39		2.04			2.04
250A	Liquid Biofuels										
309A	Biogas		0.04			0.04		0.00			0.00
309B	Sewage Sludge Gas	0.01	0.00		0.61	0.62	0.00	0.00		0.03	0.03
310A	Landfill Gas	0.03	0.12		0.05	0.20	0.00	0.01		0.00	0.01
	Total[(1)]	**181.70**	**190.09**	**209.90**	**270.95**	**852.64**	**13.01**	**9.97**	**15.69**	**13.98**	**52.65**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 66: 1990 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO_2 emissions (Mt)				
		1 A 1	**1 A 2**	**1 A 3 + 1 A 5**	**1 A 4**	**1 A**	**1 A 1**	**1 A 2**	**1 A 3 + 1 A 5**	**1 A 4**	**1 A**
		Energy Ind.	**Industry**	**Trans-port**	**Other Sectors**	**Total**	**Energy Ind.**	**Industry**	**Trans-port**	**Other Sectors**	**Total**
	Total Solid	**61.40**	**23.87**	**0.07**	**28.13**	**113.46**	**6.25**	**2.28**	**0.01**	**2.65**	**11.18**
102A	Hard Coal	38.44	7.17	0.07	5.28	50.96	3.85	0.67	0.01	0.49	5.03
104A	Hard Coal Briquettes										
105A	Brown Coal	22.73	2.19		2.36	27.28	2.37	0.21		0.26	2.84
106A	Brown Coal Briquettes	0.23	1.24		4.45	5.91	0.02	0.12		0.43	0.57
107A	Coke		1.66		16.04	17.69		0.17		1.48	1.65
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		11.61			11.61		1.10			1.10
	Total Liquid	**43.15**	**36.10**	**179.98**	**109.16**	**368.39**	**3.19**	**2.78**	**13.56**	**8.23**	**27.76**
110A	Petrol Coke	1.96	0.96			2.92	0.20	0.10			0.29
203B	Light Fuel Oil	1.61	10.99		33.54	46.14	0.13	0.86		2.58	3.57
203C	Medium Fuel Oil	0.29	0.01		4.47	4.77	0.02	0.00		0.35	0.37
203D	Heavy Fuel Oil	13.67	17.40		1.63	32.71	1.08	1.36		0.13	2.56
204A	Gasoil	0.00	0.06		52.94	53.00	0.00	0.00		3.97	3.97
2050	Diesel	0.01	3.40	74.93	10.80	89.14	0.00	0.25	5.56	0.80	6.61
206A	Other Kerosene				0.74	0.74				0.06	0.06
206B	Jet Kerosene			0.87		0.87			0.06		0.06
207A	Aviation Gasoline			0.10		0.10			0.01		0.01
2080	Motor Gasoline		0.05	103.66	1.85	105.56		0.00	7.91	0.14	8.05
224A	Other Petroleum Products	6.93	0.24		0.87	8.03	0.54	0.02		0.06	0.61
303A	Liquified Petroleum Gas (LPG)	0.41	2.99	0.41	2.32	6.14	0.03	0.19	0.03	0.15	0.39
308A	Refinery Gas	18.28				18.28	1.20				1.20
301A	**Total Gaseous (Natural Gas)**	**76.48**	**76.99**	**4.05**	**46.46**	**203.98**	**4.24**	**4.27**	**0.22**	**2.57**	**11.30**
	Total Other Fuel	**4.66**	**3.22**		**1.11**	**8.99**	**0.29**	**0.21**		**0.08**	**0.58**
114B	Municipal Waste	2.41				2.41	0.12				0.12
115A	Industrial Waste	2.25	3.22		1.11	6.58	0.17	0.21		0.08	0.46
225A	FAME										
	Total Biomass(1)	**1.66**	**29.45**		**64.46**	**95.57**	**(0.18)**	**(3.00)**		**(7.22)**	**(10.40)**
111A	Fuel Wood		0.66		62.46	63.12		0.07		7.00	7.07
112A	Char Coal	0.03			0.22	0.25				0.02	0.02
116A	Wood Wastes	1.44	10.99		1.79	14.22	0.16	1.23		0.20	1.59
118A	Sewage Sludge	0.19				0.19	0.02				0.02
215A	Black Liquor		17.80			17.80		1.70			1.70
250A	Liquid Biofuels										
309A	Biogas										
309B	Sewage Sludge Gas										
310A	Landfill Gas										
	Total(1)	**187.35**	**169.63**	**184.10**	**249.32**	**790.39**	**13.96**	**9.53**	**13.79**	**13.54**	**50.83**

(1) CO_2 emissions of Biomass are not included in Total.

Annex 3.2 – CRF 3 Agriculture – Austria's N-flow model

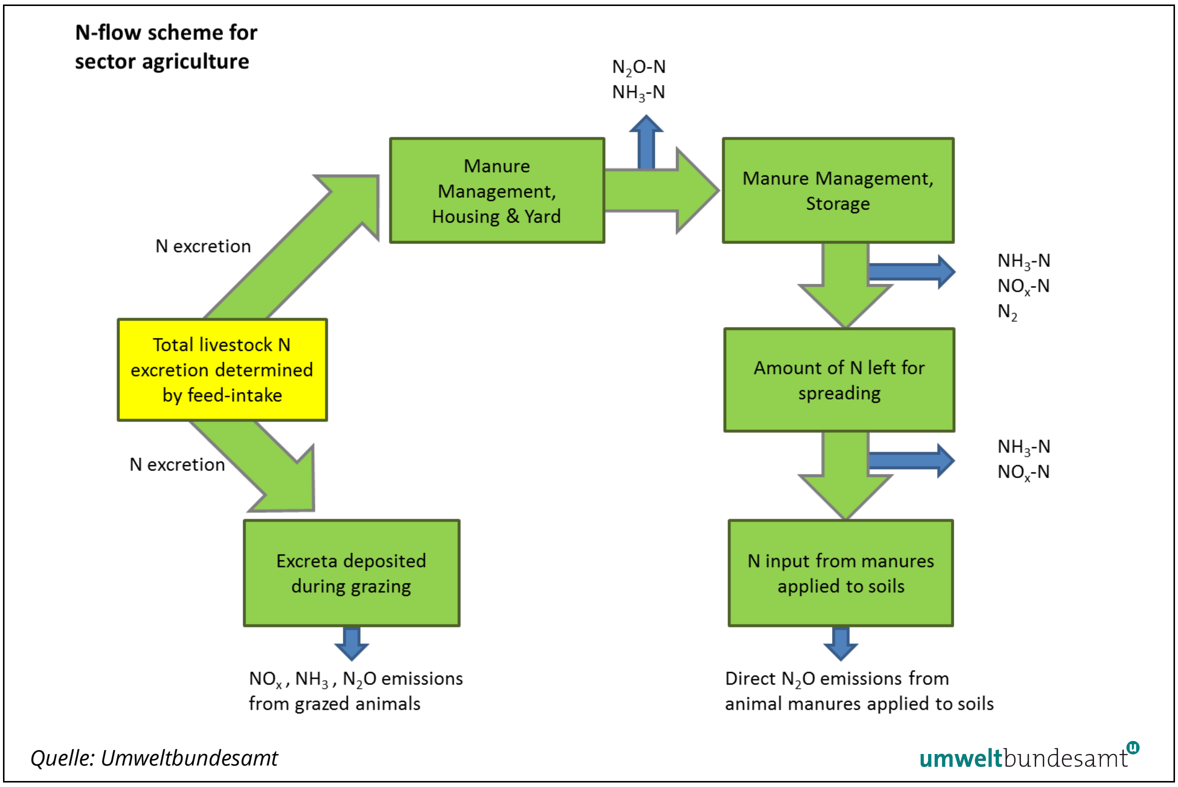
For the calculation of N_2O emissions from agricultural soils Austria uses country specific methods which are consistent with the N-flow approach. The approach used by Austria is more complex than the IPCC method in order to allow for the consideration of the management practices in Austria as those may differ from other countries.

As recommended in the EMEP/EEA Emission Inventory Guidebook 2019 for higher tier methods, NH_3 emissions are calculated on the basis of the amount of total ammoniacal nitrogen (TAN). TAN is present in the urine of animals and considered to be equivalent to the N content of urine. This calculation method is more precise than the calculation on the basis of total N excretion because emissions of NH_3 arise from TAN. The calculation addresses both N pools (N excretion and TAN) for the different stages of manure management (housing -> storage -> spreading) in terms of NH_3, NO_x, N_2O and N_2 emissions and includes information of the total N amount within each relevant stage (N excretion), and the fraction of that amount that is present as TAN. Detailed information on parameters and methods used is provided in Austria's Informative Inventory Report 2023, chapter 5 (UMWELTBUNDESAMT 2023).

The N-flux model used by Austria was developed by the University of Natural Resources and Applied Life Sciences, Vienna, on behalf of the Environment Agency Austria in 2001 and has been regularly further developed (AMON et al. 2002, 2008 & 2010), (AMON & HÖRTENHUBER 2014) and (AMON & HÖRTENHUBER 2019). In submission 2020 the N flow model has been further enhanced according to the EMEP/EEA Guidebook 2019.

The following figure illustrates the pathways of N in the calculation of N-species emissions from the N excreted by livestock.

Figure 1: Schematic diagram of the Austrian N flow (animal manure)



For the calculation of N_2O emissions occurring from N-input from manures applied to soils, the chain beginning with the feeding, the housing, the transfer to the storage, the transfer to the application machine and finally the spreading to the fields is relevant. All those emissions are accounted at the appropriate stage of the process.

Feeding

In the first step, N excretion for a given animal category is determined on the basis of national feed-intake data.

Grazing

In the second step the resulting N amount relating to the share excreted on pasture is subtracted based on the proportion of time spent on pasture. Following the 2006 IPCC Guidelines, N_2O emissions resulting from nitrogen input through excretions of grazing animals (directly dropped onto the soil) are calculated under *Manure Management* but reported under *Agricultural Soils*.

Housing:

For each animal category, the amount of N accruing from the housing is split based on the relative share of animal-housing systems used in Austria. These systems vary in terms of their emission behaviour (e.g. tied and loose housing systems, liquid versus solid manure systems).

Indirect N_2O emissions from manure management systems

Nitrogen losses begin at the point of excretion and continue through on-site management in storage and treatment systems. Further nitrogen can be lost through runoff and leaching into soils from the solid storage of manure at outdoor areas (not occurring in Austria). The indirect N_2O emissions from volatilization of N in forms of NH_3 and NO_x are estimated following the IPCC Tier 2 methodology. The country specific value of $Frac_{GasMS}$ includes NH_3-N losses from housing, storage, yard and NO_x-N losses from manure management calculated within the Austrian N-flow model.

Storage:

The remaining N is then transferred to the different storage systems used in Austria (e.g. covered or uncovered storage).

For all stages of manure NH_3 emissions are calculated in proportion to the available TAN amount. Emission factors for cattle and swine were derived from the Swiss DYNAMO-model, peer reviewed by the EAGER group and published in (REIDY et al. 2008, 2009). For the non-key livestock categories sheep, goats, horses, poultry and deer the EMEP/EEA default Tier 2 NH_3-N EF and associated parameters have been applied (EEA 2019).

N losses from manure management resulting from emissions of N_2O, NO_x and N_2 are calculated on the basis of N excretion per AWMS, jointly for housing and storage, as recommended by the IPCC guidelines. Throughout the inventory the same MMS distribution is used.

Application on agricultural soils

Remaining amounts of animal manure nitrogen ("N left for spreading") are available for soil application.

Direct N_2O-emissions

Following the 2006 IPCC guidelines for calculation of direct N_2O emissions from soils amounts of applied fertilizers are no longer adjusted for the amounts of NH_3 and NO_x volatilization after application to soils (see below).

NH_3 and NO_X emissions

NH_3 and NO_x emissions are calculated according to different application procedures (broadcast spreading, band spreading) resulting in different N-losses. In particular, volatile NH_3-N losses of cattle and swine manure are subtracted from the TAN content per animal category; volatile losses from NO_x are subtracted from the N amount per animal category available for spreading.

Indirect N_2O emissions from leaching and run-off from managed soils

Calculation basis is the nitrogen amount available for application on soils ("N left for spreading") as a result from the Austrian N-flow model. This amount is multiplied with the country-specific value of $Frac_{LEACH}$.

Results of a country specific study of the Institute for Land & Water Management Research Petzenkirchen (Federal Agency for Water Management) in cooperation with the Institute of Hydraulic Engineering and Water Resources Management (Vienna University of Technology) (EDER et al. 2015) determine a value of 15.154% for the fraction of leaching and run-off from nitrogen additions to Austria's managed soils. The peer reviewed study used 22 lysimeters covering a wide range of soils, climatic conditions and management practices in Austria to evaluate an Austria-specific value of $Frac_{LEACH}$.

Indirect N_2O emissions from atmospheric deposition of N volatised from managed soils

Basis for emission calculation are the country specific volatilization losses (NH_3-N and NO_x-N) occurring during animal grazing and manure application.

References

UMWELTBUNDESAMT (2023): Anderl, M.; Brendle, C.; Colson, J.; Gangl, M.; Makoschitz, L.; Mayer, S.; Pazdernik, K.; Poupa, S.; Purzner, M.; Reiterer, D.; Roll, M.; Schieder, W.; Schmidt, G.; Stranner, G.; Wieser, M.; Wankmüller & Zechmeister, A.: Austria's Informative Inventory Report 2023. Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Reports, DRAFT, Wien.

AMON, B. et al. (2002, 2008 & 2010): not published final reports on the revision of Austria's Air Emissions Inventory, Sector Agriculture. Vienna.

AMON, B. & HÖRTENHUBER, S. (2014): Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien 2014 (unveröffentlicht).

AMON, B. & HÖRTENHUBER, S. (2019): Implementierung der TIHALO II Ergebnisse sowie des EMEP/EEA Guidbooks 2016 in das Landwirtschafts-Emissionsmodell für die OLI 2018. Endbericht. Priv. Doz. Dr. nat. techn. Barbara Amon und Dr. nat. techn. Stefan Hörtenhuber (Forschungsinstitut für Biologischen Landbau FiBL) im Auftrag vom Umweltbundesamt. Wien 2019 (unveröffentlicht).

EAGER: European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

EDER, A., FEICHTINGER, F., STRAUSS, P. & BLÖSCHL G. (2013): Calculation of nitrogen leaching values for the annual greenhouse gas inventory of Austria – Evaluation of long term lysimeter time series. Federal Agency for Water Management, Institute for Land and Water Management Research, Petzenkirchen, and Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria.

REIDY et al. (2008, 2009): Comparisons of models used for national agricultural ammonia emission inventories in Europe. Atmospheric Environment, Band 42 and Band 43.

Annex 3.3 – CO_2 Reference Approach

This annex presents the results, methodology and detailed data for the CO_2 reference approach.

Methodology

The default methodology is applied.

Emission factors

Carbon emission factors

For estimation of emissions that arise from combustion of fossil fuels, the default carbon emission factors described in chapter 1.4.1.1 of the IPCC 1996 Reference Manual have been used (IPCC Workbook 1.6 table 1-2) except for natural gas and coal, where country specific values have been used.

Fraction of carbon oxidised

Default values of table 1-6 of the IPCC 1996 Reference Manual have been used for coal and biomass. For liquid fuels and natural gas 100% combustion efficiency is assumed. Selected values are presented Table A 71.

Activity data

Production, Imports, Exports, Stock Change

Activity data are taken from the national energy balance (IEA JQ 2022) (see Annex 2 and Annex 4). The reference approach requires more detailed fuel categories than provided in the national energy balance. Some fuel categories are aggregations of the detailed fuel categories the reference approach asks for. The following fuel types are included elsewhere:

- Ethane is included in Refinery Feedstocks.

Conversion factors

For the most important solid and liquid fuels country specific conversion factors in the unit TJ/Gg are selected. Selected values are presented below.

International Bunkers

International bunkers are relevant for aviation and international navigation on rivers (mostly Danube), the Neusiedler Lake and the Lake Constance.

Fuel consumption of international bunkers is consistent with memo item international bunkers as described in the relevant chapter for Category *1.A.3*.

Carbon Stored (C excluded)

A high amount of residual fuel oil is considered as a reductant in blast furnaces (CRF 2.C.1).

Naphta is used as feedstock for ethylen production in petrochemical plants.

Non-energy use of Bitumen is considered to be 100% stored (e.g. as Asphalt concrete).

The share of Petroleum coke which is used for calcium carbide production is considered to be 100% stored.

Non energy use of other oil products is considered to be 100% stored.

A high amount of other bituminous coal is considered as a reductant in blast furnaces (CRF 2.C.1).

A high amount of Coke oven coke is considered as a reductant in blast furnaces (CRF 2.C.1).

Coal tar imports are considered as a reductant in blast furnaces (CRF 2.C.1).

Natural gas used for Ammonia production is excluded from the RA and emissions are reported under CRF 2.B.1

A share of waste plastics are considered as a reductant in blast furnaces (CRF 2.C.1).

In the Sectoral Approach, the release of stored carbon as emissions is considered as quoted in the NIR, chapter *3.4 Feedstock*.

Recalculations

Activity data

Imports, Exports and Production are updated according to the new version of the energy balance (IEA JQ 2022). Changes of activity data are based on energy balance recalculations.

Revised Methodology

Since submission 2021, the reference approach considers energy balance data of pure fossil diesel and gasoline while in previous submissions blended biofuels were included in those fuel data.

Because of the exclusion of blended biofuels from motor diesel and gasoline, these fuels are now included in 'liquid biomass'.

Double counting of coal tar in the reference approach has been removed.

The carbon content of waste non-biomass fraction in the reference approach has been harmonized with the sectoral approach.

Results of the Reference Approach

Table A 67 to Table A 72 present calculation results, apparent fuel consumption, carbon stored, international bunker fuels, conversion factors, carbon emission factors and the fraction of carbon oxidised for all fuel types of the Reference Approach.

Table A 67 presents the calculation results for each fuel type of the Reference Approach for selected years.

Table A 67: Actual CO_2 emissions (kt CO_2) for selected years.

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Crude Oil	24 784	25 694	27 249	24 056	26 754	26 289	27 591	25 134	27 956	28 438
Orimulsion	0	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	110	287	209	360	217	468	141	99	48	43
Gasoline	-248	488	910	1 012	217	-462	-349	-350	-832	-1 054
Jet Kerosene	-846	-1 588	-1 737	-1 398	-1 934	-1 714	-1 920	-1 815	-2 267	-2 683
Other Kerosene	-44	16	-2	-1	0	0	-1	-1	-1	-1
Shale Oil	0	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	1 755	7 093	13 476	12 954	10 916	10 304	10 676	12 350	12 005	11 585
Residuel Fuel Oil	650	399	-373	-539	-1 227	-1 440	-1 494	-949	-1 224	-1 124
LPG	249	398	329	296	60	27	-163	-17	-104	-152
Ethane	0	0	0	0	0	0	0	0	0	0
Naphtha	-1 357	-1 828	-1 474	-2 257	-3 200	-3 087	-2 974	-2 544	-3 255	-3 155

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Bitumen	-907	-1 207	-1 234	-986	-1 056	-1 060	-979	-1 033	-1 244	-1 332
Lubricants	155	-173	-216	-182	73	59	55	69	53	53
Petroleum Coke	97	82	207	140	160	154	149	127	123	95
Refinery Feedstocks	3 019	1 620	873	357	92	328	-211	682	132	978
OtherOil	432	-26	-193	-620	-74	-25	43	24	41	36
Liquid Fossil Totals	**27 849**	**31 254**	**38 023**	**33 193**	**30 998**	**29 840**	**30 564**	**31 775**	**31 432**	**31 727**
Anthracite	40	7	12	8	3	4	10	212	164	55
Coking Coal	7 004	5 626	5 625	4 709	4 542	4 551	4 615	4 711	4 637	4 631
Other Bit. Coal	4 713	4 809	5 808	4 559	3 874	2 861	2 984	1 761	1 877	1 682
Sub- Bit. Coal	0	79	137	141	152	178	171	135	144	138
Lignite	2 729	1 319	1 205	13	10	7	11	13	15	3
Oil Shale	0	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	548	198	96	78	51	39	31	31	73	21
Coke Oven / Gas Coke	-3 269	-3 383	-3 565	-3 923	-3 760	-3 667	-3 664	-3 424	-3 650	-3 269
Coal Tar	0	-143	-1	-2	66	64	-140	-117	-121	-122
Solid Fossil Totals	**11 766**	**8 512**	**9 318**	**5 583**	**4 938**	**4 038**	**4 018**	**3 322**	**3 140**	**3 139**
Gaseous Fossil	11 417	14 791	18 293	18 366	15 954	14 476	15 523	17 570	16 720	17 350
Waste (non-biomass fraction)	580	714	1 059	1 678	1 757	1 886	1 919	1 995	1 964	1 879
Peat	0	0	0	0	0	0	0	0	0	0
Fossil Totals	**51 612**	**55 270**	**66 693**	**58 820**	**53 647**	**50 240**	**52 024**	**54 663**	**53 255**	**54 095**
Biomass Totals	**9 270**	**11 550**	**14 694**	**22 203**	**23 114**	**22 408**	**23 125**	**23 295**	**21 954**	**21 832**
Solid Biomass	9 197	11 254	13 584	19 354	20 142	18 546	19 035	19 710	18 708	18 640
Liquid Biomass	19	51	382	1 775	1 714	2 083	2 286	1 692	1 748	1 735
Gas Biomass	0	140	544	730	878	1 305	1 353	1 428	1 042	985
Other non-fossil fuels (biogenic waste)	**55**	**105**	**184**	**344**	**380**	**475**	**450**	**465**	**456**	**472**

Table A 68 presents the apparent fuel consumption for each fuel type of the Reference Approach.

Table A 68: Apparent Consumption (TJ) for selected years.

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Crude Oil	337 960	350 367	371 572	328 037	364 825	358 484	376 237	342 734	381 225	387 788
Orimulsion	0	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	1 743	4 550	3 315	5 711	3 438	7 421	2 238	1 564	754	684
Gasoline	-3 203	7 140	13 229	14 663	3 204	-6 604	-4 992	-5 008	-11 963	-15 170
Jet Kerosene	-11 826	-22 204	-24 294	-19 558	-27 053	-23 967	-26 852	-25 380	-31 710	-37 521
Other Kerosene	-610	217	110	50	34	30	24	34	30	24
Shale Oil	0	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	23 699	95 763	181 950	174 902	147 382	139 114	144 138	166 738	162 087	156 411
Residuel Fuel Oil	13 243	14 769	4 898	1 420	-10 696	-13 847	-18 355	-12 268	-15 822	-14 532
LPG	3 943	6 307	5 210	4 696	1 772	1 856	-1 420	105	-1 012	-1 740
Ethane	0	0	0	0	0	0	0	0	0	0
Naphtha	90	0	1 230	89	-8 289	-7 543	-6 515	-6 678	-8 657	190
Bitumen	11 328	10 643	7 878	7 219	4 155	5 203	5 993	5 888	5 250	4 326
Lubricants	5 506	-84	-1 278	-972	2 075	1 593	1 506	1 881	1 443	1 432
Petroleum Coke	2 881	2 069	3 313	3 246	2 538	2 683	1 918	2 132	1 922	1 188
Refinery Feedstocks	41 163	22 090	11 900	4 873	1 255	4 467	-2 876	9 294	1 802	13 332
OtherOil	6 646	393	-1 487	-7 462	1 204	1 697	2 449	2 376	2 687	2 612
Liquid Fossil Totals	**432 562**	**492 018**	**577 546**	**516 913**	**485 845**	**470 588**	**473 493**	**483 411**	**488 037**	**499 025**
Anthracite	448	84	142	99	42	62	131	2 245	1 749	612
Coking Coal	67 937	54 564	55 252	53 630	51 915	51 431	51 356	51 470	50 841	50 979
Other Bit. Coal	50 568	51 604	62 304	53 439	48 215	38 183	55 150	43 657	40 400	39 020
Sub- Bit. Coal	0	844	1 451	1 499	1 612	1 892	1 811	1 433	1 527	1 465
Lignite	27 294	13 188	11 861	132	99	76	114	135	159	30
Oil Shale	0	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	5 912	2 134	1 032	838	546	421	333	338	792	226
Coke Oven / Gas Coke	19 304	30 110	36 977	33 751	35 737	34 924	29 222	33 649	21 730	29 943

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Coal Tar	0	-1 810	91	36	1 600	1 605	-1 759	-1 474	-1 526	-1 409
Solid Fossil Totals	**171 462**	**150 718**	**169 112**	**143 424**	**139 766**	**128 595**	**136 357**	**131 454**	**115 670**	**120 865**
Gaseous Fossil	219 239	275 836	338 534	340 091	295 610	270 778	289 239	325 584	308 256	321 403
Waste (non-biomass fraction)	8 073	10 509	16 654	25 649	26 514	26 843	27 899	28 605	27 142	26 372
Peat	4	4	4	4	4	4	4	0	0	0
Fossil Totals	**831 340**	**929 086**	**1 101 850**	**1 026 082**	**947 739**	**896 808**	**926 992**	**969 053**	**939 105**	**967 666**
Biomass Totals	**96 503**	**120 409**	**153 723**	**236 337**	**245 599**	**239 084**	**246 781**	**247 395**	**233 978**	**232 789**
Solid Biomass	95 324	116 649	140 804	200 603	208 770	192 229	197 301	204 295	193 909	193 204
Liquid Biomass	262	720	4 882	23 313	22 456	27 007	29 600	22 294	22 933	22 701
Gas Biomass	0	1 275	4 961	6 663	8 006	11 899	12 341	13 021	9 505	8 983
Other non-fossil fuels (biogenic waste)	**917**	**1 765**	**3 076**	**5 758**	**6 366**	**7 949**	**7 540**	**7 784**	**7 631**	**7 901**

Table A 69 presents the carbon stored for each fuel type of the Reference Approach.

Table A 69: Carbon Stored (kt C) for selected years

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Crude Oil	0	0	0	0	0	0	0	0	0	0
Orimulsion	0	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	0	0	0	0	0	0	0	0	0	0
Gasoline	7	2	2	1	1	1	1	1	1	1
Jet Kerosene	0	0	0	0	0	0	0	0	0	0
Other Kerosene	0	0	3	1	1	1	1	1	1	1
Shale Oil	0	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	0	0	0	0	0	0	0	0	0	0
Residuel Fuel Oil	102	203	205	177	109	100	20	0	0	0
LPG	0	0	0	0	14	24	20	6	11	12
Ethane	0	0	0	0	0	0	0	0	0	0
Naphtha	372	499	427	617	707	691	681	560	715	864
Bitumen	497	563	510	428	380	403	399	411	455	458
Lubricants	68	46	33	30	21	16	15	19	14	14
Petroleum Coke	53	35	35	51	26	32	12	24	19	7
Refinery Feedstocks	0	0	0	0	0	0	0	0	0	0
OtherOil	15	15	23	20	44	41	37	41	43	42
Liquid Fossil Totals	**1 113**	**1 362**	**1 237**	**1 326**	**1 303**	**1 310**	**1 186**	**1 063**	**1 258**	**1 399**
Anthracite	1	0	0	0	0	1	1	1	1	1
Coking Coal	37	30	56	52	61	54	38	17	19	26
Other Bit. Coal	0	0	0	116	153	186	597	622	512	535
Sub- Bit. Coal	0	0	0	0	0	0	0	0	0	0
Lignite	0	0	0	0	0	0	0	0	0	0
Oil Shale	0	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	0	0	0	0	0	0	0	0	0	0
Coke Oven / Gas Coke	1 475	1 823	2 067	2 092	2 101	2 070	1 904	1 980	1 676	1 822
Coal Tar	0	0	2	1	17	18	0	0	0	3
Solid Fossil Totals	**1 513**	**1 853**	**2 123**	**2 260**	**2 315**	**2 310**	**2 539**	**2 620**	**2 209**	**2 385**
Gaseous Fossil	199	134	126	130	115	143	137	127	97	142
Waste (non-biomass fraction)	0	0	0	51	32	31	31	28	10	19
Peat	0	0	0	0	0	0	0	0	0	0
Fossil Totals	**2 825**	**3 349**	**3 486**	**3 716**	**3 734**	**3 763**	**3 862**	**3 811**	**3 564**	**3 925**
Biomass Totals	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Solid Biomass	0	0	0	0	0	0	0	0	0	0
Liquid Biomass	0	0	0	0	0	0	0	0	0	0
Gas Biomass	0	0	0	0	0	0	0	0	0	0
Other non-fossil fuels (biogenic waste)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table A 70 presents international bunker fuels for the relevant fuel types of the Reference Approach.

Table A 70: International Bunkers [kt fuel].

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Jet Kerosene	279	538	622	650	675	713	803	923	331	390
Diesel	15	21	24	21	15	17	13	14	13	19

Table A 71 presents conversion factors, carbon emission factors and the fraction of carbon oxidised for all fuel types of the Reference Approach. Country specific values are provided only were relevant.

Table A 71: Conversion factor, carbon emission factor and fraction of carbon oxidised for the year 2021.

	Conversion Factor [TJ/kt]		Carbon emission factor [t C/TJ]		Fraction of carbon oxidised [t C/t C]
Fuel Type	Default value	Country specific value 2021	Default value	Country specific value 2021	
Crude Oil	42.75	42.50	20.00	-	1.00
Orimulsion	-	-	-	-	-
Natural Gas Liquids	45.22	42.50	17.20	-	1.00
Gasoline	44.80	41.78	18.90	-	1.00
Jet Kerosene	44.59	43.38	19.50	-	1.00
Other Kerosene	44.75	43.38	19.60	-	1.00
Shale Oil	-	-	-	-	1.00
Gas / Diesel Oil	43.33	42.37	20.20	-	1.00
Residuel Fuel Oil	40.19	41.41	21.10	-	1.00
LPG	47.31	46.12	17.20	-	1.00
Ethane	-	-	-	-	1.00
Naphtha	45.01	45.01	20.00	-	1.00
Bitumen	40.19	41.80	22.00	-	1.00
Lubricants	40.19	41.80	20.00	-	1.00
Petroleum Coke	31.00	31.56	27.50	-	1.00
Refinery Feedstocks	42.50	41.94	20.00	-	1.00
OtherOil	40.19	46.13	20.00	-	1.00
Anthracite	28.00	28.00	26.80	-	0.98
Coking Coal	28.00	29.30	25.80	25.80	0.98
Other Bit. Coal	28.00	28.97	25.80	25.67	0.98
Sub- Bit. Coal	22.20	21.90	26.20	26.20	0.98
Lignite	10.90	15.09	27.60	27.05	0.98
Oil Shale	-	-	-	-	-
BKB & Patent Fuel	19.30	19.30	25.80	25.80	0.98
Coke Oven / Gas Coke	28.20	28.48	29.50	30.28	0.98
Coal Tar		36.90	22.01	22.01	0.98
Natural Gas	-	-	15.30	15.16	1.00
Waste (non-biomass fraction)	-	-		20.24	1.00
Peat	8.80	-	28.90	-	1.00
Solid Biomass	-	-	29.90	29.90	0.88
Liquid Biomass	-	38.66	-	20.75	1.00
Gas Biomass	-	-	29.90	29.90	1.00

Table A 72 presents selected country specific conversion factors. From 2007 on the conversion factor of lignite is higher because indigenous production and use of lignite with a comparable low calorific value (high water content) has been suspended.

Table A 72: Country specific conversion factors for selected fuels [TJ/kt]

Fuel Type	1990	2000	2005	2010	2015	2017	2018	2019	2020	2021
Other Bit. Coal	28.00	27.99	29.10	28.15	28.85	28.40	28.42	28.93	28.46	28.97
Sub Bit. Coal	22.20	22.20	22.18	21.84	22.08	21.84	21.81	22.23	21.83	21.90
Lignite	10.90	9.82	9.83	9.80	9.70	13.28	16.76	16.16	14.14	15.09
Coke	28.50	28.67	28.88	28.75	28.84	28.64	27.90	28.73	28.77	28.48

ANNEX 4: NATIONAL ENERGY BALANCE

The following tables present the data of the national energy balance by IEA categories. Calorific values for unit conversion are presented at the end of this Annex. Data was submitted to the Umweltbundesamt by STATISTIK AUSTRIA in November 2022.

Please note that for reasons of confidentiality energy consumption of autoproducers by sub sectors are not public available and therefore not presented in this ANNEX.

Annex 4.1 – Coal

Table A 73: National Energy Balance 1990-2021. Coking Coal [1000 tons].

101A Coking Coal	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	2 376	1 778	1 738	2 063	1 907	1 786	1 824	1 689	1 797	1 751	1 760	1 837	1 732	1 711
Total Exports (Balance)	0	0	0	0	0	0	0	5	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-39	130	139	-164	-69	12	-57	48	19	12	-16	-79	16	28
Gross Inland Deliveries (Obs.)	2 337	1 908	1 877	1 899	1 838	1 799	1 767	1 731	1 816	1 764	1 745	1 758	1 748	1 739
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	2 337	1 908	1 877	1 899	1 838	1 799	1 767	1 731	1 816	1 764	1 745	1 758	1 748	1 739
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	2 337	1 908	1 877	1 899	1 838	1 799	1 767	1 731	1 816	1 764	1 745	1 758	1 748	1 739
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

101A Coking Coal	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 74: National Energy Balance 1990-2021. Bituminous Coal & Anthracite [1000 tons].

102A Bitominous Coal & Anthracite (hard coal)	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	1 233	1 216	1 671	2 260	1 727	1 851	1 341	1 339	1 485	1 636	1 327	1 241	976	1 060
Total Exports (Balance)	0	1	0	3	1	2	0	6	0	1	3	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	589	268	176	-111	176	-151	0	583	230	-17	159	129	114	-49
Gross Inland Deliveries (Obs.)	1 822	1 484	1 847	2 146	1 902	1 698	1 341	1 916	1 715	1 617	1 484	1 370	1 090	1 011
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	1 421	1 082	1 422	1 885	1 576	1 399	946	967	675	584	622	532	196	34
Public Electricity	964	550	1 203	1 694	1 396	1 225	730	718	438	363	421	313	59	0
Public Combined Heat and Power	409	518	161	148	144	140	172	207	195	176	153	179	97	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	10	7	0	0	0	0	0	0	0	0	0	3
Auto Producers for CHP	48	14	48	36	36	34	43	41	43	45	47	40	40	31
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	33	0	143	121	230	750	806	838	676	702	705	818
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	143	121	230	750	806	838	676	702	705	818
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	33	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	399	401	391	260	181	177	164	197	231	192	183	133	187	158
Total Transport	3	0	1	0	0	0	0	0	0	0	0	0	0	0
Rail	3	0	1	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

102A Bitominous Coal & Anthracite (hard coal)	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Total Industry	208	252	313	213	171	168	162	195	226	183	173	123	184	155
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	7	45	57	35	20	19	30	31	28	40	34	5	12	12
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	199	164	170	86	56	43	28	32	20	23	28	30	86	49
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	2	43	86	87	94	106	104	132	178	121	111	88	85	94
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	188	149	77	47	10	9	1	2	5	9	10	10	3	3
Commerce - Public Services	11	10	8	9	0	0	0	0	0	0	0	0	0	0
Residential	176	137	69	38	9	9	1	2	5	8	10	10	3	3
Agriculture	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	2	1	1	1	1	1	1	2	3	3	3	3	1	2

Table A 75: National Energy Balance 1990-2021. Patent Fuel [1000 tons].

104A Patent Fuel (hard coal briquettes)	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	0	0	4	1	13	7	9	7	4	4	28	2	2	1
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	0	0	4	1	13	7	9	7	4	4	28	2	2	1
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	4	1	13	7	9	7	4	4	28	2	2	1
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0

104A Patent Fuel (hard coal briquettes)	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	26	1	1	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	26	1	1	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	4	1	13	7	9	7	4	4	2	1	1	1
Commerce - Public Services	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	3	1	13	7	9	7	4	4	2	1	1	1
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 76: National Energy Balance 1990-2021. Lignite and Brown Coal [1000 tons].

105A Lignite and brown coal	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	2 448	1 297	1 249	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	36	29	54	113	90	88	94	94	79	76	80	68	64	60
Total Exports (Balance)	3	0	0	0	8	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	23	417	78	1 158	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	2 503	1 743	1 381	1 272	82	88	94	94	79	76	79	68	64	60
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	2 133	1 524	1 230	1 136	0	0	0	0	0	0	0	0	0	0
Public Electricity	1 182	1 081	1 168	1 068	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	881	339	26	48	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	16	9	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	54	95	35	20	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	6	0	2	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	6	0	2	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

105A Lignite and brown coal	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	364	219	149	136	82	88	94	94	79	76	79	68	63	59
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	147	115	105	126	76	86	93	92	78	74	78	66	61	57
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	11	4	39	70	76	86	93	92	78	74	78	66	61	57
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	132	111	66	56	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	217	104	43	10	6	2	1	2	1	2	1	1	1	2
Commerce - Public Services	9	5	3	1	0	0	0	0	0	0	0	0	0	0
Residential	208	99	41	9	6	2	1	2	1	2	1	1	1	2
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Table A 77: National Energy Balance 1990-2021. Brown Coal Briquettes [1000 tons].

106A BKB-PB	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	295	173	95	53	31	17	13	10	9	14	13	10	10	12
Total Exports (Balance)	0	1	0	2	0	1	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	12	1	11	2	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	306	172	107	52	31	17	13	10	9	13	13	10	10	12
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	12	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	7	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0

106A BKB-PB	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	295	172	107	52	31	17	13	10	9	13	13	10	10	12
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	64	14	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	63	14	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	230	158	107	52	31	17	13	10	9	13	13	10	10	12
Commerce - Public Services	8	6	34	17	8	0	0	0	0	0	0	0	0	0
Residential	214	146	70	32	22	16	12	10	9	13	12	10	10	12
Agriculture	8	6	3	4	1	1	1	0	0	1	1	0	1	1
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 78: National Energy Balance 1990-2021. Coke Oven Coke [1000 tons].

107A Coke Oven Coke	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	1 725	1 448	1 385	1 404	1 381	1 329	1 330	1 329	1 352	1 355	1 316	1 316	1 327	1 319
Total Imports (Balance)	815	718	981	1 402	1 252	1 191	1 222	1 004	929	1 167	823	951	816	921
Total Exports (Balance)	1	1	1	4	3	0	0	1	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-136	189	71	-117	-75	1	-17	10	-20	9	-43	91	-48	12
Gross Inland Deliveries (Obs.)	2 402	2 354	2 435	2 684	2 555	2 521	2 534	2 343	2 260	2 530	2 095	2 359	2 095	2 251
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	623	711	909	1 162	1 200	1 195	1 250	1 214	1 177	1 276	1 069	1 136	1 084	1 220
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	623	711	909	1 162	1 200	1 195	1 250	1 214	1 177	1 276	1 069	1 136	1 084	1 220
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	913	1 076	1 076	1 167	1 067	1 049	1 011	856	828	972	810	936	716	751
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	913	1 076	1 076	1 167	1 067	1 049	1 011	856	828	972	810	936	716	751
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

107A Coke Oven Coke	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	853	557	436	339	268	252	249	244	237	230	182	255	264	257
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	290	196	247	262	215	218	230	229	223	218	173	245	255	248
Iron and Steel	235	178	207	229	206	208	219	217	213	209	167	236	247	240
Chemical (incl.Petro-Chemical)	14	6	15	9	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	7	3	6	4	4	4	5	4	5	3	3	4	4	3
Non metallic Mineral Products	23	4	10	14	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	5	2	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Food, Beverages and Tobacco	5	2	7	6	5	6	6	7	5	6	4	4	4	4
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	563	361	190	77	53	34	18	15	15	11	8	11	9	9
Commerce - Public Services	13	9	6	4	2	0	0	0	0	0	0	0	0	0
Residential	537	345	180	72	50	33	18	14	14	11	8	10	9	9
Agriculture	12	8	4	2	1	1	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	13	10	14	16	20	25	24	28	18	52	34	31	30	23

Table A 79: National Energy Balance 1990-2021. Peat [1000 tons].

113A Peat	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

113A Peat	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 80: National Energy Balance 1990-2021. Coke Oven Gas [TJ].

304A Coke Oven Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	13 117	10 906	10 466	10 854	10 716	10 696	10 087	10 337	9 954	10 154	10 321	10 428	10 217	10 250
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	13 117	10 906	10 466	10 854	10 716	10 696	10 087	10 337	9 954	10 154	10 321	10 428	10 217	10 250
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	3 385	6 228	3 592	2 332	2 584	2 592	2 771	4 328	3 352	3 367	3 165	2 961	3 290	3 045
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	3 256	2 127	2 346	2 316	2 595	4 013	3 063	3 105	2 953	2 744	3 020	2 773
Auto Producers for CHP	3 385	6 228	286	205	238	276	176	315	289	262	213	217	270	272
Auto Producer Heat Plants	0	0	50	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	4 136	3 439	3 300	4 944	4 799	5 226	4 735	3 515	3 156	3 074	3 920	3 917	4 100	3 272
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0

304A Coke Oven Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	1 072	892	856	316	536	370	288	382	2 048	1 661	2 342	1 771	2 050	1 358
Blast Furnaces (Energy)	3 064	2 547	2 444	4 628	4 264	4 856	4 446	3 133	1 108	1 414	1 577	2 146	2 050	1 914
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	5 596	1 239	3 574	3 514	3 266	2 875	2 578	2 476	3 439	3 704	3 230	3 540	2 815	3 925
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	5 596	1 239	3 574	3 514	3 266	2 875	2 578	2 476	3 439	3 704	3 230	3 540	2 815	3 925
Iron and Steel	5 596	1 239	3 574	3 514	3 266	2 875	2 578	2 476	3 439	3 704	3 230	3 540	2 815	3 925
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 81: National Energy Balance 1990-2021. Blast Furnace Gas [TJ].

305A Blast Furnace Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	17 094	19 503	25 385	32 220	33 119	32 951	34 818	33 626	32 631	35 082	28 633	31 341	29 429	34 082
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	17 094	19 503	25 385	32 220	33 119	32 951	34 818	33 626	32 631	35 082	28 633	31 341	29 429	34 082
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	4 822	6 213	6 014	12 095	14 468	14 233	16 152	15 529	14 552	17 051	14 473	15 709	14 540	17 036
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	5 011	11 292	13 502	12 898	15 371	14 584	13 640	15 595	13 580	14 351	12 918	15 311
Auto Producers for CHP	4 822	6 213	1 003	802	966	1 335	781	945	912	1 456	893	1 358	1 622	1 725
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

305A Blast Furnace Gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total Energy Sector	9 682	11 685	15 254	16 723	16 002	16 509	16 741	15 979	16 049	16 175	12 646	14 203	13 546	15 307
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	2 391	2 641	3 675	4 169	3 442	3 931	3 933	3 378	4 468	4 954	3 964	3 320	2 911	3 460
Blast Furnaces (Energy)	7 291	9 044	11 579	12 554	12 560	12 577	12 808	12 601	11 581	11 222	8 681	10 883	10 634	11 847
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	2 590	1 605	4 117	836	1 262	1 192	1 145	1 145	1 089	1 054	783	828	871	1 152
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	2 590	1 605	4 117	836	1 262	1 192	1 145	1 145	1 089	1 054	783	828	871	1 152
Iron and Steel	2 590	1 605	4 117	836	1 262	1 192	1 145	1 145	1 089	1 054	783	828	871	1 152
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex 4.2 – Oil

Table A 82: National Energy Balance 1990-2021. Crude Oil [1000 tons].

201A Crude Oil	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Indigenous Production	1 149	1 035	971	855	903	742	840	843	953	854	786	698	670	634
Refinery Losses	254	177	157	36	97	53	46	112	79	139	169	158	116	111
Refinery Intake (Calculated)	7 952	8 619	8 240	8 743	7 719	8 170	8 349	8 584	8 435	8 853	8 184	8 064	8 970	9 124
Refinery Intake (Observed)	7 952	8 619	8 240	8 743	7 719	8 170	8 349	8 584	8 435	8 853	8 184	8 064	8 970	9 124
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	6 797	7 590	7 314	7 833	6 795	7 293	7 472	7 778	7 510	8 079	7 332	7 219	8 333	8 592
Total Exports (Balance)	0	0	61	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	6	-6	16	55	20	135	37	-37	-28	-80	66	148	-34	-102
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 83: National Energy Balance 1990-2021. Natural Gas Liquids [1000 tons].

302A Natural Gas Liquids	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	41	43	101	78	134	81	79	30	23	21	6	37	18	16
Refinery Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Intake (Calculated)	41	43	107	78	134	194	123	81	175	53	6	37	18	16
Refinery Intake (Observed)	41	43	107	78	134	194	123	81	175	53	6	37	18	16
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	0	0	6	0	0	113	44	51	153	31	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	-1	1	0	0	0	0
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 84: National Energy Balance 1990-2021. Refinery Feedstocks [1000 tons].

217A Refinery Feedstocks	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Intake (Calculated)	1 069	582	540	362	325	523	430	358	390	371	531	552	293	501
Refinery Intake (Observed)	1 069	582	540	362	325	523	430	358	390	371	531	552	293	501
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	1 009	600	627	265	218	158	190	74	146	63	204	296	101	224
Total Exports (Balance)	0	39	125	18	2	13	2	0	1	47	39	52	95	64
Stock Change (National Territory)	-26	-28	-10	35	-101	38	-57	0	4	-131	156	-61	-4	118

Table A 85: National Energy Balance 1990-2021. Residual Fuel Oil [1000 tons].

203X; Residual Fuel Oil	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	1 913	1 596	1 075	1 360	934	899	954	1 011	981	1 154	898	839	710	735
Refinery Fuel	131	233	133	186	143	153	107	79	88	60	42	73	88	76
Total Imports (Balance)	602	532	261	182	173	86	58	58	40	11	16	68	65	44
Total Exports (Balance)	185	38	152	72	244	266	220	325	428	525	576	437	467	455
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-94	-100	247	7	102	98	1	2	50	67	119	71	17	56
Gross Inland Deliveries (Obs.)	2 155	1 757	1 298	1 237	823	664	547	530	442	397	344	275	188	218
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	725	721	611	506	390	310	251	243	189	243	194	177	140	164
Public Electricity	28	88	109	84	32	19	2	1	1	10	1	11	0	0
Public Combined Heat and Power	253	316	162	174	144	70	28	20	7	37	78	35	1	1
Public Heat Plants	99	70	87	81	35	27	36	34	34	30	30	26	24	10
Auto Producers of Electricity	0	0	5	72	38	58	1	15	0	1	12	8	50	44
Auto Producers for CHP	227	97	15	95	140	136	184	174	147	166	73	97	66	110
Auto Producer Heat Plants	1	1	1	0	2	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	117	149	232	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	421	345	285	219	203	202	83	54	73	88	76
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	235	202	132	112	124	114	23	12	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	1 430	1 036	687	496	231	222	184	163	139	131	138	98	47	53

203X; Residual Fuel Oil	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	517	549	277	263	187	185	160	138	114	110	100	81	39	53
Iron and Steel	19	23	21	15	8	8	5	2	2	2	2	1	1	0
Chemical (incl.Petro-Chemical)	23	27	11	13	30	26	16	20	13	14	15	14	7	5
Non ferrous Metals	4	7	9	6	5	6	6	6	6	5	2	1	0	0
Non metallic Mineral Products	115	135	51	45	39	32	17	23	18	23	21	16	7	19
Transportation Equipment	13	17	4	5	2	2	3	1	1	1	2	1	1	0
Machinery	29	32	30	32	23	29	33	15	12	12	11	9	5	6
Mining and Quarrying	6	7	12	12	4	5	4	5	1	2	2	2	1	1
Food, Beverages and Tobacco	78	89	38	42	31	32	26	18	23	16	13	10	5	5
Pulp, Paper and Printing	126	108	41	39	18	14	9	17	9	9	7	4	3	3
Wood and Wood Products	15	21	9	13	6	6	6	9	10	7	7	6	3	3
Construction	32	22	16	16	4	10	24	14	13	13	13	12	6	8
Textiles and Leather	27	25	12	11	7	6	5	2	2	2	2	1	0	0
Non Specified (Industry)	30	36	23	15	9	10	6	5	5	4	3	3	1	2
Total Other Sectors	913	487	410	233	44	37	23	25	25	22	38	17	8	1
Commerce - Public Services	315	240	118	92	5	18	11	12	15	13	27	15	8	1
Residential	471	194	232	112	30	13	6	4	0	0	0	0	0	0
Agriculture	127	53	60	29	8	6	6	9	10	8	11	2	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 86: National Energy Balance 1990-2021. Heating and Oher Gas Oil [1000 tons].

204A Heating and Other Gas Oil	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	1 239	1 454	1 062	997	795	738	688	820	683	642	635	662	581	476
Refinery Fuel	0	0	0	0	0	0	1	0	0	0	0	0	0	4
Total Imports (Balance)	0	165	533	926	725	625	605	618	565	592	580	597	555	599
Total Exports (Balance)	0	0	1	20	14	34	51	86	102	31	12	10	10	13
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	5	39	125	59	12	-22	64	-19	4	23	-49	-9	20	25
Gross Inland Deliveries (Obs.)	1 244	1 658	1 719	1 933	1 471	1 301	1 206	1 209	1 076	1 113	1 085	1 152	1 041	1 044
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	2	0	5	4	5	5	4	6	3	1	3	4	3
Public Electricity	0	0	0	1	0	1	1	1	1	1	0	1	1	1
Public Combined Heat and Power	0	2	0	3	1	1	1	1	1	1	0	2	2	2
Public Heat Plants	0	0	0	1	1	1	1	1	3	1	0	0	0	0
Auto Producers of Electricity	0	0	0	0	1	1	1	0	1	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	1	0	0	1	1	1	0	0	1
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	1	0	0	0	0	0	0	4
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

204A Heating and Other Gas Oil	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	1 244	1 656	1 719	1 928	1 468	1 296	1 201	1 205	1 071	1 109	1 084	1 149	1 038	1 040
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	1	5	38	115	75	69	79	11	9	7	7	7	21	25
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chemical (incl.Petro-Chemical)	0	0	2	2	1	1	3	0	0	0	0	0	3	5
Non ferrous Metals	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	1	2	6	6	5	7	3	2	1	2	2	5	6
Transportation Equipment	0	0	0	1	1	1	1	0	0	0	0	0	0	0
Machinery	0	1	5	13	9	8	18	1	1	1	1	1	2	2
Mining and Quarrying	0	0	1	4	1	1	2	1	2	1	1	1	1	1
Food, Beverages and Tobacco	0	1	10	29	26	24	18	2	1	1	1	1	3	3
Pulp, Paper and Printing	0	0	1	2	1	1	1	0	0	0	0	0	1	1
Wood and Wood Products	0	0	1	7	1	1	3	0	0	0	0	0	1	1
Construction	0	1	10	41	23	21	19	3	1	1	1	1	3	3
Textiles and Leather	0	0	1	4	2	2	3	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	2	6	3	3	3	0	0	0	0	0	1	1
Total Other Sectors	1 243	1 651	1 682	1 813	1 393	1 227	1 122	1 194	1 062	1 103	1 077	1 142	1 017	1 016
Commerce - Public Services	26	92	264	474	150	134	126	121	121	122	101	159	142	137
Residential	1 216	1 558	1 416	1 337	1 241	1 092	996	1 072	940	980	975	982	873	878
Agriculture	1	1	1	1	1	1	1	1	1	1	1	1	3	1
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 87: National Energy Balance 1990-2021. Diesel [1000 tons].

2050 Diesel	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Refinery Fuel	1 531	1 920	2 662	2 931	2 741	3 367	3 318	3 251	3 299	3 453	3 166	3 319	3 472	3 703
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	576	937	2 075	4 129	4 428	3 961	3 814	3 995	3 902	3 949	4 477	4 511	4 509	4 577
International Marine Bunkers	3	83	415	889	858	865	961	876	910	861	829	954	998	1 064
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	-7	112	-59	89	46	-96	-81	72	49	-42	-67	70	5	-185
Statistical Difference	2 097	2 886	4 263	6 260	6 228	6 065	6 090	6 443	6 340	6 499	6 748	6 945	6 989	7 030
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	8	1	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2050 Diesel	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transport	2 096	2 877	4 262	6 260	6 228	6 065	6 090	6 443	6 340	6 499	6 748	6 945	6 989	7 030
International Civil Aviation	1 766	2 507	3 830	5 658	5 644	5 472	5 513	5 968	5 890	6 024	6 303	6 473	6 510	6 552
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	1 691	2 436	3 757	5 568	5 556	5 393	5 434	5 893	5 811	5 958	6 234	6 400	6 442	6 479
Inland Waterways	54	45	42	52	52	44	45	39	42	32	32	35	33	33
Pipeline Transport	20	26	31	38	36	35	34	36	37	34	36	38	36	40
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	81	113	172	338	316	327	329	223	192	212	190	214	222	223
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Non ferrous Metals	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	1	1	1	1	1	1	1	4	4	4	4	4
Machinery	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Mining and Quarrying	0	0	0	0	0	0	0	0	0	7	6	6	7	7
Food, Beverages and Tobacco	2	2	3	4	4	4	4	3	3	4	4	5	5	5
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Construction	0	1	1	1	1	1	1	1	1	6	3	3	3	3
Textiles and Leather	77	108	165	331	308	319	321	218	187	189	171	194	201	203
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	250	257	260	264	268	266	248	251	257	263	256	258	256	254
Residential	9	13	19	27	35	34	16	18	25	32	26	30	30	30
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	241	245	241	237	233	232	231	234	232	231	230	228	226	225
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 88: National Energy Balance 1990-2021. Other Kerosene [1000 tons].

206A Other Kerosene	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	31	8	1	1	3	0	16	18	18	28	21	15	26	15
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	14	4	5	3	1	1	1	1	1	1	0	1	1	1
Total Exports (Balance)	21	6	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-7	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	17	6	6	3	2	2	1	1	1	1	1	1	1	1
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

206A Other Kerosene	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	17	6	6	0	0	0	0	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	17	6	6	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	17	6	6	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	3	1	1	1	1	1	1	1	1	1	1

Table A 89: National Energy Balance 1990-2021. Kerosene Type Jet Fuel [1000 tons].

206B Kerosene Type Jet Fuel	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	291	420	544	592	476	616	581	648	651	613	760	893	362	344
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	13	23	35	85	193	92	82	109	137	144	83	50	53	39
Total Exports (Balance)	5	0	5	2	6	24	31	37	24	29	19	29	9	5
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	4	-5	-22	12	2	23	-17	1	11	7	37	-56	26
Gross Inland Deliveries (Obs.)	299	447	569	653	675	687	655	703	765	739	831	951	322	404
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0

206B Kerosene Type Jet Fuel	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	299	447	569	653	675	687	655	703	765	739	831	951	322	404
Total Transport	299	447	569	653	675	687	655	703	765	739	831	951	322	404
International Civil Aviation	281	421	537	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	18	26	32	653	675	687	655	703	765	739	831	951	322	404
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 90: National Energy Balance 1990-2021. Gasoline Type Jet Fuel [1000 tons].

207A Gasoline Type Jet Fuel	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	3	4	3	6	4	3	3	4	3	4	1	2	1	1
Total Exports (Balance)	0	0	1	3	2	1	1	1	1	1	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	-2	0	0	0	1	0	0	1	-1	1	0	0	0

207A Gasoline Type Jet Fuel	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Gross Inland Deliveries (Obs.)	3	2	2	3	3	3	2	3	3	2	2	2	2	2
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	3	2	2	3	3	3	2	3	3	2	2	2	2	2
Total Transport	3	2	2	3	3	3	2	3	3	2	2	2	2	2
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	3	2	2	3	3	3	2	3	3	2	2	2	2	2
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 91: National Energy Balance 1990-2021. Motor Gasoline [1000 tons].

2080 Motor Gasoline	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Refinery Gross Output	2 631	2 276	1 815	1 798	1 589	1 636	1 867	1 812	1 759	1 782	2 030	2 075	1 805	1 870
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	271	710	680	1 107	873	903	790	844	822	771	730	671	566	566
Total Exports (Balance)	281	596	473	770	665	778	872	976	875	865	1 060	978	984	996
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-53	18	-32	-14	106	28	-64	29	-36	-13	49	-56	48	42
Gross Inland Deliveries (Obs.)	2 567	2 409	1 990	2 121	1 872	1 732	1 643	1 661	1 659	1 639	1 678	1 669	1 396	1 459
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	2 549	2 399	1 985	2 117	1 869	1 729	1 640	1 659	1 657	1 637	1 676	1 667	1 394	1 457
Total Transport	2 546	2 393	1 979	2 109	1 859	1 719	1 633	1 652	1 650	1 631	1 670	1 661	1 388	1 450
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	3	3	2	3	3	3	2	3	3	2	2	2	2	2
Road	2 540	2 387	1 974	2 103	1 854	1 714	1 629	1 647	1 644	1 627	1 665	1 656	1 383	1 446
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	3	3	3	3	2	2	2	2	2	2	2	2	2	2
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	2	1	2	3	5	5	1	1	2	2	3	3	2	2
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	1	1	1	0	0	0	0	0	0	0	1	1	1	1
Machinery	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	1	3	5	5	1	1	1	1	1	1	1	1
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	2	5	4	4	5	5	6	6	5	4	4	4	4	5
Commerce - Public Services	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	2	4	4	4	4	4	4	4	5	4	4	4	4	5
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2080 Motor Gasoline	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total Non-Energy Use	18	10	4	4	3	3	3	2	3	2	2	2	2	2

Table A 92: National Energy Balance 1990-2021. Lubricants [1000 tons].

219A Lubricants	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Refinery Gross Output	31	73	111	111	96	56	0	0	0	0	0	0	0	0
Refinery Fuel	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	177	51	57	53	45	48	81	73	110	141	144	121	97	93
Total Exports (Balance)	32	41	58	85	71	45	42	37	69	96	109	86	65	45
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-12	4	-1	1	2	1	-1	0	0	0	0	-1	-1	0
Gross Inland Deliveries (Obs.)	164	86	109	80	72	59	38	36	41	45	34	34	31	48
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	18	9	12	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	5	3	4	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	9	5	6	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	146	77	97	0	0	0	0	0	0	0	0	0	0	0
Total Transport	67	35	44	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	66	34	43	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Total Industry	76	40	51	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	15	9	9	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	6	3	4	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	2	1	2	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	10	5	7	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Machinery	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	10	5	7	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	8	4	5	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	3	1	2	0	0	0	0	0	0	0	0	0	0	0
Construction	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	4	2	3	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	8	4	6	0	0	0	0	0	0	0	0	0	0	0

219A Lubricants	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Total Other Sectors	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	164	86	109	80	72	59	38	36	41	45	34	34	31	48

Table A 93: National Energy Balance 1990-2021. White Spirit [1000 tons].

220A White Spirit	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	0	5	0	0	70	0	0	0	0	0	0	0	0	0
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	11	8	7	11	12	15	19	19	19	19	18	18	16	17
Total Exports (Balance)	0	0	0	0	65	0	1	1	1	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	-1	0	0	-3	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	11	12	7	12	15	15	18	18	18	18	18	17	16	17
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	11	12	7	7	12	11	15	16	16	16	16	15	13	15
Total Transport	0	1	1	4	7	6	12	13	13	14	13	13	11	12
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	4	7	6	12	13	13	14	13	13	11	12
Rail	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	11	11	6	3	5	5	1	1	2	2	3	3	2	2
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	11	10	4	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	1	1	0	0	0	0	0	0	0	1	1	1	1
Machinery	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0

220A White Spirit	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	1	3	5	5	1	1	1	1	1	1	1	1
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	11	11	5	4	3	3	3	2	3	2	2	2	2	2

Table A 94: National Energy Balance 1990-2021. Bitumen [1000 tons].

222A Bitumen	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	269	254	343	366	292	366	314	290	333	306	369	395	424	440
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	284	187	292	335	346	270	274	271	278	289	313	304	290	262
Total Exports (Balance)	1	5	45	147	182	205	145	131	145	144	187	201	239	240
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-12	4	-3	0	10	0	-5	3	0	-4	0	0	-28	-2
Gross Inland Deliveries (Obs.)	540	440	587	555	465	431	439	434	467	447	495	498	448	460
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	540	440	587	0	0	0	0	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	540	440	587	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0

222A Bitumen	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	540	440	587	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	540	440	587	555	465	431	439	434	467	447	495	498	448	460

Table A 95: National Energy Balance 1990-2021. Other Oil Products [1000 tons].

224A Other Oil Products	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	7	29	15	87	172	61	43	19	26	27	21	23	45	46
Refinery Fuel	70	0	0	6	8	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	182	29	149	54	33	5	27	45	50	41	46	41	13	17
Total Exports (Balance)	3	39	139	96	144	10	3	3	3	1	6	1	1	1
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-31	36	-8	-5	-12	0	-1	-1	2	-2	0	-1	3	-2
Gross Inland Deliveries (Obs.)	35	15	18	35	40	55	66	60	74	66	62	62	60	60
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	22	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	22	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	6	8	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	0	4	11	12	3	3	3	3	2	3	2	2
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0

224A Other Oil Products	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	4	11	12	3	3	3	3	2	3	2	2
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	4	11	12	3	3	3	3	2	3	2	2
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	13	15	18	31	29	44	62	57	71	63	60	59	58	58

Table A 96: National Energy Balance 1990-2021. LPG [1000 tons].

303A LPG	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	47	60	34	107	87	67	65	139	122	102	111	137	117	150
Refinery Fuel	0	0	20	49	28	4	4	16	25	21	6	18	5	17
Total Imports (Balance)	97	149	159	133	114	81	64	54	53	62	62	61	64	64
Total Exports (Balance)	14	42	17	20	11	22	21	83	68	62	86	89	92	110
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	2	20	-5	0	-1	1	-3	-3	-2	3	1	-9	-5	-4
Gross Inland Deliveries (Obs.)	133	186	150	171	161	123	101	91	80	83	83	81	80	82
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	1	3	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	1	3	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	8	19	20	49	28	4	4	16	25	21	6	18	5	17
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	124	163	150	171	161	92	71	66	64	75	69	67	65	72
Total Transport	9	11	15	20	19	20	16	12	11	11	7	5	3	3
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0

303A LPG	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	9	11	15	20	19	20	16	12	11	11	7	5	3	3
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	65	62	55	34	45	42	25	24	24	26	26	25	25	26
Iron and Steel	4	3	1	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	8	6	4	4	1	1	1	1	0	0	2	2	3	3
Non metallic Mineral Products	12	23	15	3	9	9	2	2	2	2	2	1	1	1
Transportation Equipment	1	3	1	2	1	1	1	1	1	1	1	1	1	1
Machinery	11	13	14	10	12	10	9	9	10	11	11	10	9	10
Mining and Quarrying	1	1	1	1	1	1	3	2	2	2	1	2	2	1
Food, Beverages and Tobacco	3	3	4	5	7	6	3	4	4	4	4	3	4	4
Pulp, Paper and Printing	1	1	2	1	1	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	1	1	2	2	2	2	1	1	1	1	1	1
Construction	23	9	13	6	9	10	5	4	4	3	4	3	4	5
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	1	0	0	1	1	0	0	0	0	0	1	0	0
Total Other Sectors	50	90	80	117	97	31	29	30	29	39	36	37	37	42
Commerce - Public Services	32	61	24	69	60	4	3	3	3	7	6	7	7	8
Residential	16	26	51	43	33	25	24	24	24	29	27	27	28	31
Agriculture	2	3	5	4	3	3	2	2	2	3	3	3	3	3
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	31	31	25	16	8	14	15	15	10

Table A 97: National Energy Balance 1990-2021. Refinery Gas [1000 tons].

308A Refinery Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	373	305	312	309	392	311	342	282	218	262	281	316	284	296
Refinery Fuel	373	305	310	277	356	286	312	250	94	110	108	277	245	191
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	0	0	2	32	35	25	30	32	124	152	173	39	39	105
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	30	31	22	29	31	124	152	173	39	39	105
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	17	10	72	11	15	62
Auto Producers for CHP	0	0	0	30	31	22	29	31	108	142	101	28	24	43
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	277	356	286	312	250	94	110	108	277	245	191
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0

308A Refinery Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	2	2	4	3	1	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	2	2	4	3	1	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	2	2	4	3	1	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex 4.3 – Natural Gas

Table A 98: National Energy Balance 1990-2021. Natural Gas [PJ NCV].

301A Natural Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	46.4	53.3	64.8	55.7	58.5	61.9	45.4	43.4	40.8	43.7	36.0	32.2	26.5	23.7
Total Imports (Balance)	187.9	229.1	222.8	299.4	256.0	267.8	266.1	210.0	260.5	293.7	271.8	394.8	224.9	165.1
Total Exports (Balance)	0.0	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock Change (National Territory)	-15.1	-12.3	-11.3	-16.6	25.6	-23.0	-40.8	35.8	2.0	-11.8	0.5	-105.7	55.1	134.8
Gross Inland Deliveries (Obs.)	219.2	269.6	275.8	338.5	340.1	306.7	270.8	289.2	303.2	325.6	308.3	321.4	306.4	323.7
Statistical Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Transformation Sector	74.7	95.8	83.3	115.2	113.7	89.1	60.1	75.2	82.5	102.4	91.2	96.2	87.4	93.1
Public Electricity	28.1	21.7	25.4	46.7	35.2	14.1	1.4	16.0	15.9	38.6	25.8	31.7	22.1	14.8
Public Combined Heat and Power	23.8	30.8	27.7	39.2	48.9	48.1	36.4	37.9	45.2	41.7	43.9	45.3	46.6	57.1
Public Heat Plants	7.6	9.6	9.2	9.1	10.2	12.0	12.3	11.3	11.1	12.1	9.1	7.6	7.1	8.2
Auto Producers of Electricity	9.6	21.2	12.0	9.0	7.5	5.0	2.9	2.7	2.9	2.8	5.5	4.6	4.8	5.5
Auto Producers for CHP	5.7	12.5	8.6	10.6	11.9	9.7	6.6	6.9	6.9	7.2	6.5	6.9	6.7	7.5
Auto Producer Heat Plants	0.0	0.0	0.4	0.6	0.1	0.2	0.5	0.4	0.5	0.1	0.4	0.1	0.1	0.1
Gas Works (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coke Ovens (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blast Furnaces (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conversion to Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

301A Natural Gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Non Specified (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Energy Sector	15.8	18.8	11.9	14.7	12.0	13.7	12.8	9.0	8.4	8.8	10.4	10.5	9.0	10.2
Coal Mines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil and Gas Extraction	6.6	10.8	4.3	6.8	3.8	3.2	3.3	3.6	3.4	3.1	2.9	2.6	2.5	2.9
Inputs to Oil Refineries	6.8	7.6	6.5	5.5	5.8	4.6	3.2	3.6	3.4	3.8	4.7	5.2	4.8	5.2
Coke Ovens (Energy)	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.2	0.2
Blast furnace (Energy)	0.0	0.0	0.8	2.0	2.1	5.6	6.0	1.6	1.3	1.5	2.2	2.0	1.3	1.5
Gas Works (Energy)	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Power Plants	0.0	0.0	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Non Specified (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distribution Losses	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Final Consumption	113.5	144.2	167.3	195.4	198.5	190.6	183.4	191.0	198.0	200.4	194.9	199.7	195.8	206.5
Total Transport	4.1	4.1	6.1	6.5	8.7	8.8	9.8	11.3	10.9	12.2	11.3	10.5	9.3	7.5
Road	0.0	0.0	0.0	0.0	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
Pipeline Transport	4.1	4.1	6.1	6.5	8.3	8.3	9.1	10.6	10.1	11.5	10.6	9.7	8.5	6.7
Non Specified (Transport)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Industry	69.0	73.5	88.3	99.2	106.3	105.4	106.4	107.0	109.3	110.7	112.2	113.5	111.0	114.1
Iron and Steel	10.5	11.2	13.5	14.1	14.6	16.1	16.9	17.7	17.0	17.6	17.7	17.6	17.2	15.5
Chemical (incl.Petro-Chemical)	7.7	8.3	14.4	16.0	16.5	16.8	16.6	16.7	18.6	19.1	18.4	19.5	18.8	20.3
Non ferrous Metals	1.4	2.2	2.3	3.1	3.8	3.9	4.3	4.5	4.9	4.8	5.6	5.0	4.4	4.9
Non metallic Mineral Products	10.1	11.1	11.6	14.0	13.5	12.9	14.8	14.3	14.9	15.3	15.1	15.0	16.4	18.5
Transportation Equipment	1.5	2.6	1.3	2.2	1.9	2.0	1.5	1.3	1.5	1.7	1.8	1.6	1.7	1.8
Machinery	4.3	6.1	4.8	6.5	8.8	9.0	5.8	6.1	6.3	6.0	6.2	6.2	6.0	6.5
Mining and Quarrying	2.6	2.5	2.3	2.8	2.0	2.0	6.9	5.6	6.2	7.2	6.7	6.0	5.9	4.1
Food, Beverages and Tobacco	8.9	9.4	11.4	11.5	12.4	12.8	12.3	13.3	12.4	12.1	11.9	12.1	12.8	12.9
Pulp, Paper and Printing	12.9	9.8	19.5	20.3	24.2	21.8	20.3	20.9	20.5	20.1	21.8	23.8	21.7	22.6
Wood and Wood Products	1.7	2.0	1.7	3.3	2.9	2.7	2.5	2.4	2.3	2.5	2.6	2.3	2.1	2.5
Construction	0.7	1.5	1.4	1.6	1.8	1.8	1.4	1.2	1.3	1.2	1.4	1.3	1.2	1.1
Textiles and Leather	3.5	3.4	2.9	2.1	1.8	1.7	1.5	1.4	1.7	1.4	1.4	1.6	1.4	1.5
Non Specified (Industry)	3.1	3.4	1.2	1.6	2.0	1.9	1.7	1.6	1.6	1.7	1.6	1.6	1.5	1.8
Total Other Sectors	40.4	66.6	72.9	89.6	83.5	76.5	67.1	72.6	77.8	77.5	71.4	75.8	75.5	84.9
Commerce - Public Services	6.5	21.9	23.4	23.2	17.2	16.8	14.2	15.2	14.3	15.0	14.2	15.2	14.5	15.8
Residential	33.5	44.3	48.9	65.7	65.5	59.2	52.4	56.8	62.8	61.5	56.3	59.5	60.0	68.2
Agriculture	0.4	0.5	0.5	0.8	0.8	0.5	0.6	0.6	0.7	1.0	0.9	1.1	0.9	1.0
Non Specified (Others)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Non-Energy Use	14.9	10.5	13.3	13.2	15.8	13.2	14.4	13.9	14.3	13.8	11.6	14.9	14.2	13.8

Annex 4.4 – Renewable Fuels

Table A 99: National Energy Balance 1990-2021. Fuel Wood [PJ].

111A Fuel Wood	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	61.40	65.76	58.63	56.30	63.02	58.81	48.52	52.35	55.54	56.73	50.06	52.71	55.23	62.46
Total Imports (Balance)	2.30	1.62	1.80	3.50	7.87	9.41	10.99	8.55	6.83	5.76	7.01	5.07	2.55	2.20
Total Exports (Balance)	0.04	0.22	0.18	0.84	0.98	0.74	0.78	0.17	0.15	0.18	0.27	0.23	0.14	0.17
Stock Change (National Territory)	-0.55	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	63.12	67.35	60.25	58.95	69.91	67.49	58.73	60.73	62.22	62.31	56.80	57.54	57.64	64.49
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.00	0.08	0.13	0.13	0.15	0.12	0.14	0.14	0.09	0.10	0.10	0.10	0.10
Public Electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Combined Heat and Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Heat Plants	0.00	0.00	0.00	0.04	0.04	0.04	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers for CHP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

111A Fuel Wood	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	63.12	67.35	60.17	58.82	69.78	67.34	58.61	60.59	62.08	62.22	56.71	57.44	57.54	64.39
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.66	1.07	0.95	1.14	0.65	0.58	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl.Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.05	0.06	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.05	0.06	0.03	0.06	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.12	0.09	0.02	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.23	0.30	0.71	0.36	0.37	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.29	0.11	0.27	0.09	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.02	0.02	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.19	0.25	0.08	0.36	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00
Total Other Sectors	62.46	66.28	59.22	57.69	69.13	66.76	58.60	60.59	62.07	62.21	56.69	57.43	57.52	64.39
Commerce - Public Services	1.33	1.17	0.34	0.59	0.60	0.18	0.13	0.10	0.09	0.21	0.19	0.21	0.21	0.24
Residential	57.50	61.25	55.38	53.04	64.46	62.64	55.00	56.91	58.30	58.32	53.15	53.82	53.92	60.35
Agriculture	3.63	3.86	3.49	4.06	4.06	3.95	3.47	3.59	3.68	3.68	3.35	3.40	3.40	3.80
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 100: National Energy Balance 1990-2021. Wood Waste [PJ].

116A Wood waste and other biomass	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Indigenous Production	14.34	19.78	35.70	61.63	101.12	111.22	104.06	109.68	108.00	113.23	109.52	109.23	112.65	118.83
Total Imports (Balance)	2.14	2.49	3.14	7.41	12.83	10.82	7.87	8.47	8.31	8.80	7.98	7.35	8.14	8.80
Total Exports (Balance)	2.08	2.62	6.51	13.84	12.95	11.46	8.76	10.29	11.15	12.38	14.09	14.72	15.08	15.54
Stock Change (National Territory)	0.00	0.00	0.00	0.00	1.16	0.67	0.00	0.31	0.25	-0.33	0.04	0.34	-1.24	0.13
Gross Inland Deliveries (Obs.)	14.41	19.65	32.34	55.20	102.16	111.25	103.17	108.18	105.41	109.32	103.45	102.19	104.47	112.23
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	3.19	10.12	12.50	20.71	58.00	64.62	59.29	59.90	58.02	60.43	59.39	56.81	59.49	61.96
Public Electricity	0.00	0.00	0.01	2.86	10.86	11.07	8.58	9.15	7.24	7.18	6.67	4.71	5.24	3.96
Public Combined Heat and Power	0.00	0.00	0.35	4.10	17.27	20.43	16.39	18.06	16.25	17.51	17.62	17.96	16.97	17.56
Public Heat Plants	1.63	3.98	7.59	9.81	21.92	21.83	23.47	23.96	25.38	26.91	26.42	25.95	28.88	31.86
Auto Producers of Electricity	0.00	0.19	1.51	1.32	2.99	5.30	4.44	2.16	1.38	1.42	2.53	2.68	2.79	2.56
Auto Producers for CHP	1.56	5.95	2.96	2.60	4.88	5.95	6.35	6.52	7.68	7.29	6.06	5.43	5.55	5.93
Auto Producer Heat Plants	0.00	0.00	0.08	0.02	0.08	0.04	0.06	0.06	0.09	0.11	0.09	0.08	0.07	0.10
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

116A Wood waste and other biomass	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	11.22	9.53	19.84	34.49	44.16	46.64	43.88	48.28	47.39	48.89	44.06	45.21	44.81	50.08
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	9.43	6.90	11.62	25.52	28.61	29.55	26.06	27.39	26.39	26.13	22.29	22.82	22.25	23.97
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Chemical (incl.Petro-Chemical)	2.90	1.72	2.52	1.61	2.15	2.20	1.46	1.48	1.65	1.87	1.89	2.43	1.89	2.04
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.02	0.03	0.00	0.04	0.04
Non metallic Mineral Products	0.00	0.00	0.00	2.06	3.47	3.85	3.48	4.28	3.93	3.56	2.30	2.13	2.19	2.31
Transportation Equipment	0.00	0.00	0.00	0.01	0.02	0.06	0.05	0.04	0.03	0.03	0.04	0.04	0.07	0.09
Machinery	0.00	0.00	0.05	0.31	1.37	1.21	0.24	0.26	0.25	0.26	0.30	0.24	0.26	0.35
Mining and Quarrying	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.01	0.01	0.21	0.31	0.47	0.43	0.15	0.16	0.28	0.26	0.35	0.32	0.30	0.18
Pulp, Paper and Printing	3.66	3.90	1.95	7.06	4.55	4.47	3.98	3.86	4.87	4.89	4.68	6.01	5.32	5.73
Wood and Wood Products	2.76	1.16	6.00	13.85	13.21	14.41	16.23	16.82	14.81	14.61	12.09	11.13	11.58	12.69
Construction	0.04	0.03	0.36	0.16	1.35	1.24	0.19	0.15	0.23	0.27	0.24	0.21	0.26	0.29
Textiles and Leather	0.00	0.00	0.00	0.00	0.03	0.03	0.01	0.01	0.02	0.00	0.01	0.00	0.01	0.03
Non Specified (Industry)	0.07	0.07	0.52	0.15	1.96	1.61	0.23	0.30	0.30	0.34	0.35	0.30	0.31	0.21
Total Other Sectors	1.79	2.63	8.22	8.97	15.55	17.09	17.82	20.89	21.00	22.76	21.77	22.39	22.55	26.10
Commerce - Public Services	0.64	0.60	2.27	1.67	2.55	1.46	1.61	2.20	1.63	2.77	2.89	3.21	3.10	3.63
Residential	0.77	1.40	4.50	5.61	10.69	12.93	12.97	15.39	16.00	16.30	15.55	16.37	16.59	19.24
Agriculture	0.38	0.63	1.46	1.69	2.30	2.69	3.23	3.29	3.37	3.69	3.33	2.80	2.86	3.24
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 101: National Energy Balance 1990-2021. Black Liquor [PJ].

215A Black Liquor	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	17.8	21.4	24.1	26.6	28.5	30.1	30.3	28.4	32.8	32.7	33.7	33.6	33.2	34.4
Total Imports (Balance)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Exports (Balance)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock Change (National Territory)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gross Inland Deliveries (Obs.)	17.8	21.4	24.1	26.6	28.5	30.1	30.3	28.4	32.8	32.7	33.7	33.6	33.2	34.4
Statistical Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Transformation Sector	5.3	9.3	7.6	8.8	7.3	9.8	8.4	8.5	8.1	7.9	8.3	8.5	9.4	8.6
Public Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Public Combined Heat and Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Public Heat Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Auto Producers of Electricity	2.6	5.3	2.0	2.4	0.4	1.9	0.9	1.7	0.4	0.0	0.0	0.1	0.5	0.3
Auto Producers for CHP	2.6	4.0	5.6	6.4	6.8	7.9	7.5	6.7	7.8	7.9	8.2	8.4	8.9	8.3
Auto Producer Heat Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Energy Sector	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Mines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patent Fuel Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coke Ovens (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blast Furnaces (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gas Works (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Power Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distribution Losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

215A Black Liquor	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Final Consumption	12.5	12.1	16.4	17.9	21.3	20.3	21.9	19.9	24.6	24.8	25.4	25.1	23.8	25.8
Total Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inland Waterways	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Transport)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Industry	12.5	12.1	16.4	17.9	21.3	20.3	21.9	19.9	24.6	24.8	25.4	25.1	23.8	25.8
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical (incl.Petro-Chemical)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non ferrous Metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non metallic Mineral Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transportation Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Machinery	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mining and Quarrying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Food, Beverages and Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp, Paper and Printing	12.5	12.1	16.4	17.9	21.3	20.3	21.9	19.9	24.6	24.8	25.4	25.1	23.8	25.8
Wood and Wood Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Textiles and Leather	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Industry)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Sectors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commerce - Public Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Others)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A 102: National Energy Balance 1990-2021. Biogas [PJ].

309A Biogas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	0.00	0.04	0.36	3.42	5.39	7.10	10.21	10.61	10.65	11.20	8.38	7.52	7.65	5.17
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	0.00	0.04	0.36	3.42	5.39	7.10	10.21	10.61	10.65	11.20	8.38	7.52	7.65	5.17
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.04	0.22	3.16	4.97	6.52	9.93	10.28	10.24	10.69	7.81	6.98	7.18	4.71
Public Electricity	0.00	0.00	0.00	2.65	4.36	5.94	9.39	9.77	9.50	10.18	7.17	6.47	6.58	4.26
Public Combined Heat and Power	0.00	0.00	0.00	0.20	0.33	0.28	0.15	0.10	0.27	0.16	0.15	0.14	0.12	0.14
Public Heat Plants	0.00	0.00	0.00	0.00	0.08	0.09	0.08	0.07	0.08	0.06	0.06	0.03	0.03	0.03
Auto Producers of Electricity	0.00	0.00	0.12	0.14	0.06	0.05	0.16	0.15	0.17	0.05	0.05	0.18	0.21	0.10
Auto Producers for CHP	0.00	0.04	0.10	0.18	0.13	0.16	0.16	0.18	0.22	0.24	0.38	0.16	0.24	0.17
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.00	0.15	0.25	0.42	0.57	0.28	0.33	0.41	0.50	0.57	0.54	0.46	0.46
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Total Industry	0.00	0.00	0.15	0.25	0.40	0.47	0.17	0.19	0.22	0.22	0.26	0.27	0.21	0.19

309A Biogas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.02	0.02	0.05	0.02	0.01	0.01
Chemical (incl.Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.04	0.04	0.03	0.08	0.05	0.05
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.03	0.01	0.02	0.01	0.01
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.01	0.02	0.04	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03
Pulp, Paper and Printing	0.00	0.00	0.12	0.24	0.34	0.33	0.03	0.04	0.04	0.04	0.06	0.05	0.04	0.03
Wood and Wood Products	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.00	0.00	0.00	0.02	0.10	0.08	0.12	0.18	0.27	0.29	0.26	0.24	0.25
Commerce - Public Services	0.00	0.00	0.00	0.00	0.02	0.08	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02
Residential	0.00	0.00	0.00	0.00	0.01	0.03	0.07	0.10	0.15	0.25	0.27	0.23	0.21	0.23
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 103: National Energy Balance 1990-2021. Sewage Sludge Gas [PJ].

309B Sewage sludge gas	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Indigenous Production	0.00	0.62	0.47	1.17	1.08	1.18	1.49	1.54	1.71	1.72	1.05	1.41	1.09	1.47
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	0.00	0.62	0.47	1.17	1.08	1.18	1.49	1.54	1.71	1.72	1.05	1.41	1.09	1.47
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.62	0.11	0.75	0.59	0.40	0.22	0.20	0.37	0.29	0.27	0.41	0.37	0.41
Public Electricity	0.00	0.01	0.08	0.65	0.28	0.17	0.07	0.06	0.23	0.15	0.16	0.11	0.04	0.05
Public Combined Heat and Power	0.00	0.00	0.00	0.04	0.04	0.06	0.06	0.05	0.04	0.03	0.02	0.03	0.04	0.04
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.00	0.03	0.01	0.22	0.13	0.07	0.07	0.08	0.09	0.05	0.10	0.13	0.14
Auto Producers for CHP	0.00	0.61	0.00	0.05	0.05	0.05	0.02	0.02	0.02	0.01	0.03	0.17	0.16	0.19
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.00	0.36	0.41	0.49	0.78	1.27	1.34	1.34	1.43	0.78	1.00	0.72	1.06
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.00	0.00	0.36	0.41	0.49	0.78	1.27	1.34	1.34	1.43	0.78	1.00	0.72	1.06
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl.Petro-Chemical)	0.00	0.00	0.36	0.29	0.34	0.36	0.46	0.49	0.51	0.72	0.26	0.34	0.25	0.51
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

309B Sewage sludge gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.10	0.09	0.34	0.33	0.37	0.24	0.12	0.11	0.08	0.11	0.10
Pulp, Paper and Printing	0.00	0.00	0.00	0.02	0.07	0.07	0.48	0.48	0.59	0.59	0.41	0.58	0.35	0.45
Wood and Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 104: National Energy Balance 1990-2021. Landfill Gas [PJ].

310A Landfill Gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Indigenous Production	0.00	0.20	0.44	0.38	0.19	0.16	0.20	0.19	0.16	0.10	0.08	0.05	0.05	0.04
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	0.00	0.20	0.44	0.38	0.19	0.16	0.20	0.19	0.16	0.10	0.08	0.05	0.05	0.04
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.15	0.44	0.23	0.19	0.16	0.20	0.19	0.16	0.10	0.08	0.05	0.05	0.04
Public Electricity	0.00	0.00	0.01	0.04	0.12	0.10	0.10	0.09	0.04	0.04	0.03	0.03	0.03	0.02
Public Combined Heat and Power	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.12	0.43	0.19	0.07	0.06	0.10	0.09	0.11	0.07	0.05	0.02	0.01	0.02
Auto Producers for CHP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.05	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl.Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

310A Landfill Gas	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 105: National Energy Balance 1990-2021. Municipal Solid Waste [PJ].

114B Municipal Solid Waste	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Indigenous Production	2.41	3.91	4.64	8.88	14.38	15.55	18.09	19.35	21.17	18.62	19.44	19.80	21.58	21.54
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	2.41	3.91	4.64	8.88	14.38	15.55	18.09	19.35	21.17	19.85	19.44	19.80	21.58	21.54
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	2.41	3.91	4.64	8.88	14.38	15.55	18.09	19.35	21.17	19.85	19.44	19.80	21.58	21.54
Public Electricity	0.00	0.00	0.72	2.19	2.82	4.25	4.72	5.17	5.34	4.20	4.72	4.37	4.51	4.31
Public Combined Heat and Power	1.72	2.32	2.23	3.14	3.01	2.44	1.87	3.17	4.03	3.90	4.20	4.40	6.29	6.56
Public Heat Plants	0.69	1.59	1.69	1.97	1.87	2.25	2.19	2.06	2.09	2.21	2.12	2.14	1.99	1.95
Auto Producers of Electricity	0.00	0.00	0.00	1.46	4.22	3.45	6.07	5.49	6.08	5.59	4.62	4.31	4.63	4.22
Auto Producers for CHP	0.00	0.00	0.00	0.10	2.46	3.16	3.25	3.46	3.63	3.96	3.78	4.58	4.15	4.49
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl.Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 106: National Energy Balance 1990-2021. Industrial Waste [PJ].

115A Industrial Waste	**1990**	**1995**	**2000**	**2005**	**2010**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Indigenous Production	6.58	7.01	7.63	10.85	17.03	17.80	16.70	16.09	16.94	16.54	15.33	14.48	14.42	15.49
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	6.58	7.01	7.63	10.85	17.03	17.80	16.70	16.09	16.94	16.54	15.33	14.48	14.42	15.49
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	2.54	1.93	1.46	2.61	5.15	5.95	4.67	4.31	3.93	3.81	3.27	3.18	2.14	2.45
Public Electricity	0.00	0.00	0.00	0.62	0.51	1.18	0.64	0.68	0.71	0.59	0.30	0.21	0.16	0.37
Public Combined Heat and Power	0.00	0.00	0.00	0.72	0.92	1.34	2.83	2.37	2.28	2.27	2.10	1.91	0.72	0.90
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.00	0.44	0.25	1.83	1.85	0.30	0.32	0.14	0.18	0.14	0.00	0.00	0.07
Auto Producers for CHP	2.54	1.93	1.02	0.91	1.70	1.36	0.73	0.76	0.64	0.61	0.58	0.89	1.09	0.88
Auto Producer Heat Plants	0.00	0.00	0.00	0.11	0.19	0.19	0.17	0.17	0.16	0.16	0.16	0.16	0.18	0.24
Total Energy Sector	0.00	0.00	0.00	0.44	2.32	2.14	2.01	1.87	1.82	1.65	0.60	1.12	1.77	1.79
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	4.03	5.08	6.18	7.80	9.55	9.71	10.03	9.92	11.19	11.08	11.46	10.18	10.51	11.25
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	2.92	4.56	5.61	6.73	9.49	9.71	10.03	9.92	11.19	11.08	11.46	10.18	10.51	11.25
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl.Petro-Chemical)	1.57	1.91	1.64	3.16	3.26	3.19	2.58	2.45	2.79	2.52	2.64	1.92	2.51	3.27
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.01	0.16	0.17	0.18	0.19	0.00	0.00	0.01	0.00
Non metallic Mineral Products	1.31	1.98	3.56	2.66	5.29	5.68	6.49	6.71	7.49	7.72	7.83	7.35	7.34	7.08
Transportation Equipment	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.00	0.00	0.00	0.04	0.09	0.04	0.22	0.19	0.22	0.15	0.20	0.22	0.19	0.11
Wood and Wood Products	0.04	0.55	0.37	0.63	0.76	0.75	0.53	0.31	0.42	0.41	0.69	0.58	0.34	0.69
Construction	0.00	0.01	0.02	0.06	0.04	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02
Textiles and Leather	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Non Specified (Industry)	0.01	0.09	0.02	0.10	0.05	0.03	0.05	0.06	0.09	0.08	0.09	0.10	0.10	0.06
Total Other Sectors	1.11	0.52	0.56	1.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	1.11	0.52	0.56	1.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Annex 4.5 – Net Calorific Values

The selected net calorific values of each fuel are presented below.

Table A 107: Net calorific values for 1990-2021 in [MJ/kg], [MJ/m³] taken from (IEA JQ 2022).

Fuel Code	Fuel Name		1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
101A	Coking Coal	T	29.07	29.07	29.07	29.10	29.17	29.07	29.10	29.66	28.66	29.18	29.14	29.00	28.95	29.30
102A	Hard Coal	FC	28.00	28.00	27.99	29.08	27.57	27.77	27.97	27.53	27.37	27.49	28.42	28.83	27.79	28.42
		T	28.00	28.00	26.74	29.10	28.14	28.29	28.52	28.73	28.29	28.67	28.60	28.97	28.82	29.28
104A	Hard Coal Briquettes	A	0.00	0.00	31.00	31.00	31.00	31.00	31.00	31.00	31.01	31.00	31.00	31.00	31.00	31.00
105A	Brown Coal	FC	10.90	10.90	14.71	16.04	19.86	20.00	20.92	20.53	20.63	20.69	21.21	22.06	21.41	21.33
		T	10.90	10.90	9.86	9.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106A	Brown Coal Briquettes	A	19.30	19.30	19.30	19.30	19.30	19.30	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
107A	Coke Oven Coke	T	28.50	28.50	29.00	28.88	28.75	28.72	29.01	28.84	28.88	28.64	27.90	28.73	28.77	28.48
113A	Peat	FC	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	0.00	0.00	0.00	0.00	0.00	0.00
304A	Coke Oven Gas	P	17.90	17.90	17.61	17.56	17.69	18.06	17.31	17.69	17.24	17.43	17.61	17.61	17.43	17.01
305A	Blast Furnace Gas	P	3.65	3.63	3.70	3.80	3.74	3.67	3.71	3.67	3.67	3.57	3.51	3.53	3.63	3.65
110A	Petrol Coke	A	34.30	28.40	33.92	31.33	29.92	32.83	30.79	30.86	30.84	31.02	30.26	30.98	30.94	31.56
201A	Crude Oil	A	42.50	42.50	42.52	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
203X	Residual Fuel Oil	A	41.00	40.50	41.49	42.15	45.24	40.33	41.04	41.07	41.16	41.16	41.15	40.99	41.26	41.41
204A	Gasoil	A	42.60	42.70	42.80	42.80	42.80	42.79	42.94	42.94	42.80	42.80	42.80	42.81	42.81	42.70
2050	Diesel	A	42.60	42.70	42.80	42.80	42.80	42.52	42.40	42.40	42.39	42.39	42.39	42.37	42.37	42.37
206A	Petroleum	A	43.60	43.30	43.30	43.60	43.36	43.30	43.35	43.35	43.35	43.35	43.35	43.35	43.35	43.35
206B	Kerosene	A	43.60	43.30	43.30	43.30	43.36	43.32	43.35	43.35	43.30	43.30	43.30	43.38	43.38	43.38
207A	Aviation Gasoline	A	42.50	42.50	42.50	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
2080	Motor Gasoline	A	42.50	42.50	42.50	42.68	41.98	41.10	41.42	41.31	40.53	40.73	41.61	41.64	41.65	41.64
217A	Refinery Feedstocks	A	41.87	42.56	42.56	42.59	42.47	41.86	41.60	42.34	42.65	42.29	42.96	42.51	42.57	42.91
219A	Lubricants	A	41.40	41.10	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
220A	White Spirit	A	41.60	42.50	42.50	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
222A	Bitumen	A	41.80	41.80	43.62	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
224A	Other Petroleum Products	FC	34.30	28.40	33.92	45.87	45.97	45.85	45.85	46.02	46.22	45.93	46.01	46.26	46.17	46.13
		NE	41.80	41.80	43.62	39.69	37.91	40.73	41.58	41.59	41.61	41.62	46.01	46.26	46.17	46.13
302A	NGL	A	42.50	42.50	42.52	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
303A	LPG	A	46.30	46.30	46.00	46.00	46.00	46.12	46.12	46.12	46.12	46.12	46.12	46.12	46.12	46.12
308A	Refinery Gas	A	49.00	49.00	37.18	30.68	30.68	32.00	29.87	29.87	29.87	32.44	30.32	29.78	30.32	30.32
301A	Natural Gas	A	36.00	36.00	35.85	36.00	36.26	36.26	36.42	36.48	36.64	36.61	36.61	36.61	36.71	36.64

Legend: A…Average; T…Transformation; FC…Final Consumption; P…Production; NE…Non Energy use; NGL…Natural Gas Liquids; LPG…Liquified Petroleum Gas

Table A 108 presents the net calorific values from STATISTIK AUSTRIA, which are used for default unit conversion.

Table A 108: Default net calorific values from STATISTIK AUSTRIA.

Fuel Name	NCV	Unit
Municipal Waste / renewable	8.93	MJ/kg
Municipal Waste / non renewable	9.14	MJ/kg

Fuel Name	NCV	Unit
Industrial Waste	15.76	MJ/kg
Fuel Wood	15.50	MJ/kg
Wood Wastes	11.36	MJ/kg
Bark	7.54	MJ/kg
Sewage Sludge (wet substance)	3.64	MJ/kg
Black Liquor	7.92	MJ/kg
Carcass meal	17.30	MJ/kg
Adipose	36.59	MJ/kg
Liquid Biofuels	42.00	MJ/kg
Biogas	22.06	MJ/m^3
Gas from Waste Disposal Site	17.00	MJ/m^3

Table A 109 presents the IPCC default values of net calorific values of gaseous biofuels which are used for default unit conversion.

Table A 109: Default net calorific values from IPCC Guidelines.

Fuel Name	NCV	Unit
Sewage Sludge Gas	27.00	MJ/m^3

ANNEX 5: ADDITIONAL INFORMATION

Annex 5.1 – NISA

Austria's Obligations

Regarding Austria's obligations under the United Nations Framework Convention on Climate Change (UNFCCC) the relevant COP (Conference of the Parties) Decisions and Guidelines are:

- Decision 11/CP.4 National communications from Parties included in Annex I to the Convention.
- Decision 3/CP.5 Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (referring to Document FCCC/CP/1999/7) revised with Decision 18/CP.8 (referring to Document FCCC/CP/2002/8).
- Decision 4/CP.5 Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention, Part II: UNFCCC Reporting Guidelines on National Communications (referring to Document FCCC/CP/1999/7) revised with Decision 19/CP.8 (referring to Document FCCC/CP/2002/8).
- Decision 20/CP.7 (19/CMP.1): Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol;
- Decision 21/CP.7 (20/CMP.1): Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol;
- Decision 24/CP.19: Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention.

The relevant EU Regulations are:

- Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council; ("*Governance Regulation*"[1]). The purpose of this regulation is to monitor anthropogenic greenhouse gas emissions and to evaluate the progress towards meeting the Union greenhouse gas reduction commitments in accordance with the Paris Agreement;
- Commission Implementing Regulation (EU) 2020/1208 Commission Implementing Regulation (EU) 2020/1208, specifying the reporting obligations and providing templates;
- Commission Delegated Regulation (EU) 2020/1044 of 8 May 2020 supplementing Regulation (EU) 2018/1999 of the European Parliament and of the Council with regard to values for global warming potentials and the inventory guidelines and with regard to the Union inventory system and repealing Commission Delegated Regulation (EU) No 666/2014.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

In addition to the obligation under the UNFCCC Austria has to comply with the following obligations regarding air emissions:

- Austria's annual obligation under the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and its Protocols (1979) comprising the annual reporting of national emission data on SO_2, NO_X, NMVOCs, NH_3, CO, TSP, PM_{10}, and $PM_{2.5}$ as well as on heavy metals (Pb, Cd, Hg), persistent organic pollutants (POPs), dioxins and furans, hexachlorobenzene (HCB) and polychlorinated biphenyls (PCB).
- Obligation under the Austrian Ambient Air Quality Law[2] concerning the reporting of national emission data on SO_2, NO_x, NMVOC, CO, heavy metals (Pb, Cd, Hg), benzene and particulate matter.
- Austria's obligation according to Article 15 of the European IPPC Directive 1996/61/EC is to implement a European Pollutant Emission Register (EPER). EPER was displaced and upgraded by regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register (E-PRTR Regulation). EPER and E-PRTR are associated with Article 6 of the Aarhus Convention (United Nations: Aarhus, 1998) which refers to the right of the public to access environmental information and to participate in the decision-making process of environmental issues.

History of NISA

As there are so many different obligations which are subject to continuous development, Austria's National Inventory System (NISA) has to be adapted to these changes. A brief history of the development and the activities of NISA are shown here:

- Austria established estimates for SO_2 under EMEP in 1978 (Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe).
- As an EFTA country Austria participated in CORINAIR 90, which was an air emission inventory for Europe. It was part of the CORINE (Coordination d'Information Environmentale) work plan set up by the European Council of Ministers in 1985. The aim of CORINAIR 90 was to produce a complete, consistent and transparent emission inventory for the pollutants: SOx as SO_2, NO_X as NO_2, NMVOC, CH_4, CO, CO_2, N_2O and NH_3.
- Austria signed the UNFCCC on June 8, 1992 and subsequently submitted its instrument of ratification on February 28, 1994.
- In 1994, the first so-called Austrian Air Emission Inventory (Österreichische Luftschadstoff-Inventur, OLI) was prepared.
- In 1997, a consistent time series for the emission data from 1980 to 1995 was reported for the first time.
- In 1998, also emissions of HM, POPs and FCs were included in the inventory.
- Inventory data for particulate matter were included in the inventory in 2001.
- In 2005: accreditation according to EN ISO/IEC 17020 as *Inspection Body for Emission Inventories.*
- Periodic external audits by "Accreditation Austria" in 2006, 2008 and 2009
- In 2011: first re-accreditation according to EN ISO/IEC 17020
- Periodic external audits by "Accreditation Austria" in 2012, 2013 and 2014

[2] AUSTRIAN AMBIENT AIR QUALITY LAW (1997): Immissionsschutzgesetz-Luft. Federal Law Gazette I 115/1997.

- In 2016: second re-accreditation according to EN ISO/IEC 17020
- Periodic external audits by "Accreditation Austria " in 2017 and 2018
- In 2020: third re-accreditation according to EN ISO/IEC 17020
- Periodic external audit by "Accreditation Austria" in 2022

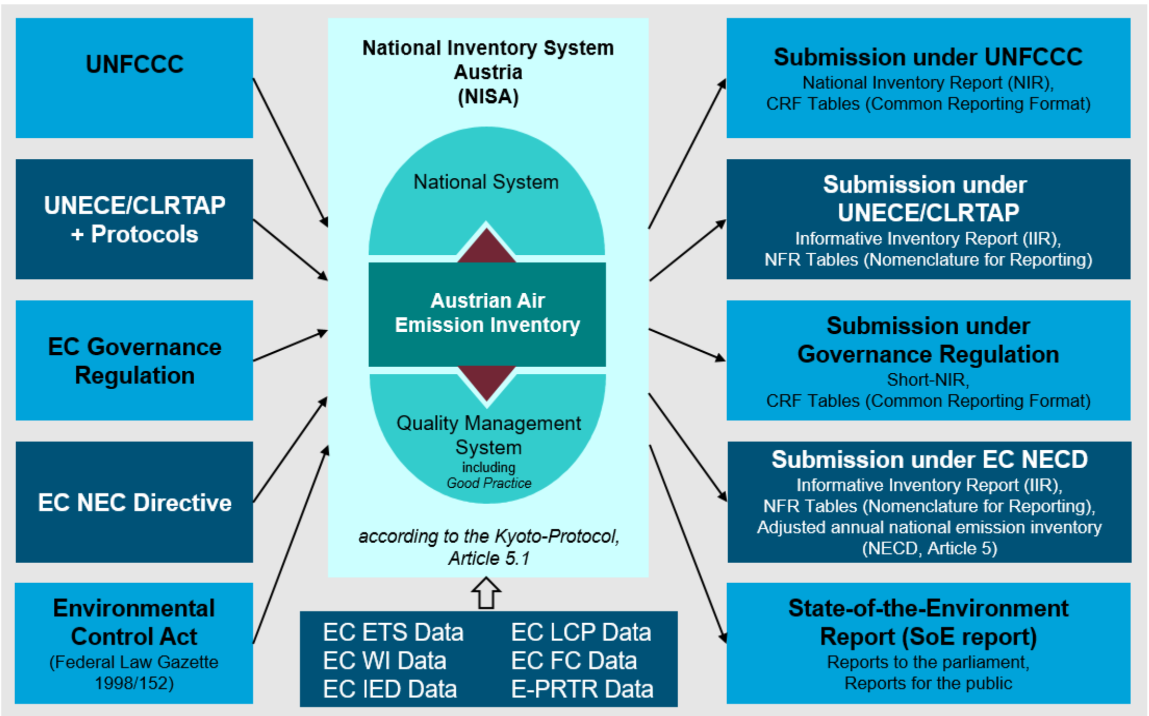
Adaptation of NISA according to the Kyoto Protocol

Regulations under the UNFCCC and the Kyoto Protocol defined new standards for national emission inventories. These standards include more stringent requirements related to transparency, consistency, comparability, completeness and accuracy of inventories. Each Party shall have in place a national system. This national system shall include all institutional, legal and procedural arrangements made within a Party for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

Austria's aim was to set up a national system that fulfils all the requirements of the Kyoto Protocol and also works as an efficient system to fulfil all the other obligations regarding air emission inventories Austria has to comply with.

The emission inventory system has a structure as illustrated in Figure 2.

Figure 2: Structure of the National Inventory System in Austria (NISA).



Source: Umweltbundesamt

The Austrian Air Emission Inventory, comprising all air pollutants stipulated in the various national and international obligations, is at the centre of NISA. The national system and the quality management system have been incorporated into NISA as complementary sections.

The Guidelines for National Systems for the Estimation of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks under Article 5.1 of the Kyoto Protocol (Decision 19/CMP.1) describe the elements to be included in a national system.

The overall goal of National Systems is to ensure the quality of the inventory through planning, preparation and management of inventory activities. National Systems should enable Parties to estimate emissions in accordance with the relevant inventory guidelines to comply with the requirements of the Kyoto Protocol.

The general principles for National Inventories are transparency, consistency, comparability, completeness and accuracy of inventories and the quality of inventory activities (e.g. collecting activity data, selecting methods and emission factors).

The general functions are

- to establish and maintain the institutional, legal, and procedural arrangements defined in the guidelines for national systems between the government agencies and other entities,
- to ensure sufficient capacity for timely performance,
- to designate a single national entity with overall responsibility for the national inventory,
- to prepare national annual inventories and supplementary information in a timely manner and
- to provide information necessary to meet the reporting requirements.

Specific functions stipulated in these guidelines are inventory planning, preparation and management.

Austria has taken significant steps to establish a high-quality emission inventory in which uncertainties are reduced as far as feasible and in which data are developed in a transparent, consistent, complete, comparable and accurate manner.

The following steps have been taken to prepare NISA to meet the requirements of the Kyoto Protocol:

- The Umweltbundesamt has been designated as the single national entity with the overall responsibility for the national inventory by law: the Environmental Control Act ("Umweltkontrollgesetz"; Federal Law Gazette I No. 152/1998) regulates responsibilities of environmental control in Austria and lists the tasks of the Umweltbundesamt. One task is the preparation of technical expertise and basic data for the fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. For further institutional arrangements, please refer to sub-chapter 1.2.4)
- The responsibilities for inventory planning, preparation and management are specified and allocated within the Umweltbundesamt. Following internal Umweltbundesamt quality management regulation, a yearly plan is implemented to ensure capacity for timely performance of the functions defined in the guidelines for national systems. The technical competence of the staff involved in the inventory preparation process is ensured by arrangements according to the QMS of the IBE as well as the internal Umweltbundesamt training plan.
- The inventory preparation, including identification of key categories, uncertainty estimates and QC procedures, is performed according to the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines

- A Quality Management System (QMS) has been developed and implemented.
- The national greenhouse gas inventory is prepared by the inspection body for GHG inventories within the Umweltbundesamt which is accredited as inspection body according to the International Standard ISO/IEC 17020 General Criteria for the operation of various types of bodies performing inspections. The accreditation audit of the Umweltbundesamt as inspection body took place in September 2005. The accreditation was completed officially in December 2005 and renewed in July 2011, May 2016 and February 2020.
- The QMS also includes the necessary procedures to ensure quality improvement of the emission inventory. They comprise documentation of allocated responsibilities, of any discrepancies and of the findings by UNFCCC review experts in particular.
- The inventory management as part of the QMS includes a control system for data and calculations, for records and their archiving as well as documentation of QA/QC activities. This ensures the necessary documentation and archiving for future reconstruction of the inventory and for the timely response to requests during the review process.
- Part of the legal and institutional arrangements in place to provide a basis for the national system concern data availability for the annual compilation of the GHG inventory. The main data source for the Austrian inventory preparation is the Austrian statistical office (Statistik Austria). The compilation of several statistics is regulated by law; the compilation of the national energy balance is regulated by contracts. Other data sources include reporting obligations under national and European regulations and reports of companies and associations.
- A process for official consideration and approval of the inventory prior to its submission is established. The inventory information is provided by the Umweltbundesamt to the Austrian Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK), where the National Focal Point for the UNFCCC is established. The inventory is then submitted by the Ministry to the UNFCCC secretariat.

The Austrian national system was reviewed during the in-country review of the initial report of Austria (February 2007). Paragraph 10 of the review report (FCCC/IRR/2007/AUT) states that the national system has been developed in line with the relevant guidelines and can fulfil the requirements of the Kyoto Protocol as well as other obligations regarding its air emissions inventory that Austria has to comply with.

Annex 5.2 – QMS and Inspection Body for Emission Inventories (IBE)

History of the Austrian QMS

A quality management system (QMS) has been designed to achieve the objectives of *good practice guidance*, namely to improve transparency, consistency, comparability, completeness and confidence in national inventories of emissions estimates. After having been effectively implemented during the development of the UNFCCC submission 2004, the accreditation audit of the Umweltbundesamt (Environment Agency Austria) as *Inspection Body for Emission inventories (IBE)* took place in autumn 2005. Accreditation was awarded in December 2005 and renewed in January 2011, 2016 and 2020.

Table A 110 presents the timetable for the implementation of the quality management system.

Table A 110: Timetable for the implementation of the Austrian QMS.

	Date
Development of a quality management system including Quality Manual	1999–2002
Development of the quality management system Implementation of the quality management system	2003–2005
Accreditation Audit Accreditation as Inspection Body for Greenhouse Gas Inventories	September 2005 December 2005
1st Re-Accreditation Audit Re-Accreditation as Inspection Body for Greenhouse Gas Inventories	January 2011 July 2011
2nd Re-Accreditation Audit Re-Accreditation as Inspection Body for Greenhouse Gas Inventories	December 2015 May 2016
3rd Re-Accreditation Audit Re-Accreditation as Inspection Body for Greenhouse Gas Inventories	February 2020 July 2020

With the start of the EU Emissions Trading system on January 1st 2005 and the entry into force of the Kyoto Protocol on February 16th 2005, greenhouse gas emissions now equal money. Pressure upon national GHG emission inventories is expected to increase, therefore a QMS is considered crucial in order to ensure the quality of emission estimates established according to the requirements of the IPCC 2006 GL as a basis for any kind of international emission trading.

The International Standard EN ISO/IEC 17020

The QMS was drawn up to meet the requirements of the International Standard EN ISO/IEC 17020[3]. It covers the functions of bodies whose work includes assessments of conformity, and the subsequent reporting of results of conformity assessment to clients and, when required, to supervisory authorities. Inspection parameters may include, among others, matters of quantity and/or quality.

The general criteria, with which these bodies are required to comply in order that their services be accepted by clients and by supervisory authorities, are harmonized in the International Standard EN ISO/IEC 17020:2012 *Requirements for the operation of various types of bodies performing inspections.* This standard has been drawn up with the objective of promoting confidence in those bodies performing inspections which conform to it.

The EN ISO/IEC 17020 also takes into account requirements and recommendations of European and international documents such as the EN ISO 9000 series of standards, and goes beyond: additionally to the requirements of the EN ISO 9000 series, the EN ISO/IEC 17020 also provides a clear statement of requirements regarding competence, independence, impartiality and integrity, as well as confidentiality.

[3] The International Standard ISO/IEC 17020 superseded the European Standard EN 45004.

Accreditation Act

According to the EN ISO 17000 series, *accreditation* is the procedure by which an authorized body (accreditation body) formally recognizes that an organisation has the competence to perform a stipulated conformity assessment activity.

The Austrian Accreditation Act 2012 ("Akkreditierungsgesetz 2012", Federal Law Gazette I No 28/2012, last amended by Federal Law Gazette I No 40/2014)) regulates the accreditation of testing, inspection and certification bodies. It designates the Federal Ministry for 'Labour and Economy' (BMAW) as accreditation body and defines the conditions for granting, maintaining and extending accreditation and the conditions under which accreditation may be suspended or withdrawn.

Accreditation is granted after a successful accreditation audit, where an expert nominated by the accreditation body assesses the conformity of the organization of the inspection body and its QMS with the standard, and additionally a technical expert assesses the competence of the inspection body and the conformity of the methodologies applied with specific requirements. This audit takes three days of in-house inspection.

The accreditation requires re-assessment in defined intervals (in the case of an inspection body a one day audit takes place every twenty months on average).

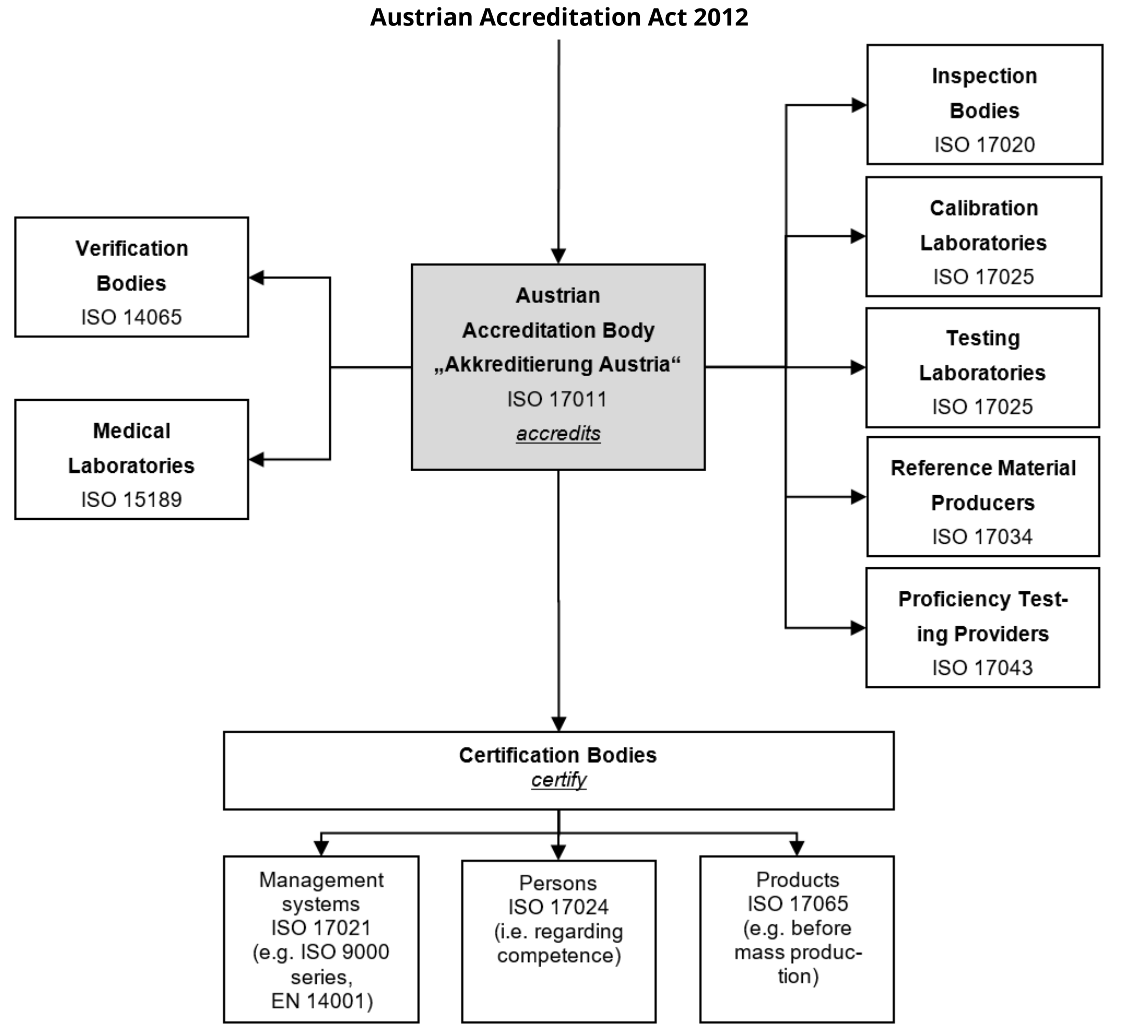
Accreditation and Certification

A certification is the procedure by which an official – or officially recognised – body (certification body) gives written assurance that a product, process or service conforms to specified requirements. Thus, in contrast to an accreditation, the certification gives warrantee for conformity, whereas the accreditation is a warrantee for competence, as well as independence, impartiality and integrity (additionally, both require a QMS that guarantees transparency).

One example for certification is the certification of a QMS according to the EN ISO 9000 series. The certification is issued by a certification body. The certification body on the other side needs an accreditation, which is the warrantee that the certification body is competent to carry out EN ISO 9000 certifications in specific business sectors.

Figure 3 gives an overview of accreditation of conformity assessment bodies by "Akkreditierung Austria" and certification by certification bodies in Austria (based on the Austrian Accreditation Act 2012).

Figure 3: Overview of accreditation of conformity assessment bodies by 'Akkreditierung Austria' and certification by certification bodies in Austria



Source: Umweltbundesamt

Reports issued by an accredited body may carry the federal emblem in addition to the accreditation logo. These reports are official documents.

Independence

The impartiality and independence of the Environment Agency Austria can be deduced from the principles laid down in the UKG (especially sections 5, 6 and 11):

- The Environment Agency Austria GmbH is an independent company which has been assigned public governance functions and specific tasks of public administration.
- In addition to these, the Environment Agency Austria performs only tasks which are in the public interest of protecting the environment.
- Basic annual funds are provided to the Environment Agency Austria as stipulated in the UKG. The responsibility for managing these funds lies with the managing directors of the Environment Agency Austria.

Impartiality and Integrity

The personnel of the inspection body shall be free from any commercial, financial and other pressures which might affect their judgement. It has to be ensured that persons or organisations external to the inspection body cannot influence the results of inspections carried out.

We feel that such a regulation is fundamental in order to guarantee that the emission data reflect real emissions as truly as possible.

Inspection body in the context of the National Greenhouse Gas Inventory

In the case of greenhouse gas emissions inventories, inspection covers (i) data collection (emission data and/or of data which are used to estimate emissions e.g. activity data, emission factors, conversion factors), (ii) the application of appropriate methodologies (IPCC, CORINAIR and country specific methodologies) to estimate emissions, (iii) the compilation of the emissions inventory and (iv) the assessment of conformity with national emission reduction targets. The QMS ensures that all requirements of a Type A inspection body as stipulated in EN ISO/IEC 17020 are met, including independence, impartiality and integrity.

When compiling emission inventories according to the standard, the methodologies applied have to be officially approved by the accreditation body.

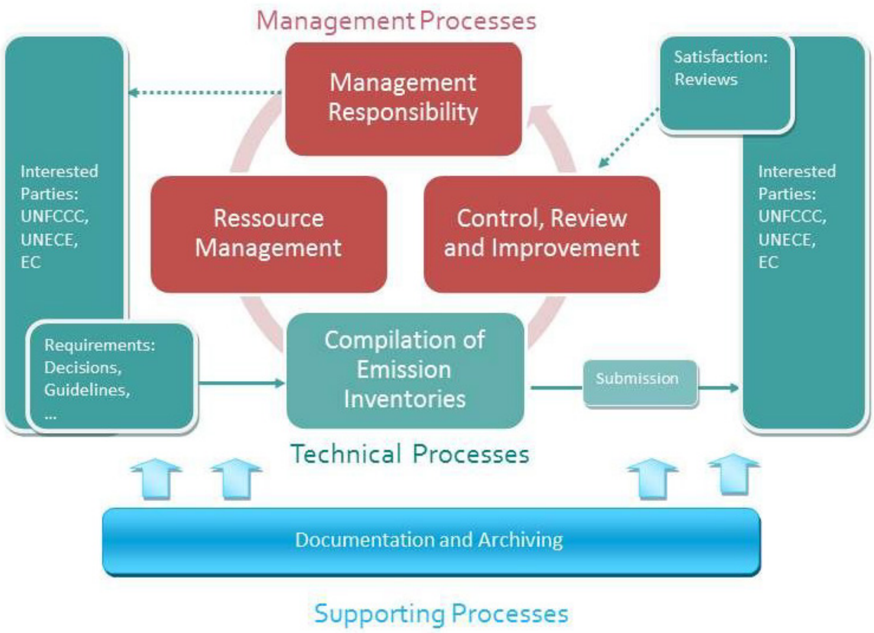
The Austrian Quality Management System (QMS) and requirements of IPCC GL

The implementation of QA/QC procedures as required by the IPCC GL support the development of national greenhouse gas inventories that can be readily assessed in terms of quality and completeness. The QMS as implemented in the Austrian inventory includes all elements of the QA/QC system outlined in the IPCC 2006 GL Volume 1 Chapter 6 'Quality Assurance, Quality Control and Verification', and goes beyond. It also comprises supporting and management processes in addition to the QA/QC procedures in inventory compilation and thus ensures agreed standards not only within (i) the inventory compilation process and (ii) supporting processes (e.g. archiving), but also for (iii) management processes (e.g. annual management reviews, internal audits, regular training of personnel, definition of procedures for external communication).

Design of the Austrian QMS

The design of the QMS of the *Inspection Body for Emission Inventories* (IBE) at the Umweltbundesamt follows a *process based approach*, as illustrated in Figure 4.

Figure 4: Process-based QMS of the IBE



Source: Umweltbundesamt

1) Realisation process

The realisation process is the *Inspection Body's for Emission Inventories* (IBE) core competence as they concern the compilation of emission inventories. The inspection process consists of two steps, (i) data collection and (ii) the application of methods to estimate emissions. The Umweltbundesamt uses IPCC methods, CORINAIR methods and country specific methods. Country-specific methods are thoroughly documented and validated. Emission estimates are subject to quality control checks before being published in an inspection report.

The inspection body performs the majority of inspection processes itself. Any subcontractor performing part of the inspection is required to work in compliance with EN ISO/IEC 17020.

2) Management processes

Management Processes comprise all activities necessary for management and control of an organisation: resources and responsibilities, quality system, internal audits, management review, corrective actions and prevention, external communication.

The most important aspect with respect to organisation and management is that it has to be ensured that the personnel is free from any commercial, financial or other pressure which might affect their judgement. Such regulations are considered fundamental in order to guarantee that emission data reflect actual emissions as truly as possible.

The personnel responsible for inspection shall have appropriate qualifications, training, experience and a satisfactory knowledge of the requirements of the inspections to be carried out. They have the ability to make professional judgements as to conformity with general requirements using examination results and to report there-on.

Computers are used for the compilation of emission inventories. Procedures for protecting the integrity of data and for maintenance of data security have been established and implemented. Access authorisation is strictly limited for protecting the integrity of data and to ensure data confidentiality where necessary.

A management review is held every year; the report is presented to the managing directors who are responsible for resources. The management review report includes an evaluation of the QMS based on information obtained mainly from internal audits, as well as results from the UNFCCC review process, the inventory improvement plan (evaluation of fulfilment of previous plan and decision on new plan) and a plan for the QMS (evaluation of fulfilment of previous plan and decision on new plan).

3) Supporting processes

Supporting processes support both the management and the realisation processes. They include a control system for all documents and data as well as for records and their archiving.

ANNEX 6: INFORMATION ON ACCOUNTING OF KYOTO PROTOCOL UNITS

This chapter refers to 'Chapter 12' as annually submitted in the NIR under the Kyoto Protocol as supplementary information required under Article 7, paragraph 1. As the true-up-period is not yet terminated, information on accounting of Kyoto Protocol Units is continued to be reported, but under this Annex 6.

Background information

Annex I Parties are required to report their national registries' holdings and transactions of Kyoto units and inform about related issues as specified in Decision 15/CMP.1 Section E. The following chapters serve this purpose.

Summary of information reported in the SEF tables

Information from the national registry on acquisition, holding, transfer, cancellation, retirement and carry-over of AAUs, RMUs, ERUs, CERs, tCERs and lCERs for CP2 units in 2022 has been reported as separate file ('SEF_AT_CP2_2022_20230109') in xls and xml format by separate upload.

The SEF for CP2 2022 was generated on 9 January 2023 with data from the Union Registry from 9 January 2023 and the SEF report tool version 3.8.3, provided by the secretariat on 26 January 2018.

Even though there is no obligation to submit a SEF for CP1 after the end of the true-up-period of CP1, the SEF was generated with data from the Union Registry from the 9 January 2023 by using the SEF report tool, version 3.8.3 provided by the secretariat at 26 January 2018 and adapted manually on 09 January 2023 to the current requirements. It is reported as separate file ('SEF_AT_CP1_2022_20230109') in xls and xml format by separate upload.

Further details can be found in the electronic SEF files as mentioned above.

Discrepancies and notifications

No discrepancies occurred in 2022. Therefore, no report R-2 is submitted.

No CDM notifications occurred in 2022. Therefore, no report R-3 is submitted.

No non-replacements occurred in 2022. Therefore, no report R-4 is submitted.

No invalid units exist at the 31 December 2022. Therefore, no report R-5 is submitted.

There were no actions necessary to correct any problem causing a discrepancy because there were no discrepancies in 2022.

Publicly accessible information

Section E of the annex to Decision 15/CMP.1 outlines provisions for making available non-confidential information to the public via a user interface. Austria makes available some of the publicly accessible information on the website of the Austrian emissions trading registry https://www.emissionshandelsregister.at/en/publicreports/unfcccreports.

Additionally Austria uses the possibility to provide this information in the public section "Kyoto Protocol Public Reports" of the Austrian part of the Union Registry which is maintained by the European Commission (https://unionregistry.ec.europa.eu/euregistry/AT/public/reports/publicReports.xhtml) to enable additional access for the public.

Although efforts are taken to keep the information consistent, it might be, that – on this additional place for public information – the information provided there is not exactly the same as on the National Website exceptionally at certain times, as it is not maintained by Austria.

Additional up-to date public information concerning the Consolidated System of EU Registries (CSEUR) is now available at the European Union Transaction Log website http://ec.europa.eu/environment/ets/.

Calculation of the commitment period reserve (CPR)

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

Calculated as 90 per cent of the assigned amount the commitment period reserve is **365 141 085** tonnes carbon dioxide equivalent.

(The calculation based on the most recently reviewed inventory would result in a higher value.)

PPSR-Accounts in the National Registry

Since 16 November 2016 the Union Registry provides the technical possibility to open a PPSR (previous period surplus reserve) account. However, prior to opening it, the PPSR account type had to be first introduced into the EU legislative framework. This was done by the Annex of Commission Delegated Regulation 2015/1844. This provision became applicable, according to Delegated Regulation 2015/1844, with the entry into force of the Doha Amendment to the Kyoto Protocol. As the Communication of the Commission announced the entry into force of the Doha Amendment to the Kyoto Protocol for the 31 December 2020, the PPSR account in our National Registry was opened on the 11 February 2021. Austria has announced in the "Report upon expiration of the additional period for fulfilling commitments by Austria" submitted in December 2015, it's plan to carry over 4 945 AAUs, valid for the first commitment period (CP1),) into the second commitment period (CP2), and 4 935 of these were carried over to the previous period surplus account on the 24 September 2021. The other 10 AAUs were subject to voluntary cancellation on 11 February 2021.

ANNEX 7: CHANGES IN THE NATIONAL REGISTRY

This chapter refers to 'Chapter 14' as annually submitted in the NIR under the Kyoto Protocol as supplementary information required under Article 7, paragraph 1. As the true-up-period is not yet terminated, information on changes in the national registry is continued to be reported, but under this Annex 7.

Information on changes according to Decision 15/CMP.1

The following changes to the national registry of Austria have occurred in 2022.

Table A 111: *Changes to the national registry of Austria 2022.*

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The name and contact of the registry administrator as an institution has not changed. A change of the alternate registry administrator was notified to the Secretariat in 2022.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There has been 3 new EUCR releases (versions 13.6.1, 13.7.1 and 13.8.2) after version 13.5.2 (the production version at the time of the last Chapter 14 submission). No changes were applied to the database, whose model is provided in Annex A. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The changes that have been introduced with ver-sions 13.6.1, 13.7.1 and 13.8.2 compared with ver-sion 13.5.2 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thor-ough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change to the registry internet address occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	No change during the reported period.

Previous Annual Review recommendations

The latest available report FCCC/ARR/2021/AUT did not include any recommendations related to the registry.

There is no SIAR report for 2022 due to the simplified process during the CP2 true-up period. This process foresees a comparison of the submitted SEF files with data of the International Transaction Log. No recommendations have been made in this context.

ANNEX 8: RECALCULATIONS

The following Table A 112 shows the recalculations of Austria's GHG emissions solely due to methodological improvements. The effect of GWP change from AR4 to AR5 however is not included in these figures.

Table A 112: Recalculations in kt CO_2e due to methodological improvements

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	Total (without LULUCF)	16.12	28.05	53.42	100.95	137.05	135.70	129.26	123.36	127.52	113.06	89.23	75.53	56.39	32.01	101.80
1	Total Energy	-237.97	-168.50	5.71	-166.07	-150.09	-126.58	-123.44	-151.80	-148.15	-11.04	-13.80	-9.77	-15.81	-34.36	3.18
1 A	Fuel Combustion Activities (Sectoral Approach)	-237.97	-168.50	5.71	-166.07	-150.09	-126.58	-123.44	-151.80	-148.15	-11.04	-13.81	-9.77	-15.80	-34.36	3.10
1 A 1	Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 a	Public Electricity and Heat Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 b	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 c	Manufacture of Solid Fuels and Other Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2	Manufacturing Industries and Construction	-230.08	-171.70	0.00	-166.34	-150.35	-126.94	-123.97	-152.68	-149.14	-12.13	-15.01	-10.54	-12.23	-26.71	-16.52
1 A 2 a	Iron and Steel	-230.08	-171.70	0.00	-166.34	-150.35	-126.94	-123.97	-152.68	-149.14	-12.13	-15.01	-10.54	-12.15	-26.42	-45.02
1 A 2 b	Non-Ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.02
1 A 2 c	Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.19	22.08
1 A 2 d	Pulp, Paper and Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.41	-0.49	27.39
1 A 2 e	Food Processing, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.58
1 A 2 f	Non-Metallic Minerals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 g	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-39.58
1 A 3	Transport	0.00	-0.01	0.00	0.24	0.35	0.43	0.57	0.85	0.97	1.04	0.85	0.49	-3.71	-7.63	-2.54
1 A 3 a	Domestic Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b	Road Transportation	0.00	-0.01	0.00	0.24	0.35	0.43	0.57	0.85	0.96	1.03	0.84	0.49	-3.71	-7.64	-2.48
1 A 3 c	Railways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	Domestic Navigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1 A 3 e	Other Transportation	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.06
1 A 4	Other Sectors	-7.89	3.21	5.71	0.03	-0.09	-0.07	-0.05	0.03	0.02	0.05	0.35	0.28	0.13	-0.02	22.16
1 A 4 a	Commercial/ Institutional	0.02	0.04	0.15	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	-17.63
1 A 4 b	Residential	-7.91	3.17	5.56	0.02	-0.09	-0.07	-0.05	0.03	0.02	0.04	0.33	0.26	0.11	-0.04	41.67
1 A 4 c	Agriculture/ Forestry/Fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.88
1 A 5	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B	Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.08
1 B 1	Solid Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B 2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.08
2	Total Industrial Processes	254.70	197.61	51.54	300.68	320.62	295.77	286.19	308.68	309.57	158.37	137.82	120.69	108.65	103.48	132.38
2 A	Mineral Industry	21.65	15.42	27.47	17.58	16.71	21.13	21.51	20.59	19.16	22.56	18.91	17.04	18.85	24.36	25.20
2 A 1	Cement Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.47	0.00	0.00	0.00	0.00
2 A 2	Lime Production	43.05	40.40	52.45	44.70	35.66	38.29	36.05	35.08	34.47	37.98	35.88	33.64	37.10	31.54	28.34
2 A 3	Glass Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 A 4	Other Process Uses of Carbonates	-21.40	-24.98	-24.98	-27.12	-18.96	-17.15	-14.54	-14.49	-15.31	-15.42	-16.50	-16.60	-18.25	-7.18	-3.14
2 B	Chemical Industry	0.26	5.57	-5.53	1.69	-5.87	-5.07	-4.60	-4.10	-3.33	-5.82	-3.23	-1.51	-4.62	-4.89	-5.97
2 B 1	Ammonia Production	0.00	0.00	0.00	0.00	0.42	0.51	0.64	0.87	0.95	1.10	1.07	1.16	0.30	-0.90	-0.53
2 B 2	Nitric Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 3	Adipic Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 4	Caprolactam, Glyoxal and Glyoxylic Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 5	Carbide Production	0.26	5.57	-5.53	1.69	-6.25	-5.58	-5.24	-4.97	-4.28	-7.09	-4.72	-2.66	-4.92	-3.99	-5.44
2 B 6	Titanium Dioxide Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 7	Soda Ash Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 8	Petrochemical and Carbon Black Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 9	Fluorochemical Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	Other (please specify)	0.00	0.00	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.17	0.42	0.00	0.00	0.00	0.00
2 C	Metal Industry	232.79	174.30	2.83	168.82	151.59	128.66	125.68	154.42	150.82	14.06	17.02	12.62	14.64	28.65	58.03
2 C 1	Iron and Steel Production	232.79	174.30	2.83	168.82	151.59	128.66	125.68	154.42	150.82	14.06	16.90	12.30	14.12	28.13	57.51

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2 C 2	Ferroalloys Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 3	Aluminium Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 4	Magnesia Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 5	Lead Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.32	0.52	0.52	0.52
2 C 6	Zinc Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 7	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 D	Non-Energy Products from Fuels and Solvent Use	0.00	0.00	0.00	0.03	-0.33	-0.40	-0.52	-0.74	-0.80	-0.92	-1.09	-1.14	-0.31	0.91	0.55
2 D 1	Lubricant Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 D 2	Paraffin Wax Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 D 3	Other (please specify)	0.00	0.00	0.00	0.03	-0.33	-0.40	-0.52	-0.74	-0.80	-0.92	-1.09	-1.14	-0.31	0.91	0.55
2 E	Electronics Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 1	Integrated Circuit or Semiconductor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 2	TFT Flat Panel Display	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 3	Photovoltaics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 4	Heat Transfer Fluid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 5	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F	Product Uses as Substitutes for ODS	0.00	2.32	26.78	112.57	158.53	151.44	144.12	138.51	143.73	128.50	106.21	93.68	80.09	54.46	52.15
2 F 1	Refrigeration and Air Conditioning	0.00	2.32	26.78	112.57	158.53	151.44	144.12	138.51	143.73	128.50	106.21	93.68	80.09	54.27	52.15
2 F 2	Foam Blowing Agents	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F 3	Fire Protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00
2 F 4	Aerosols	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F 5	Solvents	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F 6	Other applications	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 G	Other Product Manufacture and Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.42
2 G 1	Electrical Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
2 G 2	SF_6 and PFCs from Other Product Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2 G 3	N_2O from Product Uses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 G 4	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 H	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Total Agriculture	-1.26	-1.68	-4.39	-1.60	-1.29	-1.26	-1.21	-1.17	-1.41	-1.59	-1.77	-2.31	-2.96	-3.88	-1.36
3 A	Enteric Fermentation	0.00	0.00	-2.13	0.00	0.00	0.00	0.00	0.00	-0.20	-0.40	-0.59	-0.93	-1.25	-1.38	1.01
3 B	Manure Management	0.00	0.00	-0.37	0.00	0.00	0.00	0.00	0.00	-0.04	-0.08	-0.13	-0.19	0.51	1.05	1.92
3 C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 D	Agricultural Soils	-0.61	-1.06	-1.33	-1.08	-0.78	-0.75	-0.70	-0.66	-0.66	-0.60	-0.54	-0.68	-1.71	-3.04	-3.77
3 E	Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 F	Field Burning of Agricultural Residues	-0.65	-0.62	-0.56	-0.52	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51
3 G	Liming	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 H	Urea application	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 I	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Land Use, Land Use Change and Forestry	-130.01	-6 482.15	2 287.72	-7 638.57	-15 970.54	-11 189.84	-2 249.67	-3 693.13	-5 214.42	-4 349.21	-4 935.22	-446.65	8 072.74	4 775.20	-3 955.64
4 A	Forest Land	-170.16	-6 594.94	2 092.80	-7 945.24	-16 476.85	-11 839.98	-2 906.67	-4 333.04	-5 496.98	-4 578.49	-5 175.43	-880.52	7 512.57	4 202.17	-4 512.74
4 B	Cropland	-139.70	-123.90	-122.80	-117.17	-180.71	-189.33	-195.67	-202.23	-207.55	-235.93	-249.63	-232.88	-232.26	-219.42	-214.17
4 C	Grassland	59.52	24.98	28.93	75.35	186.06	183.79	181.28	180.14	177.73	174.46	161.57	149.39	143.42	141.44	138.06
4 D	Wetlands	5.39	3.56	3.74	4.72	16.83	16.73	16.63	16.60	16.56	16.55	16.53	16.51	16.50	16.57	16.64
4 E	Setllements	57.67	170.35	245.26	310.47	384.77	409.50	401.99	395.37	293.51	230.48	273.42	298.81	412.79	381.64	292.53
4 F	Other Land	57.27	37.80	39.79	33.31	99.35	229.45	252.76	250.03	2.29	43.72	38.32	202.05	219.74	252.80	273.16
4 G	Harvested Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.89
5	Total Waste	0.65	0.62	0.56	-32.06	-32.19	-32.23	-32.28	-32.35	-32.49	-32.68	-33.02	-33.09	-33.49	-33.24	-32.40
5 A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
5 B	Biological Treatment of Solid Waste	0.00	0.00	0.00	-32.58	-32.70	-32.74	-32.79	-32.85	-32.99	-33.19	-33.52	-33.59	-34.00	-33.82	-33.79
5 C	Incineration and Open Burning of Waste	0.65	0.62	0.56	0.52	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
5 D	Waste Water Treatment and Discharge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.88

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The National Inventory Report 2023 (NIR 2023) gives a detailed and comprehensive description of the trend and the methodologies applied in the Austrian air emissions inventory for the greenhouse gases carbon dioxide, methane, nitrous oxide, HFC, PFC, SF_6 and NF_3.

With this report, Austria complies with its reporting obligations under the EU Governance Regulation No 2018/1999 as well as the UNFCCC by providing transparent and verifiable documentation. It contains emission data by sector for the years 1990−2021 as well as information on emission factors, activity data and other basic data for emission calculations.

Moreover, the report provides documentation of the national inventory system and quality control and assurance activities as performed by the accredited Inspection Body for Emission Inventories (ISO/IEC 17020).

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