ENVIRONMENT AGENCY AUSTRIA **umwelt**bundesamt

AUSTRIA'S NATIONAL INVENTORY REPORT 2018

Submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol

REPORT
REP-0640
Vienna 2018

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 (www.bmdw.gv.at/akkreditierung)

Project management

Elisabeth Kampel

Authors

Michael Anderl, Marion Gangl, Simone Haider, Elisabeth Kampel, Traute Köther, Christoph Lampert, Bradley Matthews, Günter Pfaff, Marion Pinterits, Stephan Poupa, Maria Purzner, Wolfgang Schieder, Carmen Schmid, Günther Schmidt, Barbara Schodl, Elisabeth Schwaiger, Bettina Schwarzl, Gudrun Stranner, Michaela Titz, Peter Weiss, Andreas Zechmeister

Reviewed and approved by

Klaus Radunsky

Layout and typesetting

Draft

Title photograph

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Reporting entity	Contracting entity
Inspektionsstelle Emissionsbilanzen *(Inspection Body for Emission Inventories)* at the Umweltbundesamt GmbH Spittelauer Lände 5, 1090 Vienna/Austria	**BMNT** (*Federal Ministry of Sustainability and Tourism*) Stubenring 1, 1012 Vienna/Austria
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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) 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change (fulfilment of Art. 7 MMR). This report is the official submission of Austria for the year 2018 under the UNFCCC and under the Kyoto Protocol.

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 the2006 GL Supplement Wetlands (scope of accreditation regarding GHG emissions) as well as the UNFCCC Reporting Guidelines, including the Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol.

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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 (Annex I), containing revised common reporting format tables (Annex II) and global warming potential values (Annex III). According to this decision an annual GHG inventory submission shall consist of an National Inventory Report (NIR) and CRF tables.

The report also presents GHG data relevant under the Effort-sharing decision (target period 2013-2020). It is submitted to the European Commission in fulfilment of Austria's obligations under Article 7 of Regulation (EU) No 525/2013[1] ("*Monitoring Mechanism Regulation*"; MMR) repealing Decision No 280/2004/EC[2] ("*Monitoring Mechanism Decision*"; MMD) relating to a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol. The purpose of this decision is to monitor all anthropogenic greenhouse gas emissions not controlled by the Montreal Protocol[3] and to evaluate the progress towards meeting the greenhouse gas reduction commitments under the UNFCCC and the Kyoto Protocol.

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 in response to the previous UNFCCC review (2016).

This is the 17th version of the National Inventory Report (NIR) submitted by Austria and it builds on the NIR submitted in 2017[4]. The 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 2018 replaces the information submitted in previous years and the preliminary data reported to the European Commission on 15 January 2018.

Elisabeth Rigler in her function as head of the Department *Climate change mitigation & Emission inventories* of the *Umweltbundesamt* is responsible for the preparation and review of Austria's National Greenhouse Gas Inventory as well as for the preparation of the NIR.

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1 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:165:0013:0040:EN:PDF

2 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:049:0001:0001:EN:PDF

3 http://ozone.unep.org/new_site/en/Treaties/treaty_text.php?treatyID=2

4 Austria's National Inventory Report 2017 – Submission under the United Nations Framework Convention of Climate Change and under the Kyoto Protocol. Report REP-0608. Umweltbundesamt, Vienna.

Klaus Radunsky 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. Michael Anderl acts as deputy head of the *Inspection Body for Emission Inventories.*

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

Specific responsibilities for the preparation of the Austrian air pollutant inventory are:

- Data management...Stephan Poupa
- Fuel combustion stationary ....Stephan Poupa ('Sector Lead')
- Fuel combustion mobile ....Gudrun Stranner ('Sector Lead')
- Fugitive emissions ....Marion Pinterits ('Sector Lead')
- Industrial processes ....Michaela Titz ('Sector Lead')
- Product use ....Maria Purzner ('Sector Lead')
- Agriculture ....Michael Anderl ('Sector Lead')
- LULUCF ....Peter Weiss ('Sector Lead')
- Waste ....Christoph Lampert ('Sector Lead')
- Key Category Analysis ....Andreas Zechmeister
- Uncertainty Analysis..Andreas Zechmeister

Project leader for the preparation of the NIR is Elisabeth Kampel.

Specific responsibilities for the NIR 2018 have been as follows:

- Executive Summary .... Elisabeth Kampel
- Chapter 1.1 .... Elisabeth Kampel
- Chapter 1.2, 1.3.. Günther Schmidt
- Chapters 1.4, 1.5, 1.6................................ Elisabeth Kampel
- Chapter 2... Elisabeth Kampel, all sector experts
- Chapters 3.1, 3.2, 3.4................................ Stephan Poupa
- Chapter 3.2 (Road Transport, Aviation) .... Gudrun Stranner, Barbara Schodl
- Chapter 3.3.. Marion Pinterits
- Chapter 4.1–4.4... Michaela Titz, Maria Purzner
- Chapter 4.5–4.7... Maria Purzner, Michaela Titz
- Chapter 4.8.. Maria Purzner, Michaela Titz
- Chapter 5... Michael Anderl, Simone Haider
- Chapter 6... Peter Weiss, Carmen Schmid, Elisabeth Schwaiger, Bettina Schwarzl, Bradley Matthews
- Chapters 7.1–7.3, 7.5................................ Christoph Lampert, Elisabeth Kampel
- Chapter 7.4.. Stephan Poupa
- Chapter 8... Elisabeth Kampel
- Chapter 9... Elisabeth Kampel
- Chapter 10... all sector experts
- Chapter 11... Peter Weiss, Carmen Schmid, Bradley Matthews
- Chapter 12... Günter Pfaff
- Chapter 13... Günther Schmidt
- Chapter 14... Günter Pfaff
- Chapter 15... Angela Friedrich, Martin Kriech (BMNT)

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ANNEX

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.

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. The compilation of these inventories follows rules as agreed under the respective bodies of the UNFCCC and the Kyoto Protocol.

ES.2 Summary of national emission and removal-related trends

In 2016 Austria's total greenhouse gas (GHG) emissions (without LULUCF) amounted to 79.7 Mt CO_2 equivalents (CO_2e). Compared to 1990 GHG emissions increased by 1.2%, compared to 2015 GHG emissions increased by 1.0%.

The most important GHG in Austria is carbon dioxide (CO_2) with a share of 85% in 2016. The CO_2 emissions primarily result from combustion activities. Methane (CH_4), which mainly arises from stock farming and waste disposal, contributes 8.2% to national total GHG emissions, and nitrous oxide (N_2O) with agricultural soils as the main source contributes another 4.5% in 2016. The remaining 2.6% 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	Total	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
	CO_2 equivalent (kt)							
1990	78 690	62 292	10 405	4 337	2.4	1 183	471	0
1991	82 496	65 900	10 284	4 501	3.9	1 193	614	0
1992	75 796	60 431	10 000	4 192	5.6	510	656	0
1993	75 855	60 788	9 915	4 109	235	64	744	0
1994	76 393	61 190	9 628	4 316	261	71	926	1
1995	79 730	64 206	9 561	4 420	353	83	1 100	6
1996	82 924	67 674	9 257	4 311	417	80	1 177	8
1997	82 461	67 453	8 955	4 336	498	117	1 086	16
1998	81 757	67 054	8 776	4 383	609	56	870	9
1999	80 055	65 621	8 597	4 372	701	79	676	8
2000	80 432	66 262	8 434	4 349	714	88	575	11
2001	84 510	70 391	8 274	4 226	863	116	629	11
2002	86 199	72 147	8 130	4 227	969	102	613	11
2003	91 817	77 764	8 067	4 216	1 072	126	549	22
2004	91 575	78 053	8 068	3 628	1 158	158	484	27
2005	92 655	79 367	7 830	3 627	1 146	163	494	28
2006	89 832	76 688	7 705	3 628	1 152	172	453	33
2007	87 103	74 032	7 579	3 638	1 196	230	367	59
2008	86 951	73 806	7 446	3 815	1 249	208	373	53
2009	80 119	67 483	7 354	3 590	1 309	36	342	5
2010	84 931	72 383	7 255	3 391	1 483	78	336	4
2011	82 450	70 116	7 053	3 490	1 407	74	307	4
2012	79 917	67 661	6 943	3 456	1 486	51	312	9
2013	80 178	68 001	6 851	3 451	1 512	49	305	10
2014	76 442	64 253	6 709	3 520	1 583	53	313	11
2015	78 856	66 704	6 632	3 527	1 620	50	310	13
2016	79 673	67 402	6 567	3 614	1 641	50	393	6

NOTE: Emissions without LULUCF

Over the period 1990–2016 CO_2 emissions increased by 8.2%, mainly due to increased emissions from transport. Methane emissions decreased during the same period by 37% mainly due to lower emissions from solid waste disposal; N_2O emissions decreased by 17% over the same period due to lower emissions from agricultural soils and from chemical industry. HFC emissions increased remarkably between 1990 and 2016 (from 2.4 to 1 641 kt CO_2e), whereas PFC and SF_6 emissions decreased by 96% and 17% respectively. NF_3 emissions amounted to 6.1 kt CO_2 equivalents in 2016 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 68% of total national GHG emissions in 2016 (67% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (21% in 2016) and *Agriculture* (9.1% in 2016).

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	52 914	13 662	8 189	-11 982	3 925	NO*
1991	56 581	13 696	8 225	-16 685	3 994	NO
1992	52 009	12 053	7 787	-11 663	3 946	NO
1993	52 272	12 004	7 658	-11 962	3 921	NO
1994	51 932	12 739	7 899	-11 839	3 823	NO
1995	54 436	13 605	8 038	-13 261	3 651	NO
1996	58 615	13 057	7 789	-10 644	3 463	NO
1997	57 187	14 219	7 740	-19 124	3 315	NO
1998	56 989	13 865	7 708	-17 222	3 195	NO
1999	55 731	13 647	7 601	-19 497	3 075	NO
2000	55 322	14 640	7 506	-16 364	2 963	NO
2001	59 675	14 521	7 449	-19 202	2 865	NO
2002	60 835	15 164	7 337	-14 166	2 863	NO
2003	66 457	15 305	7 189	-4 789	2 867	NO
2004	66 614	14 861	7 170	-9 118	2 930	NO
2005	67 150	15 610	7 104	-10 597	2 791	NO
2006	63 834	16 249	7 077	-5 116	2 671	NO
2007	60 503	16 938	7 119	-5 510	2 543	NO
2008	60 023	17 271	7 226	-4 276	2 431	NO
2009	56 642	13 947	7 245	-4 544	2 285	NO
2010	59 752	15 926	7 095	-5 878	2 158	NO
2011	57 306	15 955	7 146	-6 106	2 043	NO
2012	55 325	15 570	7 079	-5 476	1 942	NO
2013	55 400	15 887	7 063	-4 524	1 829	NO
2014	51 440	16 073	7 189	-4 725	1 739	NO
2015	53 352	16 669	7 178	-4 445	1 656	NO
2016	54 336	16 468	7 286	-4 208	1 581	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 2016: NO_x by 31%, CO by 53%, NMVOC by 55%, and SO_2 by 81%. The most important emission source for NO_x, SO_2 and CO is *Energy* (fuel combustion). The most important emission source for NMVOC is *Solvent and other Product Use*.

Table 3: Emissions of indirect GHGs and SO_2 1990–2016.

Year	NO_x	CO	NMVOC	SO_2
	[kt]			
1990	219	1.190	302	74
1991	228	1.186	295	71
1992	215	1.132	272	54
1993	206	1.077	254	53
1994	200	1.022	232	47
1995	200	928	218	47
1996	218	937	212	44
1997	204	877	200	40
1998	217	841	193	36
1999	208	736	184	34
2000	214	740	175	32
2001	224	719	172	33
2002	230	693	169	32
2003	238	700	167	31
2004	235	690	162	27
2005	238	670	159	26
2006	225	657	154	26
2007	214	619	149	23
2008	199	600	146	20
2009	183	570	142	15
2010	183	582	143	16
2011	174	568	139	15
2012	169	571	139	15
2013	170	590	140	15
2014	160	543	135	15
2015	157	566	137	15
2016	152	563	137	14

PART 1: ANNUAL INVENTORY SUBMISSION

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

By deforestation people have influenced the local and regional climate at all times. But since the beginning of industrialization in the middle of the 18th century mankind has influenced the climate also globally by emitting greenhouse gases like carbon dioxide, methane, nitrous oxide as well as various fluorinated and chlorinated gases.

The average surface temperature of the earth has risen by about 0.65–1.06°C in the 20th century and, according to the fifth assessment report of the IPCC, will rise by another 0.9–5.4°C in the 21st century, depending on the emission scenario.

The increase of the average surface temperature of the earth will lead, with the increase of the surface temperature of the oceans and the continents, 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 which drives rainfall, wind and temperature on the regional scale. This will increase the risk of extreme weather events such as hurricanes, typhoons, tornadoes, severe storms, droughts and floods.

1.1.1.2 Climate Change in Austria

The effects of global warming in Austria are manifold because the Alps as well as the region along the Danube have a very high vulnerability to climate change, which is reflected in the overall change in temperature of the Alps of about 2° C since the 19th century. That is significantly higher than the global average (which is about 0.85 °C).

Even more important than the average temperature for agriculture, energy production, tourism etc. is precipitation. So far experts think that the overall precipitation will remain constant, however recent models show a concentration during winter, with relatively dry summers. An exact forecast of these trends is substantial for adjustments in spatial planning, agriculture and forestry, tourism, flood control measures etc. Being aware of the need for further research in this matter, 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.

1.1.1.3 The Convention, its Kyoto Protocol 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[5]: 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.

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. However it has not yet been set into force as by the end of 2017 only 108 Parties have deposited their instruments of acceptance (144 are needed).

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).

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

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 2016. 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)[6] 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 and 2016 the re-accreditation was passed successfully. In 2017, the IBE again has undergone and successfully passed an external audit by a quality expert appointed by Accreditation Austria.

For the purpose of Quality Assurance, resulting from increased requirements of transparency, consistency, comparability, completeness and accuracy of the national greenhouse gas inventory as set by the new standards defined in the KP, 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 in-country reviews (2006, 2007[7] 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 and 2016. In 2017 no UNFCCC Review was conducted. The reports on these reviews can be found on the UNFCCC website[8].

Moreover 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). According to Article 19 of the MMR (Monitoring Mechanism Regulation No 525/2013) an annual review has to take place for all EU MS inventories 2013–2020, partly to be conducted as a comprehensive review. In 2015 this 'ESD-Review' was done as a trial review as inventories were submitted delayed due to the technical problems with the CRF Reporter. In 2016 a so called "comprehensive ESD-Review" was conducted, but no technical corrections were made.

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 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

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6 http://www.umweltbundesamt.at/fileadmin/site/umweltkontrolle/gesetze/ukg.pdf

7 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.

8 http://unfccc.int/national_reports/annex_i_ghg_inventories/items/10546.php

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 or 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 an 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 are made up of staff from various organisational units of the Umweltbundesamt, who in the course of their inspection activity are assigned to the IBE and therefore responsible to the head of the inspection body. They are free from any commericial, financial and other pressures that might influence their technical judgement, and no technical instructions from outside the IBE is given for the preparation of emission inventories (see Figure 1).

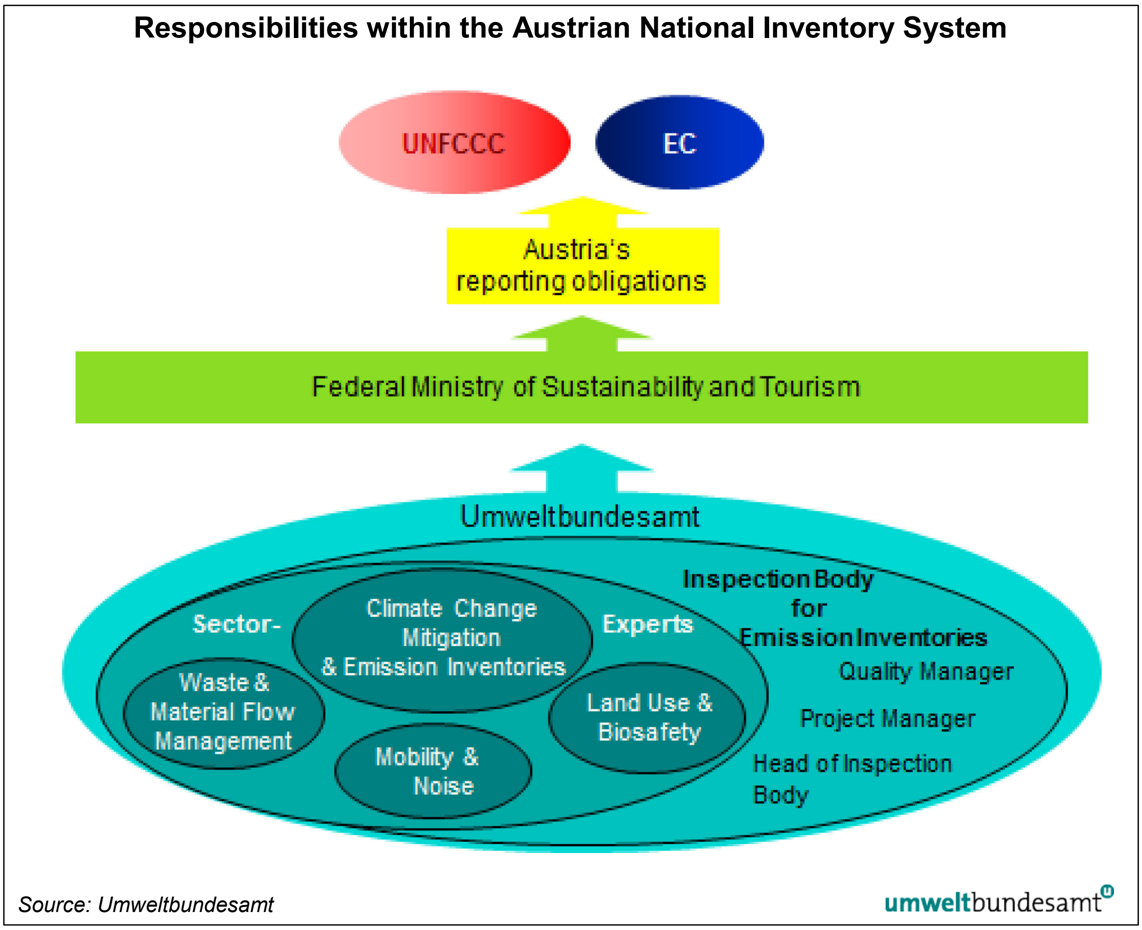

Figure 1: Responsibilities within the Austrian National Inventory System (greenhouse gases).

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 als 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). Two experts form a sector team, whereas one team member is nominated as team leader ('Sector Lead'). 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 Sustainability and Tourism. This mandate was given to the Umweltbundesamt in the Registry Ordinance (Registerstellenverordnung) Federal Law Gazette II no. 208/2012. 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 as a party of the Kyoto Protocol.

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[9] that regulates monitoring and reporting in the context of the EU Emissions Trading Scheme (ETS) in Austria.
- The Umweltbundesamt takes the 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, where more detailed information than provided in the national energy balance is available, but also for emissions from industrial processes,. First data from the EU ETS were available for the year 2005; since then ETS data were considered in the submissions.
- The Austrian statistical office (Statistik Austria) is required by contract with the 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[10]), 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"[10] (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[11] each licencee 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. These data are used to verify the data from the national energy balance for the Energy sector.
- According to the old Landfill Ordinance (Deponieverordnung 1996)[12] the operators of landfill sites had to report type and amount of waste deposited annually. This 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.

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[9] *„Emissionszertifikate-Gesetz 2011"*; Federal Law Gazette I No 118/2011, last amended by Federal Law Gazette I No 128/2015

[10] *„Bundesstatistikgesetz 2000"*; Federal Law Gazette I No 163/1999, last amended by Federal Law Gazette I No 40/2014

[11] *„Emissionsschutzgesetz für Kesselanlagen 2013"*; Federal Law Gazette I No 127/2013, last amended by Federal Law Gazette I No 81/2015

[12] *„Deponieverordnung";* Federal Law Gazette No 164/1996, last amended by by Federal Law Gazette II No 49/2004

- Starting with the deposited waste of the year 2008 landfill operators are - persuant to the new Landfill Ordinance (Deponieverordnung 2008)[13] - obliged to submit their data annually and electronically via the portal http://edm.gv.at (Electronic Data Management – 'EDM'). Responsible for data collection and analysis is the BMNT (until 2017 called BMLFUW). The necessary data is requested by the Umweltbundesamt for the purpose of inventory preparation.
- Since 2004 there is a reporting obligation to the BMNT under the Austrian Fluorinated Compounds (FC) Ordinance[14] for users of FCs for the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. These data are 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 is thus also responsible for coordinating QA/QC and verification activities. Responsibilities of the different functions – quality representative, sector expert, sector lead, project manager, head of inspection body, report coordinator 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). Two experts form a sector team, and of them is nominated as team leader ('Sector Lead'). 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. Finally, sector experts perform Quality Assurance and Quality Control (QA/QC) activities.

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 fulfillment 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 director of the Umweltbundesamt, to obtain the necessary additional resources. Furthermore issues that need intervention by the managing director or the ministry are

[13] *„Deponieverordnung 2008"*; Federal Law Gazette II No 39/2008, last amended by Federal Law Gazette II No 291/2016

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

discussed. On the basis of the decisions at the management review, the project manager and sector leads work out a detailed working plan including milestones, timelines and responsibilities.

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 (sector experts, deputies, project-/quality- and data managers of the inventory); 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 report (Short-NIR)	Compilation of a inventory report 'Short NIR' and submission to the EC (MMR Monitoring Mechanism Regulation No 525/2013)	January 15
Preparation of NIR	Compilation of the National Inventory Report	January–March
EU Submission NIR	Submission ot the National Inventory Report to the EC (MMR)	March 15
UNFCCC Submission NIR	Submission ot the National Inventory Report to the UNFCCC	April 15

Table 5 gives an overview of the registry related tasks for providing the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol including a timeline.

Table 5: Overview registry related tasks.

Task	Description	Deadline
Standard Electronic Format (SEF)	Compilation of the SEF for the previous year	January 15
Information on changes in the national registry	Preparation of the chapter on the changes in the national registry, which is part of the NIR	April 15
Information on accounting of Kyoto Protocol units	Preparation of the chapter on information on the accounting of Kyoto Protocol units, which is part of the NIR. Compilation of the files for the Standard Independent Assessment Report (SIAR), which are submitted together with the NIR.	April 15

1.2.3 Quality assurance, quality control and verification

For fulfillment of the reporting obligations the department *Climate Change Mitigation & Emission Inventories* at 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[15] as Inspection Body for emission inventories, Type A (ID No. 241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG)[16], 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 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 every 15 months; every five years the accreditation has to be renewed in a more comprehensive audit. The accreditation of the IBE has been awarded for the first time in 2005 and has been renewed in 2011 and 2016 so far.

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 ISO 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.

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

[16] Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012), last amended by Federal Law Gazette I No 40/2014

Table 6: Overview of QA/QC aspects in different technical and quality standards.

IPCC 2006 GL	EMEP/EEA GB 2016[17]	ISO 9001[18]	ISO/IEC 17020[19]
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[20]	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.

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, under the Kyoto Protocol, climate change mitigation measures and air quality control. To achieve this, the IBE is committed to strict impartiality and quality management. In this context, the term quality means:

1. Fulfilment of requirements for emission inventories.
2. For the fulfillment of these requirements, the IBE undertakes to keep its staff updated on the latest technical expertise, scientific findings and the latest developments. The IBE will therefore encourage the participation of its staff in international technical and political processes and ensure the transfer of knowledge within the IBE.
3. Compliance with the EN ISO/IEC 17020 standard by ensuring the implementation and continuous improvement of a QMS as described in this 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 re-

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

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

[19] contains additional requirements compared to ISO 9001

[20] According to the EMEP/EEA Guidebook 2016, it also is good practice to summarize lessons learned from previous inventory preparation cycles in an inventory management report.

production, 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 fulfillment 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 main 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 sub-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.): http://www.umweltbundesamt.at/umweltsituation/luft/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, ...)

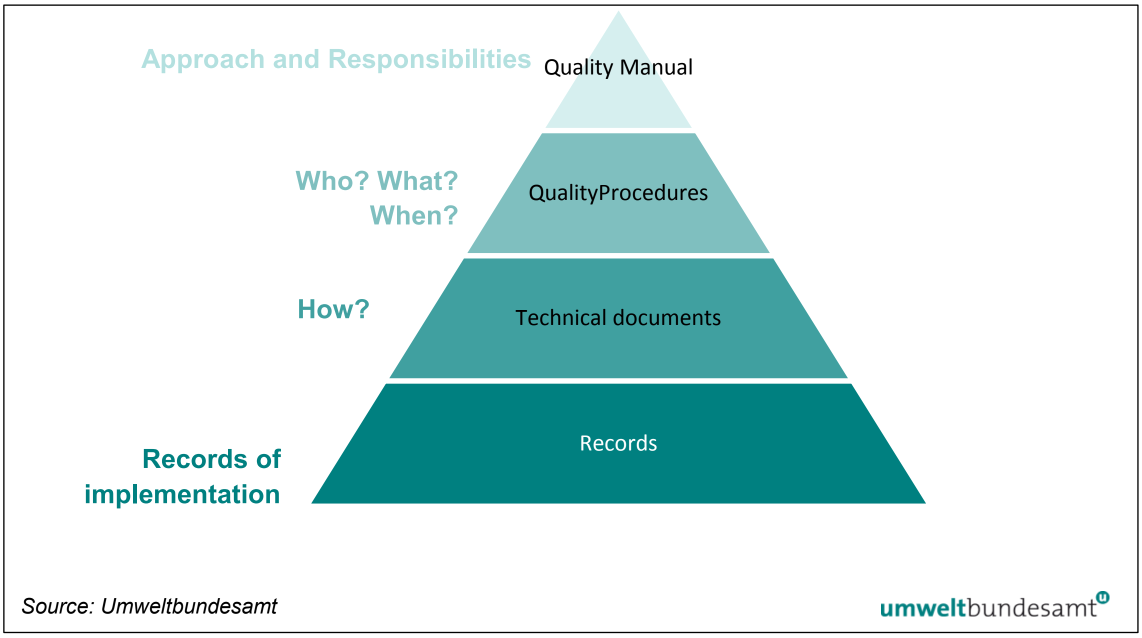

Figure 2: Structure of the Austrian Quality Management System (QMS).

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 above checks 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 report check by sector experts
(4) Tier 1/ general Step 2: final check of consistency of figures in reporting format and report by a member of the IBE team

1.2.3.5 QA Activities

The following QA activities are performed:

Validation of methodologies and calculation

Before methodologies are applied the methodology is defined as a SOP (standard operating procedure) together with a template for calculating emissions, where needed. The SOP is checked for applicability and completeness of information needed 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 (from 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 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 sub-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 ISO/IEC 17020 is regulary monitored. Audits are performed every 15 months by the accreditation body (one day audit), and every fifth year the accreditation has to be renewed (two day audit). The audits aim to assess the QM system with regard to compliance with the underlying standard 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.

Audits of data suppliers

Suppliers of annual activity data, that do not have in place a (certified) QMS or whose data are not independently verified, are audited in a so called 'input data audit'. The aim of the audits is to assess:

(1) whether the requirements regarding independence and integrity are fulfilled
(2) the long term availability of the data
(3) the data collection and management process
(4) whether the QC requirements of the data processing are fulfilled

When indicated, recommendations for improvements are made and implementation of these measures is assessed. These input data audits have proven a good basis for the cooperation with the data supplier.

Since 2007 all main data suppliers have been audited:

- 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 a follow-up audit at these institutions only when substantial changes become apparent.

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 director, and if additional resources are needed, these are notified to the Federal Ministry of Sustainability and Tourism (BMNT).

1.2.3.7 Treatment of confidentiality issues

The IBE ensures confidential treatment of sensitive information obtained in the course of its inspection activities. Information or data is declared as confidential when it could directly or indirectly identify an individual person, business or organisation. For this reason some emissions are reported at a higher aggregated level so that confidentiality is no longer an issue, e.g. for F-gases. 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[21].

[21] Federal Act on Federal Statistics (Federal Statistics Act 2000) no. 163/1999, as amended by BGBL. I, no. 136/2001, by BGBl. I, no. 71/2003, by BGBl. I, no. 92/2007 and by BGBl. I, no. 125/2009.

- 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.

- 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.

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 2017

Only some minor changes of the Quality Manual and its quality and technical procedures were made in 2017, e.g. improvement of documentation of internal audits, updating the information sheet for external data suppliers, refining the process of submissions of draft review reports if e.g. layout is not finalised in time. Moreover, the IBE-team was again slightly re-arranged, overall increasing the number of experts involved in inventory work. To strengthen the technical competence of the IBE, one IBE sector expert studied the Kyoto Protocol course for reviewers and eight attended the course for the Review of Biennial Reports (BRs) and National Communications (NCs). All team members passed their corresponding exams.

Moreover, the following QA/QC activities were done in 2017:

- An emergency exercise on data management, i.e. compilation of emission data tables and preparing the submission, was successfully conducted by the deputy of the data manager of the IBE, with the aim of training the expert and testing the quality of the internal documentation on this issue. It is planned to conduct such a dummy inventory compilation as a training every two years to keep the deputy up-to-date and fit for a submission in case of an unplanned absence of the data manager.

Furthermore, in 2017 a periodic review took place, conducted as a one-day QM audit by a competent external auditors appointed by Accreditation Austria. Improvement measures set during the Re-Accreditation 2015 were checked and further questions on the Quality Management System of the IBE and its implementation in practice raised. The audit proved continuous improvement of the system and compliance with the underlying standard ISO/IEC 17020.

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 present Austrian greenhouse gas inventory for the period 1990 to 2016 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 subcontracting studies, if needed. As part of the quality management system the head of the „Inspection Body of Emission Inventories“ approves the methodological choices. Sector experts also perform Quality Control (QC) activities that are incorporated in the Quality Management System (QMS). All data collected together with emission estimates are fed into a database (see below), where data sources are well documented for future restoration of the inventory.

Supplementary information required under Article 7 of the Kyoto Protocol regarding KP-LULUCF is prepared by the same sector experts as information for UNFCCC-LULUCF. Other Article 7 supplementary information is requested from the national registry, which is also managed by Umweltbundesamt.

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. Furthermore, as part of the QMS, backups of the entire inventory information are made on write-protected DVDs. 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 future restoration 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[22].

[22] „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.

- 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 (BMNT) 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.

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

Table 7: Main data sources for activity data.

Sector	Data Sources for Activity Data
Energy	• Energy Balance from Statistik Austria; • EU-ETS; • Steam boiler database; • Direct information from industry or associations of industry
Transport	• Energy Balance from Statistik Austria • Yearly growth rates of transport performance on Austrian roads from Austrian Ministry for Transport, Technology and Innovation
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
LULUCF	• National forest inventory obtained from the Austrian Federal Office and Research Centre for Forests • Soil inventories by the Federal States and by the Austrian Federal Office and Research Centre for Forests • National agricultural statistics and land use statistics obtained from Statistik Austria
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)

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

In cases where the IBE's capabilities or resources are exceeded, some of its inventory activities are subcontracted, in some cases routinely (e.g. the emission inventory for road transport), in other cases as required (e.g. revision of methodologies for a complex emission source). Such subcontracts have so far be concluded with:

- Technical University Graz (road and off-road transport)
- Technical University of Natural Resources and Applied Life Sciences, Research Center Seibersdorf (agriculture)
- Öko-Recherche Büro für Umweltforschung und -beratung GmbH (F-gases)

However, the final assessment of fulfillment 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 2013 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[23]
- EMEP/EEA air pollutant emission inventory guidebooks[24]
- Handbook emission factors for road transport (HBEFA), Version 3.2 (KELLER, M./WÜTHRICH, P. 2014)
- 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

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

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[23] http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm

[24] Prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (TFEIP) and published by the European Environment Agency (EEA). Latest update: http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

of the European Parliament and of the Council[1] and amended by Directive 2009/29/EC[25]. 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)**.**[2] About one third of total Austrian GHG emissions currently result from installations under the EU-ETS (~29 Mt CO_2 in 2016).

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, runs from 2013 to 2020. 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 601/2012[26]. In Austria, Member State specific regulations are defined in the Austrian Emissions Allowance Trading Act[27] and the Austrian Monitoring, Reporting and Verification Ordinance[28]. 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 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 is in charge of granting the licence to independent verifiers. In addition, the Ministry 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] 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

25 Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the emission allowance trading scheme of the Community, OJ L 140/63

[2] 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.

26 Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

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

28 Überwachungs-, Berichterstattungs- und Prüfungs-Verordnung, Federal Law Gazette II No. 339/2007, as amended

1.4.2 Electronic Data Management (EDM)

The electronic data management of the Federal Ministry of Sustainability and Tourism (BMNT) 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 included data on releases into soil, accidental releases, waste transfers and diffuse emissions[29].

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 transfers 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, which also checks the data for consistency with the national inventory.

Data from E-PRTR or its predecessor have for the submission in 2018 used for the first time in one source category (NMVOC for 2.B.10). The main reason for not using EPRTR data on a broader scale in the national inventory, is that the E-PRTR/EPER 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/EPER 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.

[29] Data can be downloaded from: http://www.umweltbundesamt.at/prtr/

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 2018 and comprises a level assessment for the years 1990 and 2016 and a trend assessment for the trend of the year 2016 with respect to the 1990 emissions. As stipulated 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 is consistent with the one included in the common reporting format (CRF) table and only differs in some subsectors as our national analysis was carried out at a more detailed level.

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

The key categories without LULUCF (determined by Approach1 as presented in Annex 1) comprise 76 587 kt CO_2e in the year 2016, which corresponds to 96.1% of Austria's total greenhouse gas emissions (without LULUCF). The key categories including LULUCF amounted to 72 193 kt CO_2e in 2016.

The following tables presents 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 8: Key categories including LULUCF.

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2016	TA 1990–2016	LA 1990	LA 2016	TA 1990–2016	1990	2016	Share 2016
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	9	4					3 294	3 997	4.6%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	19	34	15				1 228	346	0.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	44	14					352	1 464	1.7%
1 A 1 a solid	Public Electricity and Heat Production	CO2	4	12	6				6 247	1 587	1.8%
1 A 1 b gaseous	Petroleum refining	CO2	39	27					437	535	0.6%
1 A 1 b liquid	Petroleum refining	CO2	14	8					1 958	2 250	2.6%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	35	41					506	271	0.3%
1 A 2 a gaseous	Iron and Steel	CO2	27	20					650	981	1.1%
1 A 2 a liquid	Iron and Steel	CO2			26				75	6	0.0%
1 A 2 a solid	Iron and Steel	CO2	18	30	16				1 335	433	0.5%
1 A 2 b gaseous	Non-ferrous Metals	CO2		36					75	332	0.4%
1 A 2 c gaseous	Chemicals	CO2	32	19					519	984	1.1%
1 A 2 c other	Chemicals	CO2		44					174	230	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	23	15					943	1 283	1.5%
1 A 2 d liquid	Pulp, Paper and Print	CO2	25		2				853	24	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO2	41	32					398	365	0.4%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	34	22					507	783	0.9%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	46	49					343	191	0.2%
1 A 2 f gaseous	Other	CO2	30	23					559	645	0.7%
1 A 2 f liquid	Other	CO2	33		25				508	165	0.2%
1 A 2 f other	Other	CO2		24					67	600	0.7%
1 A 2 f solid	Other	CO2	31	46					535	221	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	52	17					256	1 079	1.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	22	10					1 014	1 758	2.0%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			3				91	0	0.0%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	28	37					607	329	0.4%
1 A 3 b diesel oil	Road Transportation	CO2	6	1	13		1		5 378	17 700	20.4%
1 A 3 b gasoline	Road Transportation	CO2	1	3	11				7 924	4 779	5.5%
1 A 3 e gaseous	Other	CO2	55	26					224	556	0.6%
1 A 4 a gaseous	Commercial/Institutional	CO2	26	18					707	985	1.1%
1 A 4 a liquid	Commercial/Institutional	CO2	17	29	17				1 423	483	0.6%
1 A 4 a other	Commercial/Institutional	CO2			21				116	6	0.0%
1 A 4 b biomass	Residential	CH4	53	47					228	219	0.3%
1 A 4 b gaseous	Residential	CO2	16	7					1 847	2 797	3.2%
1 A 4 b liquid	Residential	CO2	5	6	14				5 605	3 376	3.9%
1 A 4 b solid	Residential	CO2	12		1				2 511	80	0.1%
1 A 4 b solid	Residential	CH4			10				200	6	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO2	20	21					1 182	785	0.9%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2			23				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH4	47						333	NA	0.0%
1 B 2 b	Natural Gas	CH4	50	43					259	253	0.3%

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2016	TA 1990–2016	LA 1990	LA 2016	TA 1990–2016	1990	2016	Share 2016
2 A 1	Cement Production	CO2	13	11					2 033	1 729	2.0%
2 A 2	Lime Production	CO2	42	25					396	582	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO2	36	39					481	318	0.4%
2 B 1	Ammonia Production	CO2	37	28					467	527	0.6%
2 B 2	Nitric Acid Production	N2O	24		5				877	36	0.0%
2 C 1	Iron and Steel Production	CO2	3	2	19				6 610	10 418	12.0%
2 C 3	Aluminium Production	PFC	21			7			1 149	0	0.0%
2 C 3	Aluminium Production	CO2			12				150	5	0.0%
2 C 4	SF6 used in Al and Mg Foundries	SF6	54		4				228	2	0.0%
2 C 7	Metal Industry Other - Non-ferrous metals	SF6			24				14	0	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	45	48					349	205	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	22		4		0	1 582	1.8%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		38					121	319	0.4%
3 A 1	Cattle	CH4	7	5	27	2	2		4 579	3 886	4.5%
3 B 1 1	Cattle	CH4	40	35					424	336	0.4%
3 B 1 1	Cattle	N2O	51	42					258	266	0.3%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	15	9		6	3		1 884	1 793	2.1%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	43	33		10	7		363	353	0.4%
4A1	Forest land remaining forest land	CO2	2	52	7	1	15	2	-7 849	-2 579	-3.0%
4A2	Land converted to forest land	CO2	11	51	20	5	14		-3 043	-1 741	-2.0%
4B1	Cropland remaining cropland	CO2					12		-18	-184	-0.2%
4B2	Land converted to cropland	CO2		45		12	8		194	224	0.3%
4C1	Grassland remaining grassland	CO2	49	40					294	296	0.3%
4C2	Land converted to grassland	CO2	48		18	11	11	1	332	37	0.0%
4D2	Land converted to Wetlands	CO2					10		42	77	0.1%
4E2	Land converted to Settlements	CO2	29	31		8	6		577	379	0.4%
4F2	Land converted to Other land	CO2	38			9	9	3	444	166	0.2%
4G	HWP	CO2	10	50	9	4	13		-3 122	-1 042	-1.2%
5 A	Solid Waste Disposal	CH4	8	16	8	3	5		3 644	1 212	1.4%
									63 394	**72 086**	**83.3%**

Table 9: Key categories excluding LULUCF.

			Approach 1			Approach 2					
IPCC Category Code	**IPCC Category**	**GHG**	**LA 1990**	**LA 2016**	**TA 1990–2016**	**LA 1990**	**LA 2016**	**TA 1990–2016**	**1990**	**2016**	**Share 2016**
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	8	4		7	4		3 294	3 997	5.0%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	16	33	14				1 228	346	0.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	39	14		18	10		352	1 464	1.8%
1 A 1 a solid	Public Electricity and Heat Production	CO2	3	12	6			17	6 247	1 587	2.0%
1 A 1 b gaseous	Petroleum refining	CO2	34	27					437	535	0.7%
1 A 1 b liquid	Petroleum refining	CO2	11	8					1 958	2 250	2.8%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	31	39					506	271	0.3%
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CO2			21				4	0	0.0%
1 A 2 a gaseous	Iron and Steel	CO2	24	20			15		650	981	1.2%
1 A 2 a liquid	Iron and Steel	CO2			23				75	6	0.0%
1 A 2 a solid	Iron and Steel	CO2	15	30	15				1 335	433	0.5%
1 A 2 b gaseous	Non-ferrous Metals	CO2		35					75	332	0.4%
1 A 2 c gaseous	Chemicals	CO2	28	19			14		519	984	1.2%
1 A 2 c other	Chemicals	CO2		42			21		174	230	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	20	15		13	11		943	1 283	1.6%
1 A 2 d liquid	Pulp, Paper and Print	CO2	22		3			10	853	24	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO2	36	31					398	365	0.5%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	30	22					507	783	1.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	41						343	191	0.2%
1 A 2 f gaseous	Other	CO2	26	23					559	645	0.8%
1 A 2 f liquid	Other	CO2	29		22				508	165	0.2%
1 A 2 f other	Other	CO2		24			16		67	600	0.8%
1 A 2 f solid	Other	CO2	27	43					535	221	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	45	17					256	1 079	1.4%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	19	10		12	8		1 014	1 758	2.2%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	25	36					607	329	0.4%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			2			9	91	0	0.0%
1 A 3 b diesel oil	Road Transportation	CO2	5	1	11	4	1	16	5 378	17 700	22.2%
1 A 3 b diesel oil	Road Transportation	N2O					23		13	166	0.2%
1 A 3 b gasoline	Road Transportation	CO2	1	3	9	1	3	12	7 924	4 779	6.0%
1 A 3 b gasoline	Road Transportation	N2O				28		7	96	11	0.0%
1 A 3 b gasoline	Road Transportation	CH4						18	64	9	0.0%
1 A 3 e gaseous	Other	CO2	48	26					224	556	0.7%
1 A 4 a gaseous	Commercial/Institutional	CO2	23	18			13		707	985	1.2%
1 A 4 a liquid	Commercial/Institutional	CO2	14	29	16				1 423	483	0.6%
1 A 4 a other	Commercial/Institutional	CO2			18			8	116	6	0.0%
1 A 4 b biomass	Residential	CH4	46	44		21	22		228	219	0.3%
1 A 4 b gaseous	Residential	CO2	13	7		10	6		1 847	2 797	3.5%
1 A 4 b liquid	Residential	CO2	4	6	12	3			5 605	3 376	4.2%
1 A 4 b solid	Residential	CO2	9		1			5	2 511	80	0.1%

			Approach 1			Approach 2					
IPCC Category Code	**IPCC Category**	**GHG**	**LA 1990**	**LA 2016**	**TA 1990–2016**	**LA 1990**	**LA 2016**	**TA 1990–2016**	**1990**	**2016**	**Share 2016**
1 A 4 b solid	Residential	N2O						14	12	0	0.0%
1 A 4 b solid	Residential	CH4	50		8	22		1	200	6	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO2	17	21					1 182	785	1.0%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2			20				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH4	42			19			333	NA	NA
1 B 2 b	Natural Gas	CH4	43	41					259	253	0.3%
2 A 1	Cement Production	CO2	10	11		8			2 033	1 729	2.2%
2 A 2	Lime Production	CO2	37	25		16			396	582	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO2	32	38					481	318	0.4%
2 B 1	Ammonia Production	CO2	33	28					467	527	0.7%
2 B 2	Nitric Acid Production	N2O	21		5	14		4	877	36	0.0%
2 C 1	Iron and Steel Production	CO2	2	2	17	2	2		6 610	10 418	13.1%
2 C 3	Aluminium Production	PFC	18			11			1 149	0	0.0%
2 C 3	Aluminium Production	CO2			10			19	150	5	0.0%
2 C 4	SF6 used in Al and Mg Foundries	SF6	47		4			3	228	2	0.0%
2 C 7	Metal Industry Other - Non-ferrous metals	SF6			13				14	0	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	40						349	205	0.3%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	19		9	6	0	1 582	2.0%
2 G	Other Product Manufacture and Use	N2O	49						224	134	0.2%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		37		25	19		121	319	0.4%
3 A 1	Cattle	CH4	6	5	24	5	5	15	4 579	3 886	4.9%
3 A 3	Swine	CH4				23	26		138	105	0.1%
3 B 1 1	Cattle	CH4	35	34		15	18		424	336	0.4%
3 B 1 1	Cattle	N2O	44	40		20	20		258	266	0.3%
3 B 1 3	Swine	N2O				30			59	37	0.0%
3 B 2 5	Indirect N2O Emissions	N2O				26	25		107	114	0.1%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	12	9		9	7	13	1 884	1 793	2.3%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	38	32		17	17		363	353	0.4%
3 G	Liming	CO2				29	28		90	85	0.1%
5 A	Solid Waste Disposal	CH4	7	16	7	6	12	2	3 644	1 212	1.5%
5 B	Biological Treatment of Solid Waste	N2O					27		23	98	0.1%
5 B	Biological Treatment of Solid Waste	CH4					29		13	83	0.1%
5 D	Waste Water Treatment and Discharge	N2O				27	24		96	164	0.2%
5 D	Waste Water Treatment and Discharge	CH4				24		11	121	24	0.0%
									76 604	**77 481**	**97.25%**

The key category with the highest contribution to the national total emissions excl. LULUCF in 2016 is *1.A.3.b Road Transportation – diesel oil (CO_2)* 22.2% in 2016 (share of 6.8% in 1990). This strong increase is due to the general increase of road performance, but also due to a shift from gasoline to diesel driven vehicles. This catgory is also the most important category in terms of emission trends: Since 1990 emissions increased by 229%.

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 13.1% in 2016. 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 10: 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	N_2O
1.A.3.b gasoline	Road Transportation	CH_4
1.A.4.b solid	Residential	N_2O
3.A.3	Swine	CH_4
3.B.1.3	Swine	N_2O
3.B.2.5	Indirect N_2O Emissions	N_2O
3.G	Liming	CO_2
4.B.1	Cropland remaining cropland	CO_2
4.D.2	Land converted to Wetlands	CO_2
5.B	Biological Treatment of Solid Waste	CH_4
5.B	Biological Treatment of Solid Waste	N_2O
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.

In the following table transparency and completeness of the submission 2018 is shown. The 'NE' reported in the LULUCF sector refers to forest not in yield as well as category *4.D* (wetlands). The notation key 'IE' was applied for some sub-categories in almost all sectors, explanations are provided in the respective sector chapters on 'Completeness' as well as in CRF Table 9.

Table 11: Transparency and completeness in UNFCCC submission 2018.

Sector	**Submission 2018**			
	IE	**NE**	**Transparency**	**Completeness**
1 Energy	27	0	*96%*	*100%*
2 IPPU	14	0	*96%*	*100%*
3 Agriculture	0	0	*100%*	*100%*
4 LULUCF	7	16	*98%*	*96%*
5 Waste	3	0	*95%*	*100%*
Total	**51**	**16**	***97%***	***99%***
Total number of estimates*	**1 508**			

* *including IE and NE, but also NO and NA as well as empty cells.*

2 TRENDS IN GREENHOUSE GAS EMISSIONS

The EU as well as its Member States committed to reduce their GHG emissions jointly under the Kyoto Protocol. For the first commitment period, the EU-15 (i.e. those countries that were Member States before 2004) agreed to reduce greenhouse gas emissions by 8% compared to 1990. Austria agreed to reduce its GHG emissions 2008-2012 by 13% compared to 1990 emissions.

For the second commitment period under the Kyoto Protocol 2013–2020, which was agreed in the Doha Amendment, the EU again implements a joint commitment. The EU and its Member States are committed to a GHG reduction of 20% compared to 1990. This commitment is in line with the climate and energy package 2020. The corresponding national Kyoto targets of the EU Member States are thus are in line with the objectives under the Effort Sharing Decision (Decision No. 406/2009/EG). Under the Effort Sharing Decision Austria has to reduce its greenhouse gas emissions from sources not covered by the EU-ETS; the reduction target is 16% by 2020 compared to 2005.

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

In 2016, Austria's total greenhouse gas (GHG) emissions (without LULUCF) amounted to 79.7 Mt CO_2 equivalents (CO_2e). Compared to the base year[30] 1990 GHG emissions increased by 1.2%, compared to 2015 GHG emissions increased by 1.0%.

GHG emissions covered by the Effort Sharing Decision (according to Article 2(1) of Decision No. 406/2009/EC) amounted to 50.6 Mt CO_2 equivalents in 2016, which is 2.7% (1.32 Mt CO_2e) more than in 2015. Emissions were thus below the annual emission allocation (AEA) for the year 2016 (-0.4 Mt CO_2e); this difference amounted in 2015 to −2.2 Mt CO_2e, in 2014 to −3.8 Mt CO_2e and in 2013 to −2.3 Mt CO_2e), the first year of the Effort-Sharing Decision target period[31].

[30] Austria's base year under the UNFCCC is 1990. Under the Kyoto Protocol the base year for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 is 1990, for NF_3 it is 2000. Under the EU Effort Sharing Decision, 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.

[31] Initial AEAs: Annex II of Commission Decision (No 2013/162/EU) of 26 March 2013 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0162&from=EN) adjusted by Commission Implementing Decision (No 2013/634/EU) of 31 October 2013 on the adjustments to Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0634&from=EN).

Revised AEAs: COMMISSION DECISION (EU) 2017/1471 of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020

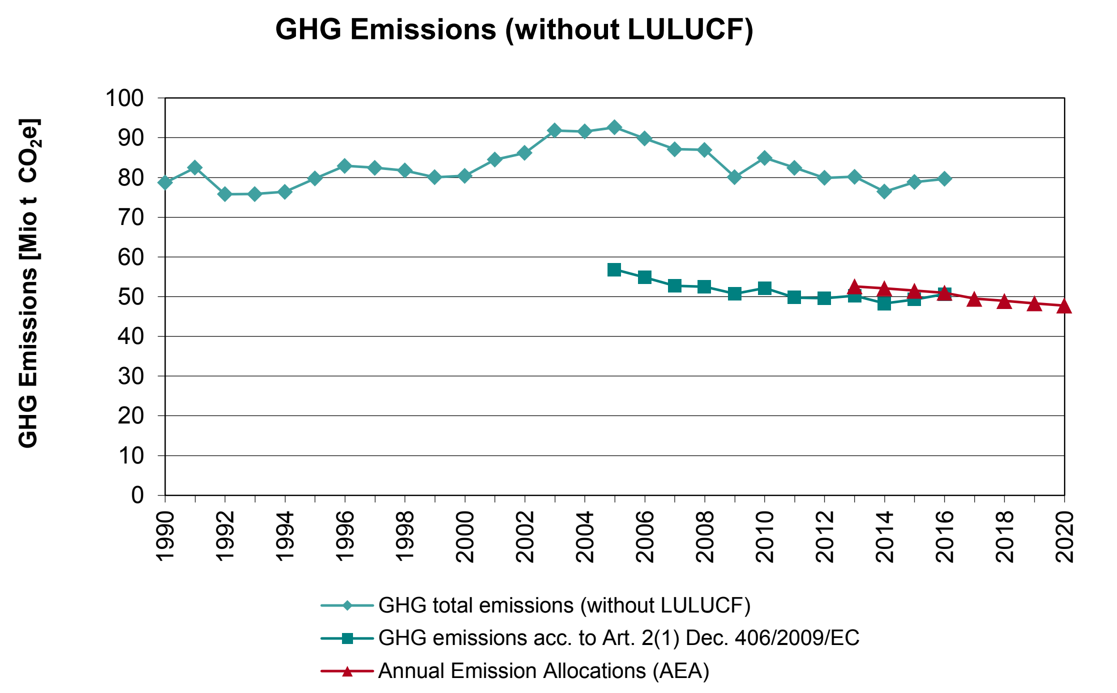


Figure 3: Trend in GHG emissions 1990–2016 without LULUCF.

Table 12: Summary of Austria's anthropogenic greenhouse gas emissions from 1990–2016 (emissions without LULUCF).

GHG		Total	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
1990	[kt CO_2 equivalent]	78 690	62 292	10 405	4 337	2.4	1 183	471	0.0
1991		82 496	65 900	10 284	4 501	3.9	1 193	614	0.0
1992		75 796	60 431	10 000	4 192	5.6	510	656	0.0
1993		75 855	60 788	9 915	4 109	235	64	744	0.0
1994		76 393	61 190	9 628	4 316	261	71	926	0.8
1995		79 730	64 206	9 561	4 420	353	83	1 100	6.4
1996		82 924	67 674	9 257	4 311	417	80	1 177	7.9
1997		82 461	67 453	8 955	4 336	498	117	1 086	15.5
1998		81 757	67 054	8 776	4 383	609	56	870	9.4
1999		80 055	65 621	8 597	4 372	701	79	676	8.2
2000		80 432	66 262	8 434	4 349	714	88	575	11
2001		84 510	70 391	8 274	4 226	863	116	629	11
2002		86 199	72 147	8 130	4 227	969	102	613	11
2003		91 817	77 764	8 067	4 216	1 072	126	549	22
2004		91 575	78 053	8 068	3 628	1 158	158	484	27
2005		92 655	79 367	7 830	3 627	1 146	163	494	28
2006		89 832	76 688	7 705	3 628	1 152	172	453	33
2007		87 103	74 032	7 579	3 638	1 196	230	367	59
2008		86 951	73 806	7 446	3 815	1 249	208	373	53
2009		80 119	67 483	7 354	3 590	1 309	36	342	4.5
2010		84 931	72 383	7 255	3 391	1 483	78	336	4.1
2011		82 450	70 116	7 053	3 490	1 407	74	307	4.1
2012		79 917	67 661	6 943	3 456	1 486	51	312	8.6
2013		80 178	68 001	6 851	3 451	1 512	49	305	10
2014		76 442	64 253	6 709	3 520	1 583	53	313	11

GHG	Total	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
2015	78 856	66 704	6 632	3 527	1 620	50	310	13
2016	79 673	67 402	6 567	3 614	1 641	50	393	6.1

Note: Global warming potentials (GWPs) according to the 4th Assessment Report (IPCC 2007) (100 years time horizon): carbon dioxide (CO_2) = 1; methane (CH_4) = 25; nitrous oxide (N_2O) = 298; sulphur hexafluoride (SF_6) = 22 800; nitrogen trifluoride (NF_3) = 17 200; hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances

The most important GHG in Austria is carbon dioxide (CO_2) with a share of 85% in 2016. The CO_2 emissions primarily result from combustion activities. Methane (CH_4), which mainly arises from stock farming and waste disposal, contributes 8.2% to national total GHG emissions, and nitrous oxide (N_2O) with agricultural soils as the main source contributes another 4.5% in 2016. The remaining 2.6% 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 13: Austria's greenhouse gas emissions by gas 1990 and 2016.

GHG	1990	2016	Trend 1990–2016	1990	2016
	CO_2 equivalent [kt]			Share [%]	
Total	**78 690**	**79 673**	**1.2%**	**100%**	**100%**
CO_2	62 292	67 402	8.2%	79%	85%
CH_4	10 405	6 567	-37%	13%	8.2%
N_2O	4 337	3 614	-17%	5.5%	4.5%
F-Gases	1 656	2 090	26%	2.1%	2.6%

Emissions without LULUCF

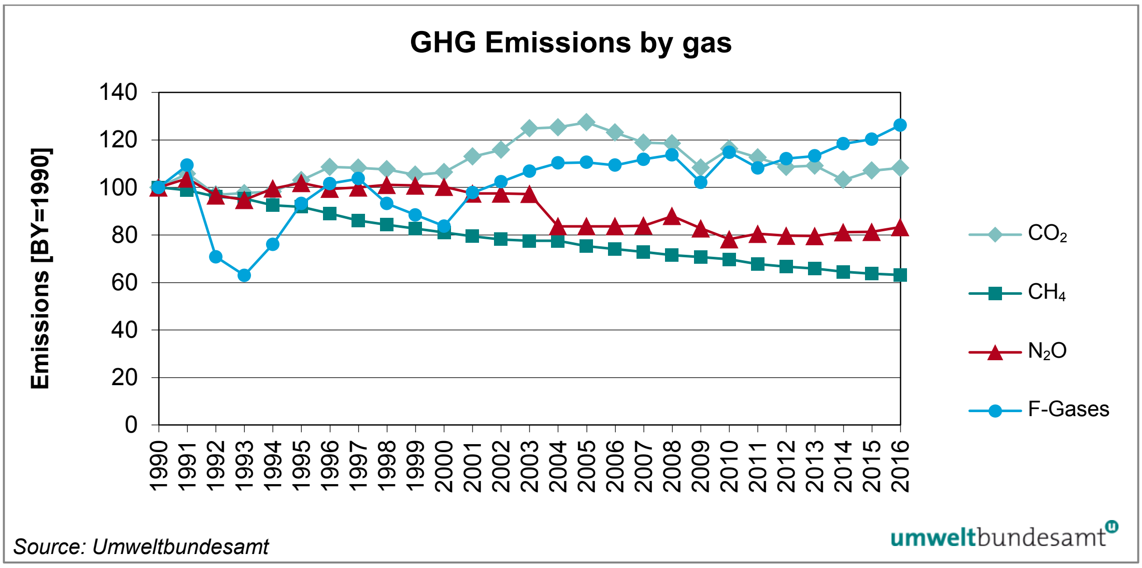


Figure 4: Trend in greenhouse gas emissions 1990–2016 by gas in index form (base year = 100).

CO_2

CO_2 emissions increased by 8.2% from 1990 to 2016. In absolute figures, CO_2 emissions increased from 62 292 to 67 402 kt during the period from 1990 to 2016 mainly due to higher CO_2 emissions from transport, which increased by 68%.

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.

CH_4

CH_4 emissions decreased steadily during the period from 1990 to 2016 from 10 405 to 6 567 kt CO_2 equivalents. In 2016, CH_4 emissions were 37% below the level of 1990, mainly due to lower emissions from solid waste disposal sites.

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

N_2O

N_2O emissions show a decreasing trend, resulting in 3 614 kt CO_2 equivalents in 2016 compared to 4 337 kt CO_2 equivalents in 1990 (−17%). The general decrease is mainly due to lower N_2O emissions from agricultural soils; the strong decrease 2003–2004 was due to emission reduction measures in the chemical industry.

The main source of N_2O emissions are agricultural soils with a share of 59% (2016) in national total N_2O emissions. Manure management has a share of 12% and fuel combustion, which is another important source of N_2O emissions, has a share of 17%.

HFCs

HFC emissions increased remarkably during the period from 1990 to 2016 from 2.4 to 1 641 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 2016, from 1 183 to 50 kt CO_2 equivalents. 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 471 kt CO_2 equivalents. Until 1996 emissions increased steadily reaching 1 177 kt CO_2 equivalents. Since then they have been decreasing. In 2016 SF_6 emissions amounted to 393 kt CO_2 equivalents, which was 17% below the level of 1990.

The main sources of SF_6 emissions are semiconductor manufacture and disposal of noise insulating windows.

NF_3

In 1990 no NF_3 was emitted in Austria. NF_3 emissions solely arise from semiconductor manufacture, and have been in use in Austria since 1994. In 2016, NF_3 emissions amounted to 6.1 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 from 1990–2016

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO_2 equivalents (kt)					
1990	52 914	13 662	8 189	-11 982	3 925	NO*
1991	56 581	13 696	8 225	-16 685	3 994	NO
1992	52 009	12 053	7 787	-11 663	3 946	NO
1993	52 272	12 004	7 658	-11 962	3 921	NO
1994	51 932	12 739	7 899	-11 839	3 823	NO
1995	54 436	13 605	8 038	-13 261	3 651	NO
1996	58 615	13 057	7 789	-10 644	3 463	NO
1997	57 187	14 219	7 740	-19 124	3 315	NO
1998	56 989	13 865	7 708	-17 222	3 195	NO
1999	55 731	13 647	7 601	-19 497	3 075	NO
2000	55 322	14 640	7 506	-16 364	2 963	NO
2001	59 675	14 521	7 449	-19 202	2 865	NO
2002	60 835	15 164	7 337	-14 166	2 863	NO
2003	66 457	15 305	7 189	-4 789	2 867	NO
2004	66 614	14 861	7 170	-9 118	2 930	NO
2005	67 150	15 610	7 104	-10 597	2 791	NO
2006	63 834	16 249	7 077	-5 116	2 671	NO
2007	60 503	16 938	7 119	-5 510	2 543	NO
2008	60 023	17 271	7 226	-4 276	2 431	NO
2009	56 642	13 947	7 245	-4 544	2 285	NO
2010	59 752	15 926	7 095	-5 878	2 158	NO
2011	57 306	15 955	7 146	-6 106	2 043	NO
2012	55 325	15 570	7 079	-5 476	1 942	NO
2013	55 400	15 887	7 063	-4 524	1 829	NO
2014	51 440	16 073	7 189	-4 725	1 739	NO
2015	53 352	16 669	7 178	-4 445	1 656	NO
2016	54 336	16 468	7 286	-4 208	1 581	NO

** not occurring*

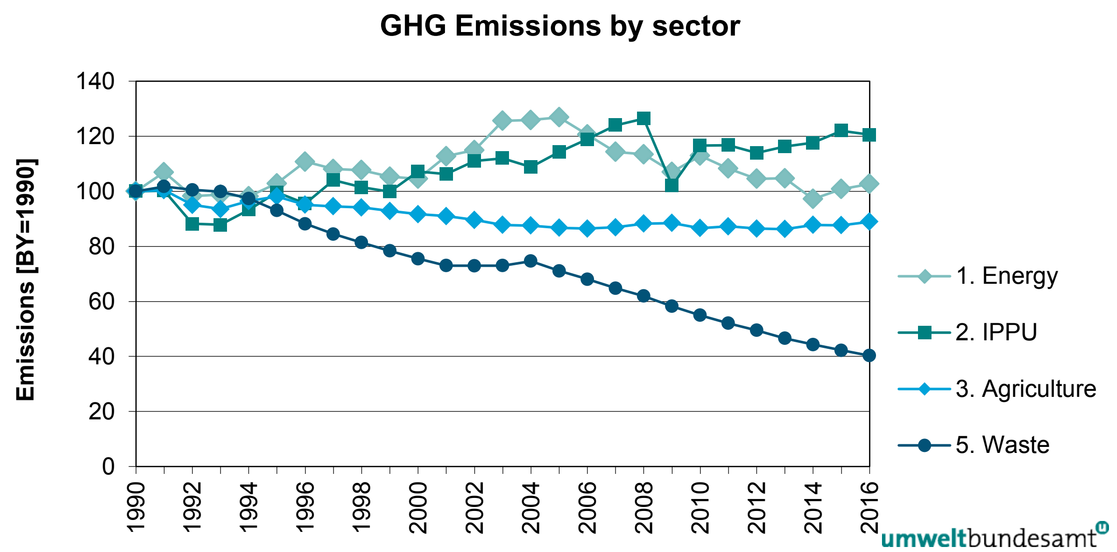
The dominant sector regarding GHG emissions in Austria is *Energy*, causing 68% of total national GHG emissions in 2016 (67% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (21% in 2016) and *Agriculture* (9.1% in 2016).

Table 15: Austria's greenhouse gas emissions by sector in 1990 and in 2016 as well as their share and trend.

GHG	1990	2016	Trend 1990–2016	1990	2016
	Emissions [kt CO_2e]			Share [%]	
Total	78 690	79 673	**1.2%**	**100%**	**100%**
Energy	52 914	54 336	2.7%	67%	68%
IPPU	13 662	16 468	21%	17%	21%
Agriculture	8 189	7 286	-11%	10%	9.1%
LULUCF	-11 982	-4 208	-65%	-	-
Waste	3 925	1 581	-60%	5.0%	2.0%

Total emissions without emissions from LULUCF

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



Source: Umweltbundesamt

Figure 5: Trend in greenhouse gas emissions 1990–2016 by sector in index form (base year = 100).

2.2.1 Energy

In 2016, greenhouse gas emissions from sector *Energy* amounted to 54 336 kt CO_2 equivalents which correspond to 68% of the total national emissions. 99% of the emissions from this sector originate from fossil fuel combustion (1.A), fugitive emissions from fuels (1.B) are of minor importance.

The most important **sub-category** is *transport* with a share of 43% in 2016, followed by, *manufacturing industries and construction* (20%), *energy industries* (19%), and the sub-category *other sectors* (17%). The most important **greenhouse gas** is CO_2, contributing 98% to the total sectoral GHG emissions, followed by N_2O (1.1%) and CH_4 (1.1%).

From 2015 to 2016, emissions from this sector increased by 1.8%. The main increase occurred in the transport sector due to higher consumption of fossil fuels, in particular diesel. The increase in emissions of *manufacturing industries* was mainly driven by higher natural gas and coal consumption. The main driver for increasing emissions from *other sectors* was the compared to 2015 higher use of natural gas and increased heating demand of households (heating degree days increased by 4.1%). Only emissions from *energy industries* show a decrease due to the closure of a coal power plant.

The **overall trend** in GHG emissions from the sector *Energy* shows increasing emissions with a plus of 2.7% from 1990 to 2016, although a decreasing trend can be observed since 2005. 2016 emissions from road transport are 68% higher than 1990. 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)

Trend 1990–2016 by sub-category

In 2016 emissions from sub-category ***energy industries*** were 25% below the level in 1990. Emissions from power plants are quite continuously 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. The share of biomass used as a fuel in this sector increased from 0.9% (1990) to 27% (2016), the contribution of hydro and wind power plants to total public electricity production increased from 69% (1990) to 79% (2016). Electricity consumption (including losses) increased by 48% since 1990 but since 2002 the increase is mainly covered by electricity imports.

Energy related GHG emissions from ***manufacturing industries and construction*** increased by 9.4% from 1990 to 2016, mainly in the chemical and other industries. Fuel consumption increased by 43% 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 is significantly smaller compared to the increase in fuel combustion.

Transport showed a strong increase in GHG emissions since 1990 (+68%) 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. Between 2005 and 2015 GHG emissions were decreasing due to lower amounts of fuel sold together with an increased use of biofuels and the gradual replacement with newer, lower fuel consumption vehicles. The year 2016 is now the second year showing an increase in GHG emissions from *transport* after 2005. Moreover, 2016 is the first year with higher total fuel sales compared to 2005.

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 ***other sectors***. Emissions in 2016 were 37% 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 decreased by 15% since 1990.

Fugitive emissions decreased by 44% since 1990 due to the progressive closure of coal mines up until 2006. There have been no coal-mining activities in Austria since 2007.

2.2.2 Industrial Processes and Other Product Use

In 2016, greenhouse gas emissions from *Industrial Processes and Other Product Use* amounted to 16 468 kt CO_2 equivalents, which correspond to 21% of total national emissions.

The most important **sub-categories** of this sector are *metal industry* and *mineral industry*, generating 63% and 17% of total sectoral emissions (2016). The most important **greenhouse gas** of this sector is CO_2 with a contribution of 86% to total sectoral emissions (2016), followed by HFCs with 10%, SF_6 with 2.4%, N_2O with 1.0%, PFCs and CH_4 with 0.3% each. NF_3 contributes 0.04% to total emissions from this sector.

From 2015 to 2016, overall emissions from this sector decreased by 1.2%, mainly due to a decrease in production of iron and steel. The sub-category *metal industry* contributes mostly to this decrease between 2015 and 2016 (−3.4%), primarily due to a decrease in steel production.

The **overall trend** in GHG emissions from *Industrial Processes and Other Product Use* shows increasing emissions of 21% from 1990 to 2016. Within this period, emissions fluctuated, with a minimum in 1993 and a maximum in 2008. **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 metal production resulting in 28% higher GHG emissions in 2016 compared to 1990 and (iv) a strong increase of HFC emissions in the period 1992 to 2016 from 2.4 to 1 641 kt CO_2 equivalents.

Trend 1990–2016 by sub-category

The largest increase in GHG emissions between 1990 and 2016 can be observed in the *metal industry* due to increased emissions from iron and steel production (+58%). In sub-categories *mineral industry* and *chemical industry*, emissions declined by 10% and 48% respectively during that period. Emissions of *fluorinated gases* increased by 26% since 1990, brought on by increasing emissions of HFCs (+364% since 1995) used as cooling agents that replaced Ozone Depleting Substances. Emissions from *solvent use (2.D.3)* dropped by 34% since 1990, due to legal measures controlling solvent content of products and their use.

2.2.3 Agriculture

In 2016, greenhouse gas emissions from *Agriculture* amounted to 7 286 kt CO_2 equivalent, which correspond to 9.1% of total national emissions.

The **most important sub-categories** of this sector are *enteric fermentation* (57%) and *agricultural soils* (29%). The sector agriculture is the largest source for both N_2O and CH_4 emissions: in 2016, 72% (8.7 kt) of total N_2O emissions and 70% (183 kt) of total CH_4 emissions in Austria originated from this sector. 63% of GHG emissions from the sector are CH_4, 35% are N_2O and 1.6% are CO_2 emissions.

From 2015 to 2016 emissions increased by 1.5%, mainly due to rising GHG emissions from agricultural soils. In 2016 Austria's crop production was significantly higher compared to the previous year because of the good growth conditions (moderate temperatures and sufficient precipitation). The cereal harvest in 2016 was one of the highest of the past ten years, but also soy, sugar beet and vegetable production increased compared to the previous year which resulted in higher N_2O emissions from crop residues. Furthermore, in 2016 a higher amount of mineral fertilizer was applied on agricultural soils.

Other drivers for the rise of GHG emissions in 2016 were the slight increase in the number of dairy cows and the higher milk yields of Austria's dairy cows.

The **overall trend** in GHG emissions from *Agriculture* shows a decrease of 11% from 1990 to 2016. The **main drivers** for this trend are decreasing livestock numbers and lower amounts of N-fertilizers applied on agricultural soils. Fluctuations, which can be seen in particular in the first half of the 1990s, result from the variation of the sales of mineral fertilizer due to the volatility in price.

2.2.4 LULUCF

In 2016, net removals from the category LULUCF amounted to −4 208 kt CO_2 equivalents, which correspond to 5.3% of the national total GHG emissions (without LULUCF) in 2016 compared to 15% in 1990.

With regard to the **overall trend** of net removals from LULUCF, the removals decreased by 65% over the observed period. The **main driver** for this trend is the biomass carbon stock change in forest land. Fluctuations are due to weather conditions which affect the growth rates on the one hand (e.g. very low increment in 2003) and wind throws on the other, as well as timber demand and prices (e.g. very high harvest rates in 2007 and 2008).

The **most important sub-category is** *forest land (4.A)* with net removals of −4 295 kt CO_2 equivalents in 2016. *Harvested Wood Products (4.G)* is the second largest sink category and contributed −1 042 kt CO_2 equivalents. In 2016, CH_4 and N_2O emissions together amounted to 159 kt CO_2 equivalents. Total net emissions arising from the other non-forest sub-sectors (4.B, 4.C, 4.D, 4.E and 4.F) amounted to 1 115 kt CO_2 equivalents in 2016.

Regarding LULUCF activities pursuant to Decision No 529/2013/EU, Austria decided to account only for greenhouse gas emissions and removals from af- /reforestation, deforestation and forest management.

The activity which contributes most to GHG removals is forest management which amounts to −3 270 kt CO_2 equivalents in 2016 (including HWPs). Afforestation/reforestation (incl. HWPs) contribute to GHG removals as well (−2 097 kt CO_2 equivalents), whereas emissions from deforestation amount to 512 kt CO_2 in 2016.

2.2.5 Waste

In 2016, greenhouse gas emissions from *Waste* amounted to 1 581 kt CO_2 equivalent, which correspond to 2.0% of total national emissions.

The **most important sub-category** of the waste sector is *solid waste disposal*, which caused 77% of the emissions from this sector in 2016, followed by *waste water treatment and discharge* (12%) and *biological treatment of solid waste* (11%). The most important **greenhouse gas** is CH_4 with a share of 83% in emissions from *waste* (2016), followed by N_2O with 17% and CO_2 with 0.1%.

From 2015 to 2016 GHG emissions continued to decrease (−4.5%) as a result of low waste volumes as well as decreasing carbon content of waste deposited in previous years.

The **overall trend** in GHG emissions from *waste* is decreasing, with a decrease of 60% from 1990 to 2016. 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). 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) 2018, Submission under the UNECE/CLRTAP Convention*, published in spring 2018 (UMWELTBUNDESAMT 2018).

Table 16: Total emissions and trends 1990–2016 of indirect GHGs and SO_2.

		NO_x	CO	NMVOC	SO_2
1990	[kt]	219	1 190	302	74
1991		228	1 186	295	71
1992		215	1 132	272	54
1993		206	1 077	254	53
1994		200	1 022	232	47
1995		200	928	218	47
1996		218	937	212	44
1997		204	877	200	40
1998		217	841	193	36
1999		208	736	184	34
2000		214	740	175	32
2001		224	719	172	33
2002		230	693	169	32
2003		238	700	167	31
2004		235	690	162	27
2005		238	670	159	26
2006		225	657	154	26
2007		214	619	149	23
2008		199	600	146	20
2009		183	570	142	15
2010		183	582	143	16
2011		174	568	139	15
2012		169	571	139	15
2013		170	590	140	15
2014		160	543	135	15
2015		157	566	137	15
2016		152	563	137	14
Trend 1990–2016		***–31%***	***–53%***	***–55%***	***–81%***

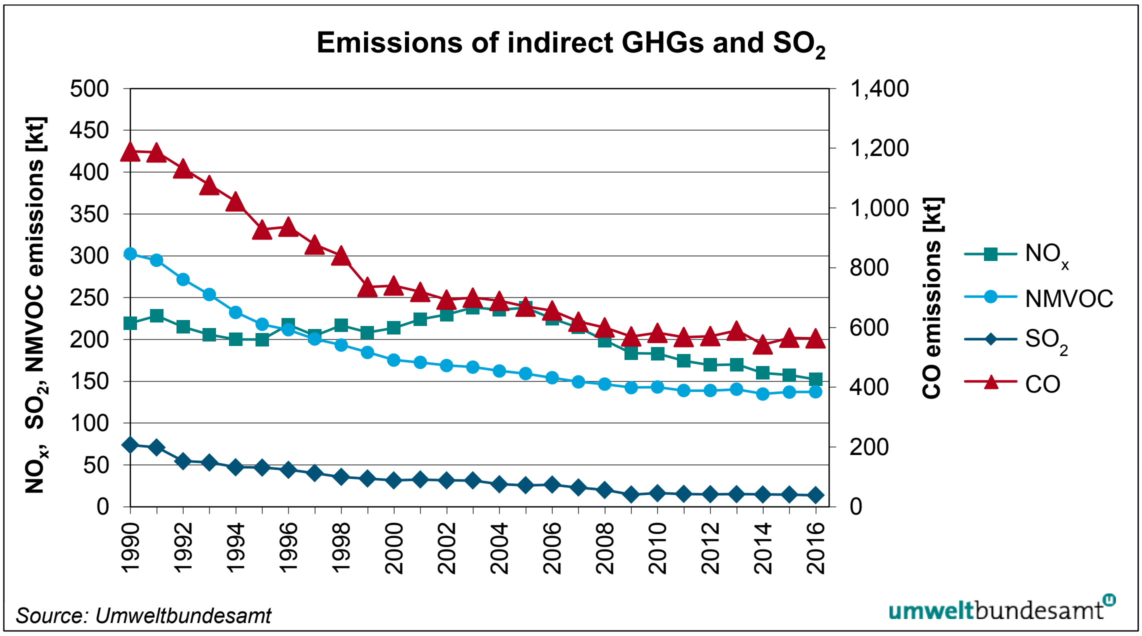


Figure 6: Emissions of indirect GHGs and SO_2 1990–2016

The most important emission source for NO_x, SO_2 and CO is fuel combustion. The most important emission source for NMVOC is Solvent and other Product Use.

NO_x

NO_x emissions decreased from 219 to 152 kt during the period from 1990 to 2016. In 2016 NO_x emissions were 31% below the level of 1990. In 2016 about 92% of NO_x emissions in Austria originated from fossil fuel combustion, with the major part originating from *1.A.3.b Road transportation* (51% in national total NO_x emissions in 2016).

CO

CO emissions decreased from 1 190 to 563 kt during the period from 1990 to 2016. In 2016 CO emissions were 53% below the level of 1990. In the year 2016, 95% 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* (50% in national total CO emissions) followed by *1.A.2 Manufacturing industries and construction* with 30% and *1.A.3 Transport* with 14% share in national total CO emissions in 2016.

NMVOC

NMVOC emissions decreased from 302 to 137 kt during the period from 1990 to 2016. In 2016 NMVOC emissions were 55% below the level of 1990. The most important source for NMVOC emissions is *2.D.3.1 Solvent Use* contributing 48%, followed by *1.A. Fuel Combustion Activities* with a 31% share in national total NMVOC emissions 2016.

SO_2

SO_2 emissions decreased from 74 to 14 kt during the period 1990 to 2016. In 2016 SO_2 emissions were 81% below the level of 1990. Fuel combustion activities (*1.A*) contribute 96% of emissions (2016).

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

For the submission 2017 the uncertainty calculation was performed applying approach 1 of the IPCC 2006 GL, for all sectors including LULUCF. As a result of the uncertainty analysis, Table 17 shows a total uncertainty of 5.0 (excluding LULUCF), Table 18 shows a total uncertainty of 23.1% (including LULUCF) for the year 2016.

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

IPCC category/Group	Gas	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	0.04	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	2.0	50.0	50.04	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	2.0	0.5	2.06	0.16	0.31
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	0.01	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	10.0	50.0	50.99	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	10.0	20.0	22.36	0.43	0.35
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	0.00	0.02
1.A Stationary Combustion – Solid Fuels	CO_2	0.5	0.5	0.71	0.00	0.00
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	0.89	1.13
1.A.3.b Transport – Road Transportation – Diesel	N_2O	3.0	30.0	30.15	0.00	0.00
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

IPCC category/Group	Gas	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
		%	%	%		%
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	0.06	0.08
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	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.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	0.5	2.06	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
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH_4	5.0	50.0	50.25	0.00	0.05
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	0.5	5.02	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	CH_4	2.0	5.0	5.39	0.00	0.00

IPCC category/Group	Gas	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
		%	%	%		%
Production						
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.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	0.55
2.C.3 Metal Industry – Aluminium Production	SF_6	5.0	5.0	7.07	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	5.0	10.0	11.18	0.00	0.00
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	NF3	5.0	10.0	11.18	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	20.0	50.0	53.85	1.14	1.33
2.F.2 Foam Blowing	HFC	20.0	50.0	53.85	0.00	0.00
2.F.3 Fire Extinguishers	HFC	20.0	50.0	53.85	0.00	0.00
2.F.4 Aerosols	HFC	20.0	50.0	53.85	0.00	0.00
2.F.5 Solvents	HFC	20.0	50.0	53.85	0.00	0.00
2.F.6 Other Applications	HFC	25.0	50.0	55.90	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	25.0	50.0	55.90	0.00	0.00
2.G.2 Other product manufacture and use – SF6 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 – SF6 and PFCs from other product use	SF_6	25.0	50.0	55.90	0.05	0.04
2.G. Other Product Manufacture and Use	CO_2	20.0	0.0	20.00	0.00	0.00
2.G. Other Product Manufacture and Use	N_2O	20.0	0.0	20.00	0.00	0.00

IPCC category/Group	**Gas**	**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**
		%	%	%		%
3.A.1 Enteric Fermentation – Cattle	CH_4	1.0	20.0	20.02	0.95	0.04
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	40.0	40.20	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH_4	10.0	40.0	41.23	0.00	0.00
3.B.1.1 Manure Management – Cattle	CH_4	1.0	20.0	20.02	0.01	0.00
3.B.1.1 Manure Management – Cattle	N_2O	1.0	100.0	100.00	0.11	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	0.00	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 N2O Emissions	N_2O	5.0	200.0	200.06	0.08	0.00
3.D.1 Direct N2O Emissions from Managed Soils	N_2O	5.0	200.0	200.06	20.28	0.11
3.D.2 Indirect N2O emissions from Managed Soils	N_2O	5.0	200.0	200.06	0.79	0.00
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 and Urea application	CO_2	100.0	10.0	100.50	0.01	0.02
3.H Urea application	CO_2	100.0	10.0	100.50	0.00	0.00
5.A Solid Waste Disposal	CH_4	12.0	25.0	27.73	0.18	0.69
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	0.00
5.D Waste Water Treatment and Discharge	N_2O	20.0	100.0	101.98	0.04	0.01
Total					25.30	4.78
Total Uncertainties				Uncertainty in total inventory %:	5.03	2.19

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

IPCC category/Group	Gas	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	0.04	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	2.0	50.0	50.04	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO_2	2.0	0.5	2.06	0.18	0.43
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	0.01	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	10.0	50.0	50.99	0.00	0.00
1.A Stationary Combustion – Other fuels	CO_2	10.0	20.0	22.36	0.48	0.46
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	0.00	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	0.99	1.54
1.A.3.b Transport – Road Transportation – Diesel	N_2O	3.0	30.0	30.15	0.00	0.00
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	0.13
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	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.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	0.5	2.06	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
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	0.5	5.02	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	0.01
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.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	0.95
2.C.3 Metal Industry – Aluminium Production	SF_6	5.0	5.0	7.07	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	5.0	10.0	11.18	0.00	0.00
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	NF3	5.0	10.0	11.18	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	20.0	50.0	53.85	1.27	1.85
2.F.2 Foam Blowing	HFC	20.0	50.0	53.85	0.00	0.00
2.F.3 Fire Extinguishers	HFC	20.0	50.0	53.85	0.00	0.00
2.F.4 Aerosols	HFC	20.0	50.0	53.85	0.00	0.00
2.F.5 Solvents	HFC	20.0	50.0	53.85	0.00	0.00

2.F.6 Other Applications	HFC	25.0	50.0	55.90	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	25.0	50.0	55.90	0.00	0.00
2.G.2 Other product manufacture and use – SF6 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 – SF6 and PFCs from other product use	SF_6	25.0	50.0	55.90	0.06	0.05
2.G. Other Product Manufacture and Use	CO_2	20.0	0.0	20.00	0.00	0.00
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	1.06	0.16
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	40.0	40.20	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH_4	10.0	40.0	41.23	0.00	0.00
3.B.1.1 Manure Management – Cattle	CH_4	1.0	20.0	20.02	0.01	0.00
3.B.1.1 Manure Management – Cattle	N_2O	1.0	100.0	100.00	0.12	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	0.00	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	22.60	1.06
3.D.2 Indirect N_2O emissions from Managed Soils	N_2O	5.0	200.0	200.06	0.88	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 and Urea application	CO_2	100.0	10.0	100.50	0.01	0.03
3.H Urea application	CO_2	100.0	10.0	100.50	0.00	0.00
5.A Solid Waste Disposal	CH_4	12.0	25.0	27.73	0.20	1.28
4 Total land use categories	CH_4			0.00	0.00	0.00
4 Total land use categories	N_2O			0.00	0.00	0.00
4.A.1 Forest land remaining forest land	CO_2			629.60	462.83	0.00
4.A.2 Land converted to forest land	CO_2			131.91	9.26	0.00
4.B.1 Cropland remaining cropland	CO_2			860.89	4.43	0.00
4.B.2 Land converted to cropland	CO_2			456.85	1.83	0.00
4.C.1 Grassland remaining grassland	CO_2			14.61	0.00	0.00
4.C.2 Land converted to grassland	CO_2			5 652.33	7.74	0.00
4.D.2 Land converted to Wetlands	CO_2			850.16	0.75	0.00
4.E.2 Land converted to Settlements	CO_2			226.94	1.30	0.00

4.F.2 Land converted to Other land	CO_2			1 893.33	17.34	0.00
4.G HWP	CO_2			50.00	0.48	0.00
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					534.16	8.19
Total Uncertainties				Uncertainty in total inventory %:	23.11	2.86

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 0.7% of total emissions from this sector.

Emissions from the energy sector are the main source of GHGs in Austria: in the year 2016 about 68.2% of national total GHGs emissions and 78.8% of national total CO_2 emissions from Austria arose from the energy sector.

Emission trends

Emissions from the energy sector decreased by 3.6% from 52.9 Mt CO_2 equivalents in 1990 to 54.3 Mt CO_2 equivalents in 2016, which is mainly caused by decreasing emissions from households and power plants.

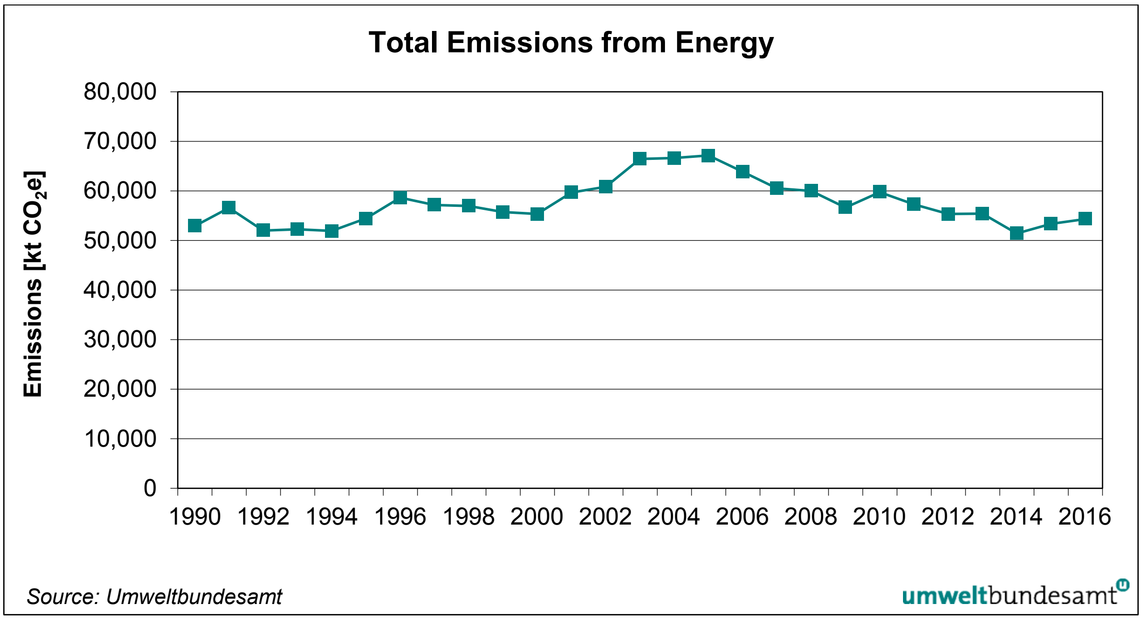


Figure 7: Trend of GHG emissions from 1990–2016 for energy.

Total emissions from energy mainly consist of CO_2 whereas N_2O and CH_4 emissions only make up about 1.1% and 1.1%, respectively. The increase of N_2O emissions is mainly caused by 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 coal mines. The strong increase of CO_2 emissions from 2002 to 2003 was additionally caused by public electricity plants. Between 2005 and 2016 CO_2 emissions decreased by 19.4%. Between 2014 and 2015 emissions from public electricity production mainly increased due to risen electricity generation from gas plants. Between 2015 and 2016 emissions from road transport increased due to higher fuel sales. In the year 2016 emissions from households (*1.A.4.b*) increased because of an increased heating demand (heating degree days in 2016 were about 5% higher than in 2015).

Table 19: Emissions of greenhouse gases and their trend from 1990–2016 from IPCC Category 1 Energy.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	kt CO_2 equivalent
1990	51 197	23.35	1.45	52 212
1991	54 932	24.34	1.58	56 012
1992	50 384	22.17	1.54	51 397
1993	50 710	20.79	1.55	51 691
1994	50 526	19.01	1.54	51 462
1995	52 988	20.35	1.59	53 972
1996	57 215	20.15	1.69	58 223
1997	55 806	17.97	1.66	56 751
1998	55 599	17.08	1.68	56 525
1999	54 300	17.11	1.70	55 235
2000	53 906	16.50	1.70	54 826
2001	58 201	17.15	1.78	59 160
2002	59 413	15.85	1.77	60 336
2003	65 007	15.62	1.82	65 941
2004	65 222	15.20	1.83	66 148
2005	65 779	14.64	1.90	66 713
2006	62 430	14.41	1.94	63 369
2007	59 108	13.71	1.95	60 031
2008	58 657	14.08	1.95	59 591
2009	55 253	13.70	1.90	56 162
2010	58 318	14.92	1.99	59 284
2011	55 899	14.01	2.00	56 845
2012	53 887	14.64	2.01	54 851
2013	53 924	15.46	2.07	54 928
2014	50 087	13.30	1.96	51 002
2015	51 979	14.17	2.00	52 928
2016	52 990	14.32	2.00	53 945
Trend 1990–2016	**3.5%**	**-38.7%**	**38.0%**	**3.3%**

The most important sub categories regarding total emissions in 1990 were *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 has the highest share since 1992. The decrease of GHG emissions from *1.B fugitive emissions from fuels* is mainly caused by the decrease of CH_4 emissions from coal mining.

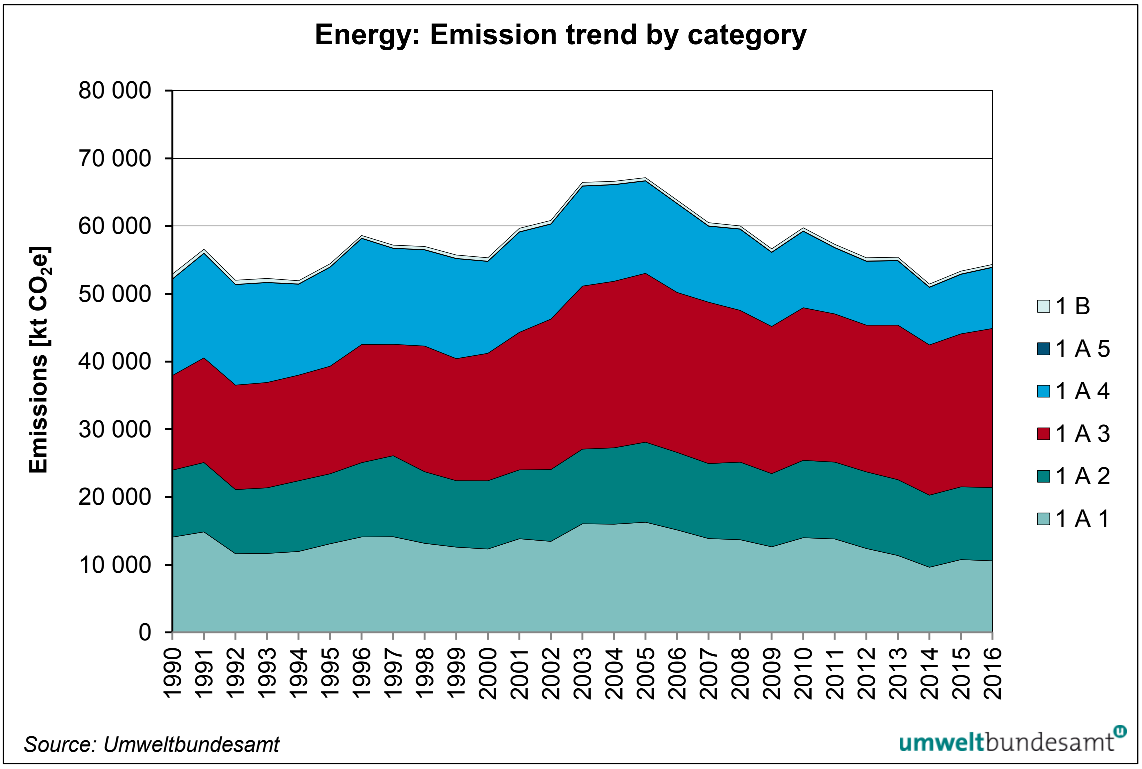


Figure 8: GHG emissions [kt CO_2e] from 1990–2016 from Energy by sub categories.

Table 20: GHG emissions [kt CO_2e] from 1990–2016 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	52 914	52 212	14 076	9 889	13 973	14 238	36	702	333	369
1991	56 581	56 012	14 847	10 246	15 453	15 427	38	569	181	388
1992	52 009	51 397	11 627	9 471	15 423	14 841	35	612	192	420
1993	52 272	51 691	11 665	9 690	15 555	14 741	40	580	164	416
1994	51 932	51 462	11 959	10 435	15 603	13 422	43	470	56	414
1995	54 436	53 972	13 094	10 336	15 884	14 625	33	464	37	427
1996	58 615	58 223	14 105	10 969	17 438	15 671	40	392	24	368
1997	57 187	56 751	14 136	11 960	16 451	14 166	38	436	25	412
1998	56 989	56 525	13 158	10 571	18 559	14 193	43	464	25	439
1999	55 731	55 235	12 599	9 811	18 021	14 761	43	496	25	472
2000	55 322	54 826	12 319	10 081	18 817	13 567	42	496	27	469
2001	59 675	59 160	13 837	10 169	20 308	14 804	42	515	26	488
2002	60 835	60 336	13 448	10 605	22 220	14 020	43	499	31	468
2003	66 457	65 941	16 045	11 026	24 073	14 753	43	515	25	490
2004	66 614	66 148	15 984	11 278	24 589	14 253	44	466	5	461
2005	67 150	66 713	16 280	11 819	24 933	13 637	45	437	0	437
2006	63 834	63 369	15 138	11 446	23 625	13 115	45	465	0	465
2007	60 503	60 031	13 862	11 073	23 829	11 221	46	472	0	472
2008	60 023	59 591	13 695	11 457	22 408	11 985	46	432	0	432
2009	56 642	56 162	12 644	10 809	21 728	10 934	47	480	0	480
2010	59 752	59 284	13 989	11 424	22 534	11 290	47	468	0	468
2011	57 306	56 845	13 807	11 346	21 882	9 763	48	461	0	461

	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
2012	55 325	54 851	12 398	11 315	21 667	9 424	48	474	0	474
2013	55 400	54 928	11 362	11 198	22 825	9 495	49	471	0	471
2014	51 440	51 002	9 627	10 644	22 184	8 498	50	438	0	438
2015	53 352	52 928	10 757	10 742	22 592	8 787	50	424	0	424
2016	54 336	53 945	10 578	10 821	23 488	9 007	51	392	0	392
1990–2016	**2.7%**	**3.3%**	**-24.9%**	**9.4%**	**68.1%**	**-36.7%**	**41.2%**	**-44.2%**	**-100%**	**6.3%**

3.2 Fuel Combustion Activities (Category 1.A)

This chapter gives an overview of emissions and key sources of fuel combustion activities, includes information on completeness, QA/QC, planned improvements as well as on emissions, emission trends and methodologies applied (including emission factors). Furthermore, information on the sectoral/reference approaches and feedstocks/non-energy use of fuels is given in this sector.

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 following figure shows the results for the two approaches for the period 1990–2016. Solid fuels show the most significant deviation.

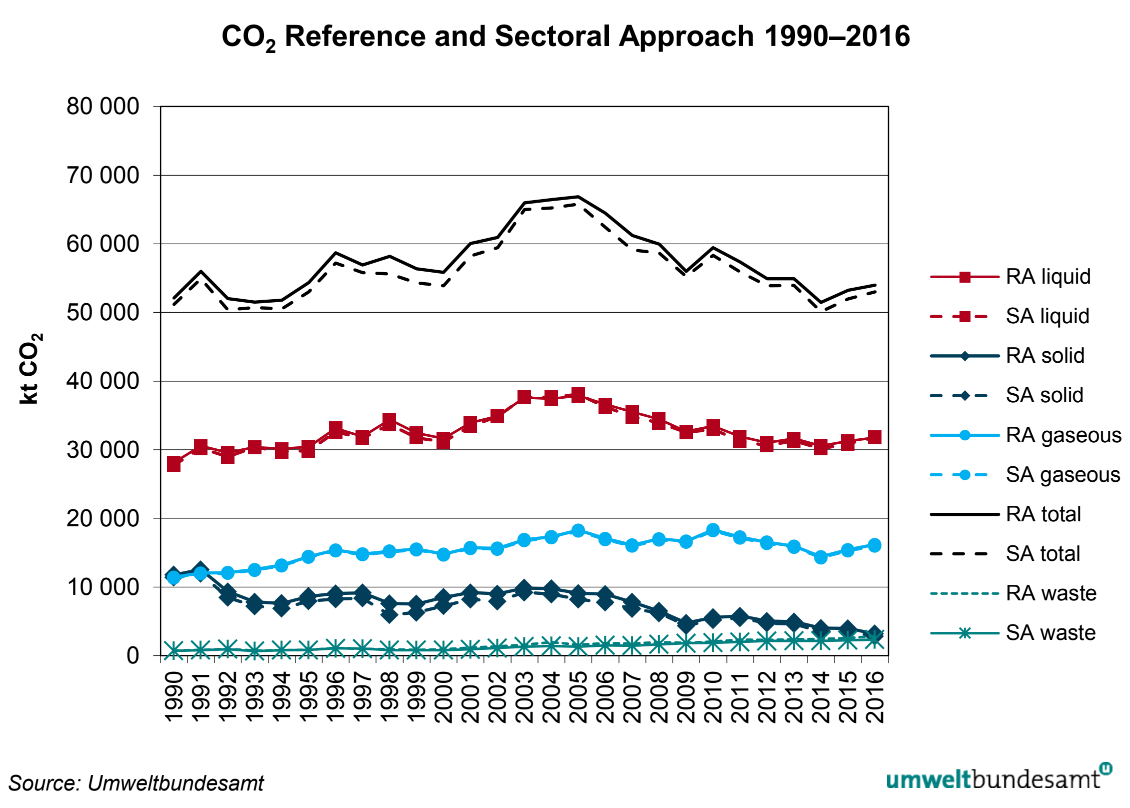


Figure 9: CO_2 Reference and Sectoral Approach 1990 to 2016.

Table 21 presents CO_2 emissions of the sectoral and reference approach.

Table 21: 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	28 152	11 766	11 417	758	52 093	27 750	11 412	11 301	734	51 197
1991	30 556	12 550	12 044	836	55 986	30 226	11 961	11 940	804	54 932
1992	29 586	9 327	12 101	994	52 009	28 961	8 466	12 000	957	50 384
1993	30 399	7 828	12 545	741	51 513	30 364	7 219	12 453	673	50 710
1994	30 141	7 618	13 201	814	51 775	29 715	6 881	13 111	818	50 526
1995	30 429	8 653	14 426	848	54 357	29 862	7 950	14 339	837	52 988
1996	33 130	9 054	15 384	1 108	58 676	32 607	8 247	15 287	1 073	57 215
1997	31 923	9 155	14 815	1 005	56 899	31 704	8 366	14 720	1 016	55 806
1998	34 401	7 598	15 233	927	58 160	33 686	5 952	15 144	815	55 599
1999	32 419	7 541	15 538	857	56 355	31 737	6 291	15 448	824	54 300
2000	31 635	8 512	14 782	936	55 865	31 156	7 248	14 686	816	53 906
2001	33 932	9 194	15 737	1 162	60 026	33 420	8 213	15 632	936	58 201
2002	34 922	9 000	15 656	1 373	60 951	34 832	7 918	15 536	1 127	59 413
2003	37 626	9 866	16 900	1 585	65 977	37 676	9 226	16 766	1 338	65 007
2004	37 402	9 772	17 321	1 954	66 450	37 663	8 952	17 176	1 430	65 222
2005	37 864	9 095	18 293	1 593	66 845	38 080	8 210	18 156	1 332	65 779
2006	36 606	8 949	17 068	1 829	64 452	36 230	7 762	16 923	1 514	62 430
2007	35 508	7 801	16 122	1 765	61 196	34 799	6 852	15 986	1 471	59 108
2008	34 447	6 499	17 025	1 958	59 929	33 901	6 212	16 878	1 665	58 657
2009	32 671	4 764	16 665	1 890	55 991	32 532	4 385	16 523	1 812	55 253

	Reference Approach					Sectoral Approach *1 A Fuel Combustion*				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
2010	33 467	5 567	18 364	2 042	59 441	33 008	5 211	18 209	1 890	58 318
2011	31 935	5 787	17 288	2 337	57 347	31 246	5 506	17 144	2 002	55 899
2012	31 049	5 027	16 523	2 296	54 896	30 626	4 728	16 382	2 150	53 887
2013	31 623	4 940	15 954	2 372	54 889	31 298	4 647	15 821	2 157	53 924
2014	30 570	4 001	14 423	2 454	51 447	30 145	3 498	14 275	2 169	50 087
2015	31 273	3 973	15 447	2 555	53 249	30 885	3 521	15 300	2 272	51 979
2016	31 756	3 199	16 191	2 842	53 988	31 829	2 834	15 978	2 350	52 990

Table 22 presents the difference of CO_2 emissions in percent between reference and sectoral approach.

Table 22: Difference of CO_2 emissions by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	1.45%	3.10%	1.03%	3.34%	1.75%
1991	1.09%	4.92%	0.87%	3.99%	1.92%
1992	2.16%	10.17%	0.84%	3.83%	3.22%
1993	0.11%	8.43%	0.74%	10.05%	1.58%
1994	1.43%	10.71%	0.69%	-0.52%	2.47%
1995	1.90%	8.85%	0.61%	1.32%	2.58%
1996	1.60%	9.78%	0.63%	3.21%	2.55%
1997	0.69%	9.43%	0.65%	-1.09%	1.96%
1998	2.12%	27.65%	0.59%	13.64%	4.61%
1999	2.15%	19.87%	0.58%	4.02%	3.79%
2000	1.54%	17.44%	0.65%	14.66%	3.63%
2001	1.53%	11.96%	0.67%	24.16%	3.14%
2002	0.26%	13.67%	0.77%	21.78%	2.59%
2003	-0.13%	6.93%	0.80%	18.46%	1.49%
2004	-0.69%	9.16%	0.84%	36.67%	1.88%
2005	-0.57%	10.78%	0.75%	19.58%	1.62%
2006	1.04%	15.28%	0.86%	20.78%	3.24%
2007	2.04%	13.84%	0.85%	20.00%	3.53%
2008	1.61%	4.63%	0.87%	17.55%	2.17%
2009	0.43%	8.66%	0.86%	4.27%	1.34%
2010	1.39%	6.83%	0.85%	8.06%	1.93%
2011	2.20%	5.11%	0.84%	16.72%	2.59%
2012	1.38%	6.32%	0.86%	6.79%	1.87%
2013	1.04%	6.31%	0.84%	9.98%	1.79%
2014	1.41%	14.38%	1.03%	13.13%	2.72%
2015	1.26%	12.83%	0.96%	12.47%	2.44%
2016	-0.23%	12.88%	1.33%	20.94%	1.88%

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 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 2016 about 9.0 Mt of solid fuels CO_2 from integrated iron plants are considered in *2.C.1* and 0.4 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 while the methodology for the reference approach uses a single emission factor of 104.2 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 23 shows the energy consumption of the two approaches. For the reference approach non energy consumption according to the energy balance has been subtracted. The comparison shown in Table 24 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 23: Energy consumption of sectoral and reference approach in [PJ].

Year	Reference Approach					Sectoral Approach				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
1990	394.95	153.27	203.98	8.07	760.29	368.21	115.87	203.98	8.99	697.05
1991	430.23	162.39	215.53	8.98	817.12	400.58	121.67	215.53	10.08	747.86
1992	424.12	123.14	216.61	10.69	774.56	384.22	87.17	216.61	12.01	700.01
1993	431.57	109.28	224.79	8.35	773.99	400.76	74.40	224.79	9.78	709.73
1994	428.61	109.08	236.67	9.08	783.44	392.04	71.01	236.67	10.53	710.25
1995	430.65	124.99	258.83	9.43	823.91	393.89	81.66	258.83	10.92	745.30
1996	469.14	126.94	275.94	12.20	884.24	435.17	85.11	275.94	14.02	810.24
1997	457.80	132.59	265.71	11.26	867.37	422.90	86.52	265.71	13.12	788.25
1998	488.45	112.18	273.36	10.47	884.47	448.73	61.79	273.36	12.29	796.17
1999	461.13	110.58	278.84	9.79	860.34	424.12	64.22	278.84	11.59	778.78
2000	449.52	123.91	262.32	10.51	846.27	417.10	74.72	265.10	12.27	769.20
2001	482.19	129.32	282.17	12.63	906.31	446.96	84.47	282.17	14.49	828.09
2002	498.26	128.23	280.44	14.81	921.74	465.08	81.52	280.44	16.78	843.82
2003	532.86	139.39	302.31	17.14	991.70	502.91	95.20	302.64	19.40	920.15
2004	532.85	136.14	308.96	21.69	999.64	502.68	93.08	310.04	24.56	930.37
2005	535.59	132.53	325.21	18.37	1 011.71	509.94	86.93	327.73	21.45	946.06
2006	528.35	133.70	303.43	21.86	987.35	485.74	82.79	305.47	25.39	899.39
2007	517.49	124.80	286.53	21.38	950.21	467.33	73.48	288.55	24.50	853.87
2008	499.39	120.77	302.24	23.52	945.92	455.32	66.78	304.65	26.20	852.96
2009	484.99	93.92	294.26	23.33	896.50	435.80	46.99	298.26	27.65	808.70
2010	501.01	108.20	324.23	25.29	958.74	442.52	55.77	328.68	29.41	856.38
2011	472.83	109.94	307.01	28.92	918.71	419.07	59.04	309.46	32.79	820.37
2012	463.53	101.59	293.45	28.15	886.73	410.05	50.84	295.70	32.68	789.28
2013	472.40	101.57	283.08	28.34	885.39	419.18	50.30	285.59	33.44	788.50
2014	462.94	90.57	255.76	30.10	839.37	403.82	37.60	257.67	36.02	735.11
2015	467.59	99.98	274.41	31.27	873.26	413.14	37.63	276.18	37.60	764.55
2016	474.04	90.23	286.48	33.77	884.51	424.07	30.52	288.41	38.06	781.05

Table 24: Difference of energy consumption by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	7.3%	32.3%	0.0%	-10.2%	9.1%
1991	7.4%	33.5%	0.0%	-10.9%	9.3%
1992	10.4%	41.3%	0.0%	-11.0%	10.7%
1993	7.7%	46.9%	0.0%	-14.6%	9.1%
1994	9.3%	53.6%	0.0%	-13.8%	10.3%
1995	9.3%	53.1%	0.0%	-13.6%	10.5%
1996	7.8%	49.1%	0.0%	-12.9%	9.1%
1997	8.3%	53.2%	0.0%	-14.2%	10.0%
1998	8.9%	81.6%	0.0%	-14.8%	11.1%
1999	8.7%	72.2%	0.0%	-15.5%	10.5%
2000	7.8%	65.8%	-1.0%	-14.4%	10.0%
2001	7.9%	53.1%	0.0%	-12.8%	9.4%

Year	Liquid	Solid	Gaseous	Waste	Total
2002	7.1%	57.3%	0.0%	-11.7%	9.2%
2003	6.0%	46.4%	-0.1%	-11.7%	7.8%
2004	6.0%	46.3%	-0.4%	-11.7%	7.4%
2005	5.0%	52.4%	-0.8%	-14.3%	6.9%
2006	8.8%	61.5%	-0.7%	-13.9%	9.8%
2007	10.7%	69.8%	-0.7%	-12.7%	11.3%
2008	9.7%	80.8%	-0.8%	-10.2%	10.9%
2009	11.3%	99.8%	-1.3%	-15.6%	10.9%
2010	13.2%	94.0%	-1.4%	-14.0%	12.0%
2011	12.8%	86.2%	-0.8%	-11.8%	12.0%
2012	13.0%	99.8%	-0.8%	-13.9%	12.3%
2013	12.7%	102.0%	-0.9%	-15.3%	12.3%
2014	14.6%	140.9%	-0.7%	-16.4%	14.2%
2015	13.2%	165.7%	-0.6%	-16.8%	14.2%
2016	11.8%	195.6%	-0.7%	-11.3%	13.2%

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

All recalculations are following the revisions of the energy balance.

3.2.2 International bunker fuels

3.2.2.1 International aviation

In 2016, 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 25.

Table 25: Greenhouse gas emissions and activity from international bunkers-aviation 1990–2016.

Year	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
				Kerosene			
1990	90	796	0.01	-	0.006	0.03	12 189
1991	103	891	0.02	-	0.006	0.03	13 674
1992	116	962	0.02	-	0.007	0.03	14 823
1993	129	1 011	0.02	-	0.008	0.03	15 684
1994	141	1 044	0.02	-	0.009	0.03	16 312

Year	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
				Kerosene			
1995	154	1 173	0.02	-	0.010	0.04	18 263
1996	165	1 302	0.02	-	0.010	0.04	20 175
1997	175	1 350	0.03	-	0.011	0.04	20 989
1998	186	1 392	0.03	-	0.011	0.04	21 713
1999	190	1 352	0.03	-	0.011	0.04	21 210
2000	210	1 485	0.03	-	0.010	0.05	23 306
2001	200	1 452	0.03	-	0.010	0.05	22 697
2002	233	1 307	0.03	-	0.010	0.04	21 179
2003	243	1 210	0.04	-	0.010	0.04	19 971
2004	290	1 435	0.04	-	0.011	0.05	23 709
2005	270	1 689	0.04	-	0.012	0.05	26 938
2006	268	1 781	0.04	-	0.012	0.06	28 162
2007	290	1 886	0.04	-	0.013	0.06	29 906
2008	294	1 888	0.04	-	0.013	0.06	29 991
2009	269	1 624	0.04	-	0.012	0.05	26 025
2010	276	1 773	0.04	-	0.012	0.06	28 171
2011	314	1 854	0.05	-	0.014	0.06	29 805
2012	302	1 771	0.04	-	0.014	0.06	28 489
2013	294	1 682	0.04	-	0.013	0.05	27 141
2014	297	1 680	0.04	-	0.013	0.05	27 177
2015	313	1 814	0.05	-	0.013	0.06	29 251
2016	321	2 005	0.02	-	0.009	0.06	31 964
1990–2016	***255%***	***152%***	***12%***	***-***	***57%***	***118%***	***162%***

Methodological Issues

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

Recalculations

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

3.2.2.2 International navigation

In 2016, the share of international navigation in the total fuel consumption in the navigation sector in Austria represented 83% (defined on energy content). Greenhouse gas emissions and activity data from navigation assigned to international bunkers are presented in the following table.

Table 26: Greenhouse gas emissions from international bunkers-marine 1990–2016.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	49.5	0.0025	0.017	54.7
1991	43.1	0.0021	0.015	47.6

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1992	41.9	0.0021	0.015	46.3
1993	43.0	0.0021	0.015	47.5
1994	54.7	0.0027	0.019	60.5
1995	61.6	0.0030	0.022	68.1
1996	63.1	0.0031	0.022	69.8
1997	61.5	0.0030	0.022	68.1
1998	67.2	0.0032	0.024	74.4
1999	66.4	0.0032	0.024	73.6
2000	72.4	0.0034	0.026	80.3
2001	76.5	0.0036	0.028	84.9
2002	86.1	0.0039	0.031	95.5
2003	68.6	0.0030	0.025	76.1
2004	81.9	0.0035	0.030	90.9
2005	80.4	0.0032	0.029	88.9
2006	70.3	0.0024	0.024	77.5
2007	75.4	0.0024	0.025	82.9
2008	69.7	0.0021	0.022	76.3
2009	59.5	0.0016	0.018	64.9
2010	70.5	0.0018	0.020	76.7
2011	62.2	0.0015	0.017	67.5
2012	63.9	0.0015	0.017	69.1
2013	68.6	0.0016	0.018	74.1
2014	63.9	0.0014	0.017	68.9
2015	52.9	0.0011	0.013	56.9
2016	58.0	0.0012	0.015	62.4
Trend 1990–2016	***17%***	***-52%***	***-16%***	***14%***

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 made up of freight transport activities on the River Danube. As domestic navigation on the River Danube is navigation between Danube harbors 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 (STATISTIK AUSTRIA 2000-2017). 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.*

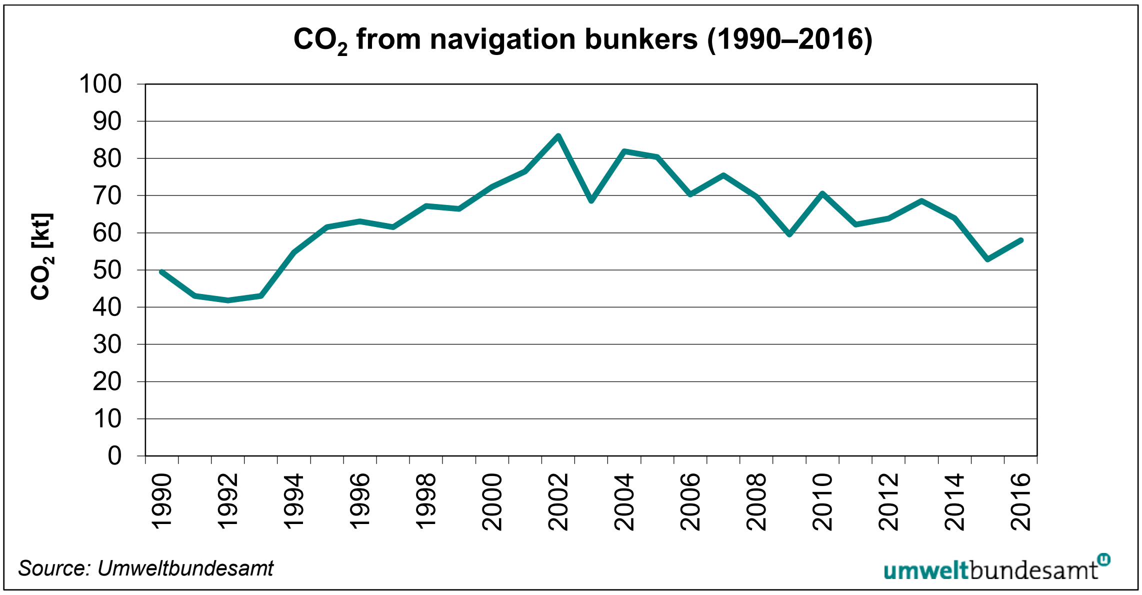


Figure 10: CO_2 emissions from navigation bunkers, 1990–2016.

Activity Data & Emission Factors

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

Table 27: Emission factors and activity data for international bunkers-marine 1990–2016.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	667	74.2	3.7	25.9
1991	581	74.2	3.7	25.8
1992	565	74.2	3.7	25.8
1993	580	74.2	3.7	25.9
1994	737	74.2	3.7	26.0
1995	830	74.2	3.6	26.1
1996	851	74.2	3.6	26.2
1997	830	74.2	3.6	26.3
1998	906	74.2	3.6	26.5
1999	895	74.2	3.5	26.6
2000	976	74.2	3.5	26.7
2001	1 032	74.2	3.5	26.9
2002	1 160	74.2	3.4	26.9
2003	925	74.2	3.3	26.9
2004	1 105	74.2	3.2	27.0
2005	1 084	74.2	2.9	26.3
2006	948	74.2	2.5	25.2
2007	1 017	74.2	2.4	24.4
2008	939	74.2	2.3	23.5

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2009	803	74.2	2.0	22.2
2010	951	74.2	1.9	21.5
2011	839	74.2	1.8	20.7
2012	861	74.2	1.7	20.2
2013	925	74.2	1.7	19.8
2014	860	74.4	1.6	19.4
2015	711	74.4	1.5	18.9
2016	780	74.4	1.5	18.6

Recalculations

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

3.2.3 Feedstocks and non-energy use of fuels

Non-energy use of fuels is considered in the national energy balance. Below explanations for the reported non-energy use is provided 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: emissions from incineration of lubricants (waste oil) are either included in categories *1.A.1.a* and *1.A.2* if waste oil is used as fuel or to a minor degree reported under category *5.C* if energy is not recovered.

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: indirect CO_2 emissions from the use of bitumen for road paving and roofing are included in sector 2.D.3 solvent use.

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 (2016) non energy use is reported for the manufacture of electrodes.

manufacture: No information about emissions from manufacture of electrodes is currently available. Therefore it is not clear if emissions are not estimated or not applicable.

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. 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*.

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. 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 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: CO_2 emissions from solvent use are considered in sector *2.D.3*.

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*.

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

In 2016 the most important source of GHGs was transport, with a share of 29.5% in national total GHG emissions. 17.6% of national GHG emissions were released by passenger cars, 1.8% by light duty vehicles, 8.9% by heavy-duty vehicles and 0.3% by mopeds and motorcycles. Austria's railway system is mainly driven by electricity, only 0.1% of overall GHGs originate from this sector. Fuels used by ships on inland waterways have a share of 0.01% 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 0.1% of national GHG arise from domestic aviation.

Energy Industries

The second largest GHG source of the energy sector in 2016 with a share of 13.3% total GHG emissions was energy industries, were fossil fuels are used for electrical power and district heating production. In the year 2016 overall gross public electricity production was 60 469 GWh[32] of which 42 396 GWh (70%) were generated by hydro plants, 11 742 GWh (19%) by thermal power plants and 6 331 GWh (10%) by solar, geothermal and wind power plants. Industrial auto producers generated 7 882 GWh of electricity in the year 2016. 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 refinery industry, which consists of only one plant in Austria, is also included in this category (sub-category *1.A.1.b Petroleum refining*). The crude oil input of the oil refinery was 8.2 Mt in 2016. Furthermore this category includes emissions from other energy industries which is mainly natural gas consumption of oil/gas exploration and gas refining industries (sub-category *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries*).

Manufacturing Industries

Combustion in manufacturing industries and construction was the third largest sub-category with a share of 13.6% in 2016 total GHG emissions. This category also includes mobile machinery mainly used in the construction sector. 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 under industrial processes (CRF Category 2).

Other Sectors

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 fourth largest sub-category with a share of 11.3% in 2016 total 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 heatings 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.

[32] Source: IEA Questionnaire December/2017 by STATISTIK AUSTRIA.

Other (Military)

Category *1.A.5 Other* includes emissions from military air and road transport as well as from other mobile machinery. It contributes 0.06% to total GHG emissions in 2016.

3.2.7 Key Categories

The methodology and results of the key category analysis is presented in Chapter 1.5. Table 28 presents the Tier 1 key source categories of *1.A Fuel Combustion Activities*.

Table 28: 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; 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; TA
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 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CO_2	TA
1 A 2 a gaseous	Iron and Steel	CO_2	LA
1 A 2 a liquid	Iron and Steel	CO_2	TA
1 A 2 a solid	Iron and Steel	CO_2	LA; TA
1 A 2 b gaseous	Non-ferrous Metals	CO_2	LA 2016
1 A 2 c gaseous	Chemicals	CO_2	LA
1 A 2 c other	Chemicals	CO_2	LA 2016
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
1 A 2 f gaseous	Other	CO_2	LA
1 A 2 f liquid	Other	CO_2	LA 1990; TA
1 A 2 f other	Other	CO_2	LA 2016
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
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	CH_4	
1 A 3 b gasoline	Road Transportation	N_2O	
1 A 3 e gaseous	Other	CO_2	LA

IPCC Category	Category Name	GHG	Key source
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 other	Commercial/Institutional	CO_2	TA
1 A 4 b biomass	Residential	CH_4	LA
1 A 4 b gaseous	Residential	CO_2	LA
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 b solid	Residential	N_2O	
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO_2	LA
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2	TA

LA = Level Assessment (if not further specified – for the years 1990 and 2016)

TA = Trend Assessment 1990–2016

3.2.8 Completeness

Table 29 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 29: Overview of subcategories of Category 1.A Fuel Combustion: transformation into SNAP Codes and status of estimation.

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		✓	✓	✓
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)

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
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		✓	✓	✓
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)**			

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
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 cm³** **0705 Motorcycles > 50 cm³** **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		NO	NO	NO
1.A.3.c Railways	**0802 Other Mobile Sources and Machinery-Railways**			
1.A.3.c Solid Fuels		✓	✓	✓
1.A.3.c Liquid Fuels		✓	✓	✓
1.A.3.c Other Fuels		NO	NO	NO
1.A.3.c Biomass		✓	✓	✓
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 Solid fuelsl		NO	NO	NO
1.A.3.d Gaseous		NO	NO	NO
1.A.3.d Biomass		✓	✓	✓
1.A.3.e Other	**010506 Pipeline Compressors**			

IPCC Category	**SNAP**	**Status**		
		CO_2	**CH_4**	**N_2O**
1.A.3.e Liquid Fuels		NO	NO	NO
1.A.3.e Solid Fuels		NO	NO	NO
1.A.3.e Gaseous Fuels		✓	✓	✓
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		NO	NO	NO
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		NO	NO	NO
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		NO	NO	NO
1.A.5 Other Fuels		NO	NO	NO
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

3.2.9 Methodological Issues

3.2.9.1 Choice of method

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 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 kilometer. Bottom up fuel consumption of civil aviation is calculated by aircraft specific LTO-cycle and cruise-kilometer consumption. Top down activity data are based on fuel sales taken from the national energy balance.

Table 30: 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

	Method			Emission factor		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1 A 2 b other	T2	T2	T1	CS	CS	D
1 A 2 b biomass	T1	T2	T1	D	CS	D
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 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

	Method			Emission factor		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
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
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 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 e 1 gaseous	T2	T1	T1	CS	D	D
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 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 5 b liquid	T2	T3	T3	CS	CS	CS
1 A 5 b biomass	T1	T3	T3	D	CS	CS

Consideration of point source emissions

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

- *1.A.1.a Public Electricity and Heat Production (55 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) 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 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.

3.2.9.2 Consideration of CO_2 emission trading system (ETS) „bottom up" data

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

- Oil refineries,
- Iron and steel manufacturing industries,
- Non-metallic mineral industries (cement, glass, lime, bricks and tiles, other ceramic materials),
- Pulp and paper manufacturing industries.

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).

<u>Description of received ETS data</u>

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.

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 in case of „non-traded fuels".

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

- Activity data: mass or volume of material flow;
- Net calorific value of material;
- Carbon content of material.

Direct CO_2 measurements have not been submitted.

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" plant operators have to make their own estimate of carbon content and NCV.

Methodology of ETS data consideration

ETS „bottom up“ data 2005–2016 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 reported 800 fuel and material flows yearly which have been considered in the inventory. From the year 2013 on 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).

- 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:
  $Activity_{category,\ fuel}$ = ($Energy\_Balance\_Activity_{category,\ fuel}$ – Σi($ETS\_Activity_{plant\ i,\ fuel}$)) x $Energy\_Balance\_NCV_{fuel}$ + Σi($ETS\_Activity_{plant\ i,\ fuel}$ x $ETS\_NCV_{plant\ i,\ fuel}$).
- ETS CO_2 emissions are considered by fuel. The remaining CO_2 emissions are calculated by remaining activity data and „national default“ emission factors:
  $CO_{2category,\ fuel}$ = ($Energy\_Balance\_Activity_{category,\ fuel}$ – Σi($ETS\_Activity_{plant\ i,\ fuel}$)) x $Energy\_Balance\_NCV_{fuel}$ x $Default\_EF_{fuel}$ + Σi($ETS\_CO_{2plant\ i,\ fuel}$).

3.2.9.3 Choice of emission factors for stationary sources

Emission factors for combustion plants are expressed as kg/GJ for CO_2 and as g/GJ for CH_4 and N_2O. Please note that emission factors sometimes are different for different sectors because of the different share of fuel types 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.

References for country specific CO_2 and CH_4 emission factors are 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) has been 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.

The CO_2 emission factor and heating value will be also used as a default value for 2016-2018 ETS reporting and has been published by the ministry of environment in January 2017 (https://www.bmnt.gv.at/umwelt/klimaschutz/eu-emissionshandel/info-anlagen/monitoring-vo.html).

Table 31 shows the typical composition of natural gas as reported by the main national natural gas supplier company *GAS CONNECT AUSTRIA GmbH* for 2015.

Table 31: Typical natural gas composition of Austrian main supplier 2015 (NCV = 36.45 MJ/Nm³)

Component	Share
CH_4	96.03%
C_2H_6	2.05%
C_3H_8	0.41%
n-C_4H_{10}	0.08%
i-C_4H_{10}	0.08%
n-C_5H_{12}	0.03%
i-C_5H_{12}	0.03%
C_6H_{14}+	0.03%
CO_2	0.43%
N_2	0.83%
O_2	0.00%

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[33] was performed by the local waste authority of Vienna (MA 48) in 1997/1998.

[33] 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 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.

In 2015 a yet unpublished study has been made available to the inventory team which used a special approach (using available input and output process measurement parameters of the plants) for CO_2 emission calculation from selected Austrian MSW incineration plants. The methodology has been developed by the Technical University of Vienna (TU 2015). The outcome of the study shows that the uncertainty of the approach was rather high but that the CO_2 emission factor used for inventory compilation is still reasonable and within the range of the uncertainty of the special approach. It has to be mentioned that the currently used average share of fossil carbon in the MSW of about 45% has not been disproved within the study project and that the currently used CO_2 emission factor is within a 'conservative range' of the study outcome.

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 3.2.11.6.

The fractions and the specific carbon contents of waste incinerated in chemical industry, pulp and paper industry and wood products manufacturing industry are not reported by the ETS report and are unknown. It is assumed that the heating value is mainly determined by combustion of carbon which is mainly of fossil origin. Therefore the default emission factor from the IPCC 2006 Guidelines (Table 5.2) is used.

A carbon content of 500 kg C/t waste is selected with a fossil share of 90% and 99.5% combustion efficiency. This leads to an emissions factor of 1 641.8 kg CO_2/t waste. By selecting a net calorific value of 15.76 GJ/t (which is the value used by STATISTIK AUSTRIA for preparing the energy balance) this leads to an emission factor of 104.17 t CO_2/TJ waste.

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 2017) 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.

3.2.9.4 CO_2 emissions reported by the ETS

The following Table 32 shows certificated CO_2 emissions from the ETS (UMWELTBUNDESAMT 2017a) 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 32: 2005–2016 CO_2 emissions [kt] as reported under the EU- ETS.

	Category	2005	2008	2010	2012	2013	2014	2015	2016
Total ETS[1)]		33 373	32 079	30 855	28 334	29 810	28 060	29 445	28 964
1.A	FUEL COMBUSTION ACTIVITIES	20 994	18 153	18 015	15 789	16 341	14 487	15 308	15 115
1.A.1.a	Public Electricity and Heat Production	11 482	8 973	9 335	7 232	6 288	4 721	5 683	5 445
1.A.1.b	Petroleum refining	2 827	2 806	2 724	2 836	2 827	2 713	2 804	2 784
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	43	47	47	43	199	181	190	187
1.A.2.a	Iron and Steel	1 382	1 117	1 082	1 250	1 531	1 482	1 089	1 198
1.A.2.b	Non-ferrous Metals	–	–	–	0	66	64	65	66
1.A.2.c	Chemicals	665	611	654	628	1 037	1 119	1 115	1 158
1.A.2.d	Pulp, Paper and Print	2 245	2 128	2 044	1 709	1 467	1 337	1 443	1 389
1.A.2.e	Food Processing, Beverages and Tobacco	316	295	352	333	303	320	344	308
1.A.2.f	Non-metallic minerals	1 656	1 845	1 528	1 530	1 552	1 613	1 606	1 631
1.A.2.g.8	Other: Stationary	354	311	234	215	412	387	337	338
1.A.3.e	Pipeline compressors	–	–	–	0	605	502	583	561
1.A.4.a	Commercial/Institutional	22	19	15	13	54	49	49	50
2	INDUSTRIAL PROCESSES	12 393	13 953	12 830	12 545	13 468	13 573	14 138	13 849
2.A.1	Cement Production	1 797	2 133	1 622	1 673	1 656	1 639	1 701	1 729
2.A.2	Lime Production	579	621	574	569	587	589	578	581
2.A.3	Glass Production	35	44	40	37	39	37	40	38
2.A.4	Other Process Uses of Carbonates				398	424	443	410	428
2.B.1	Ammonia Production	–	–	–	0	426	530	510	527
2.B.10	Other Chemical Industry	–	–	–	0	108	120	113	123
2.C.1	Steel	9 499	10 656	10 151	9 868	10 224	10 210	10 781	10 418
2.C.3	Aluminium Production	–	–	–	0	3	4	4	4

[1)] *Source: UMWELTBUNDESAMT (2017a). These data do not include N_2O emissions from nitric acid production.*

CO_2 emission factors reported within the ETS

Table 33 and Table 34 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 33: 2016 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	**92.92**	**97.27**	**113.00**	**93.22**	**78.11**	**55.41**
010101 Public Power plants >= 300 MW_{th}	93.80	-	-	-	-	55.40
010102 Public Power plants >= 50 MW_{th} < 300 MW_{th}	-	-	-	-	111.03	55.40
010103 Public Power plants <= 50 MW_{th}	-	-	-	-	-	55.40
010201 Public District Heating plants >= 300 MW_{th}	-	-	-	-	-	55.40
010202 Public District Heating plants >= 50 MW_{th} < 300 MW_{th}	-	-	-	-	-	55.40
010203 Public District Heating plants < 50 MW_{th}	-	-	-	-	-	55.40
010301 Refinery	-	-	998.37	-	-	55.40
010504 Other Energy Industries – Gas Turbines	-	-	-	-	-	55.50
010506 Pipeline Compressors	-	-	-	-	-	55.40
020103 Commercial plants < 50 MW_{th}	-	-	-	-	68.57	55.40
0301 Industry – Steel	-	-	-	-	-	55.40
0301 Industry – Non ferrous metals	-	-	104.00	-	74.93	55.40
0301 Industry – Chemicals	94.58	-	-	-	106.55	55.40
0301 Industry – Pulp and Paper	83.47	-	-	-	134.22	55.40
0301 Industry – Food and Beverages	-	-	108.34	-	68.65	55.40
03010 Industry – Other	-	-	-	-	88.63	55.40
030311 Cement kilns	94.83	97.13	-	93.15	79.81	55.40
030312 Lime kilns	-	98.05	-	-	-	55.40
030317 Glass	-	-	-	-	-	55.40
030319 Bricks and Tiles	-	95.37	-	91.50	120.41	55.40
030323 Dolomite Treatment	-	-	104.00	93.58	123.56	55.40
030326 Integrated Iron & Steel works	93.26	-	113.20	-	55.18	55.50

Table 34: 2016 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	**77.61**	**81.12**	**75.00**	**73.71**	**73.16**	**67.90**
010101 Public Power plants >= 300 MW_{th}	-	79.74	75.00	73.70	-	-
010102 Public Power plants >= 50 MW_{th} < 300 MW_{th}	-	-	75.00	73.70	-	-
010103 Public Power plants <= 50 MW_{th}	-	80.00	-	-	-	-
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	80.00	75.00	73.70	-	-
010203 Public District Heating plants < 50 MW_{th}	77.00	-	75.00	73.70	-	-
010301 Refinery	-	81.56	-	74.10	-	67.90
010504 Other Energy Industries – Gas Turbines	-	-	-	73.70	-	-
010506 Pipeline Compressors	-	-	-	73.70	-	-
020103 Commercial plants < 50 MW_{th}	-	-	75.00	73.70	-	-
0301 Industry – Steel	-	-	-	73.79	-	-
0301 Industry – Non ferrous metals	-	-	-	73.70	77.60	-
0301 Industry – Chemicals	-	78.00	75.00	73.92	67.65	-
0301 Industry – Pulp and Paper	78.00	77.92	75.00	73.70	-	-
0301 Industry – Food and Beverages	-	-	75.00	73.70	-	-
03010 Industry – Other	78.00	-	75.00	73.70	-	64.00
030311 Cement kilns	78.00	81.81	75.00	73.70	-	-
030312 Lime kilns	-	-	75.00	-	-	-
030317 Glass	78.00	-	75.00	73.70	-	-
030319 Bricks and Tiles	78.00	78.00	75.00	-	-	-
030323 Dolomite Treatment	78.00	-	75.00	73.70	-	64.00
030326 Integrated Iron & Steel works	77.00	-	75.00	-	-	-

3.2.9.5 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 2017). 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 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 13.9% for the year 2016. 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 2005–2016 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 remaining fuel consumption of the energy balance. Coal consumption is fully covered by the ETS. The general methodology is described in chapter 3.2.3.

Emission factors

National CO_2 emission factors are taken from (BMWA-EB, 1990, 1996, (UMWELTBUNDESAMT 2001a) and (GEMIS 2002). The selected emissions factors for 2016 as well as the national default emission factors are listed in the following table. The CO_2 emission factor for municipal solid waste is taken from (ABFALLWIRTSCHAFT 2003).

Table 35: Default emission factors of Category 1.A.1.a for the year 2016.

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	55.40	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 $Waste_{wet}$	48.88	12.00	4.00
Industrial Waste	104.17	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 2017) 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 36 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 and 75 PJ district heat 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 2016 was 4% higher than in 2015 because of an increased heating demand during the heating period.

Table 36: 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	24 427
1991	43 497	30 268	13 229	0	0	0	29 038
1992	42 848	33 530	9 318	0	0	0	27 601
1993	44 809	35 070	9 738	0	1	0	30 428
1994	44 804	34 078	10 725	0	1	0	30 729
1995	47 580	35 431	12 147	0	1	1	34 426
1996	45 953	32 892	13 055	0	1	5	44 483
1997	47 527	34 532	12 973	0	2	20	40 597
1998	47 789	35 596	12 146	0	2	45	43 415
1999	52 192	39 593	12 546	0	2	51	42 465
2000	52 810	41 131	11 609	0	3	67	42 197
2001	53 763	39 681	13 972	0	5	105	44 575
2002	54 385	40 597	13 636	3	9	140	45 056
2003	52 508	34 230	17 888	3	15	372	48 896
2004	56 051	37 700	17 397	2	18	934	51 786
2005	58 367	38 205	18 808	2	21	1 331	54 023
2006	56 273	36 907	17 588	3	22	1 753	54 764
2007	56 324	38 017	16 244	2	24	2 037	53 920
2008	57 947	39 458	16 446	2	30	2 011	60 638
2009	60 585	42 414	16 166	2	49	1 954	63 413
2010	61 648	40 500	18 994	1	89	2 064	74 254
2011	56 352	36 816	17 425	1	174	1 936	70 814
2012	64 030	47 158	14 072	1	337	2 462	73 929
2013	60 217	45 253	11 229	0	582	3 153	76 964
2014	57 739	44 273	8 835	0	785	3 846	70 447
2015	57 466	40 113	11 576	0	937	4 840	72 402
2016	60 469	42 396	11 742	0	1 096	5 235	75 117

[1)] *including pumped storage; Source: STATISTIK AUSTRIA 2017*

As shown in Table 37 electricity supply increased by 10.8 TWh GWh 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 hydro power. The year 2015 shows an historical maximum of net imports which contributed to 15% of total electricity supply.

Table 37: 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

Year	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
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	62 753	66 683	20 397	17 732	2 665
2006	64 143	64 695	21 257	14 407	6 850
2007	64 763	65 172	22 130	15 511	6 619
2008	64 630	66 871	19 796	14 933	4 863
2009	62 760	69 071	19 542	18 762	780
2010	65 487	71 129	19 898	17 567	2 331
2011	65 704	65 812	24 972	16 777	8 195
2012	66 582	72 601	23 264	20 455	2 809
2013	67 200	68 313	24 960	17 689	7 271
2014	66 082	65 440	26 712	17 437	9 275
2015	66 928	65 299	29 369	19 311	10 058
2016	67 580	68 351	26 366	19 207	7 159

Source: Statistik Austria

[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.

For 1990 (+234 kt CO_2) to 2000 (+ 85 kt CO_2) the MSW input of large waste incineration plants has been shifted from category 1A4a to 1A1a in order to increase time series consistency.

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 5.2% for the year 2016. Crude oil input was 8 megatons in 1990 and 8.2 megatons in 2016.

Methodology

The IPCC Tier 2 methodology is used. Activity data is multiplied by emission factors. 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 for the fuel groups *gaseous*, *liquid* and *solid* 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 38: Carbon content per fuel group for petroleum refining.

Fuel-Group	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 38. CO_2 emissions 2002 to 2005 are reported by the Austrian Association of Mineral Oil Industries, they are consistent with ETS 2005 data. For the year 2006 on 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 39. The IEF fluctuations reflect changes in refinery gas composition.

Table 39: Implied emission factors for refinery gas.

Year	t CO_2/TJ
1990	65.7
1991	66.4
1992	66.4
1993	75.4
1994	78.4
1995	82.2
1996	61.8
1997	59.7
1998	63.0

Year	t CO_2/TJ
1999	61.9
2000	65.3
2001	64.2
2002	63.6
2003	62.5
2004	63.6
2005	63.6
2006	63.7
2007	63.7
2008	63.5
2009	63.7
2010	63.4
2011	63.7
2012	63.1
2013	63.4
2014	63.8
2015	64.0
2016	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 40: 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	63.38	0.10	1.00
LPG	64.00	0.10	1.00
Natural Gas	55.40	0.10	1.00

Activity data

Fuel consumption is taken from (IEA JQ 2017) 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 41: Refinery input/output mass balance.

Material flow [kt]	1990	1995	2000	2005	2008	2010	2012	2013	2014	2015	2016
Total Input	**9 149**	**9 259**	**8 889**	**9 233**	**9 176**	**8 155**	**8 868**	**8 999**	**8 977**	**9 261**	**8 662**
Crude oil	7 952	8 619	8 240	8 743	8 666	7 749	8 349	8 566	8 435	8 881	8 185
NGL	41	43	107	78	78	89	124	81	175	53	6
Feedstocks	1 156	597	542	412	432	317	395	352	367	327	471
Biofuel (blending)	0	0	0	0	0	0	0	0	0	0	0
Total Output	**8 864**	**8 915**	**8 525**	**8 959**	**8 941**	**7 924**	**8 754**	**8 915**	**8 904**	**9 148**	**8 565**
Fuel oil	1 913	1 502	979	1 045	738	815	953	1 011	981	1 154	898
Gas oil	1 239	1 454	1 062	997	991	795	688	820	683	658	635
Diesel	1 531	1 920	2 662	2 905	2 954	2 545	3 071	3 031	3 073	3 209	2 958
Other Kerosene	31	8	1	1	8	3	16	18	18	27	21
Aviation kerosene	291	420	544	592	472	476	618	654	581	648	651
Aviation gasoline	0	0	0	0	0	0	0	0	0	0	1
Motör gasoline	2 631	2 271	1 815	1 798	1 684	1 436	1 553	1 549	1 773	1 721	1 671
White spirit	0	5	0	0	0	70	0	0	0	0	0
Bitumen	269	254	343	466	444	292	366	314	314	290	333
Other petroleum products	7	29	15	36	194	59	32	57	43	19	25
Naphtha	475	621	710	637	909	892	1 009	1 011	976	941	961
LPG	47	60	34	107	98	87	67	66	65	139	122
Refinery gas	373	305	312	309	383	392	311	311	342	282	218
Petroleum Coke (FCC)	57	66	48	66	66	62	70	73	55	60	71
Input-Output	**285**	**344**	**364**	**274**	**235**	**231**	**114**	**84**	**73**	**113**	**97**

Recalculations

Recalculations of activity data are following the revisions of the energy balance as described in Annex 4 which results in shifts of CO_2 emissions from liquid fuels to gaseous fuels for the years 1999 to 2004 in the range of 50 kt to 81 kt. Overall CO_2 emissions of category *1.A.1.b* remain unchanged by this revision.

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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 and liquid 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 0.5% for the year 2016.

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 2016 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 42: Emission factors of Category 1.A.1.c.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Natural Gas	55.40	1.00	0.10
Heavy Fuel Oil	78.00	3.00	0.60

Activity data

Fuel consumption is taken from (IEA JQ 2017).

Transformation losses in gas works are calculated by subtracting final energy use from transformation input. Since the energy balance (IEA JQ 2017) does not report gas works gas activity data is taken from the „Austrian Energy Balance" provided by STATISTIK AUSTRIA which is structured differently but is consistent with (IEA JQ 2017).

Recalculations

The change of natural gas activity data from 1999 to 2004 onwards is following the revision of the energy balance as described in Annex 4. The change in GHG emissions is –between -50 to -82 kt CO_2.

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 – 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 previous 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 43 the activity data of charcoal production is presented.

Table 43: Activity data (charcoal produced) and CH_4 emissions for Fugitive Emissions from Solid Fuel Transformation 1990–2016.

Year	Charcoal production (in t)	Charcoal [TJ]	CH_4 emissions [Mg]
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	39	0.039
2014	1 263	38	0.038
2015	1 447	43	0.043
2016	1585	48	0.048

For calculating the emissions, Austria is using a constant country specific NCV of 31 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, solid and liquid 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 3.9% for the year 1990 and 2.6% for the year 2016.

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, 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 gas 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 2016 are reported by plant operators.

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

<u>Point source CO_2 emissions 2003 and 2004</u>

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 11 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*.

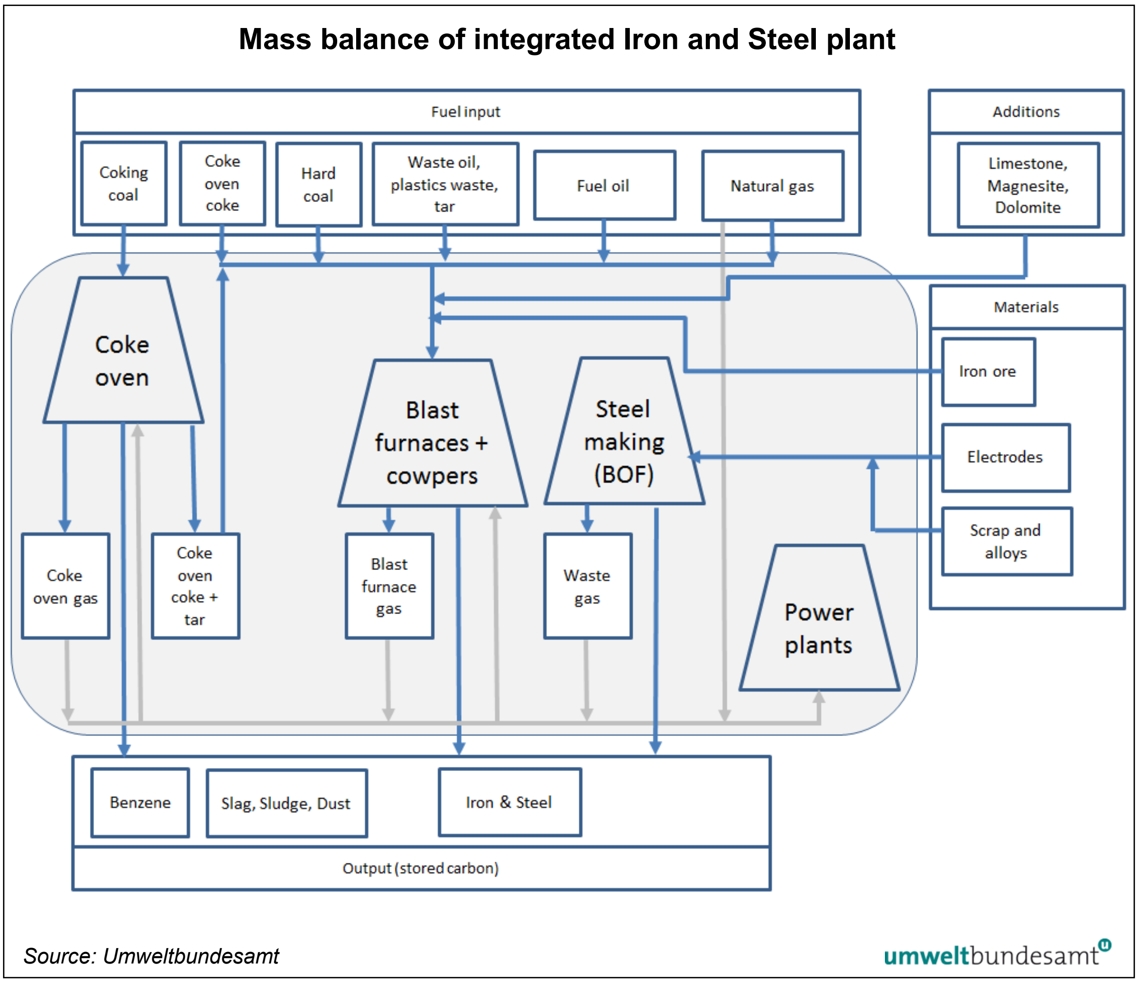

Figure 11: Mass balance of integrated Iron and Steel plant.

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 44: 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	190	0.005	0.001	1 870	0.024	0.002
1991	251	0.006	0.001	1 435	0.019	0.002
1992	203	0.005	0.001	1 152	0.016	0.002
1993	223	0.008	0.001	1 308	0.017	0.002
1994	234	0.008	0.001	1 299	0.018	0.002
1995	290	0.009	0.001	1 217	0.017	0.002
1996	446	0.012	0.002	1 363	0.019	0.002
1997	466	0.011	0.001	1 421	0.020	0.002
1998	424	0.010	0.001	737	0.013	0.001
1999	341	0.008	0.001	977	0.016	0.002
2000	443	0.010	0.001	819	0.013	0.001
2001	449	0.010	0.001	1 013	0.016	0.002
2002	525	0.011	0.001	1 230	0.018	0.002
2003	487	0.010	0.001	1 287	0.019	0.002
2004	425	0.009	0.001	1 524	0.023	0.002
2005	373	0.011	0.001	1 697	0.024	0.002
2006	392	0.011	0.002	1 272	0.019	0.002
2007	337	0.009	0.001	1 056	0.017	0.002
2008	376	0.010	0.001	1 149	0.018	0.002
2009	290	0.006	0.001	874	0.014	0.001
2010	344	0.008	0.001	1 120	0.018	0.002
2011	343	0.007	0.001	1 281	0.021	0.002
2012	366	0.008	0.001	1 307	0.021	0.002
2013	388	0.008	0.001	1 476	0.023	0.002
2014	308	0.006	0.001	1 336	0.022	0.002
2015	351	0.007	0.001	1 053	0.017	0.002
2016	305	0.006	0.001	1 115	0.017	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 2016 are presented in Table 45 and Table 46.

Activity data

Total fuel consumption is taken from (IEA JQ 2016).

Point source activity data are reported by plant operators which are widely consistent with (IEA

JQ 2017).

Table 45: 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	55.40	1.00	0.10
Wood Waste	112.00[1)]	10.00	4.00

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

Table 46: 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 Gas	94.60	1.00	0.10
Natural Gas	55.40	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 83 kt CO_2 equivalents in 2016 (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

About 60 kt CO_2 emissions have been shifted from *1.A.2.a* to category *2.C.1* due to a revised emission estimate of blast furnaces.

Other recalculations of CO_2 emissions are following 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 0.7% for the year 2016.

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. Fuel consumption is taken from (IEA JQ 2017). 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).

The emission factors for 2016 are presented in the following table.

Table 47: 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	55.40	1.00	0.10
Industrial waste	77.77	12.00	4.00

Activity data

Fuel consumption is taken from (IEA JQ 2017).

Recalculations

Changes of activity data are based on a revision of the energy balance or different rounding and result in +52 kt higher CO_2 emissions in the year 2015.

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 1.7% for the year 1990 and 2.6% for the year 2016.

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 2005-2016 CO_2 ETS data are considered.

CO_2 emissions from industrial waste: Table 48 shows the composition of the implied emissions factor 2000–2016 for industrial waste. One plant with a capacity of 150 kt solid waste/year is considered with a NCV of 10 TJ/kt waste and a CO_2 emission factor of 104.17 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 52.09 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 48: Composition of 1.A.2.c Chemical industries – industrial waste – CO_2 IEF for the years 2000 to 2016.

Year	Total energy use	Solid waste (150 kt/year)		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	104.17	378[1)]	70.62	380	52.09	89.79
2001	2 815	1 500	104.17	378[1)]	70.62	937	52.09	82.33
2002	4 128	1 500	104.17	378[1)]	70.62	2 250	52.09	72.71
2003	5 821	1 500	104.17	378[1)]	70.62	3 943	52.09	66.71
2004	7 256	1 500	104.17	378[1)]	70.62	5 378	52.09	63.82
2005	3 879	1 500	104.17	378	70.62	2 001	52.09	74.03
2006	4 001	1 500	104.17	560	74.59	1 941	52.09	74.77
2007	2 792	1 500	104.17	528	75.01	764	52.09	84.40
2008	6 074	1 500	104.17	299	84.88	4 275	52.09	66.56
2009	4 186	1 500	104.17	271	76.38	2 416	52.09	72.32
2010	4 365	1 500	104.17	276	77.47	2 589	52.09	71.59
2011	4 155	1 500	104.17	210	75.10	2 445	52.09	72.05
2012	4 289	1 500	104.17	259	82.92	2 530	52.09	72.16
2013	4 371	1 500	104.17	417	83.31	2 454	52.09	72.94
2014	4 119	1 500	104.17	588	58.28	2 031	52.09	71.94
2015	4 539	1 500	104.17	591	61.86	2 448	52.09	70.57
2016	2 689	1 500	104.17	457	77.87	732	52.09	85.52

[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 49: Emission factors of Category 1.A.2.c for 2016.

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)	67.65[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	55.40	1.00	0.10
Fuel Wood	112.00[1)]	30.00	4.00
Wood Waste	112.00[1)]	10.00	4.00

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Black Liquor	95.30[1)]	3.00	2.00
Biogas	54.60[1)]	1.00	0.10
Industrial Waste	85.52[2)]	12.00	4.00

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

[2)] *For the years 1990 to 1999: 104.17 t/TJ.*

[3)] *IEF derived from ETS data*

Activity data

Fuel consumption is taken from (IEA JQ 2017) and from ETS.

Recalculations

Changes of activity data for 'other fuels' and years 2004-2015 and for gaseous fuels and years 2011-2015 are following 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 3.2% for the year 2016.

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. Fuel consumption is taken from (IEA JQ 2017). For the years 2005 to 2016 CO_2 ETS data are considered.

CO_2 emissions from industrial waste: The following Table 50 shows the composition of the implied emissions factor 2000–2016 for industrial waste. From 2005 on 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 104.17 t/TJ. Table 50 shows fuel waste consumption as provided by energy statistics and fuel waste consumption, CO_2 emissions and the calculated IEF from ETS.

Table 50: Composition of 1.A.2.d Pulp, Paper and Print – industrial waste – CO_2 IEF for the years 2000 to 2016.

Year	Total energy use (energy balance)	ETS		CO_2 IEF	CO_2
	[TJ]	[TJ]	CO_2 IEF	[t/TJ]	[kt]
2000	0	-	-	104.17	-
2001	113	-	-	104.17	11.77
2002	122	-	-	104.17	12.67
2003	201	-	-	104.17	20.98
2004	246	-	-	104.17	25.63
2005	105	111	64.29	64.29	7.15

2006	105	149	43.85	43.85	6.53
2007	173	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	105	60	116.27	116.27	6.98
2013	205	170	128.46	128.46	21.83
2014	199	180	129.09	129.09	23.20
2015	240	180	140.21	140.21	25.23
2016	103	151	134.22	134.22	20.21

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002). Emission factors for 2016 are presented in the following table.

Table 51: 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	55.40	1.00	0.10
Fuel Wood and Sewage Sludge	112.00[1)]	30.00	4.00
Wood Waste[2)]	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	134.22	12.00	4.00

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

Activity data

Fuel consumption is taken from (IEA JQ 2017) as presented in Annex 4, and ETS.

Recalculations

Recalculations are following the revision of the energy balance as described in Annex 4. Major revision took place for gaseous fuels and the years 2014 and 2015, resulting in about 17-19 kt lower CO_2 emissions for those years.

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 1.8% for the year 2016.

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. Fuel consumption is taken from (IEA JQ 2017). For the years 2005 to 2016 CO_2 ETS data are considered.

Emission factors

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

Emission factors for 2016 are presented in the following table.

Table 52: 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	55.40	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	104.17	12.00	4.00

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

Activity data

Fuel consumption is taken from (IEA JQ 2017) as presented in Annex 4.

Recalculations

Changes of activity data are based on a revision of the energy balance as described in Annex 4. Major revision took place for gaseous fuels and the years 2014 and 2015, resulting in about 35 kt lower CO_2 emissions for those years.

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 lime kilns 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 3.1% for the year 2016.

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 mio t 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.

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, 2011, 2012, 2013, 2014, 2015, 2016, 2017). 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 2016.

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 also 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.

<u>CO_2 emissions</u>

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 2004 to 2016 are taken from the ETS allocation plan survey and ETS data.

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 3.94 GJ/t clinker in 2016.

Hard Coal, Brown Coal, Petrol Coke and Industrial Waste

In (IEA JQ 2017) 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, 100% of those fuels are allocated to the cement industry. The same is for petrol coke until 2001 but from 2002 on a share is allocated to magnesia production from dolomite by using ETS data. The following Table 53 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 waste which contains 100% biomass has been taken from ETS data. The overall IEF is between 79.25 to 88.52 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 for waste which is considered as 100% biomass is: glycerine, carcass meal, animal fat, sewage sludge, paper fibre residue and sawdust.

Table 53: Industrial waste used as fuel in cement kilns 1990–2016.

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				
1990	–	59	22.07	49.99	–	–
1991	–	67	25.02	53.27	–	–
1992	–	79	23.80	50.11	–	–
1993	–	79	23.16	28.85	–	–
1994	–	83	23.41	69.98	–	–
1995	–	87	22.71	62.26	–	–
1996	–	100	21.64	47.66	–	–
1997	–	101	20.78	66.31	–	–
1998	–	122	21.97	29.60	–	–
1999	–	135	21.43	62.13	–	–
2000	–	170	20.94	55.43	–	–
2001	–	218	20.85	48.22	–	–
2002	–	239	20.78	57.99	–	–
2003	–	254	21.91	70.58	–	–
2004	–	257	22.07	57.84	–	–
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

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				
2015	164	307	19.93	59.87	24.06	83.93
2016	158	333	20.73	60.28	20.41	80.70

[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 2017).

Activity data 2005–2016

For the years 2005–2016 ETS data are taken which covers 100% of cement plants.

Emission factors

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

Recalculations

Minor revisions 2015 result in about 6 kt higher CO_2 emmissions from liquid fuels.

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 54. The share in total GHG emissions from Sector *1.A* is 3.8% for the year 1990 and 6.1% for the year 2016.

Table 54: ISIC divisions considered in category 1.A.2.g.

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 to 2016 CO_2 ETS data are considered.

Activity data

Fuel consumption is taken from (IEA JQ 2017) as presented in Annex 4.

Since the energy balance (IEA JQ 2017) 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 2017).

Emission factors

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

The emission factors for 2016 are presented in the following table.

Table 55: Emission factors 2016 of Category 1.A.2.g 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	55.40	1.00	0.10
Fuel Wood	112.00[1)]	30.00	4.00
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)	104.17	12.00	4.00
Industrial Waste – IEF	7.70[2)]	12.00	4.00

1) *Reported as CO_2 emissions from biomass*

2) *Implied emission factor*

Recalculations

Changes of activity data are based on a revision of the energy balance as described in Annex 4. The most significant recalculation for the year 2014 is +272 kt CO_2 and for 2015 +378 kt CO_2 from gaseous fuels.

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

Key Source: yes

In the following chapter the methodology of estimating emissions from mobile sources of *1.A.2.g.vii Off-road vehicles and other machinery* is described. The share in total GHG emissions from sector *1.A* is 0.5% for the year 1990 and 2.1% for the year 2016.

Table 56: Greenhouse gas emissions from category 1.A.2.g.vii mobile sources 1990–2016.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	256	0.01	0.09	283
1991	289	0.02	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	809	0.02	0.23	880
2006	977	0.03	0.24	1 050
2007	1 057	0.03	0.23	1 127
2008	1 163	0.03	0.23	1 233
2009	1 120	0.03	0.21	1 183
2010	1 074	0.02	0.19	1 132
2011	1 078	0.02	0.19	1 134
2012	1 114	0.02	0.18	1 169
2013	1 124	0.02	0.17	1 176
2014	1 099	0.02	0.16	1 148
2015	1 064	0.02	0.15	1 111
2016	1 079	0.02	0.15	1 124
1990–2016	***322%***	***65%***	***65%***	***297%***

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 (Grazer Emissionsmodell für Off-Road Geräte). This model has been 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 categories 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)

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 *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 (fuel statistics),
- 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).

Combustion of liquid fossil fuels is the only mobile source of CO_2 emissions from category *1.A.2.g.vii Manufacturing Industries and Construction.*

Activities used for estimating emissions of *1.A.2.g.vii* as well as the implied emission factors 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 *1.A.2.g.vii* 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 57: Implied emission factors and activities from industrial mobile off-road sources 1990–2016.

Year	Activity	Implied Emission Factors		
	TJ	CO_2 t/TJ	CH_4 kg/TJ	N_2O kg/TJ
1990	3 448	74.19	3.93	26.12
1991	3 897	74.19	3.91	26.15
1992	4 127	74.19	3.90	26.17
1993	4 340	74.19	3.90	26.19
1994	4 555	74.19	3.84	26.52
1995	4 821	74.19	3.73	27.11
1996	6 008	74.19	3.57	28.00
1997	5 663	74.19	3.46	28.65
1998	6 660	74.19	3.37	29.17
1999	6 353	74.19	3.32	29.54
2000	7 426	74.19	3.27	29.82
2001	6 980	74.19	3.25	29.98
2002	6 793	74.19	3.22	29.80
2003	7 241	74.19	3.00	28.46
2004	7 965	74.19	2.68	25.56
2005	11 010	73.52	2.23	21.34
2006	13 647	71.56	1.95	17.87
2007	14 786	71.52	1.79	15.70
2008	16 304	71.35	1.68	14.14
2009	15 925	70.31	1.64	13.13
2010	15 274	70.29	1.61	12.63
2011	15 351	70.23	1.59	12.13
2012	15 905	70.07	1.56	11.41
2013	16 000	70.28	1.53	10.77
2014	15 671	70.10	1.51	10.46
2015	15 267	69.69	1.48	10.14
2016	15 375	70.16	1.45	9.67

Emission Factors

The following emission factors for four categories of engine types (average motor capacity) depending on the year of construction are used in the GEORG model. They represent emissions according to the engine power output and also fuel consumption. The values for 2014 represent the year when the latest emission standard Stage IV has been introduced on EU level.

Table 58: Emission factors for diesel engines > 80 kW.

Year	Fuel	CO_2	CH_4	N_2O
	[g/kwh]			
1994	277.54	875.09	0.04	0.32
2001	263.23	829.97	0.03	0.35
2003	258.12	813.85	0.01	0.22
2006	268.55	846.74	0.01	0.12
2011	268.55	846.74	0.01	0.08
2014	268.55	846.74	0.01	0.08

Table 59: Emission factors for diesel engines < 80 kW.

Year	Fuel	CO_2	CH_4	N_2O
	[g/kwh]			
1994	285.01	898.62	0.047	0.32
2001	268.44	846.41	0.036	0.35
2003	274.29	864.85	0.029	0.22
2006	274.29	864.85	0.016	0.12
2011	274.29	864.85	0.016	0.08
2014	274.29	864.85	0.013	0.08

Table 60: Emission factors for 4-stroke-petrol engines.

Year	Fuel	CO_2	CH_4	N_2O
	[g/kwh]			
1994	561.1	1 769.1	0.80	0.04
2001	540.0	1 702.6	0.64	0.04
2003	469.4	1 480.0	0.61	0.04
2006	469.4	1 480.0	0.59	0.04
2011	469.4	1 480.0	0.55	0.03
2014	469.4	1 480.0	0.55	0.03

Table 61: Emission factors for 2-stroke-petrol engines.

Year	Fuel	CO_2	CH_4	N_2O
	[g/kwh]			
1994	739.0	2 330.1	2.50	0.015
2001	671.7	2 117.7	1.76	0.015
2003	653.2	2 059.4	1.66	0.015
2006	500.0	1 576.5	0.51	0.014
2011	482.14	1 520.2	0.51	0.012
2014	482.14	1 520.2	0.51	0.012

Recalculations

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

3.2.12 1.A.3 Transport

3.2.12.1 1.A.3.a Civil Aviation

Key Source: No

The category *1.A.3.a Civil Aviation* contains flights according to Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) for domestic LTO (landing/take off) and domestic cruise. International LTO and international cruise is considered in *1.D.1.a International Bunkers Aviation*. Military Aviation is allocated to *1.A.5 Other.* For VFR only CO_2 emissions were considered.

Greenhouse gas emissions from domestic aviation are very low in comparison to total emissions from the transport sector *1.A.3* and amounted to 0.2% in 1990 and 2016.

Table 62: Greenhouse gas emissions from 1.A.3.a domestic Civil Aviation by subcategories 1990–2016..

Year	CO_2 [kt]			CH_4 [kt]			N_2O [kt]		
	dom. LTO	dom. LTO	dom. cruise	dom. LTO	dom. cruise	dom. cruise	dom. LTO	dom. LTO	dom. cruise
	Kerosene	Gasoline	Kerosene	Gasoline	Kerosene	Kerosene	Kerosene	Gasoline	Kerosene
1990	10.0	7.8	14.2	0.0022	0.0001	-	0.0006	0.0002	0.000
1991	10.8	8.1	18.7	0.0021	0.0001	-	0.0007	0.0002	0.001
1992	11.6	8.3	23.2	0.0021	0.0001	-	0.0007	0.0002	0.001
1993	12.4	8.6	27.6	0.0020	0.0001	-	0.0008	0.0002	0.001
1994	13.2	8.8	32.1	0.0019	0.0001	-	0.0008	0.0002	0.001
1995	14.0	7.1	36.6	0.0018	0.0000	-	0.0009	0.0002	0.001
1996	16.2	6.8	40.6	0.0029	0.0000	-	0.0010	0.0002	0.001
1997	18.4	7.6	44.5	0.0039	0.0001	-	0.0011	0.0002	0.001
1998	20.6	8.2	48.5	0.0050	0.0001	-	0.0012	0.0002	0.002
1999	21.1	8.7	51.3	0.0052	0.0001	-	0.0012	0.0002	0.002
2000	19.3	6.3	41.6	0.0048	0.0000	-	0.0023	0.0002	0.001
2001	15.8	5.8	38.4	0.0039	0.0000	-	0.0020	0.0002	0.001
2002	16.4	7.4	38.2	0.0041	0.0001	-	0.0021	0.0002	0.001
2003	16.1	8.1	38.3	0.0040	0.0001	-	0.0020	0.0002	0.001
2004	17.2	7.5	39.5	0.0043	0.0001	-	0.0020	0.0002	0.001
2005	16.4	8.6	41.6	0.0041	0.0001	-	0.0020	0.0002	0.001
2006	19.6	8.9	43.2	0.0049	0.0001	-	0.0021	0.0003	0.001
2007	20.0	8.9	44.7	0.0050	0.0001	-	0.0021	0.0003	0.001
2008	22.2	9.1	39.3	0.0055	0.0001	-	0.0021	0.0003	0.001
2009	20.4	10.1	36.8	0.0051	0.0001	-	0.0021	0.0003	0.001
2010	19.4	9.1	34.9	0.0048	0.0001	-	0.0021	0.0003	0.001
2011	16.8	13.6	31.2	0.0042	0.0001	-	0.0016	0.0004	0.001
2012	16.9	7.9	29.7	0.0042	0.0001	-	0.0016	0.0002	0.001
2013	16.9	8.1	29.5	0.0042	0.0001	-	0.0016	0.0002	0.001
2014	15.4	7.4	27.0	0.0038	0.0001	-	0.0015	0.0002	0.001
2015	14.9	8.2	26.6	0.0037	0.0001	-	0.0013	0.0002	0.001
2016	14.8	10.2	22.5	0.0009	0.0001	-	0.0004	0.0003	0.001
1990–2016	***48%***	***30%***	***59%***	***-59%***	***34%***	***-***	***-35%***	***34%***	***38%***

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

For the years 1990–1999 a country-specific methodology was applied. The calculations are based on a study commissioned by the Umweltbundesamt finished in 2002 (KALIVODA/KUDRNA 2002). This methodology is consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on the MEET model (KALIVODA/KUDRNA 1997): air traffic movement data[34] (flight distance and destination per aircraft type) and aircraft/engine performances data were used for the calculation.

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.

VFR – Visual Flight Rules

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

Activity Data

Fuel consumption (kerosene and gasoline) for *1.A.3.a. domestic Civil Aviation* is presented below.

Table 63: Activity data from 1.A.3.a Civil Aviation by subcategories 1990–2016.

Year	Activity		
	dom. LTO	**dom. LTO**	**dom. cruise**
	Kerosene [TJ]	**Gasoline [TJ]**	**Kerosene [TJ]**
1990	137	103	195
1991	148	106	257
1992	159	109	319
1993	170	113	380
1994	181	116	442
1995	192	93	503
1996	222	89	558
1997	253	100	613
1998	283	108	667
1999	290	115	706
2000	265	84	571
2001	217	77	527
2002	226	99	526
2003	221	107	527
2004	237	99	543

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

Year	Activity		
	dom. LTO	dom. LTO	dom. cruise
	Kerosene [TJ]	Gasoline [TJ]	Kerosene [TJ]
2005	226	115	572
2006	269	119	594
2007	275	118	615
2008	305	121	541
2009	280	135	506
2010	267	121	480
2011	231	182	429
2012	233	105	409
2013	232	108	405
2014	211	99	371
2015	205	111	365
2016	203	135	310
1990–2016	***48%***	***31%***	***59%***

Improvements (Tier 3A updated)

Regarding activity data two issues have been improved. First, flight movements are being sourced from a new data supplier, the Austrian air traffic and air space operator Austrocontrol. Second, an exact distance calculator has been implemented.

IFR flights

For the years 1990–1999 fuel consumptions for the different transport modes IFR national LTO, IFR international LTO, IFR national cruise and IFR international cruise as obtained from the MEET model (KALIVODA/KUDRNA 1997) were summed up to a total fuel consumption figure. This value was compared with the total amount of kerosene sold in Austria of the national energy balance. As „fuel sold" is a robust value, the fuel consumption of IFR international cruise was adjusted so that the total fuel consumption of the calculations according to the MEET model is consistent with national fuel sales figures from the energy balance. The reason for choosing IFR international cruise for this adjustment is that this mode is assumed to have the highest uncertainty.

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 above.

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. Up to the submission 2017 flight movements were obtained from special analyses by Statistik Austria (STATISTIK AUSTRIA 2008[35], 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016). In addition, domestic flight movements were compared with a second data source for flight movements, Austrocontrol (AUSTRO CONTROL 2007[36], 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016) and increased to meet these number flight movements.

Since the submission 2018 flight movements are only taken from Austrocontrol, as they seem to be more representative compared with international data.

Up to the submission 2017 the distances between airport pairs have been extracted based on IATA codes from single queries on the internet.[37] This approach has been changed in the submission 2018, as an automatic distance generator has been applied in the calculation model based on the great circle distance:

$$e = r \cdot \arccos(\sin(\varphi A) \cdot \sin(\varphi B) + \cos(\varphi A) \cdot \cos(\varphi B) \cdot \cos(\lambda B - \lambda A))$$

A…departure aerodrome
B…arrival aerodrome

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 has always been and is still being compared to the total fuel sold reported by the national energy balance (STATISTIK AUSTRIA 2017). If the bottom up approach underestimates fuel sold, the delta has been fully allocated to international cruise, as the domestic flight movements had already been increased in line with Austrocontrol. From the submission 2018 onwards any delta between the bottom up result and the official amount of kerosene sold is being allocated to domestic LTO, international LTO, national cruise and international cruise depending on their relative shares in total kerosene consumption.

VFR flights

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

The following table shows the numbers of national LTO (IFR) which were obtained from the MEET Model (KALIVODA/KUDRNA 1997) for the years 1990–1999. Numbers from 2000 onwards are taken from Statistik Austria, from 2015 onwards from Austrocontrol.

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[35] for the years 2000–2007

[36] for the years 2000–2006

[37] www.world-airport-codes.com

Table 64: Fuel consumption for VFR and IFR flights and number of IFR LTO cycles, 1990–2016.

Year	Activity			
	VFR Gasoline [kt]	**nat. LTO Kerosene [kt]**	**dom. cruise Kerosene [kt]**	**domestic LTO IFR [no.]**
1990	2.49	3.16	4.51	6 220
1991	2.56	3.42	5.93	6 644
1992	2.64	3.67	7.35	7 450
1993	2.72	3.92	8.77	7 947
1994	2.81	4.18	10.19	8 219
1995	2.24	4.43	11.62	8 923
1996	2.15	5.13	12.88	10 233
1997	2.42	5.83	14.14	11 013
1998	2.60	6.53	15.40	12 025
1999	2.77	6.70	16.28	12 210
2000	2.04	6.11	13.18	22 611
2001	1.87	5.01	12.17	20 325
2002	2.39	5.21	12.13	21 422
2003	2.60	5.10	12.15	20 243
2004	2.41	5.47	12.54	20 175
2005	2.79	5.20	13.19	20 179
2006	2.87	6.20	13.70	20 727
2007	2.86	6.33	14.19	20 740
2008	2.94	7.04	12.48	21 457
2009	3.27	6.46	11.68	20 530
2010	2.92	6.16	11.07	20 532
2011	4.40	5.32	9.89	16 185
2012	2.54	5.37	9.43	16 405
2013	2.61	5.35	9.36	15 741
2014	2.38	4.87	8.56	14 776
2015	2.65	4.73	8.43	13 282
2016	3.28	4.70	7.15	15 518
1990–2016	***32%***	***48%***	***59%***	***149%***

Emission Factors

Some emission factors have been updated in this year's submission; for IFR flights only for the year 2016; for VFR flights for 2000-2016. Please note that emissions from 1990-2000 were obtained from the MEET model (KALIVODA/KUDRNA 1997) and are not changed any more. The following table gives an overview of the changes compared to the previous submissions:

Table 65: Comparison of emission factors for 1.A.3.a Civil Aviation – IFR flights

	Submisson 2017 (1990-2015)	**Submisson 2018 (2016)**
IFR - CO_2	3.15 kg/kg fuel	3.15 kg/kg fuel
IFR - CH_4	10% of HC_LTO	9.6 % of HC_LTO

IFR - N_2O	0.1 kg/LTO 0.1 kg/t fuel for cruise	2.0 kg/TJ fuel

Table 66: Comparison of emission factors for 1.A.3.a Civil Aviation – VFR flights

	Submisson 2017 (1990-2015)	Submisson 2018 (1990-2016)
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

IFR flights

Fuel consumption

The specific fuel consumption per distance class is provided in the spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2016' - Annex 5 (EEA 2016) 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 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.

CO_2 (Tier 1)

CO_2 emission 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 2016' (EEA 2016) for the different aircraft types.

The factor used is still 3.15 kg/kg fuel. It is multiplied with a specific fuel consumption factor for every flight which is modelled bottom up all IFR flights.

CH_4 (Tier 1)

CH_4 emission factors are not included in the spreadsheet accompanying the EMEP/EEA 2016 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 IFR LTO can be estimated with the Tier 1 default value of 0.5 kg/TJ fuel (IPCC 2006 GL) or 10% of total VOC (HC) emissions (IPCC 2006, Chapter Mobile Combustion, Table 3.6.5). From the submission 2018 onwards the percentage of 10% of total VOC (HC) emissions is used. Till the submission 2017 a percentage of 9.6 % of HC_LTO was used.

HC emission factors were not included in the old CORINAIR 1996 emission factor spreadsheet for all aircraft types. Therefore, HC emissions were reported based on a calculation with HC IEFs from KALIVODA/KUDRNA (2002). From the submission 2018 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 new emission factors spreadsheet (EEA2016) for the different aircraft types').

According to the IPCC 2006 Guidelines, CH_4 emissions are assumed to be negligible in the cruise mode[38]. CH_4 emissions for domestic and international cruise are assumed to be Zero.

N_2O (Tier 1)

According to the IPCC 2006 Guidelines, 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 VFR flights are still being estimated with the Tier 1 default value of 2.0 kg N_2O/TJ fuel (IPCC 2006, Chapter Mobile Combustion, Table 3.6.5).

Quality Assurance and Quality Control (QA/QC)

Time series consistency

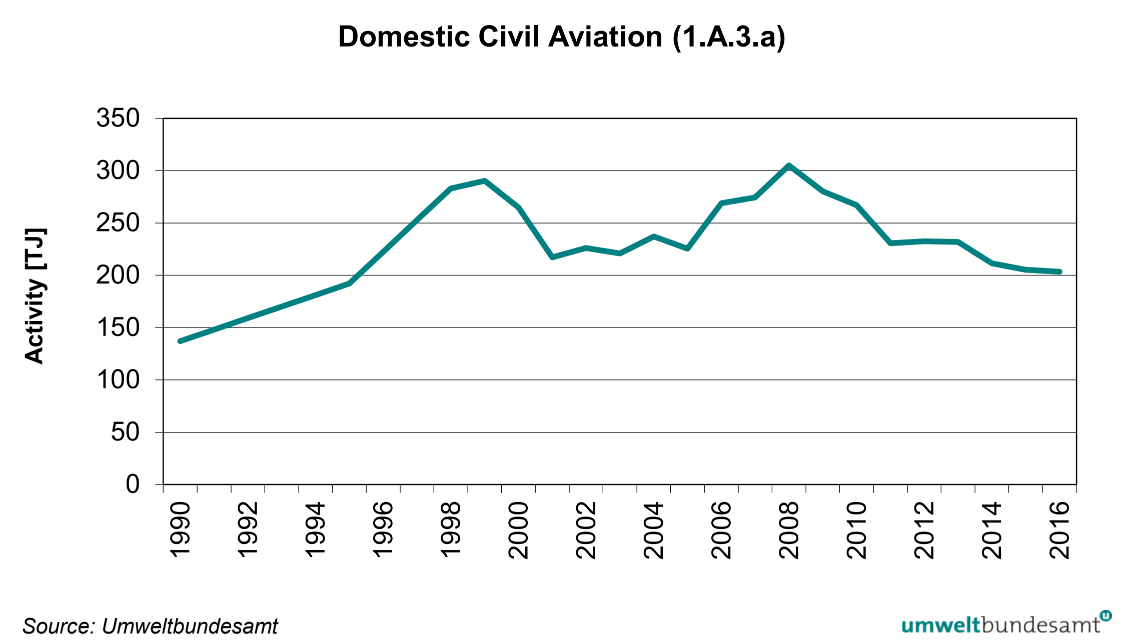


Figure 12: Activity data from 1.A.3.a domestic Civil Aviation 1990–2016.

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

Tier 3B (1990-1999) & Tier 3A (2000-2015)

From 1999 onwards a different methodology of emissions estimation has been applied for IFR flights. For the years 1990–1999 a country-specific methodology (consistent with the IPCC 2006 GL Tier 3B methodology), for the years from 2000 onwards the Tier 3A methodology was applied.

To show that there is no underestimation of domestic aviation emissions, domestic fuel consumption is multiplied with the default CO_2 emission factor of 3 150 kg CO_2/Mg fuel (CORINAIR, KALIVODA/KUDRNA. 2002). Total reported CO_2 emissions for domestic aviation in the year 2000 are consistent with the IPCC 2006 GL Tier 3A methodology (new method), whereas the Tier 3B methodology (old method) deviates by 22%.

Table 67: Methodology dependent calculation of CO_2 emissions from 1.A.3.a Civil Aviation in 2000.

	dom. LTO	dom. LTO	dom. cruise	dom.	deviation
	gasoline	kerosene		total	
2000		CO_2 [kt]			%
OLI2016 (1990–2015)	6.4	19.3	41.6	67.24	
CORINAIR CO_2 default EF Tier 3B methodology	6.4	21.6	54.1	82.11	22.1
CORINAIR CO_2 default EF Tier 3A methodology	6.4	19.2	41.5	67.18	-0.1

Since there is no systematic deviation between the two models' results, Austria has decided not to replace the more accurate data applied for the period 1990–1999 (FCCC/ARR/2011/AUT§46).

The peak of activity data and GHG emissions in 1999, followed by a decrease within two years by nearly 30% is an artefact due to the shortcomings of the method used from 1999 onwards. The old methodology reflects much better real-world effects, because this methodology is consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on MEET (KALIVODA/KUDRNA 1997): air traffic movement data (flight distance and destination per aircraft type) and aircraft/engine performances data were used for the calculation. Due to budgetary constraints such a detailed study has not been repeated since then.

Tier 3A updated (2016)

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

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

In a first step (validation 1), for the validation of the updated calculation tool, the results for the 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.

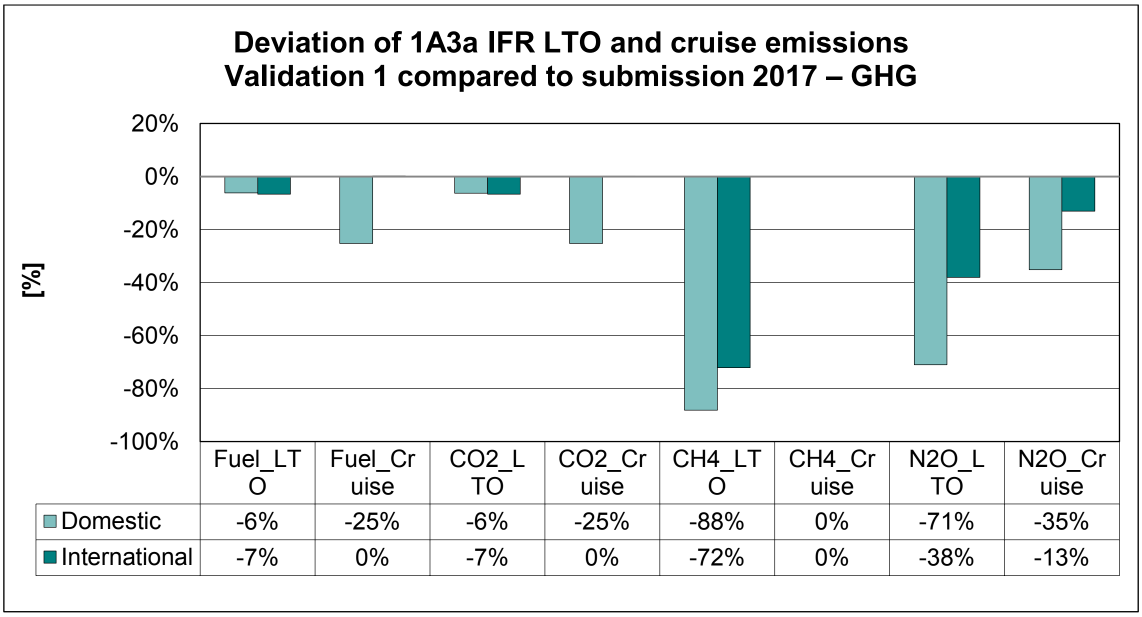


Figure 13: Deviation of GHG emissions of 1.A.3.a Civil Aviation - Validation 1.

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 previous submission with activity data from 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 68: 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%
Sum NOx_LTO [kg]	43 842	1 302 697	47 195	1 277 592	93%	102%
Sumn NOx_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 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[39] with 25%

This information is useful for the explanation of the changes in domestic emissions:

Table 69: Deviations in EFs of aircraft types DH8D and F100.

DOMESTIC Deviation		**Deviaton 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, 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.

[39] 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.

Table 70: Deviations in EFs of aircraft type A320.

INTERNATIONAL	Deviation	Deviaton 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 71: 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

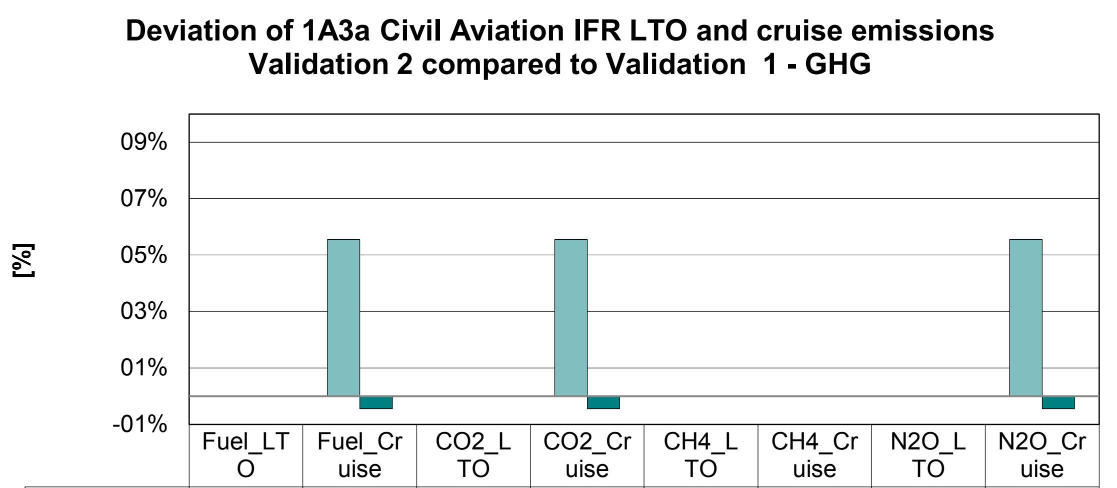
The N_2O emissions are lower due to the lower N_2O EF per unit of fuel as can be shown by comparing the IEFs. The N_2O IEF for domestic LTO is 70 % lower; for domestic cruise 10 % lower as it is for international LTO and international cruise.

Table 72: Implied emission factors of N_2O for IFR kerosene for 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

In a second step (validation 2), the results for the 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.

Table 73: Deviation of GHG emissions of 1.A.3.a Civil Aviation - Validation 2.



	Fuel_LTO	Fuel_Cruise	CO2_LTO	CO2_Cruise	CH4_LTO	CH4_Cruise	N2O_LTO	N2O_Cruise
Domestic	00%	06%	00%	06%	00%	00%	00%	06%
International	00%	00%	00%	00%	00%	00%	00%	00%

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.

However, for the submission year 2016 it was not possible to provide the split between national and international aviation in time due to the intensive update of the emission model.

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) it was explained that emissions of ground activities at domestic airports are also included, even if they are not separately reported under *1.A.3.a Aviation*. This can be assured as Austria reports emissions from **total fuel sold** from the energy balance.

The approach in the Austrian inventory is as follows: After calculating fuel consumption for inland road transport and off-road transport using a bottom-up approach (NEMO, GEORG), the sum of this fuel used is compared with the total fuel sold from the national energy balance (for details see *1.A.3.b Road Transport*). The difference is then allocated to fuel export, which includes fuel consumption for ground activities at airports and harbors as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals[40], an underestimation of emissions can be excluded.

Uncertainty Assessment

After the allocation of unknown aircrafts for the year 2015 with the new EMEP/EEA 2016 spreadsheet, 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

The updated emission model was only used for calculating the year 2016 resulting in no recalculations for the time series. Recalculations in CO_2, CH_4 and N_2O emissions between 2000 and 2015 are due to the updated heating value of aviation gasoline.

3.2.12.2 1.A.3.b Road Transport

Key Source: Yes (CO_2)

Road Transport showed a strong increase in GHG emissions since 1990 (+ 68.5%) 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 driven elsewhere – an effect mainly caused by higher fuel prices in neighbouring countries compared to Austria – has increased considerably since 1990. From 2005 onwards GHG emissions were decreasing due to the decreasing trend of total fuel sold together with the increased use of biofuels and the gradual replacement of vehicles by newer with less specific fuel consumption. However, 2016 is the second year in a row showing increased GHG emissions. In 2016 GHG emissions from road transport increased by 4.2% compared to 2015 due to increased sales of fossil fuels and a lower substitution with biofuels.

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[40] GHG emissions from fuel export are included in 1.A.3.b, and are presented separately in Table 66 (Chapter 3.2.12.2)

Table 74: Greenhouse gas emissions from Category 1.A.3.b Road Transport 1990–2016.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	13 328	2.69	0.37	13 505
1991	14 800	2.67	0.43	14 994
1992	14 776	2.36	0.44	14 965
1993	14 917	2.11	0.44	15 103
1994	14 966	1.92	0.45	15 149
1995	15 239	1.76	0.46	15 420
1996	16 802	1.59	0.45	16 977
1997	15 820	1.43	0.43	15 983
1998	17 797	1.40	0.46	17 968
1999	17 181	1.24	0.43	17 339
2000	18 090	1.15	0.42	18 245
2001	19 434	1.10	0.43	19 591
2002	21 544	1.10	0.47	21 710
2003	23 299	1.07	0.48	23 468
2004	23 813	1.00	0.48	23 980
2005	24 147	0.93	0.47	24 311
2006	22 739	0.83	0.47	22 901
2007	22 917	0.76	0.49	23 083
2008	21 529	0.68	0.49	21 691
2009	20 888	0.63	0.49	21 051
2010	21 670	0.58	0.53	21 842
2011	20 934	0.54	0.54	21 107
2012	20 829	0.51	0.55	21 006
2013	21 835	0.47	0.60	22 026
2014	21 298	0.44	0.61	21 490
2015	21 635	0.42	0.63	21 833
2016	22 550	0.40	0.65	22 755
1990–2016	***69%***	***-85%***	***78%***	***68%***

In 2016, 62% of the total greenhouse gas emissions from *1.A.3 Transport* are caused by passenger cars (petrol and diesel), 6% by light duty vehicles and 31% by heavy duty vehicles and buses. In comparison with the emissions of 1990 passenger cars caused 65% of total GHG emissions from *1.A.3 Transport;* light duty vehicles 7% and heavy duty vehicles 27%. In 2016, the total avoided fossil CO_2 emissions from the use of biofuels amounted to 1 717 kt in Austria (BMLFUW 2017a).

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 75: Greenhouse gas emissions from 1.A.3.b Road Transport differentiated by means of transportation 1990–2016.

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motor-cycles
	inland	fuel export	inland	inland	fuel export	inland
	CO_2e [kt]					
1990	8 733	-3	958	2 612	1 098	107
1991	9 029	779	985	2 824	1 273	105
1992	9 318	241	1 012	2 898	1 390	106
1993	9 485	-87	1 025	2 942	1 631	108
1994	9 838	-476	1 065	3 008	1 602	111
1995	9 932	-557	1 082	3 089	1 757	116
1996	10 112	-1 052	1 100	3 154	3 540	122
1997	10 262	-1 268	1 132	3 218	2 512	127
1998	10 473	-648	1 169	3 290	3 549	135
1999	10 742	-1 178	1 211	3 344	3 078	142
2000	10 883	-1 146	1 248	3 450	3 664	146
2001	11 004	-594	1 265	3 486	4 279	150
2002	11 183	751	1 262	3 587	4 773	154
2003	11 291	1 740	1 271	3 742	5 266	158
2004	11 355	2 131	1 283	3 828	5 222	160
2005	11 376	2 315	1 314	3 807	5 335	164
2006	11 131	2 287	1 331	3 752	4 231	168
2007	11 220	2 397	1 376	3 768	4 148	173
2008	11 156	1 724	1 351	3 579	3 707	175
2009	10 842	1 782	1 315	3 188	3 745	179
2010	10 900	1 908	1 328	3 416	4 108	182
2011	10 980	1 860	1 344	3 496	3 241	186
2012	10 840	1 819	1 335	3 518	3 303	191
2013	11 199	1 369	1 371	3 480	4 415	191
2014	11 369	1 497	1 391	3 346	3 691	195
2015	11 550	1 857	1 415	3 327	3 485	199
2016	11 913	2 083	1 460	3 690	3 404	204
1990–2016	***36%***	***-64 590%***	***52%***	***41%***	***210%***	***91%***

In 2016, the total share of fuel export in *1.A.3.b* amounted to 24% or 5 487 kt CO_2 equivalents of which 38% are attributed to passenger road transport and 62% to road freight transport.

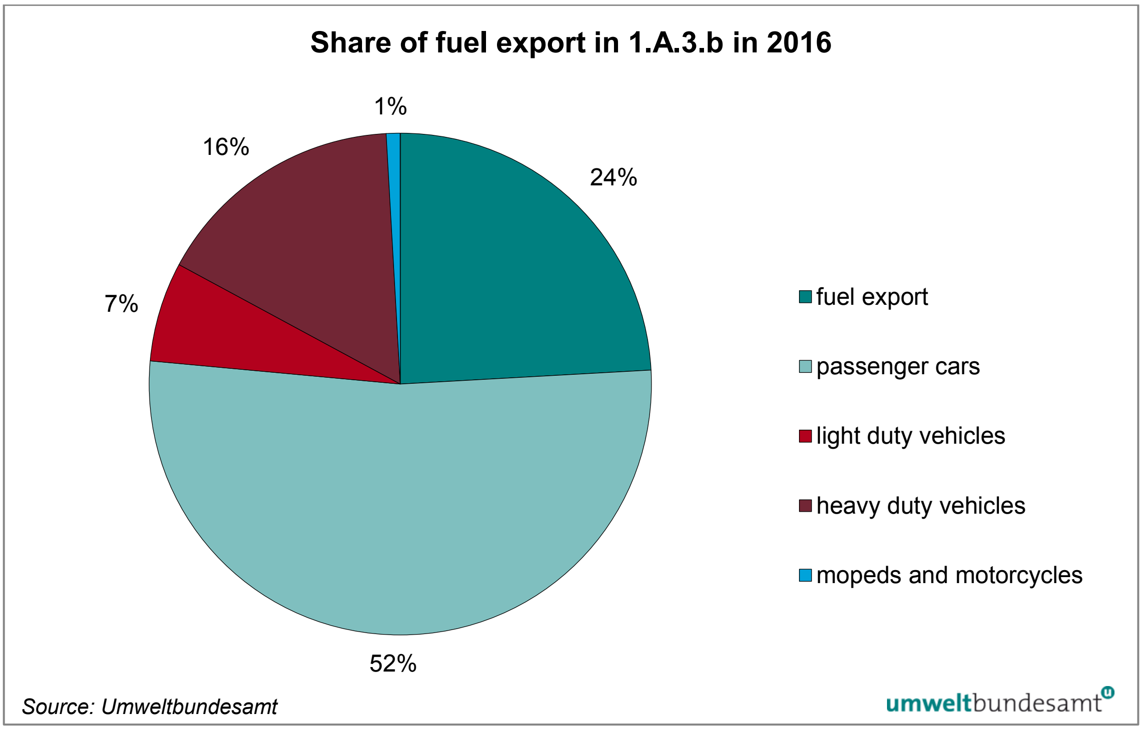

Figure 14: Share of fuel export in 1.A.3.b Road Transport in 2016.

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.

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. 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 2017).

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).

The emissions reported for Austria also include the emissions from the fuel exports.

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 et al. 2004; MOLITOR 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 2015, p.22).

NEMO – Network Emission Model

Emissions from *Mobile Combustion* have so far been calculated with the model GLOBEMI (HAUSBERGER 1997; HAUSBERGER/SCHWINGSHACKL/REXEIS 2015). The calculations have been based on a detailed depiction of fleet composition, driving behaviour, related energy consumption and emission factors.

From the submission in 2015 (1990-2013) onwards calculations are based on the model NEMO - Network Emission Model (DIPPOLD/REXEIS/HAUSBERGER 2012; HAUSBERGER/ SCHWINGSHACKL/ REXEIS 2015, 2017). NEMO is set up on the same methodology as the former model GLOBEMI and 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. The balances use the vehicle stock and functions of the km driven per vehicle and year to assess the total traffic volume of each vehicle category.

Model input is:

1. Vehicle stock of each 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 growth rates of kilometres driven by PCs and HDVs separated for the federal street network (motorways) and the federal county network (urban, rural) (BMVIT 2017)
4. Number of passengers per vehicle and tons payload per vehicle;
5. Optional either/or

- total gasoline and diesel consumption of the area under consideration,
- average km per vehicle and year.

Following data is calculated:

a) Km driven per vehicle and year or total fuel consumption,

b) Total vehicle mileages,

c) Total passenger-km and ton-km,

d) Specific emission values for the vehicle fleets [g/km], [g/t-km], [g/pass-km],

e) Total emissions (CO, HC, NO_x, particulate matter, CO_2, SO_2 and several unregulated pollutants among them CH_4 and N_2O) and energy consumption (FC) of road traffic.

Figure 15 shows a schematic picture of the methodology of NEMO.

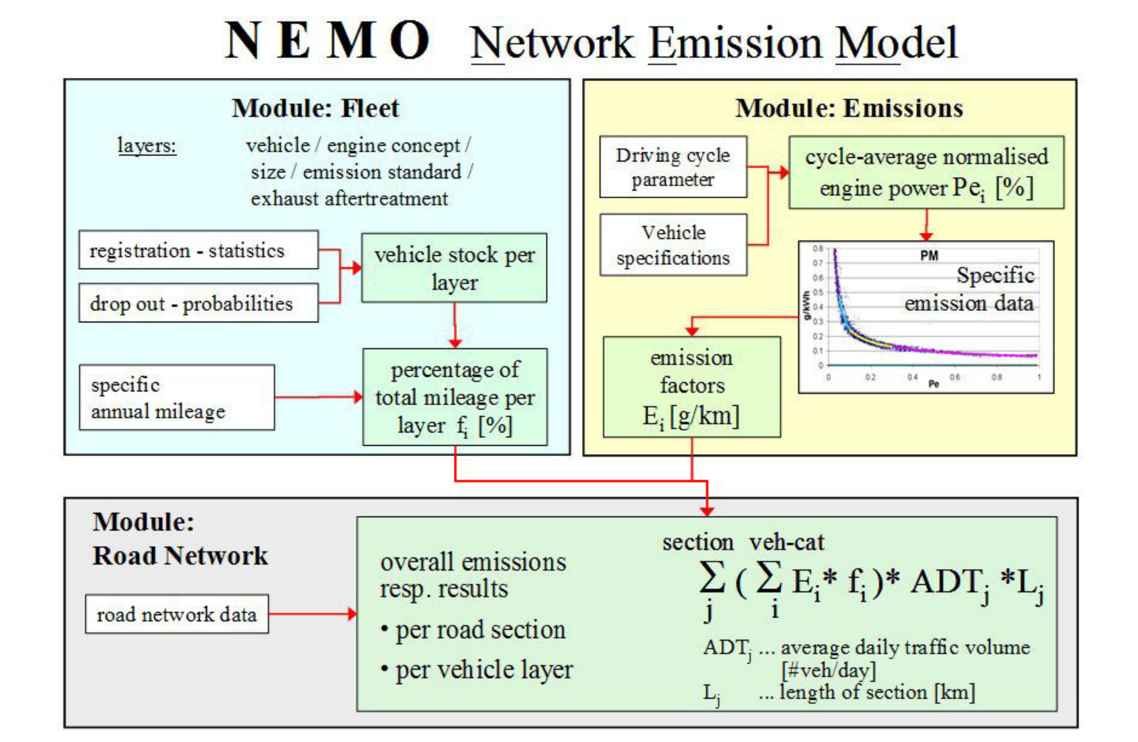

Figure 15: Schematic picture of the NEMO model.

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.

$$stock_{Jg_i,\mathrm{year\,i}} = stock_{Jg_i,\mathrm{year\,i-1}} \times \mathrm{survival\ probability}_{Jg_i}$$

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)

$$\mathrm{total\ mileage}_{E_i} = \sum_{\mathrm{Jg=start.}}^{\mathrm{end}} (\mathrm{stock}_{\mathrm{Jg,year\,i}} \times \mathrm{km/vehicle}_{\mathrm{Jg_i,year\,i}})$$

4) Calculation of the total fuel consumption and emissions of each emission category

$$\mathrm{Emission}_{E_i} = \mathrm{total\ mileage}_{E_i} \times \mathrm{emission\ factor}_{K_j,E_i}$$

5) Calculation of the total fuel consumption and emissions of each vehicle category

$$\mathrm{Emission}_{\mathrm{veh.category}} = \sum_{E_i=1}^{end} \mathrm{Emission}_{E_i}$$

6) Calculation of the total passenger-km and ton-km

$$\mathrm{transport\ volumes}_{\mathrm{veh.category}} = \sum_{E_i=1}^{end} (\mathrm{vehicle\ mileage}_{E_i} \times \mathrm{loading}_{E_i})$$

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)

As recommended by the ERT during the ICR 2013 (ARR 2013 para 34), Austria with the model NEMO is now able to report CH_4 and N_2O emissions from LPG and CNG in *1.A.3.b Road Transport* separately and not as included elsewhere (IE). CH_4 and N_2O emissions from biomass are still reported as IE.

Activity Data

From 2015 to 2016 fuel consumption in TJ (gasoline, diesel and alternative fuels including liquid biomass) by road transport increased by 3.4%. Specific consumption per average vehicle kilometer per vehicle category did not improve for diesel passenger cars between 2015 and 2016; it declined by 0.8% for gasoline passenger cars, by 0.6% for light duty vehicles and by 1.4% for heavy duty vehicles.

The following table gives an overview of the amount of fuel sold in Austria (including fuel export) differentiated by fuel type.

Table 76: Activity data from category 1.A.3.b Road Transport differentiated by fuel type 1990–2016.

Year	Fuel consumption (based on fuel sold) [TJ]					
	total	gasoline	diesel oil	LPG	gaseous	biomass
1990	176 826	103 899	72 514	413	-	-
1991	196 386	113 961	81 998	428	-	-
1992	196 215	108 960	86 811	444	-	-
1993	198 244	104 520	93 273	451	-	-
1994	199 009	100 775	97 772	462	-	-
1995	202 791	97 340	104 957	494	-	-
1996	224 096	90 040	133 386	670	-	-
1997	210 964	85 343	125 092	530	-	-
1998	237 524	89 286	147 648	590	-	-
1999	229 403	82 983	145 799	622	-	-
2000	241 748	80 175	160 901	672	-	-
2001	259 856	80 755	178 379	722	-	-
2002	288 170	86 947	200 239	984	-	-
2003	311 792	88 916	221 744	1 132	-	-
2004	318 770	86 497	231 311	947	14	-
2005	325 528	84 059	238 299	977	16	2 177
2006	312 724	80 671	222 778	1 005	15	8 255
2007	316 156	78 772	227 115	968	76	9 225
2008	299 809	70 771	216 550	1 002	138	11 349
2009	294 603	70 553	208 044	945	331	14 730
2010	306 152	69 420	219 705	889	454	15 684
2011	295 983	66 868	212 408	854	486	15 368

Year	Fuel consumption (based on fuel sold) [TJ]					
	total	gasoline	diesel oil	LPG	gaseous	biomass
2012	295 273	65 089	212 753	900	534	15 998
2013	308 639	63 803	227 607	904	650	15 675
2014	302 111	62 558	221 545	789	702	16 517
2015	308 293	63 137	225 615	618	725	18 198
2016	318 823	62 428	237 972	477	719	17 227
1990–2016	***80%***	***-40%***	***228%***	***15%***	***4 902%***[41]	***691%***[42]

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%[43]
- 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 passenger cars, 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 2016 the energetic substitution by biofuels amounted to 7.1% in the road transport sector (BMLFUW 2017a).[44] 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (UMWELTBUNDESAMT 2006b).

For the year 2016 a consumption of 495 764 tons of HVO[45] & biodiesel (for blending with diesel) and 86 912 tons of bioethanol (for blending with gasoline) are used as input data in the calculation models based on NEMO and GEORG (see 1.A.2.g.vii). The following amounts are used in pure form: 15 595 tons of plant oil; 65 280 tons of biodiesel; zero tons of pure bioethanol in E85 (BMLFUW 2017a).

[41] Trend 2004-onwards

[42] Trend 2005-onwards

[43] An allocation to agriculture is not possible at the moment, because of the technical model framework.

[44] The required substitution target amounts to 5.75%, measured by energy content.

[45] HVO…Hydrotreated Vegetable Oils

Table 77: Use of biofuels in absolute figures 2005–2016.

Year	pure	blended		biofuels total [t]
	biofuel pure [t]	biodiesel [t]	bioethanol [t]	
2005	17 000	75 000	0	**92 000**
2006	52 500	288 000	0	**340 500**
2007	89 209	298 828	20 391	**408 428**
2008	121 276	304 291	84 910	**510 477**
2009	133 690	405 909	99 424	**639 023**
2010	92 377	427 000	105 883	**625 260**
2011	101 824	422 072	102 755	**626 650**
2012	74 983	440 938	105 378	**621 299**
2013	80 536	443 389	88 842	**612 767**
2014	159 153	474 692	87 688	**721 533**
2015	174 255	528 944	89 557	**792 756**
2016	80 875	495 764	86 912	**663 551**
2005–2016	***376%***	***561%***	***326%***[46]	***621%***

As responded to the ERT's question during the Centralised 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.

Emission Factors

Emission factors used for 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. The latest HBEFA Version V3.3 published end of March 2017 has been applied.

Moreover, specific CO_2 emission factors of new passenger cars and light duty vehicles have been implemented according to the national CO_2 monitoring data for the Austrian fleet (BMLFUW 2017b,c).

<u>*Cold-start emissions*</u>

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]

[46] Trend 2007-onwards

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 V.3.2)
- HDV: cold-start study commissioned by Umweltbundesamt (REXEIS et al. 2013)
- 2-wheelers: derived from cold-start emissions of PC gasoline

Relative factors used 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. 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 (EMEP Guidebook if available) or exhaust measurements.

Table 78: Relative factors used for bioethanol E85 and biogas.

gasoline	blended gasoline	bioethanol E85	biogas
NO_x	1.00	1.51	1.00
HC	1.00	1.37	1.00
CO	1.00	0.88	1.00
PM exhaust	1.00	1.00	1.00
NO_x_raw	1.00	0.64	1.00
N_2O	1.00	0.64	1.00
NO_2	1.00	1.51	1.00
NH_3	1.00	1.00	1.00
CH_4	1.00	1.94	1.00
Benzol	1.00	1.00	1.00

Table 79: Relative factors used for biodiesel, plant oil and diesel B20.

diesel	blended diesel	biodiesel (RME[47])	plant oil	diesel B20
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

[47] rapeseed oil methyl ester

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

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 80 to Table 83 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 80: Implied emission factors of passenger cars 1990–2016.

Year	**Activity**	**Implied Emission Factors**		
		CO_2	**CH_4**	**N_2O**
	TJ	**t/TJ**	**kg/TJ**	**kg/TJ**
1990	113 090	75.9	18.84	2.80
1991	127 082	75.9	16.79	2.96
1992	123 947	75.8	14.87	3.09
1993	121 930	75.8	13.20	3.19
1994	121 595	75.7	11.78	3.25
1995	121 899	75.7	10.53	3.26
1996	118 022	75.6	9.30	3.17
1997	117 364	75.5	8.22	3.04
1998	128 387	75.5	7.28	2.90
1999	125 211	75.4	6.32	2.75
2000	127 697	75.3	5.51	2.62
2001	136 730	75.3	4.86	2.49
2002	157 018	75.2	4.28	2.35
2003	171 714	75.1	3.76	2.23
2004	177 919	75.1	3.34	2.14
2005	181 712	74.7	2.94	2.06
2006	180 971	73.5	2.52	2.02
2007	184 597	73.1	2.20	1.93
2008	177 063	72.1	1.94	1.85
2009	175 585	71.3	1.74	1.77
2010	178 558	71.2	1.54	1.73
2011	179 244	71.1	1.40	1.72
2012	177 201	70.9	1.29	1.70
2013	175 311	71.2	1.21	1.68
2014	180 327	70.8	1.09	1.68
2015	188 689	70.5	1.02	1.70
2016	195 371	71.1	0.95	1.72

Table 81: Implied emission factors of light duty vehicles 1990–2016.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	12 650	75.1	10.0	1.1
1991	13 035	75.0	8.9	1.0
1992	13 414	74.9	7.9	1.0
1993	13 607	74.9	7.1	0.9
1994	14 153	74.8	6.3	0.9
1995	14 384	74.8	5.7	1.1
1996	14 634	74.7	5.1	1.2
1997	15 063	74.6	4.5	1.3
1998	15 571	74.6	4.0	1.4
1999	16 129	74.5	3.5	1.4
2000	16 634	74.5	3.0	1.5
2001	16 871	74.5	2.7	1.6
2002	16 831	74.4	2.3	1.6
2003	16 959	74.4	2.0	1.7
2004	17 128	74.4	1.8	1.7
2005	17 682	73.8	1.6	1.8
2006	18 356	71.9	1.4	1.8
2007	19 012	71.8	1.1	1.9
2008	18 753	71.5	0.8	1.9
2009	18 514	70.4	0.7	1.9
2010	18 722	70.4	0.6	1.9
2011	18 958	70.3	0.5	1.9
2012	18 874	70.2	0.5	1.9
2013	19 321	70.4	0.4	1.9
2014	19 666	70.2	0.3	1.9
2015	20 106	69.8	0.4	1.9
2016	20 588	70.3	0.3	1.9

Table 82: Implied emission factors of heavy duty vehicles 1990–2016.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	49 808	74.2	1.4	0.7
1991	55 014	74.2	1.4	0.7
1992	57 577	74.2	1.4	0.7
1993	61 406	74.2	1.3	0.7
1994	61 913	74.2	1.3	0.7
1995	65 089	74.2	1.3	0.7
1996	89 951	74.2	1.2	0.7
1997	76 978	74.2	1.2	0.7

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1998	91 906	74.2	1.1	0.7
1999	86 305	74.2	1.0	0.7
2000	95 604	74.2	1.0	0.7
2001	104 392	74.2	0.9	0.6
2002	112 403	74.2	0.9	0.6
2003	121 151	74.2	0.8	0.5
2004	121 728	74.2	0.8	0.5
2005	124 088	73.5	0.7	0.5
2006	111 293	71.5	0.7	0.6
2007	110 358	71.5	0.6	0.9
2008	101 695	71.3	0.5	1.2
2009	98 127	70.2	0.5	1.5
2010	106 443	70.2	0.4	1.7
2011	95 291	70.1	0.4	2.0
2012	96 627	69.9	0.3	2.2
2013	111 452	70.1	0.3	2.4
2014	99 487	69.9	0.2	2.7
2015	96 807	69.5	0.2	2.8
2016	100 134	70.0	0.2	2.8

Table 83: Implied emission factors of mopeds and motorcycles 1990–2015.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	1 279	76.3	283.0	1.2
1991	1 255	76.3	272.1	1.2
1992	1 276	76.3	259.3	1.2
1993	1 301	76.3	246.0	1.2
1994	1 348	76.3	232.5	1.2
1995	1 419	76.3	218.0	1.2
1996	1 489	76.3	205.8	1.2
1997	1 559	76.3	195.4	1.2
1998	1 661	76.3	184.3	1.2
1999	1 758	76.3	173.2	1.2
2000	1 813	76.3	165.4	1.2
2001	1 863	76.3	158.6	1.2
2002	1 918	76.3	152.1	1.3
2003	1 967	76.3	146.4	1.3
2004	1 995	76.3	140.3	1.3
2005	2 046	76.3	135.4	1.3

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2006	2 104	76.3	129.5	1.3
2007	2 189	75.5	122.7	1.3
2008	2 299	72.7	115.3	1.3
2009	2 378	72.2	109.2	1.3
2010	2 429	71.9	103.8	1.3
2011	2 491	71.9	98.4	1.3
2012	2 571	71.7	92.1	1.3
2013	2 555	72.3	87.9	1.3
2014	2 631	71.8	81.1	1.3
2015	2 691	71.8	75.5	1.3
2016	2 729	72.7	71.0	1.3

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?
- ✓ 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

There have been recalculations in all subcategories of *1.A.3.b.Road Transport.*

Table 84: Recalculations with respect to previous submission for CRF 1.A.3.b.

Difference	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 [kt]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4 [kt]	0.09	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12
N_2O [kt]	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01

Difference	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 [kt]	0.00	0.00	0.00	0.00	0.00	-0.38	3.46	3.25	3.17	3.28
CH_4 [kt]	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13
N_2O [kt]	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.002

Difference	2010	2011	2012	2013	2014	2015
CO_2 [kt]	0.70	2.69	2.96	2.69	4.06	17.35
CH_4 [kt]	0.12	0.12	0.11	0.10	0.10	0.09
N_2O [kt]	0.003	0.004	0.003	-0.005	-0.007	-0.009

Revised levels of fuel according to national energy balance

For the year 2015 marginal changes in emissions are caused by downwards revised levels for liquefied petroleum gas (LPG) in the national energy balance.

Refined calibration of specific FC and CO_2 emissions of 1.A.3.b.i. PC and 1.A.3.b.ii LDV - inland

Newly registered PC and LDV registrations of all years were updated by taking into account the special characteristics of fuels used in the type approval process which were not accounted for in previous years in the generation of EFs on the roller test bench. FC/km for gasoline PC and LDV were revised upwards to a higher extent compared to diesel PC (NEMO HBEFA V3.3).

Table 85: Comparison of specific FC and EFs per km of diesel and gasoline PC per emission class.

PKW: **DIESEL**

FC	NEMO HBEFA3.2	NEMO HBEFA3.3[2]
PRE ECE	78,78	78.83
ECE15/01	85,94	86.02
ECE15/02	80,70	80.76
ECE15/03	73,00	73.05
ECE15/04	59,20	59.26
US 83	58,22	58.25
Gesetz A	57,23	57.27
EURO 2	58,20	58.26
EURO 3	57,11	57.16
EURO 4	57,46	57.52
EURO 4+DPF	58,10	58.19
EURO 5	56,02	56.14
EURO 6a/b	56,66	56.47
EURO 6d temp	55,64	55.19
EURO 6d	-	55.49

OTTO

FC	NEMO HBEFA3.2	NEMO HBEFA3.3[2]
PRE ECE	72,71	76.50
ECE15/01	73,49	77.32
ECE15/02	73,57	77.40
ECE15/03	70,46	74.13
ECE15/04	62,60	65.87
US 83	63,77	67.10
Gesetz A	63,12	66.44
EURO 2	62,95	66.26
EURO 3	61,19	64.45
EURO 4	60,12	63.35
EU4+DPF	57,18	60.35
EURO 5	53,65	56.69
EURO 6a/b	52,64	55.78
EURO 6c/d	51,75	54.79

Overall shifts of FC between inland and fuel export

NB: In the model NEMO every revision of inland FC leads to a direct shift between fuel consumption in inland and fuel export. In the emission model a higher fuel consumption in inland leads to lower activities in fuel export.

Gasoline: Due to a higher mileage of mopeds and a higher specific fuel consumption of gasoline PC and LDV in inland, less gasoline can be attributed to fuel export in PC up to 2010, where the yearly mileage of gasoline PC was revised downwards. The effect on emissions

Diesel: FC of diesel cars in inland is equal to the previous submission up to 2010, where the yearly mileage of diesel PC was revised upwards. Due to the fact that diesel fuel export in cars is being calibrated via the amounts of gasoline fuel export in cars, fuel export in diesel PC has been revised downwards. Following, fuel export of diesel trucks has been revised upwards in the same extent.

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, 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.

The mentioned improvements lead to an overall increase of emissions of 17 kt CO_{2eq} for the year 2015 in *1.A.3.b Road Transport*.

Planned improvements

The implementation of new data on specific yearly mileage of PC is being planned provided the data supplier is able to extract the relevant parameters out of a database which is not public.

3.2.12.3 1.A.3.c Railways

Key Source: No

In this category emissions from diesel railcars and steam engines are considered.

Table 86: Greenhouse gas emissions from 1.A.3.c Railways 1990–2016.

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	130	0.006	0.05	144
2002	141	0.006	0.05	156

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
2003	141	0.006	0.05	156
2004	140	0.006	0.05	155
2005	161	0.007	0.06	178
2006	153	0.007	0.06	170
2007	152	0.006	0.05	168
2008	151	0.006	0.05	167
2009	146	0.005	0.05	160
2010	143	0.005	0.04	156
2011	120	0.004	0.04	131
2012	123	0.003	0.04	134
2013	114	0.003	0.03	123
2014	119	0.003	0.03	128
2015	106	0.002	0.03	114
2016	111	0.002	0.03	119
1990–2016	***–38%***	***–73%***	***–56%***	***–40%***

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 *1.A.2.g.vii*.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of *1.A.3.c Railways* are presented below. In the following table the activity data includes all energy sources (including 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 *1.A.2.g.vii*.

Table 87: Implied emission factors and activity data for 1.A.3.c Railways 1990–2016.

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

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2000	1 814	74.5	3.5	26.5
2001	1 746	74.4	3.5	26.7
2002	1 889	74.4	3.4	26.7
2003	1 896	74.3	3.3	26.6
2004	1 886	74.2	3.3	26.5
2005	2 192	73.5	3.1	26.1
2006	2 137	71.6	3.1	25.8
2007	2 125	71.5	2.9	24.9
2008	2 121	71.4	2.7	23.9
2009	2 076	70.4	2.5	23.1
2010	2 031	70.3	2.3	22.1
2011	1 708	70.3	2.1	21.1
2012	1 757	70.1	2.0	20.2
2013	1 620	70.3	1.8	18.9
2014	1 693	70.2	1.6	17.7
2015	1 518	69.8	1.6	17.0
2016	1 575	70.3	1.6	16.7

Recalculations

For the year 2005-2015 changes in emissions (-12.7 kt CO_{2eq}) are caused by revised levels for diesel in the national energy balance.

Recalculations for the whole time series of CH_4 and N_2O can be explained by a transcription error in the overview of the emission model showing the sectoral results, which was resolved in this submission.

3.2.12.4 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 in Austria. The main sources are the river Danube and some other smaller rivers and lakes.

Table 88: Greenhouse gas emissions from 1.A.3.d Domestic Navigation 1990–2016.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	14.8	0.007	0.002	15.6
1991	15.0	0.007	0.002	15.9
1992	15.0	0.007	0.002	15.8
1993	14.2	0.007	0.002	15.0
1994	13.9	0.007	0.002	14.7

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1995	14.0	0.007	0.002	14.8
1996	14.1	0.007	0.002	14.8
1997	15.0	0.007	0.002	15.9
1998	15.2	0.007	0.002	16.1
1999	14.3	0.006	0.002	15.1
2000	14.8	0.006	0.002	15.6
2001	14.0	0.006	0.002	14.8
2002	13.2	0.006	0.002	13.9
2003	12.8	0.006	0.002	13.5
2004	15.8	0.006	0.003	16.7
2005	15.5	0.006	0.003	16.4
2006	14.7	0.005	0.002	15.5
2007	14.7	0.005	0.002	15.6
2008	12.6	0.005	0.002	13.3
2009	11.5	0.005	0.001	12.0
2010	11.7	0.004	0.001	12.2
2011	12.0	0.004	0.002	12.6
2012	12.3	0.004	0.002	12.8
2013	12.3	0.004	0.002	12.9
2014	11.4	0.004	0.001	11.9
2015	11.0	0.003	0.001	11.4
2016	10.4	0.003	0.001	10.8
1990–2016	***-29%***	***-54%***	***-51%***	***-31%***

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 2 methodology.

Austria uses bottom-up models 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. Freight transport on the River Danube is being calculated with NEMO Ship from now on, the rest of domestic navigation with the off-road model GEORG (HAUSBERGER 2000). 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 (STATISTIK AUSTRIA 2000–2017). In the 2015 submission the energy consumption of domestic navigation on the River Danube has undergone an update over the entire time series. Accordingly, the specific fuel consumption increases during the year 2011, to a value of 9.7 g diesel/tkm, which represents an increase of about 28%. This increase in the average fuel consumption for inland navigation was compared with TREMOD with 9.5 g diesel/tkm and declared plausible (HAUSBERGER & SCHWINGSHACKL 2015). 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 *1.A.2 g.vii.*

Up to 2009 Austria had reported emissions from water-borne navigation on the River Danube entirely as domestic navigation under category *1.A.3.d* thus reporting zero emissions for international navigation and overestimating national navigation. Following the recommendations by the ERT (ARR 2009 last), Austria presented in the **2010 submission** a disaggregation between domestic and international navigation, based on the following approach:

Fuel sold in Austria along the River Danube (in 2011, there were six fueling stations for ships operating in Austria and the Ministry of Economy is collecting information on the fuel sold in those fueling stations) was used as a proxy for fuel sold in international transport as most transport along the River Danube is across borders (being either transit, import or export transport). The difference between fuel attributed to total navigation and fuel sold along the River Danube was allocated to domestic navigation. This approach probably resulted in some overestimation of international navigation as it did not account for national navigation along the Danube.

Since the **submission 2011**, building on data used in the model GEORG (see *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

Activities used for estimating the emissions and the implied emission factors of *1.A.3.d Navigation* 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 89: Implied emission factors and activity data for 1.A.3.d Domestic Navigation 1990–2016.

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	1 814	74.5	3.5	26.5
2001	1 746	74.4	3.5	26.7

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	T/TJ	kg/TJ	kg/TJ
2002	1 889	74.4	3.4	26.7
2003	1 896	74.3	3.3	26.6
2004	1 886	74.2	3.3	26.5
2005	2 192	73.5	3.1	26.1
2006	2 137	71.6	3.1	25.8
2007	2 125	71.5	2.9	24.9
2008	2 121	71.4	2.7	23.9
2009	2 076	70.4	2.5	23.1
2010	2 031	70.3	2.3	22.1
2011	1 708	70.3	2.1	21.1
2012	1 757	70.1	2.0	20.2
2013	1 620	70.3	1.8	18.9
2014	1 693	70.2	1.6	17.7
2015	1 518	69.8	1.6	17.0
2016	1 575	70.3	1.6	16.7

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) it was explained that emissions of ground activities at domestic harbors are also included, even if they are not separately reported under *1.A.3.d Navigation*. This can be assured as Austria reports emissions from **total fuel sold** from the energy balance.

The approach in the Austrian inventory is as follows: After calculating fuel consumption for inland road transport and off-road transport using a bottom-up approach (NEMO, GEORG), the sum of this fuel used is compared with the total fuel sold from the national energy balance (for details see *1.A.3.b Road Transport*). The difference is then allocated to fuel export, which includes fuel consumption for ground activities at airports and harbors as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals[48], an underestimation of emissions can be excluded.

Explanation for the inconsistency in trends of emissions

The differing CH_4 trend in inland navigation can be explained as follows. The share of gasoline consumption (ca. 70%) in inland navigation is much higher than the share of diesel oil. CH_4 emission factors for gasoline engines are much higher than for diesel engines due to the different combustion and after-treatment processes. CH_4 emission factors are decreasing a lot over the constantly improving technology/emissions classes (so called stages). Technologically speaking this is mainly due to the decreasing HC emissions of newer engines. The share of gasoline consumption in inland navigation combined with the decreasing emission factors result in the fact that the gasoline activity trend is quite similar to the trend of total absolute CH_4 emissions comprising the sum of gasoline and diesel CH_4 emissions.

Recalculations

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

3.2.12.5 1.A.3.e 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 1.0% for the year 2016. The increase of emissions is mainly caused by the increase of natural gas transfer through Austria.

Methodology

The IPCC Tier 2 methodology is applied.

Activity data

Activity data (fuel consumption) is taken from (IEA JQ 2017) as presented in Annex 4.

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1996) and (UMWELTBUNDESAMT 2002).

N_2O emission factors are taken from a national study (BMUJF 1994).

Table 90: Emission factors of Category 1.A.3.e applied for all years.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Natural Gas	55.40	1.00	0.10

48 GHG emissions from fuel export are included in 1.A.3.b and are presented separately in Table 66 (Chapter 3.2.12.2)

Recalculations

Changes of activity data are based on a revision of the energy balance.

3.2.13 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 27.3% for the year 1990 and 16.7% for the year 2016.

3.2.13.1 1.A.4 Other sectors – stationary sources

Key Source: CO_2 from gaseous, liquid, solid and other fuels; CH_4 from biomass; N_2O from solid fuels.

Category *1.A.4 Other Sectors* 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* or the respective sub categories of *1.A.2 Manufacturing Industries and Construction* if district heat is sold by industry. Information about type of heating is derived from an energy demand model for space heating based on heating market surveys 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.

Methodology

For calculation of CO_2 emissions and CH_4 emissions from solid biomass the IPCC Tier 2 methodology is applied. For calculation of CH_4 emissions from solid, liquid and gaseous fuels and N_2O emissions from all fuel types the Tier 1 methodology is applied.

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)
- 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)
- 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)
- 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)
- Final energy demand by technology: by categories of module 'heating type by technology' based on results of module 'building energy performance' and calibrated according to the energy statistics supplier to maintain consistency with fuel demand reported in (IEA JQ 2017)

There are twenty-two technology and fuel dependent main subcategories (heating types) for category *1.A.4 Other sectors* presented in the following table.

Table 91: Heating types of category 1.A.4. Other sectors – stationary sources

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, sewage sludge gas, biogas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, sewage sludge gas, biogas and landfill gas
#10	LPG stoves	LPG and gas works gas
#11	LPG boilers	LPG and gas works gas
#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 char coal is assumed to be combusted in devices similar to central heating and calculated separately.

1.A.4.a Commercial/Institutional

The fuel consumption reported in (IEA JQ 2017) is assigned to twenty-two heating types derived from an energy demand model for space heating based on heating market surveys and calibrated according to the energy statistics supplier.

1.A.4.b Residential

Energy consumption by type of fuel and by type of heating is derived from an energy demand model for space heating based on heating market surveys validated with a statistical evaluation of micro census data 1990, 1992, 1999/2000, 2004, 2006, 2008, 2010, 2012, 2014 and 2016 by STATISTIK AUSTRIA. 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.

1.A.4.c Agriculture/Forestry/Fishing

The fuel consumption reported in (IEA JQ 2017) for category *1.A.4.c* is assigned to implied emission factors derived from category *1.A.4.a*. assuming similar structure of heating types in both categories.

Emission factors

CO_2 emission factors are taken from studies (BMWA-EB 1990, 1996, 1999), elementary analysis of natural gas (UMWELTBUNDESAMT 2002) 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.

Biomass CH_4 emission factors are determined assuming that 25% of VOC emissions consist of methane. The split follows closely (STANZEL et al. 1995).

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.

The selected emission factors for 2016 are presented in the following table.

Table 92: Emission factors of category 1.A.4 heating types for the year 2016.

Fuel	No.	CO_2 [t/TJ]	CH_4 [kg/TJ]		N_2O [kg/TJ]
			1.A.4.a	1.A.4.b	
Light fuel oil	#1	77.00	10.00	10.00	0.60
Medium fuel oil	#1	78.00	10.00	10.00	0.60
Heavy fuel oil	#1	78.00	10.00	10.00	0.60
Diesel	#1	75.00	10.00	10.00	0.60
Petroleum	#1	78.00	10.00	10.00	0.60
Other petroleum products	#1	64.00	10.00	10.00	0.60
Gas oil	#2 #3 #4 #5 #6	75.00	3.00	3.00	0.60

Fuel	No.	CO_2 [t/TJ]	CH_4 [kg/TJ]		N_2O [kg/TJ]
			1.A.4.a	1.A.4.b	
Natural gas	#7 #8 #9	55.40	5.00	5.00	0.10
Biogas and landfill gas	#8 #9	54.60[1)]	5.00	5.00	0.10
LPG and gas works gas	#10 #11	64.00	5.00	5.00	0.60
Fuel wood	#12 #13 #14 #15 #16	112.00[1)]	201.49[2)] 115.61 150.00 121.42 112.74	203.05[2)] 115.61 150.00 121.42 112.74	4.00
Wood waste	#17 #18 #19 #20	112.00[1)]	150.00 27.06 19.84 11.27	150.00 27.06 19.84 11.27	4.00
Hard coal and hard coal briquettes	#21 #22	93.00	300.00 8.53	300.00 255.99	1.50
Lignite and brown coal	#21 #22	108.00	300.00 8.53	300.00 255.99	1.50
Brown coal briquettes	#21 #22	97.00	300.00 8.53	300.00 255.99	1.50
Coke	#21 #22	92.00	300.00 8.53	300.00 255.99	1.50
Peat	#21 #22	106.00	10.00	300.00 255.99	1.40
Industrial waste	#22	104.17	12.00	12.00	4.00
Char coal	–	112.00[1)]	200.00	200.00	1.00

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

[2)] *Implied emission factor*

Because no measurements are available, CH_4 emission factors for new wood stoves and cooking stoves (Table 93) are derived from conventional devices emission factors with the ratio of conventional and new devices NMVOC emission factors:

$$EF(CH_4)_{new} = EF(CH_4)_{conventional} * EF(NMVOC)_{new} / EF(NMVOC)_{conventional}$$

Table 93: CH_4 emission factors of category 1.A.4 new wood stoves and cooking stoves.

Fuel	No.	CH_4 [kg/TJ]	
		1.A.4.a	1.A.4.b
Fuel wood	#12	115.61	115.61

Activity data

Total fuel consumption for each of the sub categories of *1.A.4* is taken from (IEA JQ 2017) as presented in Annex 4.

Since (IEA JQ 2017) 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 2017).

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 in general 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 and micro census data.

Table 94 shows the selected share of each heating type for category *1.A.4.a and 1.A.4.b.*

Table 94: Share of 1.A.4.a and 1.A.4.b heating type on fuel category for the year 2016.

Fuel	No.	Heating type	Share of heating type [% TJ]	
			1.A.4.a	1.A.4.b
Light fuel oil	#1	Fuel oil boilers	NO	NO
Medium fuel oil	#1	Fuel oil boilers	NO	NO
Heavy fuel oil	#1	Fuel oil boilers	NO	NO
Diesel	#1	Fuel oil boilers	100.0%	NO
Petroleum	#1	Fuel oil boilers	NO	NO
Other petroleum products	#1	Fuel oil boilers	NO	NO
Gas oil	#2	Gas oil stoves	5.3%	3.1%
	#3	Vapourizing burners	9.4%	9.1%
	#4	Yellow burners	72.4%	72.6%
	#5	Blue burners with conventional technology	1.2%	1.3%
	#6	Blue burners with low temperature or condensing technology	11.7%	13.9%
Natural gas	#7	Natural gas convectors	24.5%	13.6%
	#8	Atmospheric burners	69.4%	75.8%
	#9	Forced-draft natural gas burners	6.1%	10.6%
Biogas and landfill gas	#8	Atmospheric burners	92.0%	NO
	#9	Forced-draft natural gas burners	8.0%	NO
LPG and gas works gas	#10	LPG stoves	69.0%	NO
	#11	LPG boilers	31.0%	NO
Fuel wood	#12	Wood stoves and cooking stoves	33.4%	8.0%
	#13	Tiled wood stoves and masonry heaters	66.6%	11.3%
	#14	Mixed-fuel wood boilers	NO	72.0%
	#15	Natural-draft wood boilers	NO	1.1%
	#16	Forced-draft wood boilers	NO	7.6%
Wood waste	#17	Wood chips boilers with conventional technology	44.0%	39.0%
	#18	Wood chips boilers with oxygen sensor emission control	NO	5.7%
	#19	Pellet stoves	4.5%	4.9%
	#20	Pellet boilers	51.5%	50.4%

Fuel	No.	Heating type	Share of heating type [% TJ]	
			1.A.4.a	1.A.4.b
Hard coal and hard coal briquettes	#21 #22	Coal stoves Coal boilers	80.1% 19.9%	27.0% 73.0%
Lignite and brown coal	#21 #22	Coal stoves Coal boilers	80.1% 19.9%	27.0% 73.0%
Brown coal briquettes	#21 #22	Coal stoves Coal boilers	80.1% 19.9%	27.0% 73.0%
Coke	#21 #22	Coal stoves Coal boilers	80.1% 19.9%	27.0% 73.0%
Peat	#21 #22	Coal stoves Coal boilers	NO NO	NO NO
Industrial waste	#22	Coal boilers	100.0%	NO
Char coal	–		100.0%	100.0%

NO…not occurring (in 2016)

The following table shows biomass share of wood stoves and cooking stoves stock from 2001 which are considered with lower CO, NMVOC and CH_4 emissions than equipment installed before 2001. The selected factors are derived from the energy demand model for space heating.

Table 95: Share of wood stoves and cooking stoves stock 2001–2016.

Year	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2001	0.4%	1.8%	99.0%	98.2%
2002	2.0%	2.8%	98.0%	97.2%
2003	3.1%	3.7%	96.9%	96.3%
2004	4.1%	4.7%	95.6%	95.3%
2005	5.1%	5.7%	94.5%	94.3%
2006	6.4%	6.6%	93.4%	93.4%
2007	8.2%	7.6%	92.3%	92.4%
2008	9.5%	8.5%	91.2%	91.5%
2009	10.9%	9.5%	90.1%	90.5%
2010	11.8%	10.5%	88.9%	89.5%
2011	12.7%	11.4%	87.8%	88.6%
2012	13.7%	12.4%	86.7%	87.6%
2013	14.5%	13.4%	85.6%	86.6%
2014	15.1%	14.3%	84.5%	85.7%
2015	15.9%	15.3%	83.4%	84.7%
2016	16.8%	16.2%	82.3%	83.8%

Figure 16 shows activity data of *1.A.4.b Residential (without mobile machinery)* by type of fuel together with the correlating heating degree days for the years 1990 to 2016. It has to be noted that total floor space of dwellings and the number of households as well as population have been increased since 1990 while total energy demand has been kept rather constant. Electricity used for space heating or hot water preparation, with an estimated consumption of about 13 PJ in 2016, is not included in the figure.

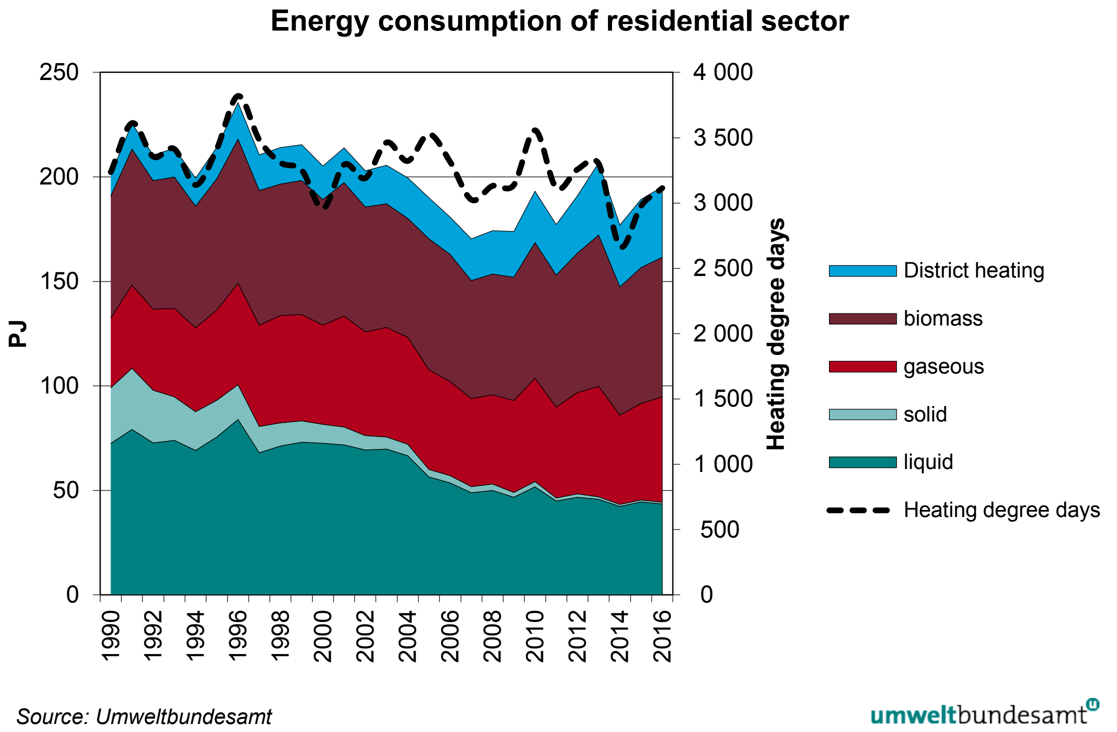

Figure 16: Energy consumption [PJ] of residential sector by type of fuel and number of heating degree days 1990–2016.

Recalculations

Minor changes of activity data are based on the revisions of the energy balance.

Methodological changes in energy balance introduce a new bottom up systematic for category *1.A.4.a*. The assignment of the remaining amount of fuel not covered by bottom up statistics does not affect total final consumption but imply shifts between *1.A.2* and *1.A.4* subcategories.

Other fuels (industrial waste) have been shifted from Category *1.A.4.a* to Category *1.A.1.a* for the years 1990 to 2000 in order to increase time series consistency of those sectors.

CH_4 emissions from *1.A.4.a* and *1.A.4.b* – biomass are now based on a new energy demand model for space heating introducing new CH_4 emission factors considering more detailed technologies (heating types).

For *1.A.4.c* CH_4 emission factors of biomass have been changed from country specific values to the default values of the IPCC 2006 Guidelines.

3.2.13.2 1.A.4 Other sectors – mobile sources

1.A.4.a.2 Commercial/institutional

Currently there is neither a statistical basis nor any new study on NRMM which would enable Austria to report emissions from mobile sources of *1.A.4.aii. 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

Key Source: No

In addition to Non-Road Mobile Machinery (NRMM) used in household and gardening this category contains ski slope machineries and snow vehicles.

Table 96: Greenhouse gas emissions from mobile sources of 1.A.4.b.ii Residential 1990–2016.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	144	0.06	0.02	153
1991	145	0.07	0.02	153
1992	146	0.07	0.02	155
1993	147	0.07	0.02	156
1994	146	0.06	0.02	155
1995	146	0.06	0.03	155
1996	145	0.06	0.03	154
1997	144	0.06	0.03	152
1998	142	0.06	0.03	151
1999	142	0.05	0.03	151
2000	142	0.05	0.03	151
2001	142	0.05	0.03	151
2002	142	0.05	0.03	151
2003	142	0.05	0.03	150
2004	141	0.05	0.02	149
2005	138	0.05	0.02	146
2006	135	0.04	0.02	142
2007	132	0.04	0.02	139
2008	128	0.04	0.02	135
2009	125	0.03	0.02	131
2010	123	0.03	0.02	129
2011	123	0.03	0.01	128
2012	122	0.03	0.01	127
2013	123	0.03	0.01	127
2014	123	0.03	0.01	127
2015	123	0.03	0.01	127
2016	125	0.03	0.01	128
1990–2016	**−13.7%**	**−59.6%**	**−60.2%**	**−16.3%**

Methodological Issues

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

The applied methodology is described in the subchapter on mobile sources of *1.A.2.g.vii*.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of *1.A.4.b.ii Residential – mobile sources* 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 97: Emission factors and activity data for mobile sources of 1.A.4.b.ii Residential 1990–2016.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	T/TJ	kg/TJ	kg/TJ
1990	1 916	75.3	33.8	12.4
1991	1 920	75.3	33.9	12.4
1992	1 937	75.3	33.7	12.5
1993	1 948	75.3	33.6	12.5
1994	1 937	75.3	33.3	12.6
1995	1 944	75.3	32.1	12.9
1996	1 923	75.3	31.3	13.0
1997	1 905	75.3	30.5	13.1
1998	1 889	75.3	29.7	13.3
1999	1 885	75.3	28.8	13.4
2000	1 885	75.3	28.0	13.5
2001	1 887	75.3	27.4	13.7
2002	1 885	75.3	27.0	13.6
2003	1 879	75.3	26.8	13.4
2004	1 867	75.3	26.0	13.0
2005	1 844	75.0	24.6	12.6
2006	1 818	74.1	23.2	12.1
2007	1 794	73.7	21.7	11.6
2008	1 765	72.5	20.2	11.0
2009	1 741	71.7	18.8	10.3
2010	1 724	71.6	17.4	9.5
2011	1 715	71.5	16.3	8.7
2012	1 708	71.4	15.5	7.9
2013	1 712	71.7	15.1	7.2
2014	1 725	71.3	15.0	6.5
2015	1 733	71.1	15.0	5.9
2016	1 735	71.8	15.1	5.5

Recalculations

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

1.A.4.c.ii Agriculture and Forestry

Key Source: No

In this category emissions from NRMM used in agriculture and forestry (mainly tractors) are considered.

Table 98: Greenhouse gas emissions from mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2016.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	770	0.07	0.25	848
1991	768	0.07	0.26	845
1992	774	0.07	0.26	853
1993	778	0.07	0.26	857
1994	785	0.07	0.26	865
1995	751	0.06	0.26	829
1996	781	0.07	0.27	863
1997	820	0.07	0.29	908
1998	805	0.06	0.29	893
1999	813	0.06	0.30	903
2000	788	0.06	0.29	876
2001	813	0.06	0.30	904
2002	809	0.06	0.30	899
2003	778	0.06	0.28	862
2004	800	0.06	0.28	885
2005	842	0.06	0.29	929
2006	822	0.06	0.28	906
2007	830	0.06	0.27	911
2008	838	0.05	0.26	916
2009	757	0.05	0.23	826
2010	740	0.04	0.21	803
2011	803	0.04	0.21	868
2012	767	0.04	0.19	826
2013	766	0.04	0.18	820
2014	774	0.04	0.17	827
2015	762	0.03	0.16	811
2016	776	0.03	0.16	823
1990–2016	***1%***	***−53%***	***−39%***	***−3%***

Methodological Issues

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

The applied methodology is described in the subchapter on mobile sources of *1.A.2.g.vii*.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of *1.A.4.c Agriculture and Forestry – mobile sources* 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 *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 99: Emission factors and activity data for mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2016.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	T/TJ	kg/TJ	kg/TJ
1990	10 377	74.2	6.8	24.5
1991	10 339	74.2	6.3	24.7
1992	10 429	74.2	6.3	24.7
1993	10 480	74.2	6.3	24.8
1994	10 569	74.2	6.4	25.0
1995	10 115	74.2	6.4	25.3
1996	10 520	74.2	6.3	25.8
1997	11 047	74.2	6.0	26.2
1998	10 847	74.2	5.9	26.6
1999	10 950	74.2	5.8	27.0
2000	10 621	74.2	5.7	27.3
2001	10 947	74.2	5.6	27.6
2002	10 900	74.2	5.6	27.3
2003	10 472	74.3	5.8	26.7
2004	10 775	74.2	5.5	26.0
2005	11 443	73.6	5.1	25.2
2006	11 460	71.7	5.1	24.3
2007	11 578	71.7	4.9	23.2
2008	11 726	71.4	4.6	22.1
2009	10 756	70.4	4.2	21.0
2010	10 518	70.4	4.1	19.8
2011	11 421	70.3	3.8	18.7
2012	10 937	70.1	3.6	17.7
2013	10 880	70.4	3.4	16.6
2014	11 030	70.2	3.3	15.7
2015	10 921	69.8	3.2	14.9
2016	11 044	70.2	3.0	14.1

Recalculations

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

3.2.14 1.A.5 Other

In this category emissions of NRMM used for military transport (off-road and aviation) are reported.

3.2.14.1 1.A.5.b Mobile combustion – Military

Key Source: No

Methodological Issues

Military Off-Road (ground activities)

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 *1.A.2.g.vii.*

Emission estimates for military activities were taken from (HAUSBERGER 2000). Back then information on the fleet composition was taken from official data presented in the internet as no other data were available.

Military Aviation

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 1 (simple) methodology for aviation with country specific emission factors.

Table 100 shows GHG emissions for the complete military sector (sum of ground activities and military aviation).

Table 100: Greenhouse gas emissions from 1.A.5.b Military 1990–2016.

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
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

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
2009	46	0.001	0.0032	47
2010	46	0.001	0.0031	47
2011	47	0.002	0.0032	48
2012	47	0.002	0.0032	48
2013	48	0.002	0.0032	49
2014	49	0.002	0.0032	50
2015	49	0.002	0.0032	50
2016	50	0.002	0.0033	51
1990–2016	***42%***	***36%***	***16%***	***41%***

Activity Data

Military Off-Road (ground activities)

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).

Military Aviation

For the years 1990–1999 fuel consumption for military flights was reported by the Ministry of Defence. The calculation of emissions from military aviation does not distinguish between LTO and cruise. From 2000 onwards FC is being estimated using a linear extrapolation.

Activities used for estimating the emissions and the emissions of *1.A.5.b Mobile combustion – Military* are presented in Table 101 (activity data includes all energy sources). The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 101: Emission factors and activity data for 1.A.5.b Military 1990–2016.

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	542	72.8	2.4	5.8
1994	571	72.8	2.4	5.7
1995	447	72.8	2.4	6.1
1996	535	72.8	2.4	5.8
1997	510	72.8	2.4	5.7
1998	583	72.8	2.4	5.4
1999	571	72.8	2.4	5.4
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	584	72.8	2.4	5.7
2004	591	72.8	2.4	5.6
2005	599	72.7	2.4	5.4
2006	607	72.6	2.4	5.3
2007	614	72.6	2.4	5.2
2008	622	72.6	2.3	5.1
2009	630	72.6	2.3	5.0
2010	638	72.6	2.3	4.9
2011	645	72.6	2.3	4.9
2012	653	72.6	2.3	4.8
2013	661	72.6	2.3	4.8
2014	669	72.6	2.3	4.8
2015	676	72.5	2.3	4.8
2016	683	72.6	2.3	4.8

Emission Factors

For tanks and other special ground military vehicles the emission factors for diesel engines > 80 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.vii.*

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 102: Emission factors used for military flights

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

Recalculations

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

3.2.15 Category-specific QA/QC

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 public trend 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.

3.2.16 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 103. For transport, the respective factors are new and have been taken from an assessment of the overall transport GHG emissions (HAUSBERGER 2005).

Table 103: Uncertainty parameters for fuel combustion activities.

	Fossil solid	Biomass & waste	liquid	Black liquor	Gas
large sources	0.5	10	0.5	–	2.0
small sources	1.0	10	1.0	10.0	5.0
transport			3.0		

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 0.5%. 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 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 15 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 of Category 1.A

This chapter presents the recalculation difference of emissions from fuel combustion activities and its sub categories with respect to the previous submission.

3.2.17.1 Overview

Updates of activity data and of NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority Statistik Austria. The national energy balance was revised for the years 1999 to 2014.

Update/Improvement of activity data

1.A.3.a Civil Aviation

Update of the aviation emission model for calculating emissions of 2016 including the newest EMEP/EEA 2016 (Annex 5) emission factors. Flight movement data and the calculation of distances between airport pairs have been improved.

As a recalculation of the whole time series (1990−2015) with the updated emission model is not possible due to a lack of detailed data needed from now on and budgetary resources the result for 2016 cannot be compared with the result for 2015 of the submission 2017. An application of the updated emission model to all inventory years or a calibration to ensure a consistent time series is planned for the next submission in 2019.

Revision 2015: −0.13 kt CO_2e

1.A.3.b Road transport

Refined calibration of specific CO_2 emissions of newly registered PCs and LDVs registrations of all years by taking into account the special characteristics of fuels used in the type approval process. Increase in inland driving performance (on average +1%) due to an increase in specific moped mileage. From 2010 onwards revision of specific passenger car mileage for cars based on the latest statistical national survey.

For the year 2015 marginal changes in emissions are caused by a downward revision of the levels for liquefied petroleum gas (LPG) in the national energy balance.

The mentioned improvements lead to an overall increase of emissions (+17 kt CO_2e) for the year 2015.

1.A.3.c Railways

For the year 2015 changes in emissions (−12.7 kt CO_2eq) are caused by revised levels for diesel in the national energy balance.

1.A.4.a Commercial/Institutional; 1.A.4.b Residential; 1.A.4.c Agriculture/Forestry/Fishing

In previous versions of the energy balance the category *1.A.4.a* has been used as a 'residual' sector for the amount of fuels which could not be attributed to sectors by default. For the years 2012 to 2015 a new systematic has been applied by Statistik Austria for gasoil, residual fuel oil, LPG, natural gas, wood pellets and briquettes. The new systematic considers the amount of fuel which is not covered by bottom up statistics or census data in a different way. These amounts of fuels are now distributed to final energy consumption of *1.A.2* Manufacturing industries and *1.A.4* 'other sectors' subcategories, depending on the estimated incompleteness (e.g. small companies which are not obliged to report energy consumption) or uncertainty (census data) of the fuel consumption in these sectors. These methodological changes do not affect total final consumption but imply shifts between *1.A.2* and *1.A.4* subcategories.

The energy balance was revised by Statistik Austria for the years 2003 to 2015 with the following main implications on energy consumption and CO_2 emissions:

- Natural gas has been shifted between final energy consumption, other energy industries and transformation input to power plants for the years 2011−2015 (between −0.1 to 3.1 PJ). As a result of the 2015 energy data revision this leads to −141 kt CO_2 from '1.A.1.c other energy industries', −29 kt CO_2 from '1.A.1.a public electricity and heat', +298 kt CO_2 from '*1.A.2* manufacturing industries' and −129 kt CO_2 from '*1.A.4* Other sectors'. Total *1.A* natural gas consumption has not been affected in any year.

- For liquid fuels minor revisions have been made 2005 to 2015 (mainly shifts between *1.A.2* and *1.A.4* subcategories). As a result of the 2015 energy data revision, this leads to –36 kt CO_2 from '*1.A.2* manufacturing industries' and +37 kt CO_2 from '*1.A.4* Other sectors'.

  For 1999−2004, up to 81 kt CO_2 from liquid fuels have been shifted to gaseous fuels within category *1.A.1.b* refinery because of the revision of refinery fuels within the energy balance.
- For solid fuels minor revisions have been made for the years 2002−2004 and category '*1.A.1.a* public electricity and heat production' (between +2 and +5 kt of CO_2). For 2005–2015 minor revisions have been made for category '*1.A.2* manufacturing industries' (−74 kt CO_2 in 2015, of which about 41 kt have been shifted to category '*2.C.1* Iron and Steel'), and category '*1.A.4* Other sectors' (−16 kt CO_2 in 2015).
- For 'other fuels' the major revision of the energy balance took place for the years 2005 to 2013, which resulted in +48 kt higher CO_2 emissions from 'other fuels' in category *1.A.1.a* public electricity and heat production in 2013. Other revisions of the energy balance resulted in +81 kt higher CO_2 emissions from *1.A.2.c* Chemicals Industries – other fuels for the year 2015 and –129 kt lower CO_2 emissions for the year 2009.

Other methodological improvements

Other fuels (industrial waste) have been shifted from category *1.A.4.a* to category *1.A.1.a* for the years 1990 to 2000 in order to increase time series consistency of those sectors.

For *1.A.4.c* – biomass the IPCC default CH_4 emission factor has been selected (previously a country specific factors has been used), which leads to +28 kt CO_2-equivalent in 1990 and +34 kt CO_2-equivalent in 2015.

CH_4 emissions from *1.A.4.a* and *1.A.4.b* – biomass are now based on a new energy demand model for space heating. The model considers more detailed technologies (boilers, ovens) and provides an improved time series consistency. The change in emissions is about −139 kt CO_2-equivalent in 1990 and +22 kt CO_2-equivalent in 2015.

3.2.17.2 CO_2 recalculations 1.A

Table 104 shows the recalculations of CO_2 emissions for the subcategories of sector *1.A Fuel Combustion.*

Recalculations of CO_2 emissions 1990-2015 are due to revised energy data with the exception of category *1.A.2* for the year 2014, were about 60 kt have been shifted to category *2.C.1*.

Table 104: 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	0.00	233.97	–	0.00	–233.97	–
1991	0.00	172.19	–	0.00	–172.19	–
1992	–	266.78	–	0.00	–266.78	–
1993	0.00	157.09	–	0.00	–157.09	–
1994	0.00	152.71	–	0.00	–152.71	–
1995	0.00	126.57	–	0.00	–126.57	–
1996	0.00	244.38	–	0.00	–244.38	–
1997	0.00	203.46	–	0.00	–203.46	–
1998	0.00	104.07	–	0.00	–104.07	–
1999	–81.29	7.75	–	0.00	–89.04	–

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2000	–81.51	3.87	–	–0.10	–85.27	–
2001	–63.41	–63.31	–	–0.09	0.00	–
2002	–49.75	–49.64	–	–0.12	0.00	–
2003	–45.05	–44.93	–	–0.13	0.00	–
2004	–64.21	–75.76	11.67	–0.12	0.00	–
2005	45.41	39.33	25.18	–0.15	–18.95	–
2006	59.66	56.93	29.58	–0.26	–26.58	–
2007	59.41	59.51	3.98	–0.45	–3.62	–
2008	54.17	64.45	1.86	–0.52	–11.62	0.00
2009	–100.90	30.88	–126.21	–0.64	–4.93	–
2010	–110.33	0.73	–109.45	0.56	–2.17	–
2011	–117.29	8.67	–124.66	1.75	–3.05	–
2012	–5.89	9.94	61.07	2.23	–79.12	–
2013	105.45	26.99	79.66	3.55	–4.74	–
2014	101.38	–27.69	242.98	3.94	–117.85	–
2015	–4.87	–172.79	270.08	5.41	–107.57	–

3.2.17.3 CH_4 recalculations 1.A

Table 105 shows the recalculations of CH_4 emissions for the subcategories of sector *1.A Fuel Combustion.*

Recalculations of CH_4 emissions 1990-2014 are mainly due to the switch from country specific emission factors to default emission factors of the IPCC 2006 Guidelines.

Table 105: 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	–4.35	0.03	–	0.09	–4.47	–
1991	–5.54	0.02	–	0.08	–5.64	–
1992	–4.91	0.03	–	0.09	–5.03	–
1993	–4.69	0.02	–	0.10	–4.81	–
1994	–4.05	0.02	–	0.10	–4.17	–
1995	–3.13	0.01	–	0.11	–3.25	–
1996	–4.06	0.03	–	0.11	–4.20	–
1997	–1.07	0.02	–	0.12	–1.21	–
1998	–1.08	0.01	–	0.12	–1.21	–
1999	–1.22	0.01	–	0.12	–1.36	–
2000	–0.56	0.01	–	0.13	–0.69	–
2001	–0.16	–	–	0.13	–0.29	–
2002	0.18	0.00	–	0.12	0.06	–
2003	0.44	0.00	–	0.12	0.32	–
2004	0.69	0.00	–	0.12	0.58	–
2005	0.83	0.00	–0.01	0.12	0.72	–
2006	1.20	0.01	0.01	0.12	1.06	–
2007	1.26	0.01	0.01	0.12	1.13	–
2008	1.42	0.01	–0.04	0.13	1.32	–
2009	1.64	0.00	–0.09	0.13	1.60	0.00
2010	1.74	0.00	–0.07	0.12	1.70	–

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2011	2.08	0.02	–0.05	0.12	1.99	0.00
2012	2.35	0.02	–0.01	0.11	2.22	–
2013	2.50	0.03	0.06	0.10	2.31	0.00
2014	2.35	0.02	0.04	0.10	2.19	–
2015	2.26	0.02	0.03	0.09	2.13	–

3.2.17.4 N_2O recalculations 1.A

Table 106 shows the recalculations of N_2O emissions for the subcategories of sector *1.A Fuel Combustion.*

Recalculations of N_2O emissions 1990–2015 are mainly due to the switch from country specific emission factors to default emission factors of the IPCC 2006 Guidelines.

Table 106: 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	–0.02	0.01	–	–0.02	–0.01	–
1991	–0.02	0.01	–	–0.02	–0.01	–
1992	–0.02	0.01	–	–0.02	–0.01	–
1993	–0.02	0.01	–	–0.02	–0.01	–
1994	–0.02	0.01	–	–0.02	–0.01	–
1995	–0.02	0.00	–	–0.02	0.00	–
1996	–0.02	0.01	–	–0.02	–0.01	–
1997	–0.02	0.01	–	–0.02	–0.01	–
1998	–0.02	0.00	–	–0.02	0.00	–
1999	–0.01	0.00	–	–0.01	0.00	–
2000	–0.01	0.00	–	–0.01	0.00	–
2001	–0.01	0.00	–	–0.01	–	–
2002	–0.02	0.00	–	–0.01	0.00	–
2003	–0.02	0.00	–	–0.01	–	–
2004	–0.02	0.00	–	–0.01	0.00	–
2005	–0.02	0.00	0.00	–0.01	0.00	0.00
2006	–0.01	0.00	0.00	–0.01	0.00	–
2007	–0.02	0.00	0.00	–0.01	–0.01	–
2008	–0.03	0.00	–0.02	–0.01	–0.01	–
2009	–0.03	0.00	–0.03	0.00	0.00	–
2010	–0.03	0.00	–0.03	0.00	0.00	0.00
2011	0.00	0.01	–0.02	0.00	0.01	0.00
2012	0.02	0.01	0.00	0.00	0.01	–
2013	0.03	0.01	0.02	0.00	0.00	–
2014	0.02	0.01	0.02	–0.01	0.00	–
2015	0.01	0.01	0.01	–0.01	0.00	–

3.2.17.5 GHG recalculations [kt CO_2e] 1.A

Table 107 shows the recalculations in [kt CO_2 equivalent] for the subcategories of sector *1.A Fuel Combustion.*

Table 107: 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	–113.59	237.32	0.00	–2.51	–348.40	0.00
1991	–144.06	174.66	0.00	–3.51	–315.21	0.00
1992	–128.47	270.60	0.00	–3.42	–395.65	0.00
1993	–123.07	159.34	0.00	–3.35	–279.06	0.00
1994	–106.83	154.90	0.00	–3.04	–258.69	0.00
1995	–83.84	128.38	0.00	–2.92	–209.30	0.00
1996	–106.66	247.88	0.00	–2.40	–352.15	0.00
1997	–31.70	206.37	0.00	–1.91	–236.16	0.00
1998	–31.89	105.56	0.00	–1.94	–135.51	0.00
1999	–116.26	9.03	0.00	–1.35	–123.94	0.00
2000	–99.60	5.09	0.00	–1.16	–103.52	0.00
2001	–71.64	–63.31	0.00	–1.11	–7.21	0.00
2002	–49.68	–49.79	0.00	–1.44	1.55	0.00
2003	–38.62	–45.07	0.00	–1.52	7.96	0.00
2004	–51.35	–76.00	11.67	–1.43	14.41	0.00
2005	60.82	39.89	23.64	–1.19	–1.52	0.00
2006	87.91	57.75	30.99	–1.27	0.44	0.00
2007	85.48	60.36	4.89	–0.48	20.70	0.00
2008	80.51	65.67	–4.01	1.10	17.76	0.00
2009	–68.67	31.33	–137.86	1.60	36.26	0.00
2010	–74.57	0.74	–119.24	4.56	39.38	0.00
2011	–64.26	11.30	–130.78	5.95	49.27	0.00
2012	58.05	12.85	59.84	5.83	–20.46	0.00
2013	175.61	31.45	87.93	4.60	51.64	0.00
2014	167.18	–24.12	249.18	4.24	–62.11	0.00
2015	54.14	–170.28	274.95	4.13	–54.66	0.00

3.2.18 Planned Improvements

Category *1.A.4 Other Sectors* is planned to be improved by using more detailed regional data on heating types and year of installation leading to more accurate modelling of the twenty-two technology and fuel dependent main subcategories and shares of new and conventional heating stock within these subcategories over time series. Announced publications on building typology are expected to improve the module 'building energy performance' of the energy demand model for space heating.

It is expected to decrease uncertainty of category 1.A.4 emissions significantly if emission factors which are linked to regional statistical data more accurate are further developed. The level of detail of heating types will be evaluated to accurately consider the improved combustion efficiency of modern boilers and to cover upcoming heating system technologies.

3.3 Fugitive Emissions (Category 1.B)

3.3.1 Emission Trends

In 2016 0.5% of national total emissions arose from IPCC category *1.B Fugitive Emissions*. Table 108 presents GHG emissions arising from this category and the trend from 1990 to 2016.

Table 108: Greenhouse gas emissions from Category 1.B Fugitive Emissions.

	GHG emissions [kt CO_2e]		
	Total	**CO_2**	**CH_4**
1990	701.81	102.16	599.65
1991	569.10	111.16	457.94
1992	612.01	120.21	491.80
1993	580.42	112.20	468.21
1994	470.33	127.71	342.61
1995	464.03	127.22	336.81
1996	391.64	71.22	320.42
1997	436.27	120.70	315.58
1998	463.60	142.01	321.59
1999	496.35	170.72	325.62
2000	496.47	164.72	331.75
2001	514.60	182.93	331.67
2002	498.84	167.24	331.61
2003	515.39	184.02	331.37
2004	465.79	165.09	300.69
2005	437.16	160.09	277.07
2006	465.46	180.44	285.02
2007	471.64	184.70	286.94
2008	432.40	162.29	270.11
2009	480.19	204.93	275.25
2010	467.83	183.60	284.23
2011	461.06	179.60	281.46
2012	474.46	183.60	290.86
2013	471.49	190.94	280.55
2014	438.11	168.71	269.40
2015	424.39	161.71	262.67
2016	391.83	131.25	260.58
Trend 1990–2016	***–44%***	***28%***	***–57%***

3.3.2 Completeness

Table 109 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 occurring in Austria is one coking plant as part of an integrated iron and steel site.

Furthermore, emissions from oil and gas exploration and gas production 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 109: 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)]
ii Surface Mines			
1 Mining	050101 Open cast mining	NA	✓
2 Post-mining seam gas emissions	050103_X54 Surface mines - Postmining activities	NA	✓
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 a IPCC Tier 1 methodology except *1.B.2.b.4* (Transmission and Storage) 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 0.67×10^{-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/t and the conversion factor of 0.67×10^{-6} kt/m^3.

Table 110: Activity data (brown coal produced) and CH_4 emissions from mining and post mining activities for Fugitive Emissions from underground mines 1990–2016.

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
1990	870 403	10.5	1.5
1991	422 350	5.1	0.7
1992	478 095	5.8	0.8
1993	396 549	4.8	0.7
1994	82 625	1.0	0.1
1995	26 713	0.3	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
2014	NO	NO	NO
2015	NO	NO	NO
2016	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 more than 50% 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 111.

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 1.2m^3 CH_4/t coal and using the conversion factor of 0.67x10-6 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 0.67x10-6 kt/m^3.

Activity data are taken from the national energy balance and statistical year books (e.g. WKÖ 2005, WKÖ 2006).

Table 111: Activity data (brown coal produced) and CH_4 emissions from mining and post mining activities for Fugitive Emissions from surface mines 1990–2016.

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
1990	1 577 307	1.3	0.1
1991	1 658 382	1.3	0.1
1992	1 292 768	1.0	0.1
1993	1 294 644	1.0	0.1
1994	1 286 091	1.0	0.1
1995	1 270 718	1.0	0.1
1996	1 108 081	0.9	0.1
1997	1 130 303	0.9	0.1
1998	1 140 101	0.9	0.1
1999	1 137 388	0.9	0.1
2000	1 248 869	1.0	0.1
2001	1 205 618	1.0	0.1
2002	1 411 819	1.1	0.1
2003	1 152 383	0.9	0.1
2004	235 397	0.2	0.02
2005	6 168	0.005	0.0004
2006	6 677	0.005	0.0004
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

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.

For distribution and storage only NMVOC emissions are estimated, the CH_4 content of the NMVOC emissions is assumed to be negligible.

CH_4 emissions contribute 99.9% to GHG emissions from 1.B.2.a. In 2016 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 $5.4*10^{-06}$ kt per 1 000 m^3 oil transported by pipeline is used. For the calculation of CO_2 emissions, the default emission factor of $4.9*10^{-07}$ kt 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 31.66g CH_4/t crude oil input is used. It is in the range of default emission factors in the IPCC Guidelines between $2.6*10^{-6}$ and $41.0*10^{-6}$ kt per 103 m^3 oil refined. (The conversion from kt per 103 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 CH_4 g/t crude oil.

Table 112: Activity data (Crude Oil Refined) and emissions for Fugitive Emissions from Fuels – Oil Transport and Refining 1990–2016.

Year	Crude Oil Refined [kt]	Transport CH_4 [kt]	Refining CH_4 [kt]
1990	7 952	0.04	0.25
1991	8 273	0.05	0.26
1992	8 732	0.05	0.28

Year	Crude Oil Refined [kt]	Transport CH_4 [kt]	Refining CH_4 [kt]
1993	8 522	0.05	0.27
1994	8 898	0.05	0.28
1995	8 619	0.05	0.27
1996	8 754	0.05	0.28
1997	9 376	0.05	0.30
1998	9 190	0.05	0.29
1999	8 636	0.05	0.27
2000	8 240	0.05	0.26
2001	8 799	0.05	0.28
2002	8 947	0.05	0.28
2003	8 819	0.05	0.28
2004	8 442	0.05	0.27
2005	8 778	0.05	0.28
2006	8 513	0.05	0.27
2007	8 496	0.05	0.27
2008	8 710	0.05	0.28
2009	8 286	0.05	0.26
2010	7 719	0.04	0.24
2011	8 170	0.05	0.26
2012	8 349	0.05	0.26
2013	8 566	0.05	0.27
2014	8 435	0.05	0.27
2015	8 881	0.05	0.28
2016	8 185	0.05	0.26

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 distribution and storage and CO_2 and CH_4 emissions from combined oil and gas production and gas transmission 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 gas transmission are 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.

CH_4 emissions contributed 66% to total GHG emissions from *1.B.2.b* in 2016. In 2016 fugitive CH_4 and CO_2 emissions from natural gas contributed 0.5% to total greenhouse gas emissions in Austria. CH_4 emissions from natural gas decreased between 1990 and 2016 by 2% due to extension of the pipeline network and storage sites. Although the natural gas distribution network has more than doubled since 1990 in length, CH_4 emissions from this source have decreased 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 114).

Due to the implementation of technical measures there is only a slight increase of 41% in CH_4 emissions from storage between 1990 and 2016 although the storage capacity and volume increased by 268% within the same period of time.

Production

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 2016)* (see Table 113). 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 this category.

Methane emissions from production are calculated using IPCC Tier 1 with an aggregate production-based emission factor and the national production data.

Data 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 a calculation based on assumptions on the composition of raw gas, derived from the Executive Summaries *of the Austrian Petroleum Industry* [FVMI 1999–2016] has been developed and the OGP Tier 1 emission factor (0.0026 t CH_4/t oil and gas produced) was applied for the whole time series.

Table 113: Activity data (natural gas produced) and emissions for Fugitive Emissions from Fuels – Production 1990–2016.

	Production			
Year	**Gas Produced [Mio m³]**	**CH_4 [kt]**	**CO_2 [kt]**	**IEF CO_2 [kg/1 000 m³]**
1990	1 288	5.77	43	33
1991	1 326	6.19	43	32
1992	1 437	6.17	40	28
1993	1 488	6.21	37	25
1994	1 355	5.78	48	35
1995	1 482	5.89	38	26
1996	1 492	5.82	41	27
1997	1 428	5.61	31	22
1998	1 568	5.87	61	39
1999	1 741	6.35	90	52
2000	1 805	6.41	72	40
2001	1 954	6.69	88	45
2002	2 014	6.76	84	42
2003	2 030	6.76	84	41
2004	1 963	6.55	77	39
2005	1 637	5.80	77	47
2006	1 819	6.14	88	48
2007	1 848	6.20	89	48
2008	1 531	5.56	85	56
2009	1 670	5.83	103	61
2010	1 816	6.24	91	50
2011	1 684	5.86	91	54
2012	1 807	6.07	91	51
2013	1 467	5.38	103	70
2014	1 247	5.02	89	72
2015	1 166	4.73	89	77
2016	1 253	4.65	84	67

Sour Gas Processing

Activity data for 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 and storage has been collected in a national study for the year 1999 (WARTHA 2005). In this study emissions were calculated 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 gas transmission and distribution and gas storage. For this update a detailed survey and a literature study were performed. The data in this update was collected for the year 2009.

Fugitive CH_4 emissions from 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 for 2009. The lower emission factor in 2009 is due to technical improvements such as the exchange of valves and a reduction of gas that is released to the atmosphere during tests. It was assumed that technical improvements to reduce fugitive emissions from gas storage were made continually since the year that was assessed in the original study (WARTHA 2005) the emission factor was interpolated between 1999 and 2009. For years before 1999 the emission factor from the original study was used. From 2009 onwards the emission factor for 2009 was used. 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. The activity data was obtained from annual reports of the Association of the Austrian Natural Gas and District Heat Association (if no value was available for a certain year, the value of the year before or after was used) and from direct information from E-Control (Austrian Energy Regulator).

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 emissions calculated in 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 and 386 kg 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 storage were made continually since the year that was assessed in the original study (WARTHA 2005) the emission factor was interpolated between 1999 and 2009. For years before 1999 the emission factor from the original study was used. From 2009 onwards the emission factor for 2009 was used.The annual pipeline length was provided by the Austrian Natural Gas and District Heat Association and equals to pipelines working under high and medium pressure.

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 114. 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 were provided by the Austrian Natural Gas and District Heat Association for all years and with the material specific emissions factors from the national study emissions were calculated for each year. In the updated study (WARTHA 2011) no data on pipeline material was published and no new information could be obtainted from the Association of Gas- and District Heating Supply Companies. Therefore the calculation for gas distribution was not changed.

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 114 gives an overview of the development of the structure of the gas-distribution network since 1990. Specific annual information on the smaller emission sources, except connections to dwellings, mentioned above were not available, thus these emissions were kept constant. 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 114: Structure of the gas distribution network.

Gas distribution network	**Length of distribution network [km]**			**Change [%]**	**Emission factors [kg CH_4/km and year]**
Material	**1990**	**2000**	**2016**	**1990–2016**	
Insulated steel	2 881	3 760	3 452	+20%	25
Plastics (HDPE,PVC)	6 368	18 501	25 307	+297%	13
Ductile cast iron	2 213	1 720	1 435	–35%	701
Grey cast iron	210	118	2	–99%	892
Total	**11 672**	**24 099**	**30 215**	**+159%**	

Table 115: Activity data and emissions for 1.B.2.b.5 Fugitive Emissions from Fuels – Natural Gas Distribution and Sour Gas Processing 1990–2016.

Year	**Natural Gas Distribution**			**Sour Gas Processing**	
	Gas network	**CH_4 Emissions**	**CO_2 Emissions**	**Sour Gas Prod.**	**CO_2 Emissions**
	[km]	**[kt]**	**[kt]**	**[1 000 m³]**	**[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
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

Year	Natural Gas Distribution			Sour Gas Processing	
	Gas network	CH_4 Emissions	CO_2 Emissions	Sour Gas Prod.	CO_2 Emissions
	[km]	[kt]	[kt]	[1 000 m³]	[kt]
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

Table 116: Activity data and emissions for 1.B.2.b.4 Fugitive Emissions from Fuels – Natural Gas Transmission and Storage 1990–2016.

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
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

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%) the IPCC 2006 Guidelines.

For transmission the developed EFs (1999: 495 kg 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) and medium (2000) in the 2006 IPCC GL.

For distribution the IEFs range between 0.05 and 0.17 t/km/a, this is lower than the range given by IPCC. 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 3% for AD, 6% for EF, resulting in a total uncertainty of emissions of 7%.

3.3.6 Recalculations

1.B.2.b.2 production

Recalculations in CO_2 emissions in the category 1.B.2.b.2 (production) for the years 2003–2015 are due to revision of data reported *by the Association of the Austrian Petroleum Industry*). Since 2003 emissions from this source were erroneously reported including not only fugitive emissions but also pyrogenic emissions by one company. This error was corrected and led to a total reduction of CO_2e emissions from this source of −52.5 kt CO_2e in 2015 (cumulative 680 kt CO_2e between 2003 and 2015).

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 2016.

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 allocated to IPCC Category *1.A.2 Fuel Combustion – Manufacturing Industries and Construction* (see Chapter 3). For example the categories *pulp and paper* as well as *food and drink industry* emit only process related GHGs of biogenic origin and those have not been accounted for according to the guidelines.

Categories where emissions are not occurring because there is no such production in Austria, and categories that are not estimated or included elsewhere are summarized in Table 123.

4.1.1 Emission Trends

In 2016, greenhouse gas emissions from Sector *2 Industrial Processes and Product Use* amounted to 16 468 kt CO_2 equivalent, compared to 13 662 kt in 1990. These emissions constituted 20.7% of Austria's total greenhouse gas emissions (excluding LULUCF) in 2016 and 17.4% of total emissions in 1990.

Greenhouse gas emissions from this sector fluctuate during the reporting period:

- The minimum in 1993 results from the termination of primary aluminium production in Austria.
- The decrease from 2003 to 2004 is due to a strong reduction of N_2O emissions from the chemical industry.
- In the following years, emissions increased due to extended activities in the iron and steel industry.
- The trend from 2008 onwards is dominated by the effects of the economic crisis, followed by a moderate recovery.

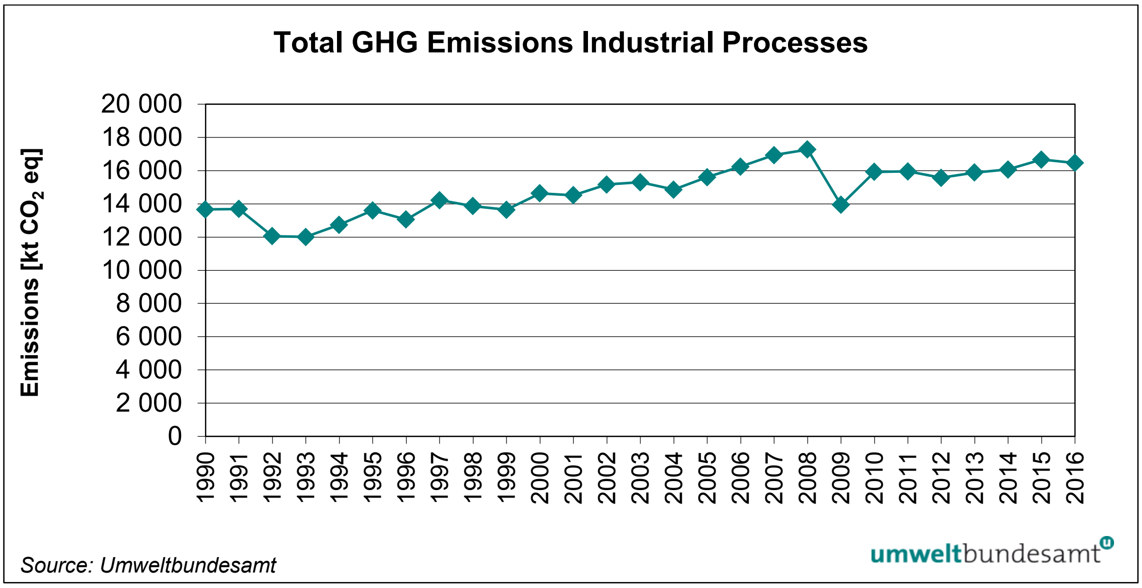

Figure 17: GHG emissions from Sector 2 Industrial Processes and Product Use 1990–2016.

Emission trends by gas

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 2016.

Table 117: GHG emissions from Sector 2 Industrial Processes and Product Use by gas.

GHG	Emissions [kt CO_2e]		Percent of total	
	1990	2016	1990	2016
Total	**13 662**	**16 468**	***100%***	***100%***
CO_2	10 871	14 162	*79.6%*	*86.0%*
CH_4	35	47	*0.3%*	*0.3%*
N_2O	1 100	170	*8.1%*	*1.0%*
HFCs	2	1 641	*0.0%*	*10.0%*
PFCs	1 183	50	*8.7%*	*0.3%*
SF_6	471	393	*3.4%*	*2.4%*
NF_3	0	6	*0.0%*	*0.04%*

Carbon dioxide constitutes the most important greenhouse gas of the IPPU sector, contributing 86% of emissions to this sector in 2016, followed by HFCs with 10%, SF_6 with 2.4%, N_2O with 1.1%, CH_4 with 0.3%, PFCs with 0.3% and finally NF_3 with 0.04%.

Table 118: Emissions from IPCC Sector 2 Industrial Processes and Product Use by gas from 1990 to 2016 and overall trend.

	Emissions [kt CO_2e]							
	Total	**CO_2**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF_6**	**NF_3**
1990	13 662	10 871	35	1 100	2	1 183	471	NO,NA
1991	13 696	10 735	35	1 115	4	1 193	614	NO,NA
1992	12 053	9 818	34	1 029	6	510	656	NO,NA
1993	12 004	9 858	35	1 068	235	64	744	NO,NA
1994	12 739	10 428	35	1 017	261	71	926	1
1995	13 605	10 979	35	1 048	353	83	1 100	6
1996	13 057	10 276	35	1 064	417	80	1 177	8
1997	14 219	11 414	35	1 053	498	117	1 086	16
1998	13 865	11 200	36	1 086	609	56	870	9
1999	13 647	11 037	35	1 111	701	79	676	8
2000	14 640	12 080	35	1 138	714	88	575	11
2001	14 521	11 899	34	968	863	116	629	11
2002	15 164	12 457	35	977	969	102	613	11
2003	15 305	12 462	35	1 039	1 072	126	549	22
2004	14 861	12 551	35	448	1 158	158	484	27
2005	15 610	13 312	36	430	1 146	163	494	28
2006	16 249	13 963	48	427	1 152	172	453	33
2007	16 938	14 624	48	414	1 196	230	367	59
2008	17 271	14 876	47	464	1 249	208	373	53
2009	13 947	11 911	46	299	1 309	36	342	5
2010	15 926	13 772	47	205	1 483	78	336	4
2011	15 955	13 930	47	187	1 407	74	307	4
2012	15 570	13 481	47	186	1 486	51	312	9
2013	15 887	13 777	49	186	1 512	49	305	10
2014	16 073	13 884	47	183	1 583	53	313	11
2015	16 669	14 449	47	180	1 620	50	310	13
2016	16 468	14 162	47	170	1 641	50	393	6
1990–2016	***+ 2808***	***+ 3291***	***+ 11***	***-931***	***+ 1638***	***-1132***	***-78***	***+ 6***

Concerning sub-categories of the sector, approx. 65% of GHG emissions (expressed in CO_2 equivalent) originate from *Metal Industry* (mainly *Iron and Steel Production*) and approx. 16% from *Mineral Industry*. 10% originate Product uses as substitutes for ODS, and 5% from *Chemical Industry* (mainly *Ammonia Production*).

CO_2 emissions

As can be seen 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 2016, CO_2 emissions from industrial processes amounted to 14 162 kt, which corresponds to an increase of 30% compared to 1990 emissions.

CH_4 emissions

CH_4 emissions from this sector 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 2016 were 33% above 1990 level.

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 2016, N_2O emissions from *Industrial Processes* were 85% below the level of 1990.

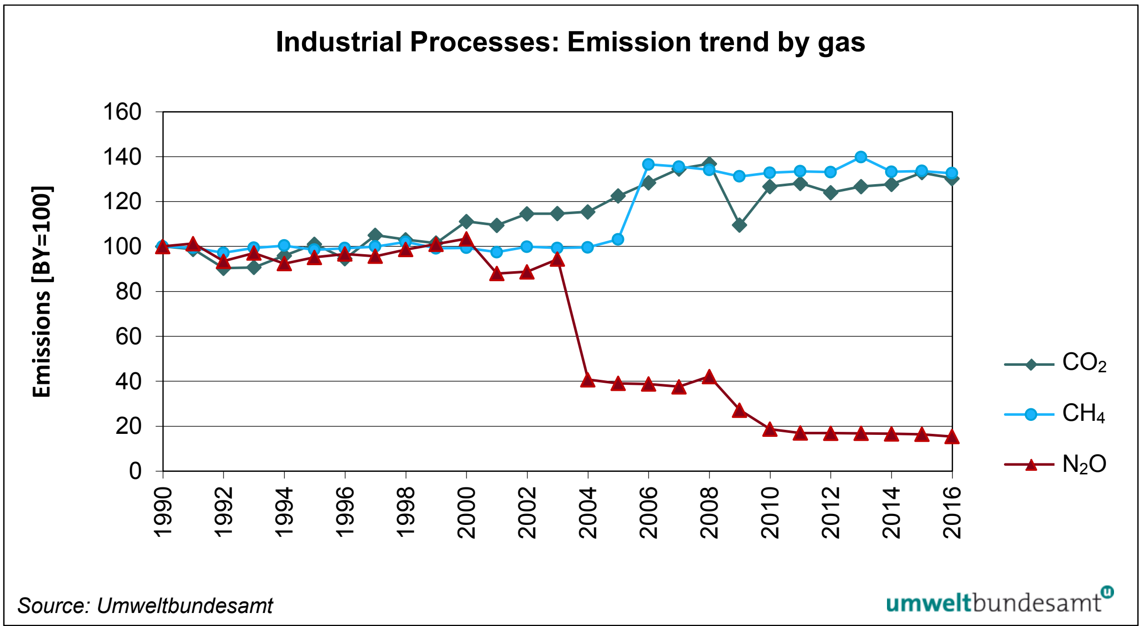

Figure 18: CO_2, CH_4 and N_2O emissions from Industrial Processes 1990–2016 (base year = 100).

HFC emissions

As can be seen in Figure 19, HFC emissions increased remarkably during the period from 1990 to 2016 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*.

HFC emissions continued to increase in recent years, as large numbers of HFC containing refrigerators, placed on the market at the beginning of the millennium, are decommissioned and emissions occur during disposal.

PFC emissions

As can also be seen in Figure 19, PFC emissions decreased remarkably during the period from 1990 to 1993 – from 1 183 kt CO_2 equivalent to approx. 50 kt CO_2 equivalent – 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. The level from 2009 onwards is dominated by the economic crisis which strongly affected this industry branch.

In 2016, PFC emissions amounted to 50 kt CO_2 equivalents, which is 96% 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 2016, SF_6 emissions amounted to 393 kt CO_2 equivalents which is 17% below the 1990 level.

NF_3 emissions

NF_3 emissions solely arise from semiconductor manufacture. NF_3 has been in use in Austria since 1994. In 2016, NF_3 emissions amounted to 6 kt CO_2.

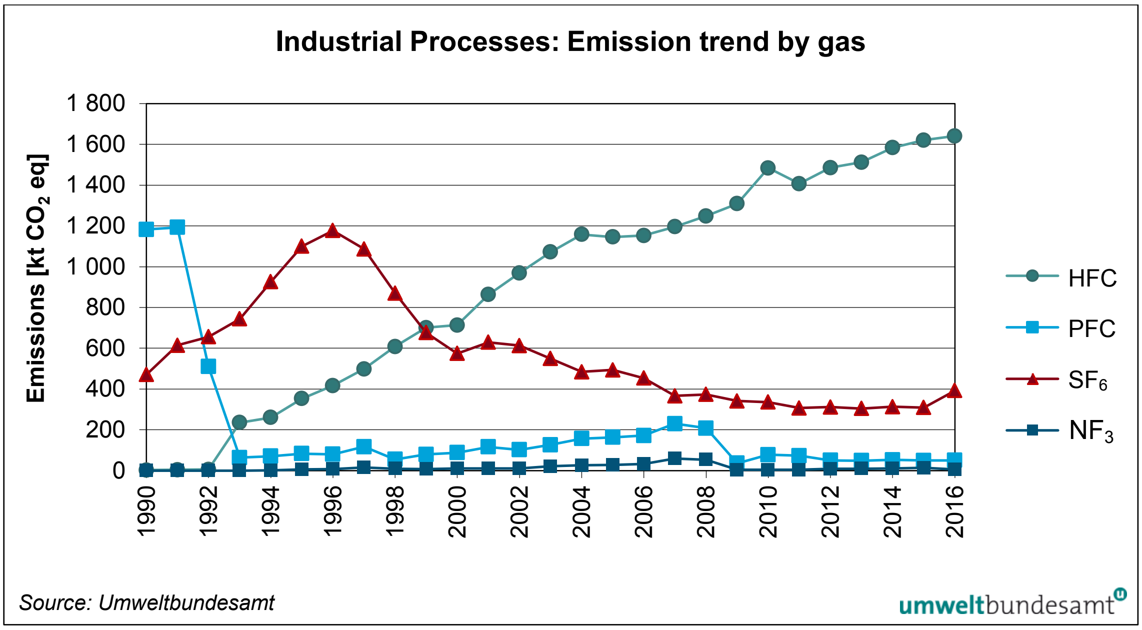

Figure 19: HFC, PFC, SF_6 and NF_3 emissions from Industrial Processes 1990–2016.

Emission trends by sources

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Industry* and *Mineral Industry*, which cause 64% and 17%, respectively, of the emissions from this sector in 2016 (see Table 119).

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 of Austria's greenhouse gas inventory (see below and Chapter 4.4.1).

Table 119: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use by Category, their share and trend for 1990 and 2016.

	Emissions [kt CO_2e]		**Share [%]**		**Trend 1990–2016**
	1990	**2016**	**1990**	**2016**	
2 Industrial Processes	13 662	16 468	100%	100%	21%
A Mineral Industry	3 092	2 788	0%	17%	-10%
B Chemical Industry	1 555	805	11%	5%	-48%
C Metal Industry	8 177	10 450	60%	63%	28%
D Non-Energy Products from Fuels and Solvent Use	349	205	3%	1%	-41%
E Electronics Industry	134	92	1%	1%	-31%
F Product Uses as Substitutes for ODS	0	1 638	0%	10%	-
G Other Product Manufacture and Use	355	491	3%	3%	38%

Figure 20 and Table 120 present greenhouse gas emissions from IPCC Sector *2 Industrial Processes and Product Use* by category for the years 1990 to 2016.

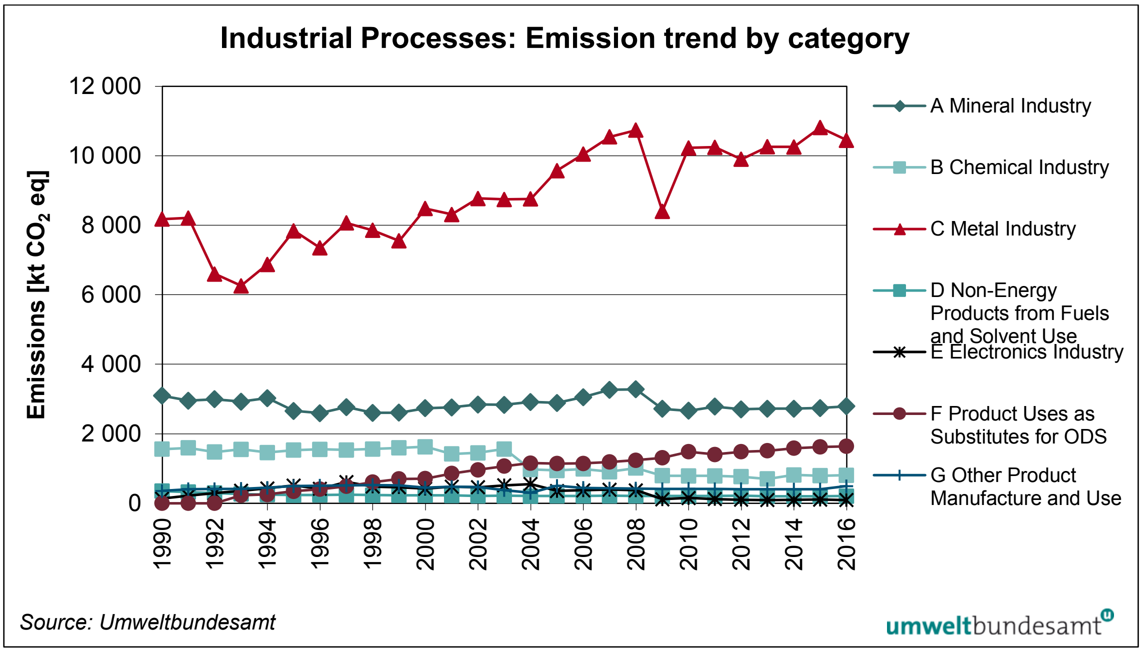

Figure 20: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use per category 1990–2016.

Table 120: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes (total and per category),1990–2016.

Year	GHG emissions [kt CO_2e]							
	2 Total	**2.A**	**2.B**	**2.C**	**2.D**	**2.E**	**2.F**	**2.G**
1990	13 662	3 092	1 555	8 177	349	134	0	355
1991	13 696	2 950	1 591	8 210	323	215	0	406
1992	12 053	2 990	1 471	6 599	295	287	0	410
1993	12 004	2 926	1 553	6 258	266	359	228	415
1994	12 739	3 027	1 460	6 876	250	429	252	445
1995	13 605	2 657	1 528	7 841	234	510	343	492
1996	13 057	2 594	1 552	7 348	239	414	405	505
1997	14 219	2 765	1 534	8 070	242	610	486	511
1998	13 865	2 602	1 560	7 856	236	479	605	526
1999	13 647	2 606	1 591	7 551	231	460	697	510
2000	14 640	2 733	1 624	8 480	228	420	709	446
2001	14 521	2 759	1 419	8 313	227	475	857	472
2002	15 164	2 843	1 448	8 772	212	459	964	465
2003	15 305	2 829	1 559	8 746	215	514	1 067	375
2004	14 861	2 916	973	8 759	209	552	1 153	299
2005	15 610	2 889	943	9 574	210	352	1 141	500
2006	16 249	3 053	983	10 047	209	370	1 146	441
2007	16 938	3 266	908	10 544	213	391	1 187	428
2008	17 271	3 276	1 012	10 737	212	371	1 239	424
2009	13 947	2 715	792	8 402	207	114	1 307	410

Year	GHG emissions [kt CO_2e]							
	2 Total	2.A	2.B	2.C	2.D	2.E	2.F	2.G
2010	15 926	2 661	785	10 227	207	150	1 481	414
2011	15 955	2 779	788	10 246	210	119	1 405	409
2012	15 570	2 704	762	9 901	216	101	1 483	403
2013	15 887	2 720	699	10 261	202	90	1 510	404
2014	16 073	2 722	814	10 256	202	97	1 581	401
2015	16 669	2 740	792	10 813	201	107	1 618	399
2016	16 468	2 788	805	10 450	205	92	1 638	491

2.A Mineral Industry

Greenhouse gas emissions decreased by 10% from 1990 to 2016 in this category. In particular, emissions from *Cement Production, Sinter Production and Glass Production* as well as *Bricks* decreased over that time period. Emissions from *Lime Production, Limestone, Dolomite and Soda Ash Use* increased. Only CO_2 emissions arise from this category.

2.B Chemical Industry

For the source *Chemical Industry*, greenhouse gas emissions remained quite stable over the period from 1990 to 2003, with nitric acid production as the main emission source (56% in 1990). Due to the implementation of emission reduction measures, ammonia production is now the main source, contributing 66% to total emissions from this category in 2016. Minor sources include nitric acid, carbide and ethylene production. In 2016, emissions were 48% 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* (+58%). The overall trend from 1990 to 2016 shows an increase by 28%. 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 41% below 1990 level. This is due to several legal measures (see chapter 4.4.1) that resulted in a decrease of emissions due to less solvent use, as well as less lubricant use.

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 2016 are 31% lower compared to 1990, which is due to 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 10% to the total emissions of the IPPU sector. Emissions from this sector did not occur in 1990, but emissions have been increasing ever since 1993. This is mainly due to the fact that refrigeration equipment and especially the use of air conditioning have increased.

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 have increased by 38% compared to 1990, due to stock emissions from uses of the 1990s and an increase in electrical equipment due to higher electricity consumption.

2.H Other

This category includes pulp and paper as well as food and drink industry. For these industries, energy-related emissions are reported in category 1.A.2. Under category 2.H, emissions of indirect greenhouse gases, but not greenhouse gas emissions are reported.

4.1.2 Key Categories

The following table summarizes the key categories in IPCC Sector *2 Industrial Processes and Product Use*.

Table 121: 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;TA
2.C.3	Aluminium Production	CO_2	TA
2.C.3	Aluminium Production	PFCs	LA 1990
2.C.4	SF_6 used in Al and Mg Foundries	SF_6	LA 1990; TA
2.C.7	Metal Industry: Other	SF_6	TA
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	LA 1990
2.F.1	Refrigeration and Air conditioning	HFC	LA 2016;TA
2.G	Other Product Manufacture and Use	N_2O	LA 1990
2.G.2.	Other Product Manufacture and Use- SF_6 and PFCs from other product use	SF_6	LA 2016

LA = Level Assessment (if not further specified – for the years 1990 and 2016)

TA = Trend Assessment 1990–2016

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. Methodologies are described for all IPCC categories.

For the sub category *2.B.1 Ammonia Production,* the methodology applied is similar to IPCC Tier 2, including accounting for carbon bound using country-specific parameters and accounting for emissions from downstream processes (urea, fertilizer and nitric acid production) to avoid double counting of emissions.

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 were available for the years 2005–2016. These emissions have been incorporated in the inventory as far as possible (see respective sub-chapters for more information). The relevant sources are *2.A.1 Cement Production, 2.A.2 Lime Production, 2.A.4.d Other Process Uses of Carbonates , 2.A.3 Glass Production, 2.A.4.a Ceramics, 2.A.4.c Non Metallurgical Magnesia Production, 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 122, for explanations see the respective subchapters).

Table 122: Uncertainty assessment for key sources of Sector 2 Industrial Processes and Product Use.

IPCC Category	Source Categories	Uncertainty [%]		
		Activity data	Emission factor	Emission estimate
2.A.1	Cement Production – CO_2	1.1	2.0	2.3
2.A.2	Lime Production – CO_2	1.6	5.0	5.2
2.A.4.d	Other – CO_2	20.0	2.0	20.1
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.4	SF_6 used in Al and Mg Foundries-SF_6	5.0	5.0	7.1
2.C.7	Metal Industry – Other – SF_6	5.0	5.0	7.1
2.D	Non-Energy Products from Fuels and Solvent Use – CO_2	5.0	10.0	11.2
2.F	Product Uses as Substitutes for Ozone Depleting Substances – HFC	20.0	50.0	53.9
2.G	Other Product Manufacture and Use (PFC, SF_6)	25.0	50.0	55.9

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[49] and the Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions[50].

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

Due to the reallocation of categories according to the 2006 IPCC Guidelines, emissions changed in various categories. In the following only those categories are presented where changes of emissions resulted from new activity data, methodologies or emission factors.

Update of activity data

2.B.1 Ammonia Production

Due to updated data of urea used in traffic (see below, 2.D.3)) as well as in agriculture (3.H) from 2005–2015, the time series for CO_2 emissions in sector 2.B.1 also changed to +5.2 kt CO_2e in 2015.

2.C.3. Aluminium Production

Plant specific data for secondary aluminum production have been updated from 2008 on.

2.F.1. Refrigeration and Air Conditioning

Due to information provided by railway and tramway companies, refills of air conditioning with 134a during the lifetime of the equipment happens on a regular basis. Thus, 134a used for refills during the lifetime of equipment of railed vehicles was subtracted from total R 134a use, which affected amounts used in refrigeration and air conditioning (Commercial Refrigeration as well as Industrial Refrigeration). The change amounts to −41.6 kt CO_2e in 2015, and –129.3 kt CO_2e in 2011)

2.F.4. Aerosols – Metered Dose Inhalers

Updated producer information provided information on two types of inhalers that contain R 227ea instead of R134a. Thus, numbers of units with R 227ea were re-allocated and the exact amount of gas used per inhaler used. Emissions in 2015 were updated by 0.1 kt CO_2e.

2.G.2 Other product manufacture and use

Updated numbers on SF6 use for particle accelerators for 2015 led to an update of emissions in 2015 by +0.2 kt CO_2e.

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[49] *Emissionszertifikategesetz 2011*, Federal Law Gazette I No. 118/2011, as amended

[50] Überwachungs-, Berichterstattungs- und Prüfungsverordnung, Federal Law Gazette II No. 339/2007, as amended

Improvements of methodologies and emission factors

2.C.3. Aluminium Production

Plant specific data have been updated from 2008 on. This lead to an improvement in the IEF from 2013 backwards. No changes in the emissions for 2014 and 2015.

2.B.10.i Chemical Industry – Other: Production of bulk chemicals

Due to a transcription error emissions for 2015 changed (−7.1 kt CO_2e).

2.F.1.d Transport Refrigeration

A transcription error was amended, which led to an increase of emissions in 2015 of 17.1 kt CO_2e

Reallocations

2.C.1. Iron and Steel Production

The allocation for 2015 changed due to an update of the emissions, which were formerly occurring in the sector 1.A.2.a are now allocated to 2.C.1.a. This resulted in +41.1 kt CO2e in 2015.

2.D.3.d Other

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 convertors 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).

2.G.4 Other

Carbon dioxide emissions from the use of urea in selective catalytic reduction are no longer reported under this category, but in category 2.D.3 instead, cf. above. For this reason emissions in 2015 are −26.5 kt CO_2e lower.

4.1.7 Completeness

Table 123 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 123: 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

	IPCC Category		SNAP	Status		
				CO_2	CH_4	N_2O
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 Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	040617	Magnesia sinter production	✓	NA	NA
	2.A.4.d Other Proces Uses of Carbonates – other	040618	Limestone and dolomite use	✓	NA	NA
2.B	**CHEMICAL INDUSTRY**					
2.B.1	Ammonia Production	040403	Ammonia	✓	✓	NA
2.B.2	Nitric Acid Production	040402	Nitric acid	NA[2]	NA	✓
2.B.3	Adipic Acid Production	040521	Adipic acid	NO	NO	NO
2.B.4	Caprolactam. Glyoxal and Glyoxylic Acid Production			NO	NO	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	NO	NO
2.B.7	Soda Ash Production	040619	Soda ash production and use	NO	NO	NO
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	NPK fertilisers Urea	✓	✓	NA
2.C	**METAL INDUSTRY**					
2.C.1	Iron and Steel Production					
	2.C.1.a Steel	040206	Basic oxygen furnace steel plant	✓	IE	IE
	2.C.1.b Pig Iron	040202	Blast furnace charging	IE[3]	IE	IE
	2.C.1.c Direct Reduced Iron			NO	NO	NO
	2.C.1.d Metal Industry Other – Sinter and Pelletizing Plant	040209	Sinter and pelletizing plant	NO	NO	NO
	2.C.1.e Pellet			NO	NO	NO

	IPCC Category		SNAP	Status		
				CO_2	CH_4	N_2O
	2.C.1.f Metal Industry – Other		Other iron cast etc.	✓	NA	NA
	2.C.1.f.1 Electric Furnace Steel	040207	Electric furnace steel plant	✓	NA	NA
	2.C.1.f.2 Rolling Mills	040208	Rolling mills	NA	NA	NA
	2.C.1.f.3 Foundries			NA	NA	NA
2.C.2	FerroFerroalloys Production	040302	Ferro alloys	✓	NA	NA
2.C.3	Aluminium Production			✓	NA	NA
	2.C.3. Aluminium Production - By-product emissions	040301	Aluminium Production	✓ 4) (PFC)		
2.C.4	Magnesium Production			✓ (F-Gases)		
2.C.5	Lead Production	030307		✓	NA	NA
2.C.6	Zinc Production			NO	NO	NO
2.C.7	Other – Non-ferrous metals	40309 X42	SF_6 Used in Aluminium and Magnesium Foundries	✓ (F-Gases)		
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	IE5)	NA	NA
	2.D.3.3 Roof covering with asphalt materials	040610	Roof covering with asphalt materials	IE5)	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	SF6 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

	IPCC Category	SNAP	Status		
			CO_2	CH_4	N_2O
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) Emissions are included in category 2.B.10.

3) Emissions are included in category 2.C.1.a.

4) Primary aluminium production was terminated in 1992.

5) Emissions are included in category 2.D.3.1.

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 2016. In 2016, CO_2 emissions from cement production contributed 2.2% 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 124 presents process-related CO_2 emissions from cement production for the period from 1990 to 2016.

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 124: CO_2 emissions from decarbonising in cement production, clinker production, raw meal used and implied emission factor, 1990–2016.

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

Year	Clinker [t]	Raw meal used [t]	Process specific CO_2 emissions [kt]	IEF [kg CO_2/t Clinker]
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
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
1990–2016			-15.0%	

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 2016 is minus 15.0%. Production decreased by 10.7% 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 with respect to the 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.

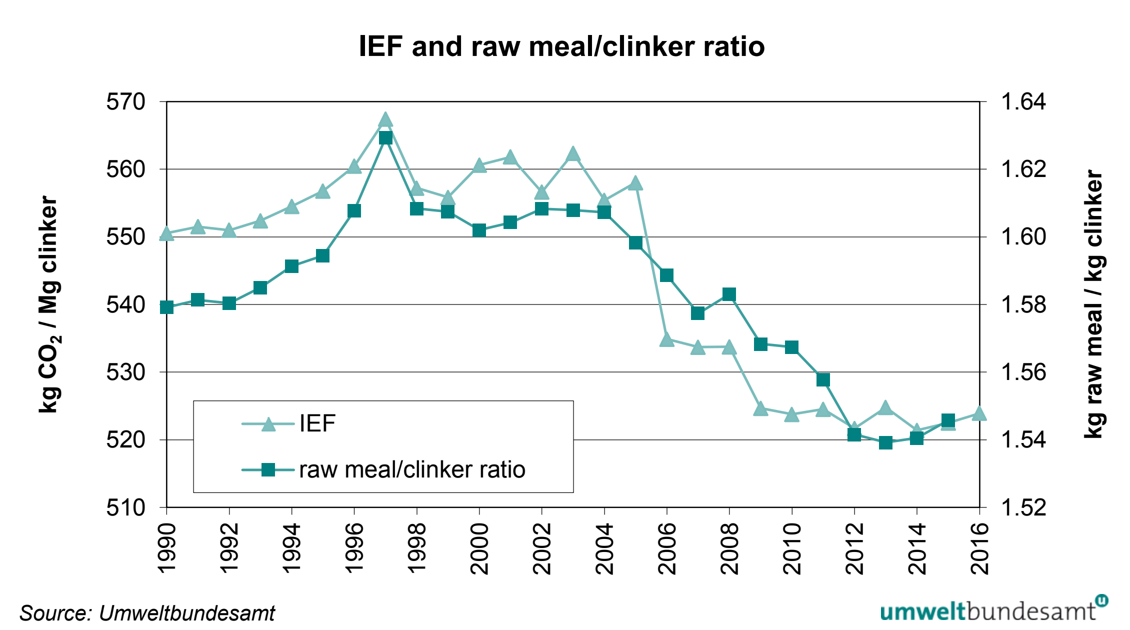

Figure 21: Time series of the implied emission factor (IEF) for cement production and ratio of raw meal used to clinker produced.

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 2004–2016 were determined in line with the requirements of the EU ETS. Verified CO_2 emissions, covering the whole cement industry in Austria, were reported directly by the Association of the Austrian Cement Industry; data are also published in annual reports (e.g. MAUSCHITZ 2017). The methodology for these emission calculations is the same as in the years before.

4.2.1.3 Source 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 2005–2016, 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 (1.1% – revision due to plant specific data for 2010). 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

No recalculations have been made for this years' submission.

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 2016, as well as because of their contribution in terms of their trend. In the year 2016, emissions from this category contributed 0.7% to the total amount of greenhouse gas emissions in Austria.

CO_2 is emitted during the calcination step of lime production. Calcium carbonate ($CaCO_3$) in limestone and calcium/magnesium carbonates in dolomite rock ($CaCO_3$•$MgCO_3$) are decomposed to form CO_2 and quicklime (CaO) or dolomite quicklime (CaO•MgO) respectively.

Table 125 presents activity data for this category (lime produced) as well as CO_2 emissions from lime production for the period from 1990 to 2016.

Table 125: CO_2 emissions, activity data and implied emission factors for lime production 1990–2016.

Year	LimeProduced [t]	CO_2 [kt]	IEF [kg CO_2/t lime produced]
1990	512 610	396	773
1991	477 135	361	757
1992	462 392	355	768
1993	479 883	365	761
1994	518 544	391	753
1995	522 934	395	755
1996	505 189	383	758
1997	549 952	413	750
1998	594 695	454	763
1999	595 978	453	761
2000	654 437	498	760
2001	666 633	507	760
2002	718 662	543	755
2003	754 156	572	758
2004	785 931	595	757
2005	788 328	579	734
2006	780 565	570	730
2007	816 370	596	730
2008	846 298	621	734
2009	695 019	507	730
2010	764 845	575	751

Year	LimeProduced [t]	CO_2 [kt]	IEF [kg CO_2/t lime produced]
2011	809 982	605	747
2012	761 040	569	748
2013	779 299	588	754
2014	786 565	589	749
2015	772 225	579	749
2016	772 526	582	753
1990–2016		46.8%	

The overall trend for CO_2 emissions from this category shows increasing emissions, with a pronounced dip due to the economic crisis in 2009. In the year 2016, emissions were 47% higher than in 1990 (see Table 125).

4.2.2.2 Methodological Issues

Emissions were estimated using a country specific method based on detailed production data.

Activity data and emission values were reported by the *Association of the Stone & Ceramic Industry.* For 2005–2016, verified CO_2 emissions reported under the ETS were used for the inventory.

The methodology for this emission calculation is the same as in the years before. The reported CO_2 emission data is 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.

For the years from 2005 onwards, detailed, verified data from the ETS is available: 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.

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 is also used in the process of 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. CO_2 resulting from decarbonising of limestone and combustion of coke is collected in a closed system and transferred to the purification unit. In fact, coke is used as a fuel specifically to maximise the amount of CO_2 available for the internal process.

In the sugar purification unit (see Figure 22), lime is added to the raw sugar solution. In a subsequent step, the CO_2 collected during decarbonisation is injected into the solution. At this point, the surplus CO_2 leaves the system. It has to be noted, that this surplus CO_2 corresponds to the amount of CO_2 from the combustion of the coke, which is reported as combustion emission in the energy sector. Surplus CO_2 is needed to ensure the conversion from lime to limestone. This limestone sediments and bounds the impurities in the raw sugar solution. The majority of CO_2 originating from lime is contained in the sediment. Known as 'Carbokalk', this solid by-product, which also contains organic substances and minerals (WASNER 2009), is used as a fertilizer.

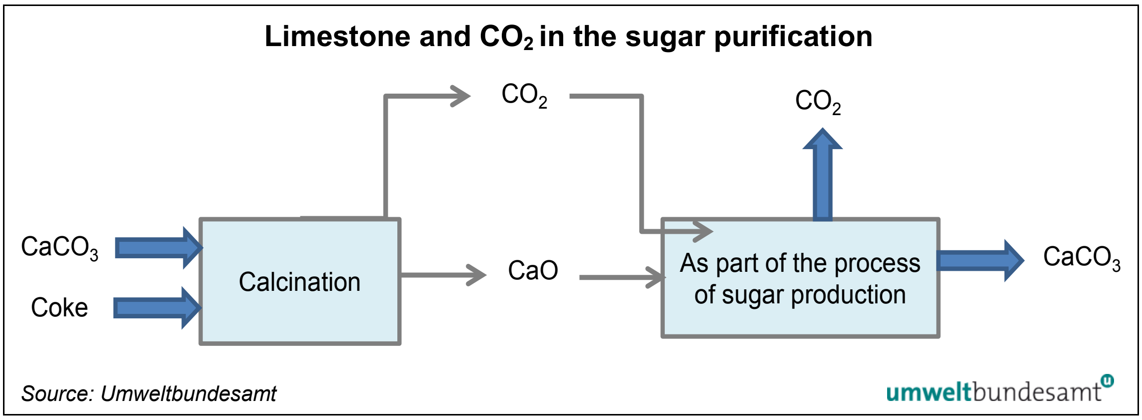

Figure 22: Purification step in the sugar production: lime production (calcination) and reaction of CO_2 and lime back to limestone (sediment).

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.

In addition, there is non-marketed lime production in the chemical industry in Austria that is reported under category 2.A.3. CO_2 emissions from the lime production step in calcium carbide production are included in category 2.B.4. Apart from the already-mentioned lime production in the chemical industry, in calcium carbide production and in the sugar industry, there is no identified non-marketed lime production in Austria.

4.2.2.3 Source 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.

4.2.2.4 Uncertainty Assessment

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 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

No recalculations have been made for this years' submission.

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 minor carbonates used in glass industry is considered. CO_2 emissions from glass production contributed 0.05% to total greenhouse gas emissions in Austria (without LULUCF).

4.2.3.2 Methodological Issues

From 2005 on, the IPCC methodology based on carbonates used was applied (2006 IPCC GL, Tier 3). For calculation of CO_2 emissions from 1990 to 2004, 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 used starting with 2005, EU ETS background data provided more detailed information on the actual carbon content of the carbonates used. Therefore, the IEFs from 2005 onwards are slightly different compared to the IPCC default values.

Activity data for limestone, dolomite and soda ash used in glass industry were reported by the *Association of Glass Industry* for the years 2002–2004 (2006 IPCC GL, Tier 2). For the years before, activity data was estimated using a constant ratio of the carbonates used per tonne of glass produced (glass production was reported by the *Association of Glass Industry* for all years) (2006 IPCC GL, Tier 1). This ratio includes the use of recycled glass for the total amount of glass produced. This value fits very well also for the following years and was considered to also reflect well the situation in the past, because glass recycling is common practice in Austria since the late 1970s.

For 2005–2016, verified CO_2 emissions and activity data, reported under the ETS, were considered for the inventory. These data cover small amounts of other carbonates used in glass industry that have been included from 2005 onwards.

Table 126 presents activity data and CO_2 emissions from this category for the period from 1990 to 2016.

Table 126: CO_2 emissions and carbonate use in glass production 1990–2016.

Year	Glass Prod. [t]	Limestone [t]	Dolomite [t]	Soda ash [t]	Other Carbonates [t]	CO_2 emissions [kt]
1990	398 515	17 449	24 020	46 690		39
1991	458 666	20 082	27 646	53 737		44
1992	405 863	17 770	24 463	47 551		39
1993	406 222	17 786	24 485	47 593		39
1994	434 873	19 040	26 212	50 950		42
1995	435 094	19 050	26 225	50 975		42
1996	435 094	19 050	26 225	50 975		42
1997	405 760	17 766	24 457	47 539		39
1998	405 760	17 766	24 457	47 539		39
1999	445 069	19 487	26 826	52 144		43
2000	375 348	16 434	22 624	43 976		36
2001	440 865	19 303	26 573	51 652		43
2002	389 497	17 054	23 477	45 633		38
2003	476 901	20 892	30 368	45 263		42
2004	356 702	15 178	19 208	28 559		28
2005	417 685	21 163	21 241	36 876	2 467	35
2006	448 176	21 103	23 405	38 814	2 673	37
2007	496 709	23 632	24 914	41 539	2 577	40
2008	504 213	25 852	28 411	45 186	1 741	44
2009	442 515	24 757	26 817	40 731	1 153	41

Year	Glass Prod. [t]	Limestone [t]	Dolomite [t]	Soda ash [t]	Other Carbonates [t]	CO_2 emissions [kt]
2010	498 156	23 841	26 082	40 527	1 276	40
2011	474 222	22 168	24 358	35 766	1 010	36
2012	472 040	19 719	27 188	35 415	609	37
2013	487 359	19 671	30 628	37 184	517	39
2014	496 782	19 011	28 473	35 180	577	37
2015	497 368	21 463	30 645	38 539	493	40
2016	480 781	18 027	20 933	24 959	23 856	38
1990–2016						-0.6%

4.2.3.3 Source specific QA/QC

Limestone and dolomite use in glass industry is compared with glass production figures.

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%. Thus different tier emthods were used; time series consistency was checked by comparison of the IEF.

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

No recalculations have made required for this years' submission.

4.2.4 Other Process Uses of Carbonates (2.A.4)

In this category, ceramics (bricks), magnesia sinter production and limestone use for desulphurisation 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 127 presents CO_2 emissions from bricks production for the period from 1990 to 2016. CO_2 emissions from bricks production showed a maximum in 1995/1996, which coincided with a peak in brick production. In 2016, emissions from this category contributed 0.1% to total greenhouse gas emissions in Austria and were -22% lower than in 1990.

Methodological Issues

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. For 2005–2016, verified CO_2 emissions, reported under the ETS, were used for the inventory (2006 IPCC GL, Tier 3). These data cover the complete brick industry in Austria. For intermediate years, the same implied emission factor was applied.

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. 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. Since 2006 the volumes sold of the short-term statistics are directly provided by the Statistik Austria on annual basis.

Table 127 presents activity data for production of bricks and CO_2 emissions for this category for the period from 1990 to 2016.

Table 127: Activity data and CO_2 emissions for bricks production 1990–2016.

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
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

Year	Bricks [m³]	CO_2 emissions [kt]	IEF [kg CO_2/m³]
2016	1 800 235	91	51
1990–2016		-21.7%	

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. The higher the density of the particular brick, the more CO_2 is emitted during production. High and low density bricks have different properties. Consequently, fluctuating quantities of brick types are produced from year to year depending on the demand.

Variations in the implied emission factor over time can also be attributed to changes in the carbon content of the raw material. 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

No recalculations have been made for this years' submission.

4.2.4.2 Other Uses of Soda Ash (2.A.4.b)

Source Category Description

Emissions: CO_2

Key Source: *No*

CO_2 emissions from soda ash use occur in metallurgy and other industries. CO_2 emissions from soda ash used in glass production are included in *2.A.7.c* Glass Production.

In 2016, 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 128: Activity data and CO_2 emissions for soda ash use 1990–2016.

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

Year	Soda ash used [t]	CO_2 emissions [kt]
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
1990–2016		109%

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. This data has been provided by Solvay Österreich GmbH (personal communication) for 2008 and 1990, as well as for 2009–2014. Activity for the other years was calculated by interpolation. From this total amount, the amount used in glass production was subtracted (reported in *2.A.3*). The remaining amount was classified emissive and non-emissive according to its use. Soda used for the production of detergents is subtracted as a non-emissive. Applications in metallurgy, like in the production of vanadium are declared as emissive, additionally any other unspecified use is also assumed emissive. The total amount of emissive use (metallurgy and other non-identified use) is included as activity data for CO_2 emission calculation.

In Austria, soda ash is *produced* by the Solvay process only which is CO_2-neutral except for coke used for calcination of limestone. This coke used in soda ash production was considered as fuel in the energy sector (subcategory *1.A.2.c*).

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

No recalculations have been made for this years' submission.

4.2.4.3 Magnesia Sinter Production (2.A.4.c)

Emissions: CO_2

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 2016. In 2016, this category contributed 0.4% to the total amount of greenhouse gas emissions in Austria.

During production of magnesia sinter, CO_2 is generated during the calcination step, when magnesite ($MgCO_3$) is sintered at high temperatures in a kiln to produce MgO. Magnesia sinter is processed in the refractory industry.

Table 129 presents CO_2 emissions from production of magnesia sinter for the period from 1990 to 2016. CO_2 emissions from magnesia sinter plants vary over the period from 1990 to 2016, 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 2005–2016, verified CO_2 emissions, reported under the ETS, were used for the inventory. Emissions are calculated according to "calculation method B: alkali oxides" in Annex II of the EU ETS monitoring and reporting guidelines[51]. The composition of the oxides is measured using X-ray fluorescence analysis.

Table 129 presents activity data and CO_2 emissions from this category for the period from 1990 to 2016.

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[51] 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.

Table 129: CO_2 emissions from magnesia sinter production 1990–2016.

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
1990–2016		-33.9%	

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.

Recalculations

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

4.2.4.4 Other (2.A.4.d)

Source Category Description

Emissions: CO_2

Key Source: *No*

In this category, CO_2 emissions from limestone use for desulphurization in power plants, chemical and other industry are considered. CO_2 emissions from decarbonising of limestone and dolomite in the glass industry are accounted for in *2.A.3* Glass Production. In 2016, this category contributed 0.02% to the total amount of greenhouse gas emissions in Austria.

Table 130: Activity data and CO_2 emissions from limestone and dolomite use 1990–2016.

Year	Limestone Used (Desulfurisation) [t]	CO_2 emissions [kt]
1990	48 647	21
1991	48 647	21
1992	53 247	23
1993	53 247	23
1994	54 065	24
1995	56 767	25
1996	56 767	25
1997	56 767	25
1998	56 767	25
1999	56 767	25
2000	56 767	25
2001	56 767	25
2002	56 767	25
2003	56 767	25
2004	56 767	25
2005	61 961	27
2006	87 010	38
2007	65 391	28
2008	58 505	26
2009	48 112	21
2010	43 036	19
2011	39 747	17
2012	33 642	15
2013	36 968	16
2014	40 417	17
2015	42 614	17
2016	52 579	19
1990–2016		-11.9%

Methodological Issues

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.

Source specific QA/QC

The country specific EFs for limestone were compared with the IPCC default range, they deviate from the IPCC default in the range of 1–2%, depending on the actual composition and fractional purity of limestone used.

For category *2.A.4.d,* the following specific QA/QC procedures are carried out in order to deliver accurate emission data (avoid missing emissions as well as double-counting) from limestone/dolomite use in Austria:

- Emissions were estimated using the methodology and – for comparison – the default emission factor of the IPCC guidelines.
- It was checked whether data cover all industrial activities of this type in Austria.

Uncertainty Assessment

Uncertainty of activity data derives mainly from emission of limestone and dolomite use in unidentified industries. For limestone, the uncertainty range is assumed to be 20%.Taking into account an uncertainty of 2% for the emission factor, this approach results in a combined uncertainty of emissions of 20.1%.

Recalculations

No recalculations have been required for this years' submission.

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)*

CO_2 emissions from production of ammonia are a key category due to their contribution to total greenhouse gas emissions in Austria in 1990 and in 2016. In 2016, 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. By way of these processes, 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 following process chart (Figure 23) shows the scheme of ammonia synthesis and downstream processes at the integrated plant: the main production lines (ammonia, urea, melamine, nitric acid, fertiliser etc.) with their main raw material as well their internal subsequent processing of related products.

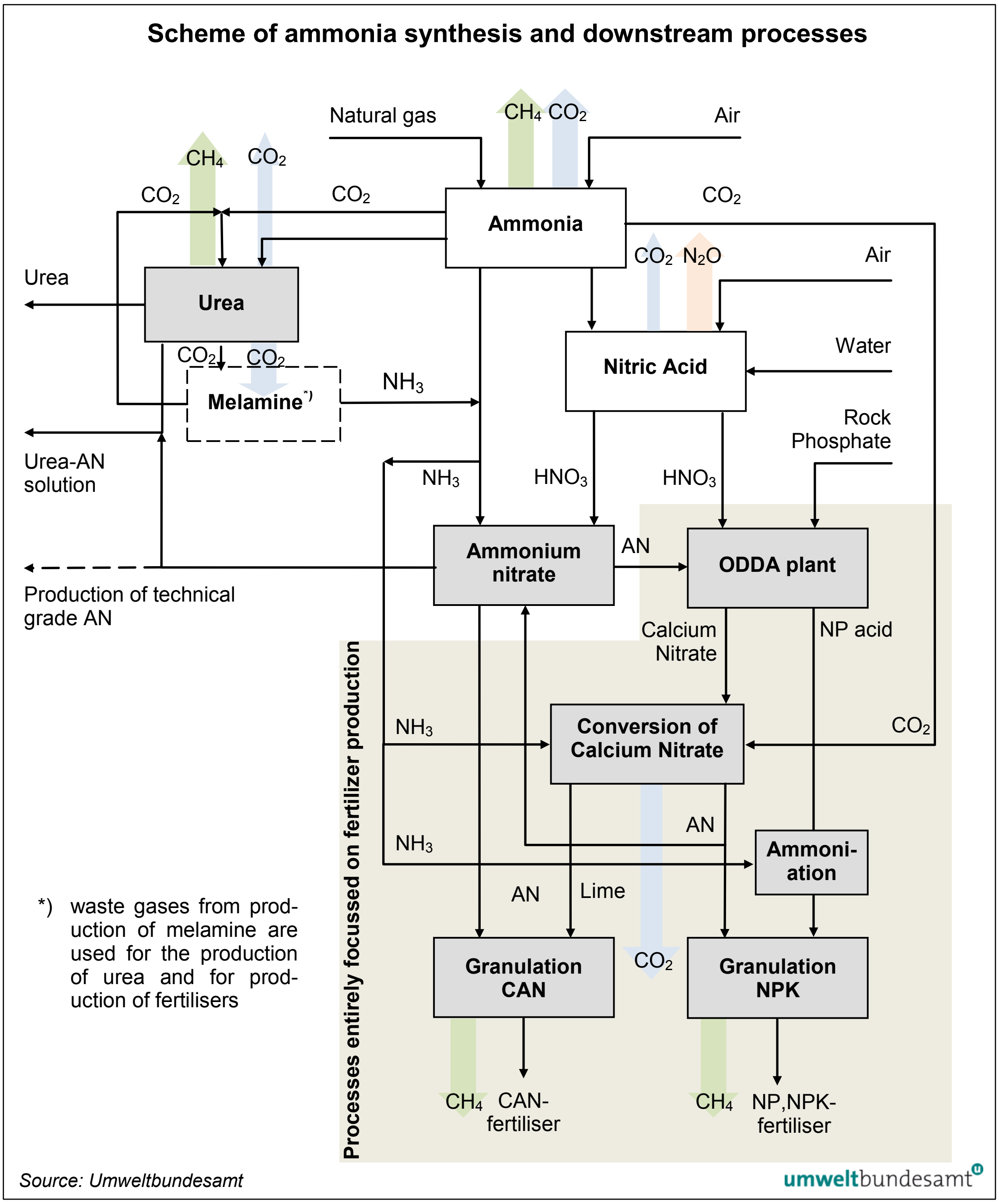

Figure 23: Scheme of ammonia synthesis and downstream processes at Austria's integrated ammonia plant. Note: Grey coloring highlights those processes entirely focused on fertilizer production.

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 131 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 2016.

Emissions vary during the period and closely follow the trend in ammonia production. CO_2 emissions reach a first minimum in 1994, a second in 2001, a third in 2007 and a fourth in 2009, all due to low production figures. In 2007 and 2009, production figures are low due to a lower demand as raw material for the production of fertilizers. In 2016, CO_2 emissions are 13% 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. Theoretically the CH_4 emissions constitute fugitive emissions. However they are reported here for simplicity reasons.

CO_2 emissions are calculated from natural gas input – 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. The total carbon input equals the total carbon output, consisting of the following components (compare Figure 23):

1. CO_2 emissions from **ammonia** production
2. Fugitive CH_4 emissions during start-ups of the **ammonia** production
3. CO_2 emissions from **nitric acid** production (downstream process at the same site). These emissions are reported under CRF category *2.B.2 Nitric Acid Production,* further explanation see chapter 4.3.1.
4. CO_2 and CH_4 emissions from **urea** production at the same site that both derive directly from ammonia. These emissions are reported under CRF category *2.B.5*, further explanation see chapter 4.3.6.
5. CO_2 emissions from **fertilizer production** (downstream process at the same site, see Figure 23). These emissions are reported under CRF category *2.B.5,* further explanation see chapter 4.3.6.

6. Carbon solid bounded and therefore stored in **melamine**.[52]

Consequently, CO_2 emissions from ammonia production were calculated by balancing the outputs from the overall carbon input.

The urea produced as a downstream product contains carbon which will be converted into CO_2 during urea use. There are two utilizations of urea, which are reported separately in the Austrian GHG emission inventory. On the one hand urea is used in the transport sector as a fuel additive, called 'AdBlue', to decrease the NO_x emissions of diesel engines by selective catalytic reduction. On the other hand urea is added to agricultural soils during fertilisation and therefore reported in sector Agriculture (see chapter 5.7). In line with the IPCC 2006 Guidelines, and in order to avoid double-counting, only those emissions are considered here, which are not reported elsewhere under 'urea use'. Hence, CO_2 emissions, caused by urea use in the transport and agriculture sector, listed in Table 131 are subtracted from CO_2 emissions reported under category *2.B.1*.

Table 131: CO_2 emissions from urea use within the borders of the country which are reported elsewhere and therefore are not reported in category 2.B.1.

Activity	Reported in category	Emissions in [kt CO_2]						
		1990	1995	2000	2005	2010	2015	2016
Urea use in selective catalytic reduction (SCR) in the transport sector	2.D.3.d other	NO	NO	NO	0.4	14.3	21.3	23.0
Application of urea to soils in the agriculture sector	3.H Urea application	4.5	7.9	8.4	11.8	19.6	23.6	31.3

Table 132 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 132: Activity data, emissions and implied emission factor for ammonia production 1990–2016.

Year	Ammonia produced [t]	Natural gas input [TJ]	CO_2 Emissions subtracted[53] [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	491	64	1 034
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

[52] According to the IPCC Guidelines no account should be taken for intermediate binding of CO_2 in downstream manufacturing processing and products. Nevertheless in the Austrian ammonia production facility melamine is produced, a product in which carbon can be considered to be stored for a long time. 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 highly stable structure.

[53] CO_2 emissions reported in other categories and bounded in solid matter, through the production of melamine.

Year	Ammonia produced [t]	Natural gas input [TJ]	CO_2 Emissions subtracted[53] [kt]	CO_2 Emissions [kt]	CH_4 Emissions [t]	CO_2 IEF [kg/t ammonia]
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	959
2008	489 131	11 137	142	475	88	970
2009	449 395	10 214	136	430	71	957
2010	495 353	11 248	146	477	70	964
2011	502 461	11 347	132	497	77	988
2012	479 475	10 881	129	473	76	987
2013	435 244	9 840	119	426	225	978
2014	537 000	11 973	133	530	86	987
2015	519 860	11 562	131	510	91	980
2016	551 118	12 093	143	527	69	957
1990–2016				**12.8%**	**10.2%**	

4.3.1.3 Source 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 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).

4.3.1.5 Recalculations

Due to updated data of urea used in traffic from 2005–2014 which have to be subtracted from emissions from ammonia production, the timeline has changed.

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 2016, this source contributed 0.05% to the total amount of greenhouse gas emissions in Austria, in contrast to a contribution of 1.1% in 1990.

In line with the IPCC 2006 Guidelines, N_2O emissions from nitric acid production are reported under category *2.B.2* and CO_2 emissions are reported under *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 133 presents N_2O and CO_2 emissions from production of nitric acid for the period from 1990 to 2016.

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[54] 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

[54] This facility is documented as example in BAT Reference Document LVIC-AAF, section 3.4.7 (EUROPEAN COMMISSION 2007)

In 2016, N_2O emissions were 95% below the emissions in 1990.

CO_2 emissions also varied over the period from 1990–2016, 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 133).

4.3.2.2 Methodological Issues

Following the IPCC Guidelines and monitoring and reporting guidelines[55] 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 the years 1990 to 1993 as no CO_2 emission data was available for these years.

[55] 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.

Table 133: Activity data, emissions and implied emission factors for N_2O and CO_2 from nitric acid production 1990–2016.

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	5.7	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	5.1	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	.37	0.73
2011	542 289	154	0.40	.28	0.74
2012	534 641	170	0.39	.32	0.74
2013	475 254	161	0.34	.34	0.72
2014	552 041	160	0.40	.29	0.73
2015	562 426	157	0.40	.28	0.72
2016	567 507	120	0.41	.21	0.72
1990–2016		**-95.9%**	**-1.8%**		

4.3.2.3 Source 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[56], 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.

[56] Überwachungs-, Berichterstattungs- und Prüfungsverordnung, Federal Law Gazette II No. 339/2007, as amended

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

According to WINIWARTER (2007), uncertainty of N_2O emissions is mainly affected by EF uncertainty (20%). The EF uncertainty is based on a national study from the beginning of the 1990s and is considered to be valid for 1990 emissions.

For recent years, an uncertainty of 5% was considered to be more appropriate, because the measuring of N_2O concentrations changed from discontinuous to online spectroscopic measurements. The uncertainty of activity data is assumed to be low (2%).

4.3.2.5 Recalculations

No recalculations have been required 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

Calcium carbide is produced by producing lime from calcium carbonate and subsequently reducing the lime obtained with carbon – both steps lead to emissions of CO_2.

This category is a minor source of CO_2 emissions in Austria. In 2016, it contributed 0.06% to national total emissions.

4.3.3.2 Methodological Issues

Activity data were directly reported by the plant operator of the only carbide production plant in Austria.

Emissions were estimated using a country specific methodology. An emission factor of 1.2957 t CO_2/t carbide obtained from industry was applied. It was obtained by summing up the emission factors for the lime production and the reduction step:

- Emission factor for the lime production step: 0.7153 t CO_2/t carbide produced
- Emission factor for the reduction step: 0.5804 t CO_2/t carbide produced

Table 134: Activity data and CO_2 emissions from calcium carbide production 1990–2016.

Year	Calcium Carbide [t]	CO_2 Emissions [kt]
1990	28 951	38
1991	27 159	35
1992	31 896	41
1993	25 374	33
1994	19 406	25
1995	20 236	26
1996	25 324	33
1997	25 313	33
1998	27 043	35
1999	25 047	32
2000	37 130	48
2001	36 026	47
2002	31 488	41
2003	32 010	41
2004	27 613	36
2005	27 677	36
2006	23 557	31
2007	28 004	36
2008	31 404	41
2009	32 459	42
2010	33 041	43
2011	38 155	49
2012	37 606	49
2013	37 159	48
2014	36 022	47
2015	40 639	53
2016	36 752	48
1990–2016		27%

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%. These are the default factors from the IPPC 2006 Guidelines.

4.3.3.4 Recalculations

No recalculations have been required for this year's submission.

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 2016). In Austria, there is only one plant, which produces Ethylene. This plant is located on the same general site as the refinery.

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 350 tonnes CH_4 until 2005 and 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, therefore detailed production data are available.

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 Uncertainty Assessment

The 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 have been required for this year's submission.

4.3.1 Chemical Industry – Other: CO_2 from Nitric Acid Production (2.B.10.i)

As under category 2.B.2 Nitric Acid Production only N_2O emission can be reported, this category was introduced to also report CO_2 emissions. For further details please see chapter 4.3.2.

4.3.2 Chemical Industry – Other: Production of bulk chemicals (2.B.10.ii)

4.3.2.1 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 154 kt in 2016.

4.3.2.2 Methodological Issues

Detailed information on process emissions for the years 2013 onwards are available as these processes were included in the ETS in 2013 year. For the years prior 2013, the emission factors obtained in 2013 were used and applied to activity data obtained from the industry.

4.3.2.3 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%

4.3.2.4 Recalculations

Due to a transcription error the emissions for 2015 have changed. (-7 kt CO_2)

4.3.3 Chemical Industry – Other: Production of Fertilizers and Urea (2.B.10.ii)

4.3.3.1 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.

This category is a minor GHG emission source in Austria: in 2016, total emissions from this category contributed 0.04% to national total emissions.

CO_2 emissions varied over the reporting period, following the trend of fertilizer production. They first decreased, reaching a minimum in 1997 and since then increased again. In 2016, emissions from this category significantly decreased again and were 20.9% lower than in 1990.

The high CO_2 emissions from urea production in 2010 resulted from repeated shutdown and start-up of the urea plant, leading to increased emissions.

4.3.3.2 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.

CH_4 emissions from the production of urea were reported for the years 2002–2016. For earlier years, no 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.

Data for fertilizer production for 1990 to 1994 were taken from national statistics (STATISTIK AUSTRIA), for 1995 to 2016, 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 1994 to 2016 were directly reported by industry and thus represent plant–specific data. With the emission and activity data from 1994, an implied emission factor for 1994 was calculated and applied to the years 1993 to 1990. CO_2 emissions from fertilizer production were calculated using a mass-balance approach.

CH_4 emissions from the production of fertilizers were reported for the years 2002–2016; 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 135 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 2016.

Table 135: Activity data, emissions and implied emission factors for CO_2 and CH_4 from NPK fertilizer production and urea production 1990–2016.

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	1 388 621	30	184	22
1991	295 000	0.29	113	0.97	1 273 467	28	168	22
1992	259 000	0.25	100	0.97	1 182 595	38	156	32
1993	305 000	0.30	117	0.97	1 250 804	34	165	27
1994	360 000	0.35	138	0.97	1 222 578	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
1999	408 386	0.24	157	0.59	988 662	20	131	20
2000	390 185	0.22	150	0.57	1 022 983	21	135	20
2001	367 218	0.26	141	0.70	959 698	20	127	21
2002	389 574	0.35	150	0.90	1 013 767	24	134	23
2003	447 450	0.18	163	0.39	1 073 940	24	134	22
2004	442 252	0.14	166	0.33	1 090 069	24	126	22
2005	416 407	0.21	156	0.50	1 043 916	24	149	23
2006	429 243	0.22	162	0.52	1 092 182	26	149	24
2007	384 402	0.43	144	1.12	892 680	20	118	23
2008	419 711	0.34	157	0.80	1 042 098	25	138	24

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]
2009	400 420	0.29	151	0.72	859 852	16	120	19
2010	419 997	0.49	156	1.16	1 051 087	26	140	25
2011	426 861	0.26	160	0.60	1 058 249	26	138	24
2012	421 659	0.22	156	0.53	1 034 833	28	137	27
2013	351 921	0.46	131	1.32	890 501	19	106	21
2014	433 364	0.20	159	0.46	1 046 152	22	126	21
2015	434 587	0.20	160	0.46	1 044 451	22	125	21
2016	446 020	0.22	165	0.50	1 065 611	24	128	22
1990–2016	**58.2%**	**-18.3%**				**-20.9%**	**-30.3%**	

4.3.3.3 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%

4.3.3.4 Recalculations

No recalculations have been required for this year's submission.

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, CH_4

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 2016 and in terms of their trend. In the year 2016, CO_2 emissions from production of iron and steel contributed 13.1% 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 2016. CO_2 emissions from Iron and Steel Production decreased from 1990 to 1992, then increased steadily following the trend of pig iron production, until this trend was interrupted by the economic downturn in 2009. In 2016, emissions were 57.6% above the level of 1990.

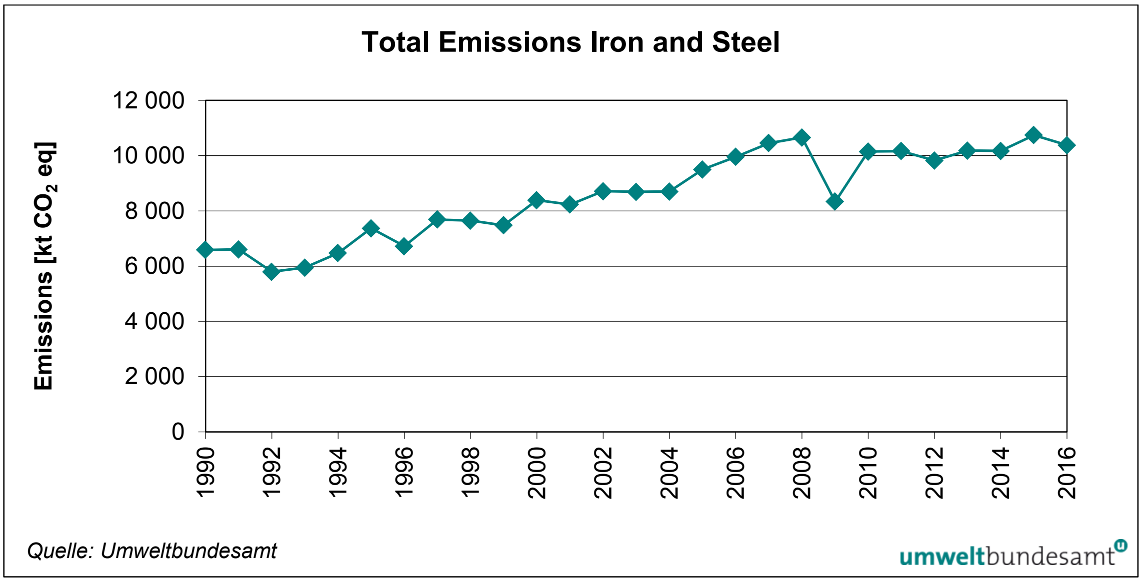

Figure 24: Time series of the CO_2 emissions from iron and steel production.

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 (consumption of electrodes in electric arc furnaces). In steel production, CO_2 emissions also result from the lowering of the carbon content of the input material (pig iron or steel scrap).

According to the IPCC 2006 Guidelines, all emissions from iron and steel production are reported under category 2.C.1, irrespective of their role as reducing agent or fuel. The only emissions that are still reported in the energy sector are those related to the coke oven and those from on-site power plants at the integrated iron and steel plants.

CO_2 emissions from the two integrated iron and steel plants in Austria were estimated using a mass balance. Detailed mass balance data are available from reporting under the EU ETS. As these data cover the overall integrated plants, emissions cannot be separated into subcategories *2.C.1.a* and *2.C.1.b*. Therefore, all emissions are reported und *2.C.1.a* (steel) and emissions under *2.C.1.b* (pig iron) are reported as "IE".

The emissions associated with the use of limestone as reducing agent were estimated according to the same method as previously under category *2.A* (verified emission data under the ETS; default emission factor for previous years).

For the overall emissions of the iron and steel plants from 2007 on, the following inputs and outputs were accounted for:

- CO_2 emissions from coke and coal introduced into the blast furnace: based on activity data reported by the company and emission factors from ETS data.
- CO_2 emissions from ore and steel scrap introduced into the process: from ETS data.
- CO_2 emissions from the use of reducing agents: from ETS data.
- CO_2 emissions from the use of additives: from ETS data.
- CO_2 removals from carbon leaving the integrated plant in products and by-products (iron, steel, blast furnace slag etc.): from ETS data.

All CO_2 emissions and removals were added up in order to estimate the overall CO_2 emissions of the integrated plants.

Emissions for the years 1990 to 2004 were estimated using correlation techniques.

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 2005–2016, 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.

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 2016 (approx. 0.071 kt CO_2 per kt steel) is close to the IPCC default value of 0.08.

Table 136 presents iron, steel and electric steel production and CO_2 emissions from this category.

Table 136: Activity data, emissions and implied emission factors for CO_2 and CH_4 from steel production 1990–2016.

Year	Iron and Steel Production			Electric Steel Production		Total CO_2 [kt]
	Iron [kt]	Steel [kt]	CO_2 [kt]	Electric Steel [kt]	CO_2 [kt]	
1990	3 444	3 921	6 591	370	20	6 610
1991	3 442	3 896	6 606	290	15	6 621
1992	3 074	3 592	5 797	361	19	5 816
1993	3 070	3 738	5 947	411	22	5 968
1994	3 320	3 968	6 472	431	23	6 494
1995	3 888	4 538	7 369	454	24	7 393
1996	3 432	4 032	6 721	396	21	6 742
1997	3 972	4 718	7 686	466	25	7 711
1998	4 032	4 801	7 647	503	27	7 674
1999	3 912	4 722	7 479	486	26	7 505
2000	4 320	5 183	8 391	541	29	8 420
2001	4 380	5 346	8 232	546	29	8 261

[3] Überwachungs-, Berichterstattungs- und Prüfungs-Verordnung, Federal Law Gazette II No. 339/2007, as amended

Year	Iron and Steel Production			Electric Steel Production		Total CO_2
	Iron [kt]	Steel [kt]	CO_2 [kt]	Electric Steel [kt]	CO_2 [kt]	[kt]
2002	4 669	5 647	8 714	538	28	8 742
2003	4 677	5 707	8 690	568	30	8 720
2004	4 861	5 901	8 703	614	32	8 736
2005	5 458	6 408	9 499	622	45	9 544
2006	5 565	6 487	9 960	643	49	10 009
2007	5 888	6 871	10 459	708	58	10 517
2008	5 846	6 873	10 656	723	57	10 713
2009	4 376	5 077	8 335	588	42	8 377
2010	5 644	6 570	10 151	637	47	10 198
2011	5 822	6 786	10 168	689	49	10 217
2012	5 751	6 746	9 822	674	46	9 868
2013	6 144	7 290	10 184	664	40	10 224
2014	6 015	7 185	10 171	691	39	10 210
2015	5 795	7 020	10 744	667	37	10 781
2016	5 634	6 766	10 382	666	36	10 418
1990–2016			**57.5%**		**85.1%**	**57.6%**

4.4.1.3 Source 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 2005–2016, 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[57]).

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%

[57] World Steel Association statistics archive, http://www.worldsteel.org/statistics/statistics-archive.html

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

Due to a transcription error in 2015 emissions, which were formerly reported in 1.A.2.a are now allocated to 2.C.1

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 2016, 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.

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 2016 were obtained by personal communication from the British Geological Survey, as the report had not been published at the time of emission calculation. These are the only available data on ferroalloys from the one company, that produces ferroalloys in Austria. On annual basis the company transmits their production data to the British Geologicial Survey.

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 137: Activity data and emissions from ferroalloys production 1990–2016.

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

Year	Ferroalloys production [kt]	CO_2 emissions [kt]
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
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
1990–2016		**-5.2%**

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 have been 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, 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 2016, emissions from this source contributed 0.01% to national total emissions.

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 PFC 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.

Table 138 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 138: 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 from1990 until 2016.

	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
1991	150	148	0.62	600
1992	60	59	0.62	600
1993	NO	NO	0.62	600
1994	NO	NO	0.62	600
1995	NO	NO	0.62	600
1996	NO	NO	0.62	600
1997	NO	NO	1.95	600
1998	NO	NO	1.95	770
1999	NO	NO	1.95	690
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	4.92	3.0
1990–2016	**–100%**	**–100%**	**699.0%**	**–99.5%**

4.4.3.2 Methodological Issues

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):

kg CF_4/t_{Al} = (1.7 x AE/pot/day x F x 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]*
AE_{min}	*= anode effect duration in minutes (5 min)*
F	*= fraction of CF_4 in the anode gas (13%)*
CE	*= current efficiency (85%)*
1.7	*= constant resulting from Faraday's law*

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 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 the industry.

In secondary aluminium smelting works, normally inert gases without additives are used to remove, prior to casting, hydrogen as well as alkaline and alkaline earth metals and solids from smelt to prevent porosity in the cast pieces (aluminium cleaning). Until 2000 in some cases a purification system of inert gases is used to which SF_6 is added in concentrations of 1–2.5%.

For aluminium casting SF_6 as a fire quencher was used until 1999, when it was not further used by companies. From the (formaly) six secondary aluminium smelters only one started the use of SF_6 as cleaning gas again from 2006 onwards. 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).

In 2015 the secondary aluminium plant closed down for a few months due to bankruptcy of the company, and was reopened in 2016 under new management.

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

Plant specific data have been updated from 2008 on. This lead to an improvement in the IEF from 2013 backwards. No changes of the emissions in 2014 and 2015.

4.4.4 SF_6 Used 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 2016 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 139 presents SF_6 emissions from magnesium for the period from 1990 to 2016.

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 2016 they decreased by nearly 100%. 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[58]. Currently, only one aluminium foundry uses SF_6 in some cases, and one magnesium foundry uses SF_6 as a cover gas for one particular magnesium alloy that is produced irregularly.

[58] Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenho use gases.

Table 139: SF_6 emissions from magnesium foundries 1990–2016.

Year	SF_6 emissions [t] from magnesium production
1990	10.00
1991	11.00
1992	10.00
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	0.68
2015	0.10
2016	0.10
1990–2016	**–99.0%**

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 coer gas, but continued the use of SF_6 to quech fires.

4.4.4.3 Source 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 have been required 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 2016 has a fluctuation range of ± app.20%.

This category is a minor source of CO_2 emissions in Austria: in 2016, emissions from this source contributed 0.01% to national total emissions.

4.4.5.2 Methodological Issues

Activity data are taken from the Montanhandbuch, 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. As data for 2016 were not available in time, the annual production for 2015 was used.

Table 140: Activity data and CO_2 emissions from secondary lead production 1990–2016.

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

Year	Secondary lead production [t]	CO_2 Emissions [kt]
1999	21 955	4.4
2000	21 977	4.4
2001	21 998	4.4
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	24 399	4.9
1990–2016		**3.8%**

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 50.99%. These uncertainties are IPPC default values for the Tier 1 method in the secondary lead production.

4.4.5.4 Recalculations

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

4.5 Non-Energy Products from Fuels and Solvent Use (Category 2.D)

4.5.1 Source Category Description

Emissions: CO_2 (indirect)

Key source: Yes (CO_2)

This chapter entails greenhouse gas emissions from non-energy products from fuels and solvent use (former CRF sector 3, Solvent and other Product Use) in Austria. This includes emissions from lubricant use (which used to be accounted for in the waste and transport sector) and emissions from paraffin waxes. In the year 2016, 0.26% of total GHG emissions in Austria (179.01 kt CO_2 equivalents) originated from *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 41% from 1990 to 2016, due to several legal requirements that are described in the different subsectors.

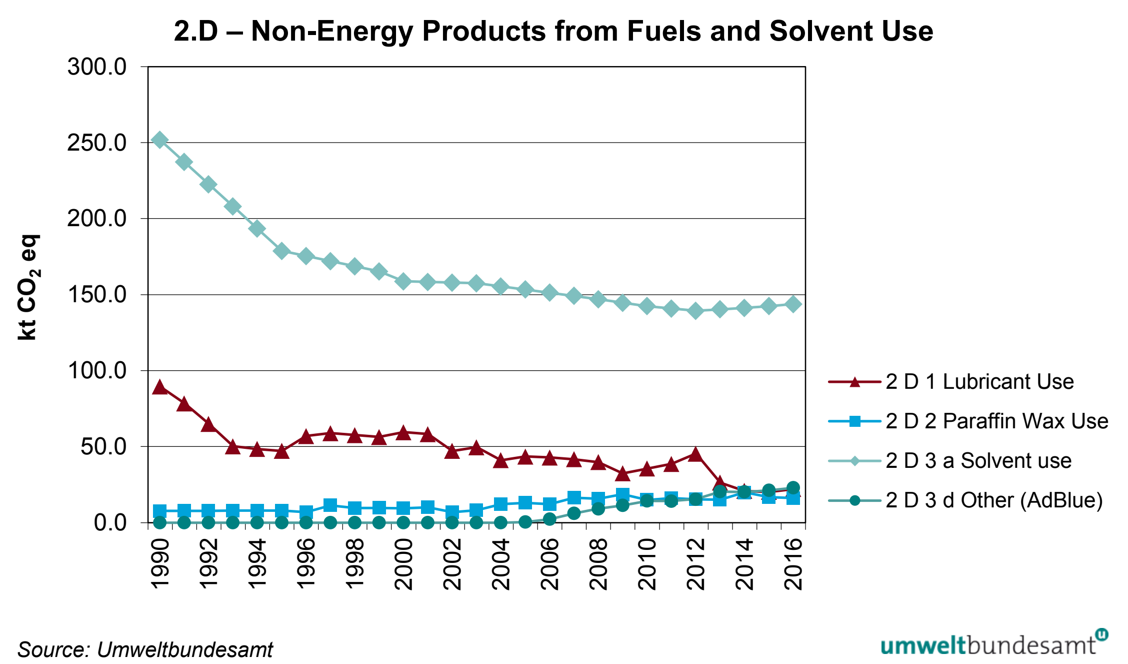

Figure 25: Emissions from Sector 2.D, Non-Energy Products from Fuels and Solvent Use, 1990–2016.

Table 141 presents the trend in total greenhouse gas emissions by subcategories.

Table 141: Total greenhouse gas emissions and trend from 1990–2016.

Year	2.D.1 Lubricant Use	2.D.2 Paraffin Wax Use	2.D.3.a Solvent use	2.D.3.b Road paving with asphalt	2.D.3.c Asphalt roofing	2.D.3.d Other (AdBlue)
1990	89.5	7.8	251.8	IE	IE	NO
1991	78.5	7.9	237.2	IE	IE	NO
1992	65.0	8.0	222.6	IE	IE	NO
1993	50.3	8.0	208.0	IE	IE	NO
1994	48.4	8.1	193.4	IE	IE	NO
1995	47.2	8.1	178.8	IE	IE	NO
1996	57.0	7.1	174.8	IE	IE	NO
1997	58.9	11.5	170.8	IE	IE	NO
1998	57.6	9.7	166.8	IE	IE	NO
1999	56.4	9.8	162.8	IE	IE	NO
2000	59.5	9.6	158.8	IE	IE	NO
2001	58.2	10.2	158.3	IE	IE	NO
2002	47.2	7.0	157.9	IE	IE	NO
2003	49.7	8.4	157.5	IE	IE	NO
2004	41.1	12.2	155.4	IE	IE	NO
2005	43.5	13.2	153.4	IE	IE	0.37
2006	42.9	12.4	151.3	IE	IE	2.27
2007	41.7	16.6	149.1	IE	IE	6.07
2008	39.8	16.0	146.9	IE	IE	9.20
2009	32.5	19.0	144.7	IE	IE	11.42
2010	35.6	14.9	142.4	IE	IE	14.35

Year	2.D.1 Lubricant Use	2.D.2 Paraffin Wax Use	2.D.3.a Solvent use	2.D.3.b Road paving with asphalt	2.D.3.c Asphalt roofing	2.D.3.d Other (AdBlue)
2011	38.6	16.2	140.9	IE	IE	14.17
2012	45.4	15.4	139.4	IE	IE	15.53
2013	26.4	15.5	140.3	IE	IE	20.39
2014	20.8	19.9	141.3	IE	IE	20.26
2015	20.2	16.9	142.4	IE	IE	21.29
2016	22.1	16.1	143.7	IE	IE	22.95

Emissions from asphalt roofing (*2.D.3.c*) are accounted for in the solvents model (category *2.D.3.d* chemical products) therefore emissions are reported as "IE". The significant reduction of greenhouse gas emissions in this sector between 1990 and 2015 is mainly due to decreasing solvent and N_2O use as well as due to the positive impact of the enforced laws and regulations in Austria.

4.5.2 Methodological issues

4.5.2.1 Lubricant Use (2.D.1)

Emission calculation follows the rules set out in 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 estimated, as there are hardly any 2-stroke engines in use in Austria, and an estimation of the amount of lubricants used in the 310 million km driven by 2 stroke engines per year amounts to 0.2 kt CO_2, which is below the uncertainty threshold.

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.

Paraffin wax use is based on 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 turned into TJ, using a Net Calorific Value of 40.2 TJ/kt, and then 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 CO_2/C

4.5.2.3 Other: Solvent Use (2.D.3)

This methodology was renewed in 2015, and based on reported emissions from the VOC directive:

This chapter describes the methodology used for calculating air 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)[59] (repealed by Solvent Ordinance 1995)
- Solvent Ordinance 1995[60] (repealed by Solvent Ordinance 2005)
- Paint finishing systems Ordinance (1995)[61] (repealed by VOC Installations Ordinance)

In the subsequent years the legislation was adapted to be in line with European legislation:

- VOC Installations Ordinance (2002)[62], implementation of"Solvent Emission Directive"[63]
- VOC Ordinance 2005[64] – implementation of"Paints Directive"[65]

[59] Verordnung des Bundesministers für Umwelt, Jugend und Familie über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung**), BGBl. Nr. 492/1991

[60] Verordnung des Bundesministers für Umwelt über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung 1995 – LMVO 1995**), BGBl 872/1995

[61] 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

[62] 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

[63] 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

- Amendment of VOC Ordinance (2005) [66] – implementation of "Industrial Emissions Directive" 2010/75/EC[67]

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.

CO_2 emissions from solvent use were calculated from NMVOC emissions of this sector. As a first step the quantity of solvents used and the solvent emissions were calculated, then CO_2 emissions allocated depending on the solvents used.

NMVOC emissions

To determine the quantity of solvents used in Austria in the various applications, a bottom up and a top down approach were combined. 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 inquires in solvent consuming sectors

Top down data:

Data from national import/export and production statistics provide a balance for substances used as solvents and solvents contained in products

$$\text{Solvent Balance per Substance}_i = (\text{Substance}_i \text{ Import} - \text{Substance}_i \text{ Export} + \text{Substance}_i \text{ Production})$$

From the Solvent Balance per Substance (or substance group, respectively) the non-solvent use of substances (i.e. where the substance is used as a reagent) is subtracted:

$$\text{Solvent Use per Substance}_i = \text{Solvent Balance per Substance}_i - \text{Non Solvent Use of Substance}_i$$

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 accounted for in this equation, as the amount of solvents used for their production are already accounted for in the above mentioned balance based on substance (groups):

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[64] 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

[65] 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

[66] 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

[67] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

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 Use per Substance$_i$+ $\sum p$ Solvents in Product$_p$

QA/QC measures as explained under "recalculations" showed that variations from year to year reflect market effects rather than actual changes in overall consumption, this is why a regression estimation of the top down data is used rather than annual data, which fluctuates. Where data on the overall consumption is available from the bottom up approach, it is used for those years; data for the years in between is interpolated. The reason behind this approach is that it became apparent that an analysis of the statistical data every year is far more difficult than retrospective analysis of a period of years. In an annual evaluation of statistical data, it is impossible to differentiate between short term market or consumption effects and long term developments (such as new non solvent application processes) that would make methodological changes or new further inquiries/data necessary.

Bottom up data:

Extensive inquiries concerning solvent applications were made in several studies in the 90ies (WINDSPERGER et al. 2002a/2002b/2004/2008): for a reference year (2000) and several other years (1980, 1990, 1995, 2003) and the amount of solvents consumed in the different sub categories was estimated.

In a first step an extensive survey on the use of solvents in the year 2000 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 was gathered on:

- 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 142).

Table 142: 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 solvents used per industrial branch were extrapolated using the number of employees (the values of "solvent use per employee" of the sample was multiplied by total employment of the relevant branches taken from national employment statistics (STATISTIK AUSTRIA) and using information from the credit rating association, which provided numbers of employees for the companies in question.

For three years (1980, 1990, 1995) the values for solvent use were extrapolated using the factor "solvent use per employee" of the year 2000 and the number of employees of the respective year taken from national statistics (STATISTIK AUSTRIA) (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).

In a second step a survey in 1 800 households was conducted (WINDSPERGER et al. 2002a) for estimating the domestic solvent use (37 categories in 5 main groups: cosmetic, do-it-yourself, household cleaning, car, fauna and flora). Also, solvent use in the context of moonlighting besides commercial work and do-it-yourself was calculated.

The comparison of top down and bottom up approach helped to identify several additional applications that contribute to a large extent to the total amount of solvents used. Thus in a third step the quantities of solvents used in these applications such as windscreens wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism, cement- respectively pulp industry, were estimated in surveys.

The outcome of these three steps was the total stock of solvents used for each application in the year 2000 (at SNAP level 3) (WINDSPERGER et al. 2002a). To achieve a time series the development of the economic and technical situation in relation to the year 2000 was considered. It was distinguished between "general aspects" and "specific aspects". The information about these defined aspects 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. On the basis of this information calculation factors were estimated. With these factors and the data for solvent use and emission of 2000 data for the years 1980, 1990 and 1995 was estimated. For the years in between data was linearly interpolated. Up until 2015, the 2000 data was also used for the subsequent years as no new survey had been conducted, up until 2015. For the reporting year 2015, data based on the assumptions of growth of the sector was applied, or constant emissions assumed. An in-depth re-evaluation of data obtained from reports under the VOC solvents directive is currently being performed, as well as further re-evaluations of the top down approach.

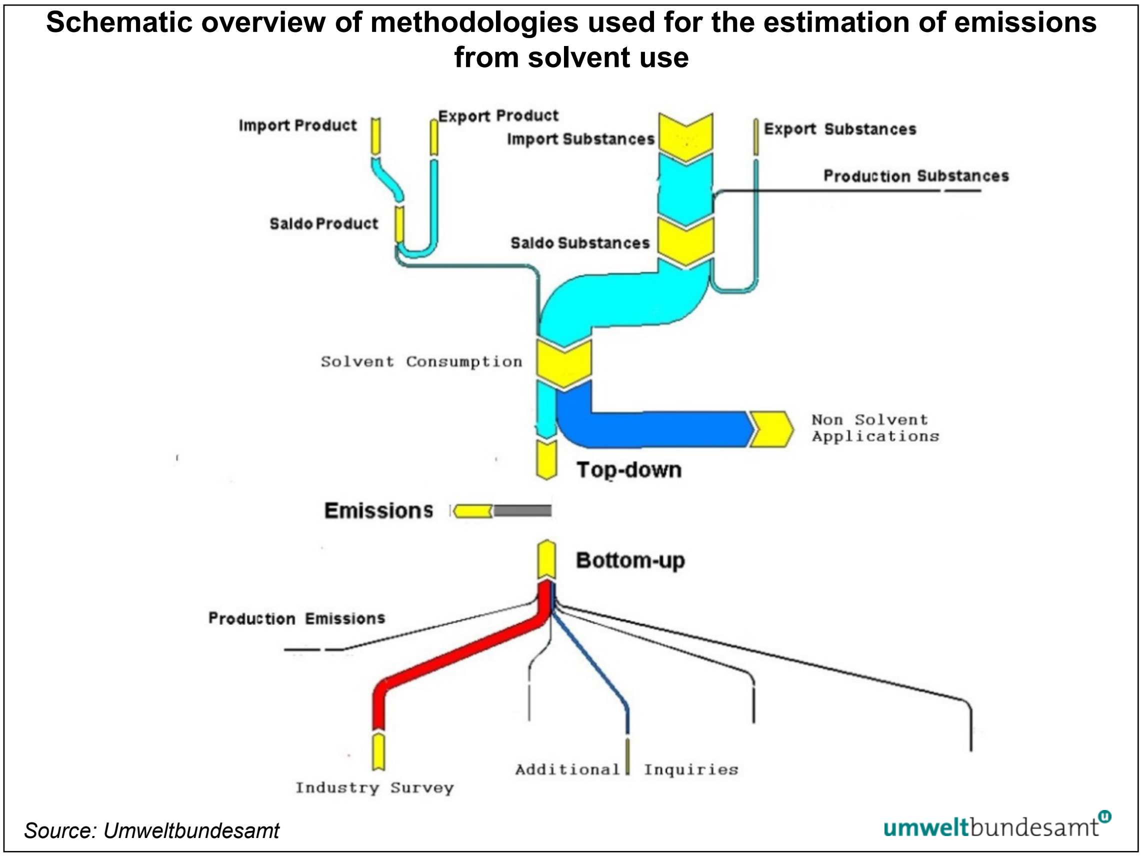

Figure 26: Combination of top-down and bottom-up methods for the calculation of emissions.

Top down / bottom up combination:

Data from the top down/bottom up approach (for the reference year 2000) were compared, and sub sectors further investigated, until the data matched. This was also done for the recalculation for the years after 2000. Data was then split into sub sectors (based on those investigations) and this data also used for the extra- and interpolation of data for those years, for which no data on the development of the market was available. Finally, emission factors mainly from the inquiries of the bottom-up approach were applied, resulting in final emissions data per sub category.

For the years 2003 onwards the following improvements were made:

- new data collected in the course of the VOC installations ordinance mentioned above was used to update emissions data for 2012:

  Data available from reports under directive 1999/13/EC (VOC Solvents Directive)[68] was collected, and the allocation of the respective companies to different subsectors of the directive checked, and compared to those of the reporting requirements. It has to be noted that the reporting requirement under this directive (ordinance) comprises only emissions data, that's why the full implementation into the model requires further investigations concerning emission factors. Where no complete coverage was given, employment data was used to extrapolate emissions for total sub category emission in Austria. For those categories where the number of companies reporting was either too low or where the classification was unclear, trends of the VOC emissions reports were used. This concerns car repairing and maintenance, winding wire coating, surface cleaning (incl. electronics industry), and natural rubber.

[68] VOC-Anlagen-Verordnung (VAV), BGBl. II Nr. 301/2002 vom 26.7.2002

- Domestic use: extrapolation using population data
- Paints: extrapolation using paint consumption

4.5.3 Category-specific QA/QC

The calculations of the data for this category are embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 1.6). Emissions data are checked as follows.

- Check of the correctness of all equations in the estimate files
- Check of the correctness of all interim results
- Check of the plausibility of the results and their trends related to activity data and emission factors and documentation of the plausibility of changes and non-changes as above mentioned
- Check of the correctness of all data and results transfer

The results of these checks are described in the QA/QC documentation.

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 convertors 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

The overall uncertainty for emissions from solvent use was estimated to be in the range of 11 to 14% (refer to NIR 2015 and NIRs before). However, some improvements were made to the model and some new data sources were used, that's why the uncertainty assessment has to be re-evaluated.

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

2.D.3 Solvent Use

A transcription error was corrected, which led to a small increase in Domestic Solvent Use.

2.D.3. Other

CO_2 emissions from the use of urea in selective catalytic reduction in the transport sector, which had previously been reported under 2.G.4, are now reported under 2.D.3, in line with footnote 6 in CRF Table2 (I).A-Hs2.

The slight changes in CO_2 emissions from this use (marginal increases up to 2011, reductions from 2011 onwards) are not caused by changes in vehicle technology but by the use of the latest NEMO version. The use of the newest NEMO version (4.0.0 from November 2016) results in slight shifts between fuel consumption in inland and fuel export, which causes revised AdBlue© consumptions in fuel export due to the fact of the specific fleet composition in fuel export.

4.5.6 Planned Improvements

2.D.3: Solvent Use:

It is assumed that the amount of substances used as solvents is presumed overestimated. Further research has to be conducted in order to be able to correctly estimate solvents used. Further investigations concerning emission factors for full implementation of the data obtained from the VOC installations ordinance are still required. This evaluation is still ongoing. Also, more information on substances currently assumed as used as solvents is necessary. Due to the long process of obtaining data from reports of the VOC directive, it will only be possible to do a full investigation every few years, thus emissions are either bound to population growth or economic growth, or assumed constant for the time being.

4.6 Electronics Industry (Category 2.E) – Integrated Circuit or Semiconductor (2.E.1)

4.6.1 Source Category Description

Emissions: HFC, PFC, SF_6, NF_3

Key Source: no

According to the IPCC 2006 Guidelines, emissions formerly reported under category *2.F* are reallocated to categories *2.E, 2.F, 2.G.1* and *2.G.2*. Category *2.E Electronics Industry* comprises the emissions which were formerly reported under *2.F.7 Semiconductor Manufacture,* all emissions arise from subcategory *2.E.1 Integrated Circuit or Semiconductor*.

All relevant processes in the electronics industry have already been monitored and reported in previous years. However, additional fluorinated gases have to be reported. Among the new gases listed in the updated UNFCCC Reporting Guidelines, NF_3 is relevant in Austria. The other gases are not in use in the Austrian electronics industry, as confirmed by industry data.

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 has been 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 0.56% of the emissions of the IPPU sector, and to 0.12% of the national total. Emissions in 2016 were 31% 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.

Table 143: Emissions of Sector 2.E Electronics Industry.

Year	HFCs	PFCs	SF_6	NF_3	Total
			[kt CO_2e]		
1990	2.44	34.03	97.40	0.00	**133.87**
1991	3.89	43.86	167.17	0.00	**214.92**
1992	5.62	53.69	227.64	0.00	**286.95**
1993	7.35	63.52	288.10	0.00	**358.97**
1994	9.08	70.96	348.57	0.76	**429.37**
1995	10.79	83.35	409.03	6.44	**509.61**
1996	12.32	80.25	313.18	7.93	**413.68**
1997	11.93	117.47	465.39	15.53	**610.33**
1998	3.75	55.53	410.63	9.43	**479.34**
1999	4.09	79.18	368.72	8.24	**460.23**
2000	4.78	87.32	317.35	10.51	**419.96**
2001	5.61	116.34	342.36	10.51	**474.82**
2002	5.11	101.97	341.88	10.51	**459.47**
2003	4.91	126.38	360.68	21.56	**513.53**
2004	5.14	157.57	362.86	26.54	**552.11**
2005	5.03	157.79	161.36	28.16	**352.34**
2006	6.36	170.57	160.42	32.73	**370.08**
2007	8.94	228.85	93.86	59.39	**391.05**

2008	9.35	207.25	100.87	53.47	**370.94**
2009	2.16	36.02	71.14	4.54	**113.86**
2010	2.05	78.05	65.55	4.12	**149.77**
2011	2.06	73.51	39.48	4.10	**119.16**
2012	2.09	50.72	39.88	8.56	**101.25**
2013	2.12	49.23	29.25	9.75	**90.35**
2014	2.01	53.03	31.34	10.56	**96.94**
2015	2.37	49.55	41.67	13.46	**107.05**
2016	2.13	50.39	33.57	6.14	**92.23**

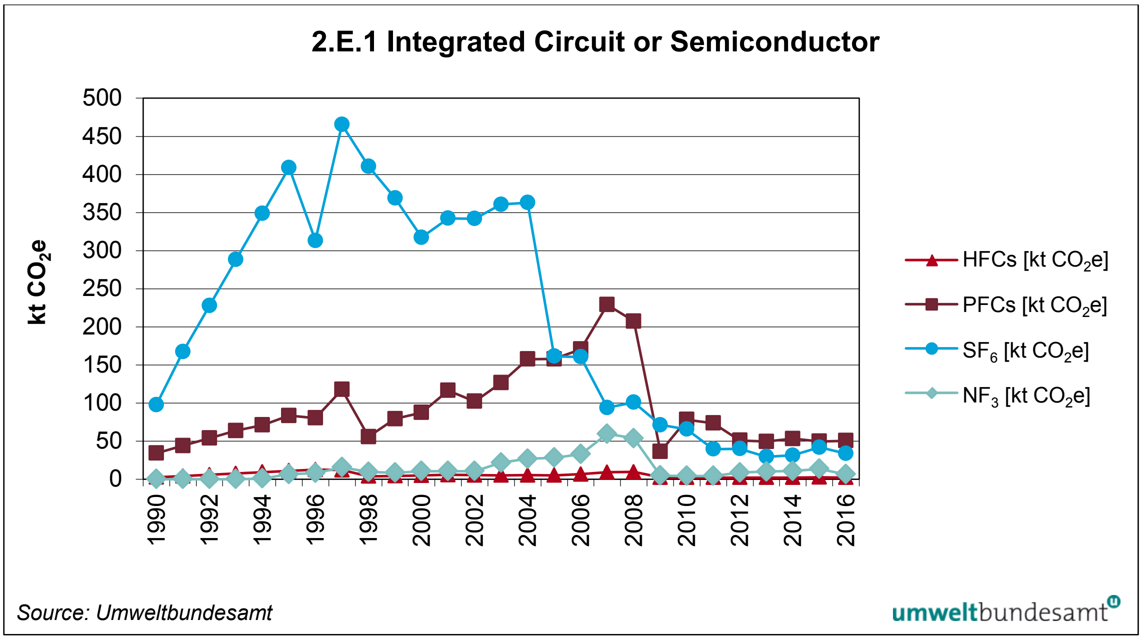

Figure 27: Emissions from 2.E.1 Integrated Circuit or semiconductor.

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 have been required for this years´ 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 (HFC)

This category includes the following emission sources:

- refrigeration and air conditioning equipment,
- foam blowing,
- fire extinguishers,
- aerosols.

There is no production of Halocarbons in Austria.

On the European level, the so-called F-gas Regulation[69] 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).[70]

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 is now 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; ODS are regulated under the Montreal Protocol and are therefore not considered under the UNFCCC and the Kyoto Protocol). In 2016, F-Gas emissions from

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[69] 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. 411/200570.
- F-Gas Regulation 2006, replaced by F gas regulation 2015

Category 2.F amounted to 1.64 Mio t CO_2 equivalents. Emissions have been increasing since 1993 (1.4% from 2015 to 2016) as HCF have been used increasingly as refrigerant, as well as other uses described below.

Table 144: 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	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.02	0.00	0.00	0.00	0.00	0.00
1993	1.43	0.00	226.31	0.18	0.00	0.00
1994	14.82	0.61	236.59	0.00	0.00	0.00
1995	31.40	6.21	300.56	0.00	4.50	0.00
1996	56.91	12.93	326.05	0.00	9.00	0.00
1997	98.88	23.59	350.24	0.00	13.49	0.00
1998	175.34	35.76	375.70	0.00	17.99	0.00
1999	243.07	51.83	379.29	0.17	22.49	0.00
2000	332.70	71.21	277.53	0.04	26.99	0.38
2001	446.96	91.13	282.74	4.06	31.47	1.14
2002	514.23	111.72	299.65	2.38	33.79	1.90
2003	636.88	130.11	265.08	0.42	32.50	2.29
2004	716.98	152.81	243.69	4.56	34.03	1.15
2005	760.67	175.36	155.03	7.39	42.28	0.00
2006	822.40	210.37	49.26	6.95	57.13	0.00
2007	850.83	228.33	49.17	6.47	52.16	0.00
2008	919.04	254.42	28.94	12.79	24.00	0.00
2009	968.89	269.58	33.99	12.78	21.37	0.00
2010	1123.19	289.13	34.43	12.78	21.88	0.00
2011	1046.37	303.63	17.58	15.11	21.92	0.00
2012	1118.07	312.66	17.40	12.74	22.56	0.00
2013	1138.68	316.29	17.22	12.78	24.54	0.00
2014	1208.96	316.71	17.04	12.78	25.58	0.00
2015	1239.07	323.08	16.87	12.78	26.16	0.00
2016	1254.37	327.15	16.70	12.78	27.49	0.00

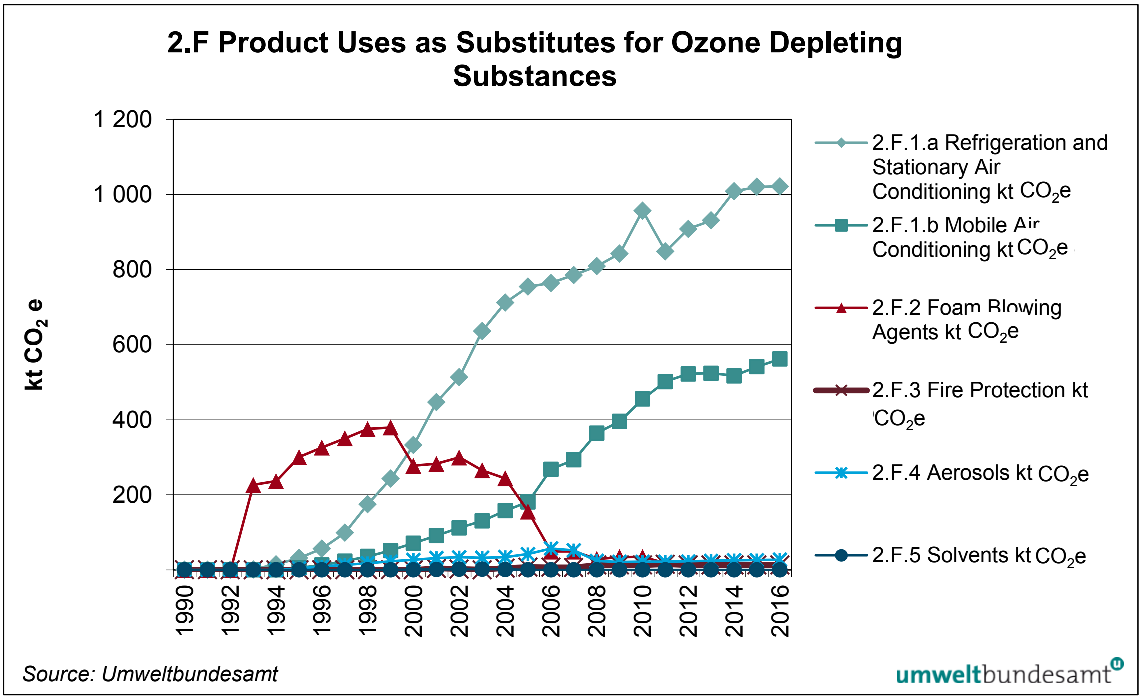

Figure 28: Emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances.

The peak in the year 2010 for 2.1.F.a is due to an increase in imports of mainly R 507a. As this was due to several importers, it can be assumed that this was due to an increase in demand.

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[71] 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[72]. However, especially the refrigeration sector is very complex, 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

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[71] 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

[72] 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).

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 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). The model is currently (2015 onwards) re-evaluated in order to improve allocation of emissions to the different subsectors. As an overview,

Table 145 provides the data sources and interpolation methods for each sub-category and each year.

Table 145: Data sources for categories 2.F.1 to 2.F.9.

Category	Data source			
	collected	extrapolated	interpolated	technique
2.E.1 Electronics Industry – Integrated Circuit or Semiconductor	1990–2016			
2.F Product Uses as Substitutes for Ozone Depleting Substances				
2.F.1 a Refrigeration and Stationary Air Conditioning				
Stationary refrigeration	2000, 2004, 2007[1)] 2010–2016	1990–1999	2001–2003, 2005–2006, 2008–2009	Exponential (1990–1999) Linear (other years)
Commercial refrigeration	2000, 2003–2016	1990–1999	2001–2002	Exponential (1990–1999)

Category	Data source			
	collected	**extrapolated**	**interpolated**	**technique**
				Linear (2001–2002)
Room air conditioning	2000, 2008	2009–2016	2001–2007	Linear Note: No HFCs prior to 2000
Heat pumps	1990–2016			
Domestic refrigeration	1993, 1994, 2004, 2005		1995–2003	Linear Note: No HFCs in new refrigerators prior to 1993 and after 2008
Transport refrigeration	2000[5], 2007, 2011[5]	1990–1999, 2015–2016	2000–2006, 2008–2010	Exponential (1990–1999, expert judgement based on information for country with similar structure[1]) Linear (2001–2007, 2008-2010, 2012)
2.F.1.b Mobile air conditioning	1993–2016			Note: No HFCs in vehicles prior to 1993
2.F.2 Foam blowing agents	2000–2016	1995–1999		Linear[2]. Note: No HFCs in foams prior to 1995
2.F.3 Fire protection	1990–2016			
2. F.4 Aerosols	2000–2016	1990–1999		Proportional to GDP
2.F.5 Solvents	2001, 2002	1990–2000, 2003		Proportional to GDP
2.G. Other Product Manufacture and Use				
2.G.1. Electrical equipment	1990–1999, 2003–2014		2000–2002	Linear
2.G.2: SF_6 and PFCs from Other Product Uses				
Noise insulating windows (2.G.2.a)	1999–2003	1990–1998		Based on production data[3]
Tyres (2.G.2.a)	1998–2003			Note: no SF_6 in tyres in other years
Research (2.G.2.b)	1990, 2000–2014		1991–1999	Linear
Shoes (2.G.2.a)	2003–2005[4]			Note: 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 130.

Table 146: Emissions of IPCC Category 2.F by sub-category 1990, 1995, 2000, 2003–2007.

GHG	GWP	Unit	1990	1995	2000	2003	2004	2005	2006	2007
2.F.1 Refrigeration and Air Conditioning Equipment										
Stationary										
HFC-32	675	t	0.00	0.16	5.67	16.76	17.48	19.16	20.90	24.67
HFC-125	3 500	t	0.00	2.22	26.03	57.15	62.61	68.71	75.54	80.15
HFC-134a	1 430	t	0.00	9.04	91.83	149.01	170.46	168.48	139.03	137.77
HFC-152a	124	t	0.00	0.01	0.04	0.04	0.04	0.04	0.04	0.05
HFC-143a	4 470	t	0.00	2.37	23.81	47.41	53.05	58.24	64.24	65.20
HFC-23	14 800	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C3F8	8 830	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	1 300	t	0.00	4.34	49.80	91.34	110.46	126.80	187.63	205.25
2.F.2 Foam Blowing Agents										
HFC-134a	1 430	t	0.00	203.10	140.56	126.27	128.42	84.85	9.93	9.87
HFC-152a	124	t	0.00	81.68	595.17	637.09	429.03	204.65	247.77	248.65
HFC-245fa	1 030	t	0.00	0.00	1.50	3.02	3.71	4.55	2.36	2.31
HFC-365mfc	794	t	0.00	0.00	1.50	3.02	3.81	4.57	2.38	2.33
2.F.3 Fire Protection										
HFC-23	14 800	t	0.00	0.00	0.00	0.00	0.19	0.43	0.33	0.41
HFC-227ea	3 220	t	0.00	0.00	0.00	0.13	0.54	0.31	0.63	0.11
2.F.4 Aerosols										
HFC-134a	1 430	t	0.00	3.15	18.87	22.73	23.80	29.57	39.95	36.48
HFC-227ea	3 220	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F.5 Solvents										
HFC-43-10mee	1 640	t	0.00	0.00	0.23	1.39	0.70	0.00	0.00	0.00
Total kt CO_2e			**0.00**	**343**	**709**	**1 067**	**1 153**	**1 141**	**1 146**	**1 187**

Table 147: Emissions of IPCC Category 2.F by sub-category 2008–2016.

GHG	GWP	Unit	2008	2009	20010	2011	2012	2013	2014	2015	2016
2.F.1 Refrigeration and Air Conditioning Equipment											
Stationary											
HFC-32	675	t	27.25	32.57	38.92	47.70	53.35	56.42	58.00	64.76	63.08
HFC-125	3 500	t	88.20	98.44	116.73	111.94	119.54	121.76	127.40	132.99	128.47
HFC-134a	1 430	t	112.88	90.76	78.26	60.11	73.87	86.14	110.79	106.88	128.78
HFC-152a	124	t	0.04	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	4 470	t	71.70	77.52	91.75	75.72	77.99	76.91	81.66	80.21	76.78
HFC-23	14 800	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C3F8	8 830	t	0.00	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	1 300	t	254.86	276.68	318.49	350.76	365.08	366.26	361.66	378.73	392.94
2.F.2 Foam Blowing Agents											
HFC-134a	1 430	t	9.80	9.73	9.66	9.60	9.53	9.47	9.40	9.34	9.27
HFC-152a	124	t	87.11	129.34	134.36	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245fa	1 030	t	2.26	2.21	2.16	2.11	2.06	2.01	1.97	1.92	1.88
HFC-365mfc	794	t	2.28	2.22	2.17	2.12	2.08	2.03	1.98	1.94	1.89
2.F.3 Fire Protection											
HFC-23	14 800	t	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
HFC-227ea	3 220	t	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00
2.F.4 Aerosols											
HFC-134a	1 430	t	16.78	14.95	15.30	15.33	15.78	17.16	17.86	18.00	18.55
HFC-227ea	3 220	t	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	0.30
2.F.5 Solvents											
HFC-43-10mee	1 640	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total kt CO2e			**1 239**	**1 307**	**1 481**	**1 405**	**1 483**	**1 510**	**1 581**	**1 618**	**1 641**

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
- Supermarkets (Part of CRF category commercial refrigeration)
- Other commercial refrigeration (Part of CRF category commercial refrigeration)
- Stationary air conditioning (part of CRF category stationary air conditioning)

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**:

- Room air conditioning (part of the CRF category stationary air conditioning)
- Heat pumps (part of CRF category stationary air conditioning)

- Commercial stand-alone refrigeration equipment manufacturing (part of CRF category commercial refrigeration)
- Domestic refrigeration
- Transport refrigeration
- Mobile air conditioning

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, 2010, 2011, 2012, 2013, 2014, 2015 and 2016. There are four large importers that cover about 95% of the market. Additionally there are several small importers that change over the years.

The information from the importers also includes information on refrigerant used in other sub categories than covered by the top down model (e.g. use for filling of new mobile ACs and refilling of mobile ACs and transport refrigeration in Austria). This information was combined with more detailed information from industry to obtain the remaining refrigerant use in the considered sub categories (see list above).

According to information from the Austrian Railway (ÖBB) as well as public transportation providers of the biggest cities, R 134a is bought locally to refill leakages in ACs in trams, underground trains and trains. Thus, the amount that was being refilled in the MAC sector was taken off the total in the Refrigeration and Air Conditioning Sector for the years 2011-2016. As the year 2010 was based on an extensive study, these amounts were already taken into account for 2010 and the years before. This change results in a peak in this sector in the year 2010, which is due to increased imports of especially R507F, which is not affected by the substraction. As this increase of imports was due to several importers, it can be assumed that this was due to an increased demand.

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.

2) 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. Based on their GWPs, the refrigerants (apart from R134a) were divided into two groups of similar GWP and composition: on the one hand R404A and R507A and on the other hand the rest of blends (R410, R407C, R413A, R422D) with a GWP of around 2 000 and all other refrigerants (which have a share of < 1% in all years).

The composition of the blends is known for each collected year (refer to table above), it varies over the years; for the calculation 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 148.

Table 148: Composition of blends (in percent) as used in the top-down model for category 2.F.1.

	Refrigerants				
Groups of refrigerants	**R32**	**R125**	**R134a**	**R143a**	**GWP used in the model**
R134a	0	0	100	*0*	1 430
R404A, R507A[73]	0	44	4	52	3 922
Other blends with medium GWP (R410,R407C, R413A, R422D and others)[74]	35	35	30	0	1 893

For the sub-categories of 2.F.1 which are included in the top-down approach, time series of emissions are calculated for R134a and for the two refrigerant groups. In a final step, the blends are again split into their main components R32, R125 and R134a. Emissions of other gases (HFC23[75] and C_4F_8), which are imported in small quantities only, are not disaggregated but are included in the emissions of the three main components R32, R125 and R134a). Therefore, emissions of HFC23 and C_4F_8 in sub category 2.F.1 are reported as "IE".

Even though this simplification of the model (of grouping refrigerants with similar GWP) leads to a small error in total emissions, this is negligible due to the fact that it leads to a simple and robust, and thus fully consistent model. The model that was in use before, was difficult to handle and therefore error-prone.

3) <u>Estimation of emissions</u>

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).

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[73] The total amount of this refrigerant group was accounted for as R404A, because (1) the composition is apart from the small portion of R134a content virtually the same, (2) thus also the GPW differates less than 2%, and (3) for all years the R507A share ranges from about 10-20%; the error resulted from this simplification is about 0,3%

[74] For all years the main blend was R407c, for the years 2000 and 2004 R413A was the 2nd relevant, from 2010 onwards R410A and R422D were – after R407C – of high relevance. These four blends make up more than 90% of the blends summed up in this group.

The comparison between the used composition with the actual composition yields:

➔ **: 24/41/35:**-10% 2000/2004; +17% 2007, +1-5% for 2010ff;, the reason for the change of the deviation is the decreasing share of R422D.

[75] R23 in 2007 the imported amount was about 5t, for all other years the amounts are below 0,5 t (thus has a share in total HFC amounts of less than 1% in 2007, and less than 0,1% in all other years)

Table 149: 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%
Supermarkets	10	0.2%	15–14%	*10–30%*	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.*

The approach of combining refrigerants into groups and estimating emissions as described above resulted in a fully consistent time series. One importer reported small quantities of HFC R-23, which has been used as a replacement of R 13 as a high pressure refrigerant (Class A1) for very low temperatures (more than -50°C). It is being used in (medical) research and development and laboratories. Emissions of R-23 are included in this calculation.

Details on b) bottom up approach for the rest of the sub category 2.F.1

2.F.1.a: Refrigeration and Stationary Air Conditioning

Room air conditioning

Room AC devices (split devices, Variable Refrigerant Flow (VRF) and small mobile equipment) are imported already charged with refrigerant and are not manufactured in Austria. However in cases where refilling occurs, these quantities are considered for in the top down approach.

Data on annual sales as well as the filling volumes, type of used refrigerants (R407C and R410A) and the market development (annual rising sales) were estimated based on information from the AC industry (LEISEWITZ & SCHWARZ 2010) for the years 2000–2008. For the subsequent years data was extrapolated. For earlier years, HFC use was not relevant (a pure HCFC – R22 – was used as refrigerant). Average charges were used for various types of equipment, ranging between 1 and 3 kg per unit, based on data from industry. An average lifetime of 10 years was assumed.

From this data stocks were estimated and, an EF of 2.5% (LEISEWITZ & SCHWARZ 2010) was applied for calculating emissions from stocks.

Heat pumps (part of the CRF category stationary air conditioning)

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 65% of the newly installed equipment in 2006 was dedicated to space heating and about 28% 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. In Austria the share of heat pumps for heating of water for domestic use is comparably high.

Underlying data on installed heat pumps are obtained from an annual report (BIERMAYR et al. 2013). 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. Average charges were used for various types of equipment, ranging between 0.7 and 2.5 kg per unit, based on data from industry.

Applied EF were also estimated by LEISEWITZ & SCHWARZ (2010):

- product manufacturing 0.1%
- emissions from stock 2%
- disposal 30% (life time 15 years)

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)

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%.

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 (29% of stock = emissions from stocks) 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.

An EF for disposal of 30% and a life time of 10 years were estimated by LEISEWITZ & SCHWARZ (2010).

2.F.1.b 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.

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).

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 prohibited – with the exemption of XPS panels > 80 mm thickness –from 01.01.2005 onwards, in case of PU one component foams from 01.01.2006 onwards. Differing, special approval for such products may be given under specific conditions (for two years).

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 150).

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 (>20 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 150).

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 150). 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 150: 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 a 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 implied EF from bank is at ~1.5% within the range estimated in the IPCC 2006 guidelines (page 7.63) for installed flooding systems (2 ± 1% per year). The mean value of 1.7% was applied to estimate emissions for the years before 2000, for which no detailed data on refilled amounts were available.

4.7.2.4 Aerosols (2.F.4)

Metered dose inhalers

Production:

Metered dose inhalers containing R134a were produced in Austria from 1990 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%.

Consumption:

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, up until now, the emissions amount to a few kilograms. 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.

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. Refrigeration and Air Conditioning

Due to information provided by railway and tramway companies, refills of air conditioning with 134a during the lifetime of the equipment happens on a regular basis. Thus, 134a used for refills during the lifetime of equipment of railed vehicles was subtracted off total R 134a use, which affected amounts used in refrigeration and air conditioning (Commercial Refrigeration as well as Industrial Refrigeration). The change amounts to -41.6kt CO_2 eq in 2015, and – 129.3 kt CO_2e in 2011).

2.F.1d Transport Refrigeration:

A transcription error was corrected, which led to an increase of emissions in 2015 of 17.1 kt CO_2e

2.F.4. Aerosols – Metered Dose Inhalers

Updated producer information provided information on two types of inhalers that contain R 227ea instead of R134a. Thus, numbers of units with R 227ea were re-allocated and the exact amount of gas used per inhaler used. Emissions in 2015 increased by 0.1 kt CO_2e.

4.7.6 Planned Improvements

Emissions from R 23 have been included in the commercial refrigeration sector, this inclusion will be re-assessed for the next submission, together with the life factors for some HFCs, as they are rather low. This will also be re-assessed for the 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, N_2O)

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*). CO_2 emissions from Other Sources 2.G.4 (AdBlue emissions) were transferred to 2.D.3. Please refer to chapter 2.D. for a description of methods.

Emission Trends

Emissions from this category amount to 3.0% of the IPPU sector, which equals 0.62% of total emissions. Between 2015 and 2016, emissions increased by 23%, which is due to an increase of emissions at decommissioning of sound-proof windows containing SF_6. Emission trends are described in depth in the different subcategory chapters.

Table 151: 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**
	[22 800]		[22 800]	[8 830]		[298]	
1990	0.47	**10.80**	5.30	0.00	**120.73**	750.00	**355.03**
1991	0.51	**11.54**	7.50	0.00	**170.95**	750.00	**405.99**
1992	0.54	**12.29**	7.66	0.00	**174.67**	750.00	**410.46**
1993	0.57	**13.03**	7.82	0.00	**178.39**	750.00	**414.92**
1994	0.60	**13.78**	9.13	0.00	**208.15**	750.00	**445.43**
1995	0.63	**14.30**	11.14	0.00	**254.06**	750.00	**491.86**
1996	0.62	**14.25**	11.71	0.00	**266.93**	750.00	**504.68**
1997	0.63	**14.44**	11.99	0.00	**273.46**	750.00	**511.40**
1998	0.70	**16.05**	12.57	0.00	**286.57**	750.00	**526.12**
1999	0.69	**15.79**	11.87	0.00	**270.65**	750.00	**509.94**
2000	0.75	**17.02**	8.98	0.00	**204.73**	750.00	**445.80**
2001	0.78	**17.82**	10.60	0.00	**241.72**	750.00	**471.71**
2002	0.82	**18.66**	10.79	0.00	**245.90**	750.00	**465.42**
2003	0.85	**19.40**	7.28	0.00	**165.94**	750.00	**374.87**
2004	0.91	**20.75**	4.40	0.00	**100.39**	750.00	**299.35**
2005	0.97	**22.20**	13.40	0.00	**305.49**	560.00	**500.12**
2006	1.00	**22.82**	11.32	0.21	**259.94**	530.00	**440.69**
2007	1.07	**24.50**	10.89	0.17	**249.84**	517.00	**428.40**
2008	1.13	**25.87**	10.81	0.11	**247.33**	505.00	**423.69**
2009	1.17	**26.61**	10.68	0.00	**243.40**	470.00	**410.07**
2010	1.28	**29.12**	10.57	0.00	**240.93**	484.60	**414.45**
2011	1.28	**29.27**	10.46	0.00	**238.45**	472.70	**408.58**
2012	1.39	**31.58**	10.35	0.00	**235.96**	454.01	**402.83**
2013	1.43	**32.61**	10.27	0.00	**234.18**	461.43	**404.29**
2014	1.51	**34.41**	10.16	0.00	**231.72**	453.18	**401.18**
2015	1.59	**36.32**	10.05	0.00	**229.24**	447.86	**399.02**
2016	1.68	**38.37**	13.97	0.00	**318.55**	448.80	**490.66**

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)

All emissions from this subsector are allocated in *2.G.1.b*. Use of Electrical Equipment. 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, but has been completely 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)

Accelerators (Research) (2.G.2.b)

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.

Other (2.G.2.c)

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. This showed that the amount of gases that were exported was previously reported as emissions in Austria. With the submission of 2015, this mistake has been eliminated and recalculations were made for the years since 2005.

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)

Emissions in this sector arise from whipped cream in aerosol cans. This concerns whole cans sold in supermarkets as well as capsules used for devices, in which fresh cream is filled and turned into whipped cream. There is one producer of capsules in Austria. The numbers used in this sector were estimated based on the assumption that 400 tons of N_2O are used every year for the production and the use of aerosol cans. However, discussions with the producer have shown that the value reported includes N_2O in capsules for export. Investigations on production and sales data are ongoing, results are expected within the next 2 years.

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 000kg of 3m PF-5052 (PFC C5F12) were filled in. These 3 000 kg were then decommissioned in 2005, and 3 000kg 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[76], 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.

[76] 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.

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

Investigations showed that the uncertainty of data is higher than previously estimated, that's why it is now assumed to be 100% (expert judgement Umweltbundesamt).

4.8.5 Recalculations

2.G.2 Other product manufacture and use

Updated numbers on SF_6 use for particle accelerators for 2015 led to an update of emissions.

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 and urea application.

As a result of previous UNFCCC reviews the ERT recommended Austria to update its information on average waste management system (AWMS) 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 AWMS 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.

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).

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 and NO_x are extensively described in Austria's Informative Inventory Report 2018 (UMWELTBUNDESAMT 2018).

To give an overview of Austria's agricultural sector some information is provided below (according to the 2010 Farm Structure Survey – full survey and the Agriculture Structure Surveys 2013 and 2016) (BMLFUW 2000–2017): Agriculture in Austria is rather small-structured: 166 317 farms are managed, 56.4% of these farms manage less than 20 ha, whereas only 5.2% of the Austrian farms manage more than 100 ha cultivated area. 128 164 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 agricultural area comprises 2.70 million hectares that is a share of ~ 32% of the total territory (forestry ~ 41%, other area ~ 14%). The shares of the different agricultural activities are as follows:

- 50% arable land,
- 21% grassland (meadows mown several times and seeded grassland),
- 27% extensive grassland (meadows mown once, litter meadows, rough pastures, alpine pastures and mountain meadows),
- 2% other types of agricultural land-use (vineyards, orchards, house gardens, vine and tree nurseries).

5.1.1 Emission Trends

In the year 2016 the sector agriculture contributed 9.1% to the total of Austria's greenhouse gas emissions (without LULUCF). The trend of GHG emissions from 1990 to 2016 shows a decrease of 11.0% for this sector (see Figure 29 and Table 153) due to a decrease in activity data.

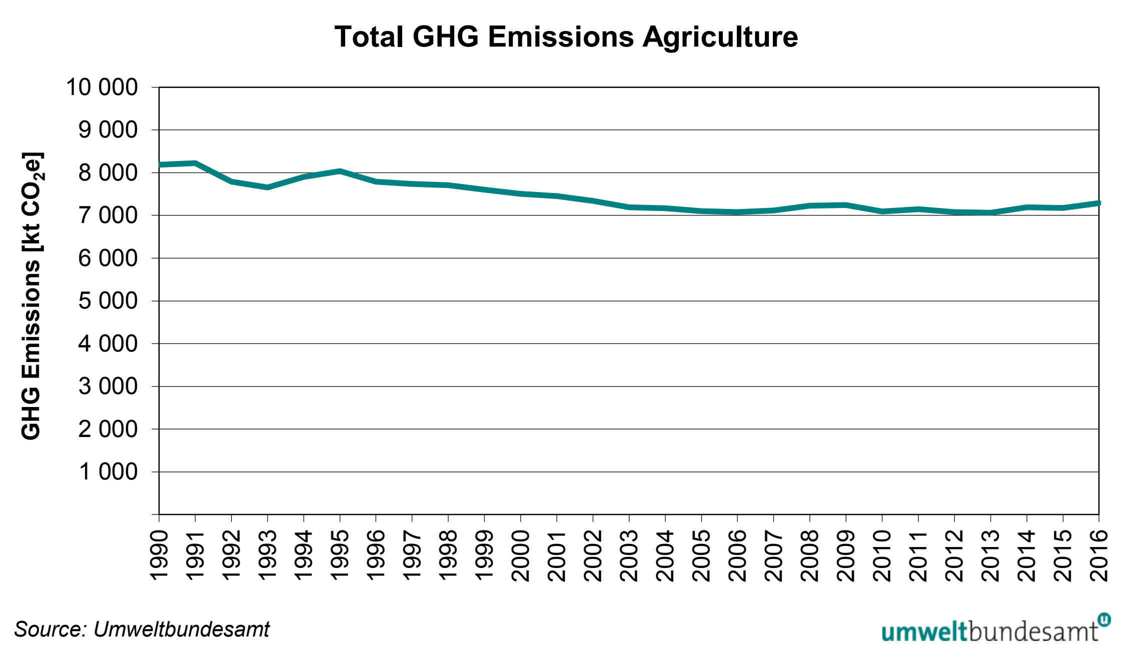

Figure 29: Trend of total GHG emissions from agriculture.

The main drivers for the trend shown in Figure 29 are decreasing livestock numbers and lower amounts of N-fertilizers applied on agricultural soils. Fluctuations which can be seen in particular in the first half of the 1990s result from the variability of mineral fertilizer sales data related to volatility in prices. From 2015 to 2016 emissions increased by 1.5% mainly due to rising GHG emissions from agricultural soils. In 2016 Austria's crop production was significantly higher compared to the previous year, because of the good growth conditions (moderate temperatures and sufficient precipitation). The cereal harvest in 2016 was one of the highest of the past ten years, but also soy, sugar beet and vegetable production increased compared to the previous year which resulted in higher N_2O emissions from crop residues. Furthermore, in 2016 a higher amount of mineral fertilizer was applied on agricultural soils.

Other drivers for the rise of GHG emissions in 2016 were the slight increase in the number of dairy cows and the higher milk yields of Austria's dairy cows.

Emission trends per gas

From 1990 to 2016 CH_4 emissions from agriculture decreased by 15.2%, N_2O emissions decreased by 3.7% and CO_2 emissions increased by 23.1%. Trends are presented in Table 152.

Table 152: Emissions of greenhouse gases from 1990–2016 from agriculture.

Year	GHG emissions [kt]		
	CH_4	N_2O	CO_2
1990	216.36	9.01	94.42
1991	213.35	9.38	97.29
1992	204.44	8.65	97.25
1993	204.68	8.20	96.60
1994	204.34	9.04	97.98
1995	207.80	9.21	99.80
1996	204.32	8.66	100.19
1997	200.64	8.80	100.76
1998	199.17	8.82	101.57
1999	196.91	8.65	101.28
2000	195.57	8.45	98.56
2001	193.01	8.48	95.74
2002	188.95	8.44	96.19
2003	186.82	8.12	98.72
2004	186.58	8.07	102.01
2005	184.39	8.03	102.95
2006	183.73	7.99	104.76
2007	184.48	8.05	106.97
2008	183.89	8.47	104.89
2009	186.29	8.31	110.01
2010	185.81	7.86	107.24
2011	183.40	8.24	105.60
2012	182.11	8.11	108.42
2013	182.33	8.04	107.86
2014	183.07	8.39	111.43
2015	182.79	8.38	111.98
2016	183.37	8.68	116.19
Trend 1990–2016	***–15.2%***	***–3.7%***	***23.1%***

Emission trends per sub category

Table 153 presents total GHG emissions and trend 1990–2016 from agriculture by sub-categories as well as the contribution to the overall inventory emissions. Important categories are *3.A enteric fermentation* (5.2%) and *3.D agricultural soils* (2.7%) followed by *3.B manure management* (1.1%).

Table 153: GHG emissions 1990–2016 of agriculture by categories.

Year	GHG emissions [kt CO_2 equivalent] by categories						
	3	3.A	3.B	3.D	3.F	3.G	3.H
1990	8 188.65	4 820.53	1 025.30	2 246.74	1.66	89.97	4.45
1991	8 225.10	4 755.57	1 016.91	2 353.71	1.62	91.06	6.23
1992	7 786.71	4 550.69	989.35	2 147.78	1.64	91.09	6.17
1993	7 658.22	4 555.56	997.10	2 007.46	1.50	90.81	5.79
1994	7 899.42	4 552.90	993.39	2 253.55	1.61	91.39	6.60
1995	8 037.92	4 638.25	1 010.15	2 288.12	1.61	91.85	7.95
1996	7 789.37	4 563.33	993.36	2 130.97	1.53	92.49	7.70

Year	GHG emissions [kt CO_2 equivalent] by categories						
	3	3.A	3.B	3.D	3.F	3.G	3.H
1997	7 740.33	4 481.74	981.10	2 175.14	1.59	92.08	8.67
1998	7 708.29	4 447.96	979.35	2 177.85	1.56	91.45	10.12
1999	7 601.46	4 410.82	953.08	2 134.68	1.60	90.87	10.41
2000	7 506.39	4 386.67	942.85	2 076.86	1.45	90.19	8.37
2001	7 448.91	4 326.93	939.64	2 085.02	1.58	90.10	5.64
2002	7 336.53	4 239.51	918.84	2 080.48	1.51	90.06	6.13
2003	7 188.87	4 196.41	908.66	1 983.65	1.43	90.09	8.62
2004	7 170.21	4 197.94	900.62	1 967.51	2.13	91.17	10.84
2005	7 104.08	4 146.58	896.76	1 956.41	1.38	91.19	11.76
2006	7 077.47	4 134.62	893.57	1 943.23	1.29	89.85	14.91
2007	7 118.67	4 151.50	902.09	1 956.78	1.33	89.05	17.92
2008	7 226.09	4 145.31	891.67	2 082.95	1.28	88.33	16.55
2009	7 245.16	4 199.70	903.82	2 030.44	1.20	88.03	21.97
2010	7 094.75	4 189.65	901.15	1 895.56	1.15	87.68	19.56
2011	7 146.41	4 137.41	887.88	2 014.61	0.91	87.24	18.36
2012	7 079.34	4 110.16	880.07	1 979.98	0.72	86.73	21.69
2013	7 062.84	4 117.37	877.93	1 959.01	0.67	86.36	21.51
2014	7 189.04	4 136.34	878.09	2 062.45	0.73	85.99	25.44
2015	7 177.66	4 130.84	876.73	2 057.46	0.65	85.50	26.48
2016	7 286.42	4 146.65	876.27	2 146.63	0.67	84.90	31.30
Share in Austrian Total 2016	***9.1%***	***5.2%***	***1.1%***	***2.7%***	***0.0%***	***0.1%***	***0.0%***
Trend 1990–2016	***–11.0%***	***–14.0%***	***–14.5%***	***–4.5%***	***–59.7%***	***–5.6%***	***603.2%***

As can be seen in Figure 30 and Table 153 the overall trend concerning emissions from all categories is decreasing with the exception of urea application. The reason for the decrease of emissions from enteric fermentation and manure management is the decrease in livestock numbers (cattle and swine). Fluctuations of emissions from agricultural soils are mainly due to varying underlying activity data (sales figures of mineral fertilizers).

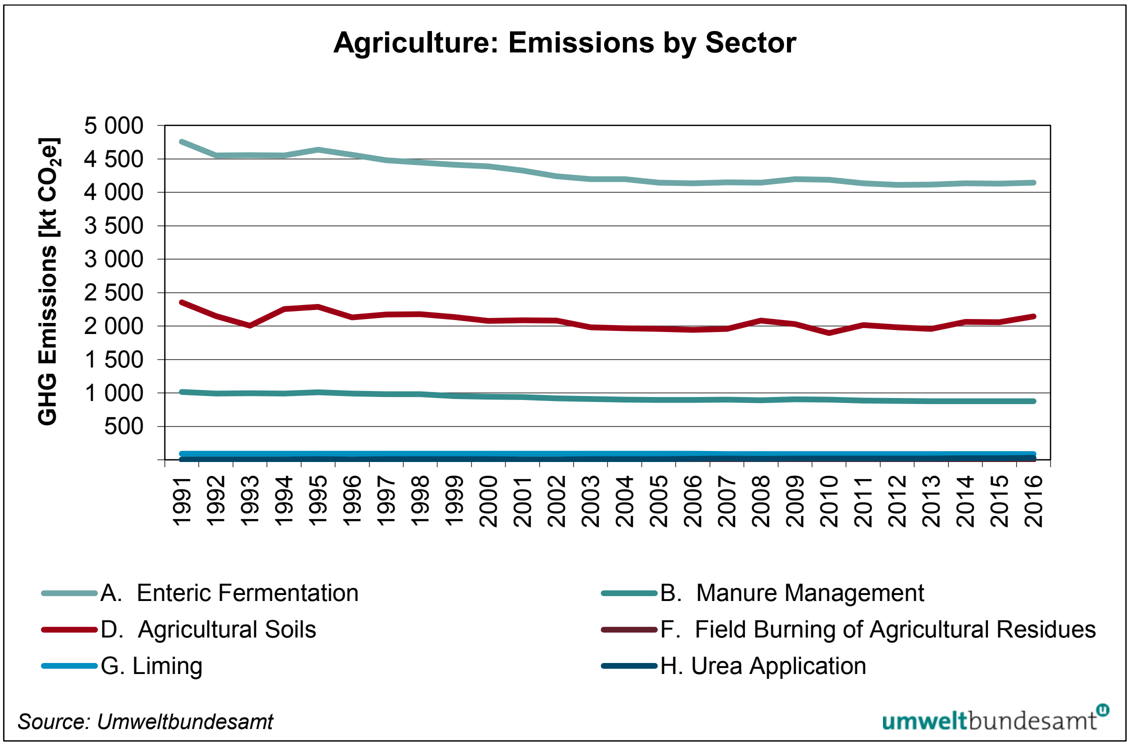

Figure 30: Emission trends of agriculture by categories.

As can be seen in Table 154, in 2016 about 57% of emissions from agriculture originate from enteric fermentation and 29% from agricultural soils. Manure management contributes 12% and the source categories liming, urea application and field burning of agricultural wastes contribute only a negligible part (1.2%, 0.4% and 0.01%, respectively in 2016).

Table 154: Share of categories of agriculture,1990 and 2016.

	GHG emissions [%] by sub categories						
Year	**3**	**3.A**	**3.B**	**3.D**	**3.F**	**3.G**	**3.H**
1990	100.0%	58.9%	12.5%	27.4%	0.0%	1.1%	0.1%
2016	100.0%	56.9%	12.0%	29.5%	0.0%	1.2%	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 sources within this category are presented in Table 155.

Table 155: Key sources 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

IPCC Category	Source Categories	Key Categories	
		GHG	KS-Assessment
3.D.a	Direct Soil Emissions	N_2O	LA
3.D.b	Indirect Emissions	N_2O	LA

LA = Level Assessment (if not further specified – for the years 1990 and 2016)

TA = Trend Assessment 1990–2016

5.1.3 Methodology

For enteric fermentation the IPCC Tier 1 method was used, except for key sources of these categories (cattle). In sector manure management the more detailed Tier 2 method and country specific emission factors were used for cattle and swine. 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 (gross energy intake, methane conversion rate) were used as Tier 1. Farming practices in Switzerland are very similar to the Austrian ones.

In sector manure management the same AWMS distribution taken from (AMON et al. 2007) was applied as in the previous inventory.

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 the category 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 the agriculture inventory including a short indication on the sources for this data as recommended in the ARR 2013, Table 8 (para 49).

Table 156: Information on country specific data.

Category	Parameter	Source
3.A Enteric Fermentation		
3.A.1 Cattle	GE-Intake	PÖTSCH (2005), GRUBER & PÖTSCH (2006), GRUBER & STEINWIDDER (1996)
3.A.4 Poultry	CH_4 EF	SBV (2007), HADORN & WENK (1996)
3.B Manure Management		
3.B (all livestock)	AWMS distribution	AMON & HÖRTENHUBER (2010)
3.B (cattle, swine, chicken, horses)	Anaerobic digestion	AMON (2002), E-CONTROL (2017)

Category	Parameter	Source
3.B.1 Cattle	VS e xcretion	PÖTSCH (2005), GRUBER & STEINWIDDER (1996)
3.B.3 Swine	VS excretion	SCHECHTNER (1991)
3.B.1 Cattle, 3.B.3 Swine	MCF liquid systems	AMON et al. (2006), AMON et al. (2007a)
3.B (cattle, swine, chicken, horses)	MCF anaerobic digestion	FNR (2010); AMON, T. (2011)
3.B (all livestock)	N excretion	PÖTSCH (2005), GRUBER & PÖTSCH (2006), STEINWIDDER & GUGGENBERGER (2003), UNTERARBEITSGRUPPE N-ADHOC (2004) UND ZAR (2004)
3.D. Agricultural Soils		
Austria's N-flow model	Country-specific consideration of N-losses	(AMON et al. 2002, 2008, 2010 & 2014)
3.D.a Direct Soil Emissions		
Sewage sludge spreading Compost application Mineralization/immobilization of soil organic matter Cultivation of organic soils	N content data	UMWELTBUNDESAMT (1997) Expert judgement by UMWELTBUNDESAMT (2015) C losses reported in sector LULUCF (4.B.1.3) 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) (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:

1) Activity data check

- ✓ Check for transcription errors, comparison with published data (BMLFUW 2000–2017),
- ✓ Consistency checks of sub-categories with totals,
- ✓ Plausibility checks of dips and jumps,

2) Emission factors

- ✓ Check of implied emission factors (time series) and CRF background data,
- ✓ Comparison with IPCC default values and factors reported by other countries (S & A Reports);

3) Calculation by spreadsheets

- ✓ Consistent use of livestock characterization,
- ✓ Cross-checks through all steps of calculation,
- ✓ Documentation of sources and correct use of units;

4) Results (emissions)

- ✓ Check of recalculation differences,
- ✓ Plausibility checks of dips and jumps;

5) Documentation

- ✓ Findings and corrections marked in the spreadsheets,
- ✓ 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 AWMS 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 the course of the most recent 'Re-Accreditation audit' (see chapter 1.2.3 on general QAQC) the technical auditor concentrated on the sector agriculture with a special focus on the technical process as well as internal documentation. The audit was successful, only some minor improvements in the internal documentation were suggested.

Following a recommendation of the ARR 2009, source specific procedures are presented in the respective sub-chapters. A general description of Austria's QMS (Quality Management System) 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, animal manures, agricultural soils as well as liming and urea application. Overall uncertainties result from uncertainties in the activity data and from uncertainties in the emission factors.

Animal waste management systems distribution (AWMS)

AWMS distribution based on the comprehensive surveys of (KONRAD 1995) and TIHALO (AMON et al. 2007) is estimated with an uncertainty of ± 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

In submission 2016 uncertainties of cattle and swine numbers were re-evaluated. 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 dairy cattle of 2%, for non-dairy cattle of 1% and for swine of 4%.

Uncertainties of emission factors for CH_4 emissions of enteric fermentation were considered 20% for cattle as this livestock category is calculated by using Tier 2 methodology (IPCC 2006) 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 were assessed at 20% for livestock categories calculated with Tier 2 methodology (cattle and swine) and 30% for all other animal categories calculated with the Tier 1 methodology 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 157 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 157: 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

Milk yield data for dairy cows for the years 1991−1993 and 2001 was updated on the basis of official data from the Ministry of Agriculture (BMLFUW 2017). The revision resulted in slightly higher emissions for the years 1991−1993 and slightly lower emissions for 2001.

In 2017 new information on input materials for Austria's biogas plants became available (raw material balances for 2014 and 2015). The updated data were taken from (E-Control 2017) and resulted in revised amounts of digested manure and energy crops from 2012 to 2015 (latest available raw material balance used in a previous inventory was for 2011).

3.D.a.5 Mineralization/immobilization

Revisions of land-use data within sector LULUCF resulted in slightly decreased N_2O emissions in all reported years (−0.002 kt N_2O in 2015).

3.G Liming

The cropland and grassland areas for the years 2014 and 2015 were revised according to the results of the farm structure survey 2016 resulting in higher CO_2 emissions for 2014 (+0.1 kt CO_2) and lower CO_2 emissions for 2015 (−0.2 kt CO_2).

3.H Urea Application

Revised 2015 data on urea consumption (AMA 2017) resulted in higher CO_2 emissions for the respective year (+2.9 kt CO_2).

Improvements of methodologies and emission factors

3.B Manure Management (CH_4)

Revised Tier 1 calculations of chicken and horses resulted in slightly increased emissions of CH_4 (+0.01 kt CH_4 in 2015)

3.D Agricultural Soils (N_2O)

3.D.b Agricultural Soils (indirect soil emissions – N_2O)

Austria's agriculture model is based on the N-flow concept. Thus, revisions within Austria's air emission inventory affect calculations of Austria's GHG inventory.

The correction of a linkage error in the calculation of NO-N losses from sewage sludge application resulted in slightly increased indirect N_2O emissions from atmospheric deposition of managed soils for the whole time series. The higher amount of urea fertilizers in 2015 as well as the revised activity data, as described before (milk yields and input to digesters), are other reasons for the slight increase of indirect emissions (both, atmospheric deposition and N leaching from managed soils) in the years 1991−1993 and 2012− 2015 (+0.01 kt N_2O 2015).

5.1.7 Completeness

Table 158 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 158: 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
3.B.	**MANURE MANAGEMENT**	**1005**	**MANURE MANAGEMENT REGARDING ORGANIC COMPOUNDS**	**NA**	✓	**NA**
		1009	**MANURE MANAGEMENT REGARDING NITROGEN COMPOUNDS**	**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**

IPCC Category		SNAP		CO_2	CH_4	N_2O
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	✓
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	✓	✓
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.F.5	Other: Vine	100305 [0907]	Other: Open burning of agricultural wastes (except 1003)	NA	✓	✓
3.G	**Liming**	1001	Cultures with fertilizers	✓	**NA**	**NA**
3.H	**Urea application**	1001	Cultures with fertilizers	✓	**NA**	**NA**

1) *included in 3.A.4 Horses, SNAP 100406*

2) *included in 3.B.4 Horses, SNAP 100506*

5.1.8 Planned Improvements

Consultations and exploratory work for the planning of a new investigation on Austria's agriculture practice has been started in 2015. The official project start was in spring 2016 and the questionnaires were sent to the farmers by the end of 2016. The evaluation of data was finalized by the end of 2017. Currently, work is in progress and the implementation to Austria's emission inventory is planned for submission 2019.

5.2 Enteric fermentation (Category 3.A)

This chapter describes the estimation of CH_4 emissions from enteric fermentation. In 2016 90.5% of agricultural CH_4 emissions arose from this category.

5.2.1 Source Category Description

CH_4 emissions amounted to 192.8 kt in 1990 and have decreased by 14.0% to 165.9 kt in 2016. Almost all emissions of category 3.A (93.7% in 2016) 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 49.4% in 1990 to 43.0% in 2016.

Table 159: Greenhouse gas emissions from enteric fermentation by sub-categories 1990–2016.

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	192.82	95.16	88.01	2.48	5.53	0.27	0.89	0.19	0.30
1991	190.22	92.46	87.88	2.61	5.46	0.28	1.04	0.20	0.30
1992	182.03	89.15	82.94	2.50	5.58	0.26	1.11	0.20	0.30
1993	182.22	88.17	83.67	2.67	5.73	0.28	1.17	0.24	0.30
1994	182.12	86.75	85.01	2.74	5.59	0.27	1.20	0.25	0.30
1995	185.53	78.75	96.13	2.92	5.56	0.27	1.30	0.27	0.32
1996	182.53	78.04	93.78	3.05	5.50	0.25	1.32	0.27	0.33
1997	179.27	81.28	87.04	3.07	5.52	0.28	1.34	0.29	0.45
1998	177.92	83.03	83.98	2.89	5.72	0.28	1.36	0.27	0.40
1999	176.43	80.38	85.73	2.82	5.15	0.28	1.47	0.29	0.31
2000	175.47	72.47	92.94	2.71	5.02	0.23	1.49	0.28	0.32
2001	173.08	70.91	92.06	2.56	5.16	0.24	1.52	0.30	0.32
2002	169.58	70.41	89.38	2.43	4.96	0.24	1.54	0.29	0.33
2003	167.86	67.53	90.44	2.60	4.87	0.25	1.57	0.27	0.33
2004	167.92	65.99	92.14	2.62	4.69	0.26	1.62	0.28	0.34
2005	165.86	65.45	90.51	2.61	4.75	0.26	1.67	0.28	0.34
2006	165.38	65.22	90.36	2.50	4.71	0.26	1.72	0.27	0.35
2007	166.06	65.35	90.27	2.81	4.93	0.27	1.76	0.30	0.36
2008	165.81	66.40	89.39	2.67	4.60	0.27	1.81	0.31	0.37

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
2009	167.99	66.79	90.88	2.76	4.71	0.28	1.86	0.34	0.37
2010	167.59	66.93	90.15	2.87	4.70	0.28	1.91	0.36	0.38
2011	165.50	66.94	88.18	2.89	4.51	0.29	1.96	0.36	0.37
2012	164.41	67.44	86.55	2.92	4.47	0.30	2.01	0.37	0.35
2013	164.69	68.47	85.97	2.86	4.34	0.30	2.06	0.36	0.33
2014	165.45	69.96	85.29	2.79	4.30	0.30	2.11	0.35	0.33
2015	165.23	69.68	85.27	2.83	4.27	0.30	2.16	0.38	0.33
2016	165.87	71.39	84.05	3.03	4.19	0.30	2.16	0.41	0.33
Share 2016	***100%***	***38.9%***	***45.8%***	***1.7%***	***2.3%***	***0.2%***	***1.2%***	***0.2%***	***0.2%***
1990–2016	***–14.0%***	***-25.0%***	***-4.5%***	***22.1%***	***-24.3%***	***14.1%***	***143.9%***	***121.6%***	***12.7%***

The overall reduction is caused by a decrease in total numbers of animals. 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 160: Greenhouse gas emissions from non-dairy cattle (3.A.1.2) by sub-categories 1990–2016.

Year	CH_4 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	88.01	4.71	33.22	18.17	21.71	10.19
1991	87.88	5.76	32.09	18.03	21.47	10.53
1992	82.94	6.09	29.73	16.99	19.97	10.15
1993	83.67	7.00	25.13	18.26	22.30	10.98
1994	85.01	9.10	25.08	18.62	21.87	10.34
1995	96.13	21.34	24.41	18.74	21.01	10.62
1996	93.78	21.61	23.65	18.29	19.55	10.68
1997	87.04	17.37	22.24	18.26	17.95	11.22
1998	83.98	15.75	22.39	17.90	17.03	10.92
1999	85.73	18.07	22.24	17.96	16.40	11.06
2000	92.94	25.91	23.11	17.34	15.49	11.09
2001	92.06	26.48	23.23	17.00	15.07	10.28
2002	89.38	25.22	22.57	16.66	15.01	9.92
2003	90.44	25.08	22.63	16.13	15.27	11.33
2004	92.14	27.04	22.78	16.21	14.77	11.33
2005	90.51	27.97	22.12	16.13	14.49	9.80
2006	90.36	28.05	22.22	15.59	14.94	9.56
2007	90.27	28.05	22.30	14.81	15.86	9.25
2008	89.39	27.55	22.37	14.08	16.16	9.22

Year	CH_4 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
2009	90.88	27.35	22.60	13.77	17.49	9.68
2010	90.15	26.97	22.25	13.13	17.95	9.86
2011	88.18	26.56	21.86	12.90	17.21	9.65
2012	86.55	25.69	22.06	12.95	16.74	9.11
2013	85.97	24.47	22.00	13.38	17.06	9.06
2014	85.29	23.78	22.08	13.38	16.91	9.14
2015	85.27	23.20	21.91	13.62	17.13	9.41
2016	84.05	22.40	22.14	13.47	16.76	9.28
Share 2016	***100%***	***26.7%***	***26.3%***	***16.0%***	***19.9%***	***11.0%***
1990–2016	***–4.5%***	***375.2%***	***-33.4%***	***-25.9%***	***-22.8%***	***-9.0%***

The rise in suckling cow numbers (see Table 161) 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 swine, sheep, goats, horses and 'other animals'. For *Cattle* 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 and mainly includes 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 (gross energy intake, methane conversion rate) applied by Switzerland have been chosen to be also applied for the Austrian emission inventory. Agricultural practices in Switzerland are very similar to those in Austria: Both countries have a small structured agriculture due to similar alpine conditions, comparable traditions and culture. In both countries high shares of farms (in Austria 56% and in Switzerland 59%) manage less than 20 ha. No IPCC default values are available.

Activity data

The Austrian official statistics (STATISTIK AUSTRIA 2017b) provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year[77].

In Table 161 and Table 162 applied animal data are presented. Background information to the data is listed below:

From 1990 onwards: The continuous decline of dairy cattle numbers is connected with the in-

[77] 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).

creasing 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.

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 behavior, 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 behavior, saturation of swine production, epidemics, etc.

Table 161: Domestic livestock population and its trend 1990–2016 (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	255 464	305 339	146 312
1991	876 000	1 658 088	57 333	894 111	253 522	301 910	151 212
1992	841 716	1 559 009	60 481	831 612	239 569	281 509	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

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**
1997	720 377	1 477 563	170 540	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
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
1990–2016	***-40.3%***	***-15.8%***	***360.8%***	***-31.7%***	***-24.7%***	***-21.5%***	***-8.7%***

* *adjusted age class split for swine as recommended in the centralized review (October 2003)*

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.

Table 162: Domestic livestock population and its trend 1990–2016 (II).

Year	Population size [heads] * Livestock category							
	Swine	**Young & Fattening Pigs > 20 kg**	**Breeding Sows > 50 kg**	**Piglets < 20 kg**	**Sheep**	**Goats**	**Horses[1)]**	**Deer**[2)]**
1990	3 687 981	2 347 001	382 335	958 645	309 912	37 343	49 200	37 100
1991	3 637 980	2 315 181	377 152	945 648	326 100	40 923	57 803	37 259
1992	3 719 600	2 367 123	385 613	966 864	312 000	39 400	61 400	37 418
1993	3 819 798	2 425 852	396 001	997 945	333 835	47 276	64 924	37 577
1994	3 728 991	2 368 061	394 938	965 992	342 144	49 749	66 748	37 736
1995	3 706 185	2 356 988	401 490	947 707	365 250	54 228	72 491	40 323

Year	Population size [heads] * Livestock category							
	Swine	Young & Fattening Pigs > 20 kg	Breeding Sows > 50 kg	Piglets < 20 kg	Sheep	Goats	Horses[1)]	Deer**[2)]
1996	3 663 747	2 311 988	398 633	953 126	380 861	54 471	73 234	41 526
1997	3 679 876	2 330 334	397 742	951 800	383 655	58 340	74 170	56 244
1998	3 810 310	2 456 935	386 281	967 094	360 812	54 244	75 347	50 365
1999	3 433 029	2 226 307	343 812	862 910	352 277	57 993	81 566	39 086
2000	3 347 931	2 160 338	334 278	853 315	339 238	56 105	82 943	39 612
2001	3 440 405	2 220 765	350 197	869 443	320 467	59 452	84 319	40 138
2002	3 304 650	2 146 968	341 042	816 640	304 364	57 842	85 696	40 664
2003	3 244 866	2 125 371	334 329	785 166	325 495	54 607	87 072	41 190
2004	3 125 361	2 016 005	317 033	792 323	327 163	55 523	89 816	42 102
2005	3 169 541	2 091 225	315 731	762 585	325 728	55 100	92 560	43 014
2006	3 139 438	2 038 170	321 828	779 440	312 375	53 108	95 304	43 926
2007	3 286 292	2 171 519	318 349	796 424	351 329	60 487	98 048	44 839
2008	3 064 231	2 023 536	297 830	742 865	333 181	62 490	100 792	45 751
2009	3 136 967	2 083 459	293 901	759 607	344 709	68 188	103 536	46 663
2010	3 134 156	2 084 923	284 691	764 542	358 415	71 768	106 280	47 575
2011	3 004 907	2 011 138	275 874	717 895	361 183	72 358	109 024	45 654
2012	2 983 158	2 001 150	263 200	718 808	364 645	73 212	111 768	43 733
2013	2 895 841	1 956 862	254 373	684 606	357 440	72 068	114 512	41 812
2014	2 868 191	1 928 596	246 870	692 725	349 087	70 705	117 256	41 812
2015	2 845 451	1 912 442	249 655	683 354	353 710	76 620	120 000	41 812
2016	2 792 803	1 891 492	240 756	660 555	378 381	82 735	120 000	41 812
1990–2016	***-24.3%***	***-19.4%***	***-37.0%***	***-31.1%***	***22.1%***	***121.6%***	***143.9%***	***12.7%***

** from 1990 to 1992 adjusted age class split for swine as recommended in the centralized review (October 2003)*

*** 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 and 2011-2012: interpolated values

Horse numbers for 2015 and 2016 were provided by the Ministry of Agriculture and are published in (BMLFUW 2000–2017, p. 44). 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 163: Domestic livestock population and its trend 1990–2016 (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

Year	Livestock category – Population size [heads] *					
	Total Poultry	Chicken**	Laying hens**	Broilers**	Turkeys***	Other Poultry ***
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	15 771 551	15 079 069	7 997 468	7 081 601	600 497	91 985
2015	15 771 551	15 079 069	7 997 468	7 081 601	600 497	91 985
2016	15 771 551	15 079 069	7 997 468	7 081 601	600 497	91 985
1990–2016	***14.1%***	***14.8%***	***-4.7%***	***49.2%***	***14.5%***	***-41.5%***

* *adjusted age class split for swine as recommended in the centralized review (October 2003)*

** *interpolated values for the years 2004-2009 and 2011-2012*

*** *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 and 2011-2012*

Information about the extent of organic farming in Austria was provided in the Austrian INVEKOS[78] database (KIRNER & SCHNEEBERGER 1999), which was established to account for the financial support for sustainable agriculture including organic farming. INVEKOS data were used to calculate the share of animals that are subject to organic farming practices.

For the years 1990–1996, a trend extrapolation using surrogate data was made, namely the number of farms that apply organic farming practices (BMLFUW 2000–2017). These data for expansion development of organic farming in Austria were applied to derive a trend of the animal

[78] INVEKOS (Integriertes Verwaltungs- und Kontrollsystem, Integrated Administration and Control System) contains data about the regional distribution, land use, and the number of animals per farm. The INVEKOS is managed by the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

population numbers in organic farming for the years 1990–1996 where no other relevant data were available. For the years 2001 to 2003 the data for 2000 was used. From 2004 onwards INVEKOS data of organic cattle population as reported in the so called 'Green Reports' of the Ministry of Agriculture (BMLFUW 2000–2017) was used. In this report data on organic animal population is available for total cattle number, dairy cattle and suckling cows. The share of the other cattle categories under organic farming systems was derived from these data.

Table 164 shows the results of the shares of organic farming in the relevant livestock categories for 1990 and 2016.

Table 164: Share of cattle population under organic farming systems 1990 and 2016.

IPCC Category	% organic 1990	% organic 2016
CATTLE	1%	21%
Dairy Cattle > 2 yr	1%	20%
Suckling Cows > 2 yr	2%	38%
Other Cattle > 2 yr	1.5%	18%
Young Cattle < 1 yr	1%	18%
Young Cattle 1–2 yr	1%	18%

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 2016, emissions from enteric fermentation – cattle contributed 5.2% to total greenhouse gas emissions in Austria.

CH_4 emissions were calculated using the IPCC Tier 2 methodology. Activity data were obtained from national statistics and are presented in Table 161 and Table 162.

Emission factors

Country specific emission factors were used. They were calculated from the specific gross energy intake and the methane conversion rate (IPCC 2006, Equation 10.21).

$EF = [GE * (Y_m/100) * 365 \text{ days/yr})/55.65]$ MJ/kg

Y_m *Methane conversion factor*

The methane conversion factor (Y_m) was taken from the IPCC recommended value for cattle (6.5% +/-1.0%) as presented in table 10.12, because there are few if any feedlot cattle with a high-energy diet (i.e. with 90% or more of the diet in form of concentrates) in Austria.

Country specific values for the Gross Energy Intake were applied. The estimation was done separately for dairy and non-dairy cows.

GE Gross energy intake of dairy cows (3.A.1.a):

Austrian specific values for dairy cows were derived from feed intake data and energy content of feed (forage and concentrate) in dependency of annual milk yields (GRUBER & STEINWIDDER 1996). Following a recommendation of the Centralized Review 2004 in the year 2005 Austrian N excretion values and energy intake data were recalculated by Dr. Erich M. Pötsch from the Agricultural Research and Education Centre (AREC) Raumberg-Gumpenstein (PÖTSCH 2005), (GRUBER & PÖTSCH 2006).

Table 165: Energy intake data for dairy cattle in Austria (PÖTSCH 2005).

Annual milk yield	kg/cow/yr	3 000	3 500	4 000	4 500	5 000	5 500	6 000	6 500	7 000
animal weight	kg/cow/yr	700	700	700	700	700	700	700	700	700
energy intake	MJ NEL* (kg dry matter)$^{-1}$	5.6	5.7	5.7	5.8	5.9	6.0	6.0	6.1	6.1
forage intake	kg dry matter day^{-1}	13.9	14.0	14.0	13.9	13.8	13.8	13.8	14.1	14.3
concentrate intake	kg dry matter day^{-1}	0.4	0.7	0.9	1.3	1.8	2.3	2.8	3.1	3.3
net energy intake	MJ NEL* day^{-1}	80.3	82.8	85.3	88.5	91.7	95.8	99.8	103.9	107.8
gross energy intake	MJ GE day^{-1}	235.3	242.5	249.8	259.2	268.7	280.7	292.3	304.2	315.7

* *net energy lactation*

Austrian dairy cattle show average milk yields from 3 791 kg/cow (1990) to 6 759 kg/cow (2016). The time series of average milk yields per dairy cow was taken from national statistics and are presented in Table 166. For dairy cattle there was a 25.7% increase of GE intake between 1990 and 2016 due to the increase of the milk yield per dairy cow in this time. The resulting emission factor is presented in the following table:

Table 166: Annual milk yield, gross energy intake and emission factors of dairy cattle 1990–2016.

Year	Milk Yield	Gross Energy Intake	Emission Factor
	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
1990	3 791	246.75	105.20
1991	3 848	247.57	105.55
1992	3 908	248.44	105.91
1993	3 997	249.72	106.46
1994	4 076	251.21	107.10
1995	4 619	261.47	111.47
1996	4 670	262.44	111.88
1997	4 787	264.65	112.83
1998	4 924	267.25	113.93
1999	5 062	270.17	115.18
2000	5 210	273.73	116.70
2001	5 394	278.16	118.59
2002	5 487	280.41	119.55
2003	5 638	283.92	121.04
2004	5 802	287.72	122.66
2005	5 783	287.28	122.47
2006	5 903	290.07	123.67
2007	5 997	292.26	124.60

Year	Milk Yield	Gross Energy Intake	Emission Factor
	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
2008	6 059	293.73	125.22
2009	6 068	293.93	125.31
2010	6 100	294.69	125.64
2011	6 227	297.72	126.92
2012	6 418	302.26	128.86
2013	6 460	303.26	129.29
2014	6 542	305.18	130.11
2015	6 579	306.03	130.47
2016	6 759	310.17	132.23

[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 "Fleckvieh" still dominates the herd.

In the CRF tables 3.A and 3.B(a) Austria reports for the typical animal mass of dairy cattle a constant value of 700kg over the entire time series. This value is in line with the Austrian calculation model which applies for all reported years the average weight of the dominant Austrian breed "Fleckvieh" (700kg). Following the Austrian nutrition expert Dr. Erich Pötsch, the calculation with average animal masses of 700kg is the best approach for average milk yields lower than 7 000kg/hd/yr in Austria. Lower animal weights of high-yield breeds (e.g. Holstein Friesian: 640kg) will be considered for average milk yields from 7 000kg onwards. The chosen approach prevents emissions from being underestimated (ARR 2013, para 50).

GE Gross energy intake of non-dairy cattle (3.A.1.b):

Suckling cows:

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, resulting in a Gross Energy Intake of 235.21 MJ per suckling cow and day (see Table 167).

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 month 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 500kg milk per calve, an average milk yield of 3 500kg has been assumed for the years from 2004 onwards, resulting in a Gross Energy Intake of 242.53 MJ per suckling cow and day. Values between 1990 and 2004 have been derived by interpolation (see Table 167).

Table 167: Annual milk yield, gross energy intake and emission factors of suckling cows 1990–2016.

Year	Milk Yield	Gross Energy Intake	Emission Factor
	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]
1990	3 000	235.21	100.28
1991	3 036	235.73	100.50
1992	3 071	236.25	100.72
1993	3 107	236.78	100.94
1994	3 143	237.30	101.17
1995	3 179	237.82	101.39
1996	3 214	238.35	101.61
1997	3 250	238.87	101.84
1998	3 286	239.39	102.06
1999	3 321	239.92	102.28
2000	3 357	240.44	102.51
2001	3 393	240.96	102.73
2002	3 429	241.48	102.95
2003	3 464	242.01	103.17
2004	3 500	242.53	103.40
2005	3 500	242.53	103.40
2006	3 500	242.53	103.40
2007	3 500	242.53	103.40
2008	3 500	242.53	103.40
2009	3 500	242.53	103.40
2010	3 500	242.53	103.40
2011	3 500	242.53	103.40
2012	3 500	242.53	103.40
2013	3 500	242.53	103.40
2014	3 500	242.53	103.40
2015	3 500	242.53	103.40
2016	3 500	242.53	103.40

Other non-dairy cattle categories:

Gross energy intake for all other cattle categories were calculated from typical Austrian diets. Animal nutrition expert Andreas Steinwidder worked out animal diets as shown in Table 168 and Table 169 (AMON et al. 2002).

These livestock categories show distinct differences in organic and conventional diets. Thus, in this section a differentiation between both production systems was worked out. Gross Energy

Intake was calculated using the methodology as described in (GRUBER & STEINWIDDER 1996).

Table 168: Typical Austrian diets and gross energy intake of Non-Dairy Cattle, conventional production system.

CONVENTIONAL	cattle < 1 year	cattle 1–2 years	non-dairy cattle > 2 years
live weight	210 kg	530 kg	600 kg
animal diet	15% green feeding	20% green feeding	40% green feeding
	20% hay	15% hay	20% hay
	30% grass silage	30% grass silage	30% grass silage
	35% maize silage	35% maize silage	10% maize silage
forage intake [kg dry matter day^{-1}]	2.5	7.4	8.2
concentrate intake [kg dry matter day^{-1}]	2	2	1
Gross Energy Intake [(MJ GE (kg dry matter)$^{-1}$]	84.4	167.0	163.4

Table 169: Typical Austrian diets and gross energy intake of Non-Dairy Cattle, organic production system.

ORGANIC	cattle < 1 year	cattle 1–2 years	non-dairy cattle > 2 years
live weight	190 kg	480 kg	580 kg
animal diet	35% green feeding	40% green feeding	40% green feeding
	20% hay	15% hay	15% hay
	45% grass silage	45% grass silage	45% grass silage
forage intake [kg dry matter day^{-1}]	2.9	7.5	8
concentrate intake [kg dry matter day^{-1}]	1	1	1
Gross Energy Intake [(MJ GE (kg dry matter)$^{-1}$]	72.1	151.1	159.9

As no major changes in diets of *Non-Dairy Cattle* occurred in the period from 1990–2016, methane emissions from enteric fermentation of *Non-Dairy Cattle* are calculated with a constant gross energy intake for the whole time series. The resulting emission factor is presented in the following table:

Table 170: Emission factors and gross energy intake of non-dairy cattle.

IPCC Category	Farming type	Gross Energy Intake [MJ/head*day]	Calculated Emission Factor [kg CH_4/head.yr]
Cattle > 2 yr	conventional	163	70
Cattle > 2 yr	organic	160	68
Young Cattle < 1 yr	conventional	84	36
Young Cattle < 1 yr	organic	72	31
Young Cattle 1–2 yr	conventional	167	71
Young Cattle 1–2 yr	organic	151	64

5.2.2.2 Sheep (3.A.2), Swine (3.A.3) and Other livestock (3.A.4: Poultry, Horses, Goats and Deer)

Key Source: No

As presented in Table 159, CH_4 emissions from sheep, swine and other livestock (poultry, horses, goats and deer) are only minor emission sources of enteric fermentation. Together they contributed 5.7% to total emissions from this category in 2016. The most important sub-category is swine, with a contribution of 2.3%, followed by sheep (1.7%), horses (1.2%) and goats, poultry as well as deer with each about 0.2% (figures are also presented in Table 159).

The IPCC Tier 1 methodology and default emission factors have been used (see Table 171):

Table 171: 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.3 Swine	1.5	3.A.4.3 Goats	5.0

** Source: IPCC 2006 Guidelines, Table 10.10, p.10.28*

Deer:

The deer category is very inhomogeneous including roe deer, red deer, fallow deer and to some extent wild boars ('furred game'). 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 furred game 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)) were used as Tier 1.

Y_m: 0.16%

GE: 1.80 MJ/head/yr

Swiss data on energy intake (see Swiss NIR 2008) are taken 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 161 and Table 162.

Agricultural practices in Switzerland are very similar to those in Austria: Both countries have a small structured agriculture due to similar alpine conditions, comparable traditions and culture. In both countries high shares of farms (56% in Austria and 59% in Switzerland) manage less than 20 ha.

5.2.3 Source 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 meetings);

- ✓ 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.
- ✓ External review of the revised agricultural model according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting in 2014.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.2.4 Uncertainties

Uncertainties are presented in Table 157.

5.2.5 Recalculations

Update of activity data

Milk yield data for dairy cows for the years 1991−1993 and 2001 was updated on the basis of official data from the Ministry of Agriculture (BMLFUW 2017). The revision resulted in slightly higher emissions for the years 1991−1993 and slightly lower emissions for 2001.

5.3 Manure management (Category 3.B)

This chapter describes the estimation of CH_4 and N_2O emissions from animal manure. In 2016 9.5% of the agricultural CH_4 emissions and 17.0% of the agricultural N_2O emissions were caused by this category.

5.3.1 Source Category Description

From 1990 to 2016 CH_4 emissions from manure management decreased by 25.6% to 17.48 kt.

Table 172: CH_4 emissions from manure management 1990–2016.

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	23.48	10.01	6.97	0.06	5.96	0.40	0.08	0.00	0.01
1991	23.08	9.71	6.98	0.06	5.80	0.42	0.09	0.01	0.01
1992	22.36	9.35	6.60	0.06	5.85	0.40	0.10	0.01	0.01
1993	22.41	9.23	6.66	0.06	5.92	0.43	0.10	0.01	0.01
1994	22.18	9.03	6.82	0.07	5.72	0.42	0.10	0.01	0.01
1995	22.22	7.96	8.00	0.07	5.65	0.41	0.11	0.01	0.01
1996	21.73	7.86	7.81	0.07	5.49	0.38	0.11	0.01	0.01
1997	21.32	8.13	7.13	0.07	5.43	0.42	0.12	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
1998	21.20	8.24	6.84	0.07	5.51	0.40	0.12	0.01	0.01
1999	20.43	7.91	7.02	0.07	4.88	0.40	0.13	0.01	0.01
2000	20.06	7.07	7.77	0.06	4.66	0.34	0.13	0.01	0.01
2001	19.88	6.85	7.72	0.06	4.74	0.36	0.13	0.01	0.01
2002	19.32	6.76	7.48	0.06	4.52	0.36	0.13	0.01	0.01
2003	18.92	6.43	7.53	0.06	4.39	0.36	0.14	0.01	0.01
2004	18.59	6.22	7.70	0.06	4.09	0.37	0.14	0.01	0.01
2005	18.48	6.17	7.60	0.06	4.11	0.38	0.14	0.01	0.01
2006	18.30	6.10	7.59	0.06	4.00	0.38	0.15	0.01	0.01
2007	18.38	6.08	7.59	0.07	4.08	0.39	0.15	0.01	0.01
2008	18.04	6.16	7.51	0.06	3.73	0.39	0.16	0.01	0.01
2009	18.27	6.19	7.64	0.07	3.79	0.40	0.16	0.01	0.01
2010	18.19	6.20	7.58	0.07	3.75	0.41	0.17	0.01	0.01
2011	17.88	6.17	7.41	0.07	3.62	0.42	0.17	0.01	0.01
2012	17.68	6.17	7.27	0.07	3.55	0.43	0.17	0.01	0.01
2013	17.61	6.26	7.19	0.07	3.46	0.44	0.18	0.01	0.01
2014	17.59	6.37	7.12	0.07	3.39	0.44	0.18	0.01	0.01
2015	17.53	6.34	7.11	0.07	3.38	0.44	0.19	0.01	0.01
2016	17.48	6.45	7.00	0.07	3.31	0.44	0.19	0.01	0.01
Share 2016	***100%***	***36.9%***	***40.0%***	***0.4%***	***19.0%***	***2.5%***	***1.1%***	***0.1%***	***0.0%***
1990–2016	***–25.6%***	***-35.5%***	***0.4%***	***22.1%***	***-44.4%***	***10.2%***	***143.9%***	***121.6%***	***12.7%***

From 1990 to 2016 the direct N_2O emissions from manure management decreased by 1.8% to 1.09 kt. Emissions of cattle dominate the trend. The reduction of dairy cows 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 173: Direct N_2O Emissions from manure management per livestock category 1990–2016.

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
1990	1.112	0.402	0.465	0.016	0.199	0.013	0.015	0.002	0.001
1991	1.110	0.396	0.468	0.017	0.195	0.013	0.017	0.002	0.001
1992	1.082	0.387	0.447	0.016	0.199	0.013	0.018	0.002	0.001
1993	1.094	0.389	0.449	0.017	0.202	0.013	0.019	0.002	0.001
1994	1.100	0.388	0.461	0.018	0.197	0.013	0.020	0.002	0.001
1995	1.145	0.363	0.529	0.019	0.197	0.013	0.022	0.003	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
1996	1.134	0.364	0.521	0.020	0.192	0.012	0.022	0.003	0.001
1997	1.122	0.385	0.487	0.020	0.192	0.013	0.022	0.003	0.001
1998	1.125	0.399	0.474	0.019	0.195	0.012	0.022	0.003	0.001
1999	1.110	0.391	0.488	0.018	0.174	0.012	0.024	0.003	0.001
2000	1.114	0.357	0.534	0.017	0.168	0.010	0.024	0.003	0.001
2001	1.113	0.353	0.533	0.016	0.172	0.011	0.025	0.003	0.001
2002	1.094	0.354	0.520	0.016	0.165	0.011	0.025	0.003	0.001
2003	1.093	0.343	0.532	0.017	0.162	0.011	0.025	0.003	0.001
2004	1.094	0.339	0.546	0.017	0.152	0.011	0.026	0.003	0.001
2005	1.088	0.340	0.537	0.017	0.154	0.011	0.027	0.003	0.001
2006	1.090	0.342	0.539	0.016	0.151	0.011	0.027	0.003	0.001
2007	1.103	0.346	0.541	0.018	0.155	0.011	0.028	0.003	0.001
2008	1.099	0.355	0.539	0.017	0.143	0.011	0.029	0.003	0.001
2009	1.115	0.357	0.549	0.018	0.145	0.011	0.030	0.003	0.001
2010	1.112	0.358	0.545	0.018	0.143	0.012	0.032	0.003	0.001
2011	1.098	0.358	0.533	0.019	0.138	0.012	0.033	0.003	0.001
2012	1.089	0.362	0.523	0.019	0.135	0.012	0.034	0.004	0.001
2013	1.087	0.367	0.519	0.018	0.131	0.013	0.034	0.003	0.001
2014	1.090	0.376	0.515	0.018	0.128	0.013	0.035	0.003	0.001
2015	1.089	0.374	0.516	0.018	0.128	0.013	0.036	0.004	0.001
2016	1.092	0.385	0.509	0.019	0.125	0.013	0.036	0.004	0.001
Share 2016	***100%***	***35.2%***	***46.6%***	***1.8%***	***11.5%***	***1.2%***	***3.3%***	***0.4%***	***0.1%***
1990–2016	***–1.8%***	***-4.3%***	***9.6%***	***22.1%***	***-37.2%***	***-1.7%***	***144.6%***	***121.6%***	***12.7%***

Total N_2O emissions (direct and indirect) from sector *3.B Manure Management* increased slightly by 0.2% between 1990 and 2016. The share of direct N_2O emissions in total N_2O emissions from sector *3.B* is 74.1% and 25.9% of indirect N_2O emissions in 2016.

Table 174: Direct, indirect and total N_2O Emissions from manure management 1990–2016.

Year	N_2O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
1990	1.471	1.112	0.359	NO
1991	1.476	1.110	0.367	NO
1992	1.444	1.082	0.361	NO
1993	1.466	1.094	0.372	NO
1994	1.473	1.100	0.373	NO
1995	1.526	1.145	0.381	NO
1996	1.510	1.134	0.376	NO

Year	N_2O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
1997	1.503	1.122	0.381	NO
1998	1.508	1.125	0.383	NO
1999	1.485	1.110	0.374	NO
2000	1.481	1.114	0.367	NO
2001	1.485	1.113	0.372	NO
2002	1.462	1.094	0.368	NO
2003	1.462	1.093	0.369	NO
2004	1.463	1.094	0.368	NO
2005	1.459	1.088	0.371	NO
2006	1.463	1.090	0.373	NO
2007	1.486	1.103	0.382	NO
2008	1.479	1.099	0.380	NO
2009	1.501	1.115	0.386	NO
2010	1.498	1.112	0.386	NO
2011	1.480	1.098	0.382	NO
2012	1.470	1.089	0.381	NO
2013	1.469	1.087	0.381	NO
2014	1.471	1.090	0.381	NO
2015	1.471	1.089	0.382	NO
2016	1.474	1.092	0.382	NO
Share 2016	***100%***	***74.1%***	***25.9%***	**NO**
1990–2016	***0.2%***	***–1.8%***	***6.5%***	**-**

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

The IPPC-Tier 2 methodology has been applied to estimate CH_4 emissions from manure management of cattle (identified as key category) and swine. This method requires detailed information on animal characteristics and the manner in which manure is managed. All the other animal categories are of minor importance in Austria, thus CH_4 emissions are estimated with the Tier 1 approach.

During an inventory update carried out within submission 2010 the following improvements have been 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.

For the estimation of N_2O emissions a Tier 1 methodology is used. N_2O emissions are calculated on the basis of N excretion per animal and waste management system.

Inventory revision 2015 (AMON & HÖRTENHUBER 2014) concentrated on implementing the IPCC 2006 Guidelines.

Animal Waste Management Systems (AWMS)

As noted in several review reports (ARR 2006, ARR 2008), the distribution of housing and storage systems undergoes major changes, which should be reflected in the inventory. Austria therefore was recommended to update its information on animal waste management systems (AWMS) distribution. Hence, in 2008 the Umweltbundesamt commissioned the University of Natural Resources and Applied Life Sciences with the revision of the national emission model of sector agriculture (AMON & HÖRTENHUBER 2010).

Input-data on AWMS (cattle and swine) was taken from the research project 'Animal husbandry and manure management systems in Austria (TIHALO)' (AMON et al. 2007). In this project a comprehensive survey on the agricultural practices in Austria has been carried out. 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. Firstly, a questionnaire was developed to assess animal housing, manure storage and manure application on typical Austrian farms. In November 2005, the questionnaire was sent to 5 000 Austrian farms. The statistical sampling plan was set up with the assistance of the Statistics Austria to guarantee the selection of a representative sample of Austrian farms. A questionnaire return of about 40% had to be achieved to receive representative data on animal husbandry and manure management systems in Austria. With the active assistance of the regional chambers of agriculture, a rate of questionnaire return of 39% was achieved. The returned questionnaires were manually fed into a data template by the Statistics Austria. On the basis of this template, a data base was created that contained the questionnaire information. Anonymity of the farms that supplied data is guaranteed. The data base was checked for representativeness and plausibility.

As a result of TIHALO, for 2005 updated representative data on animal husbandry and manure management systems all over Austria was available. For the year 1990 AWMS 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.

For the creation of a plausible time series the AWMS distribution of 1990 (based on KONRAD 1995) partly had to be adopted. Changes to the year 1990 were derived from new study results (AMON et al. 2007) and expert opinion carried out by DI Alfred Pöllinger (Agricultural Research and Education Centre Raumberg-Gumpenstein) in June 2008. The AWMS data from 2005–2008 were derived by linear extrapolation. From 2008 onwards the AWMS distribution is held constant in order to prevent implausible trends. Within the inventory update 2014, the assumptions on current distributions for housing and manure management systems were reviewed with data from the Farm Structure Survey 2010 (Statistik Austria 2013). As the comparison showed a good agreement, the activity data used in the inventory has not to be adjusted. Information on anaerobic digestion is based on data published by the Austrian Energy Regulator (E-CONTROL 2017). 1990 data are based on (AMON 2002).

For the Tier 1 livestock categories sheep, poultry, horses, goats and deer country specific AWMS data based on expert judgement has been applied (PÖLLINGER 2008; poultry: FRANKHAUSER 2007, BERNHAUSER 2014). Except for chicken, the AWMS distribution of these animal categories has been kept constant over the entire time series.

Austria's AWMS data are provided in Table 175 and Table 176.

Table 175: Manure Management System distribution in Austria 2016.

Livestock category	Liquid/ Slurry	Solid Storage	Pasture/ Range/Paddock	Composting	Anaerobic Digestion	Other Systems
	[%]	[%]	[%]	[%]	[%]	[%]
Dairy cattle	32.2	49.0	2.9	7.4	0.6	8.0
Non-dairy cattle	24.8	43.1	6.0	6.0	0.6	19.5
Suckling cows	14.6	40.0	14.3	6.0	0.6	24.5
Cattle < 1 year	15.3	48.0	1.9	7.2	0.6	27.0
Breeding heifers 1–2 years	30.5	44.4	5.8	6.5	0.6	12.2
Fattening heifers, bulls and oxen 1–2 years	43.5	38.8	0.2	4.2	0.6	12.7
Other cattle > 2 years	27.0	44.1	7.1	6.3	0.6	15.0
Sheep	0.0	50.0	50.0	0.0	0.0	0.0
Goats	0.0	50.0	50.0	0.0	0.0	0.0
Horses	0.0	80.0	20.0	0.0	0.0	0.0
Swine (Total)	74.3	7.0	0.0	1.1	5.0	12.6
Breeding sows	49.9	21.7	0.0	3.5	5.0	19.8
Young and fattening pigs	83.1	1.7	0.0	0.2	5.0	9.9
Chicken	0.0	92.6	0.0	0.0	7.4	0.0
Layers	0.0	92.6	0.0	0.0	7.4	0.0
Broilers	0.0	92.6	0.0	0.0	7.4	0.0
Other poultry	0.0	100.0	0.0	0.0	0.0	0.0
Turkeys	0.0	100.0	0.0	0.0	0.0	0.0
Other Poultry	0.0	100.0	0.0	0.0	0.0	0.0
Deer	0.0	20.0	80.0	0.0	0.0	0.0

Table 176: Other systems 2016 in detail.

Livestock category	Yard	Deep Litter	Aerobic Treatment
	[%]	[%]	[%]
Dairy cattle	2.0	1.4	4.6
Non-dairy cattle	1.9	14.2	3.4
Suckling cows	2.3	20.0	2.2
Cattle < 1 year	1.8	22.5	2.7
Breeding heifers 1–2 years	1.7	7.5	3.0
Fattening heifers, bulls and oxen 1–2 years	1.7	6.8	4.3
Other cattle > 2 years	2.1	7.0	5.9

Livestock category	Yard	Deep Litter	Aerobic Treatment
	[%]	[%]	[%]
Sheep	0.0	0.0	0.0
Goats	0.0	0.0	0.0
Horses	0.0	0.0	0.0
Swine (Total)	1.6	7.4	3.6
Breeding sows	2.5	14.0	3.3
Young and fattening pigs	1.2	5.1	3.7
Chicken	0.0	0.0	0.0
Layers	0.0	0.0	0.0
Broilers	0.0	0.0	0.0
Other poultry	0.0	0.0	0.0
Turkeys	0.0	0.0	0.0
Other Poultry	0.0	0.0	0.0
Deer	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 AWMS shows for cattle a decreasing share of pasture and increasing shares of composting, anaerobic digestion and 'other systems' (see Annex 6). Deep litter dominates the other system category for non-dairy cattle and breeding sows. Young and fattening pigs are increasingly held on liquid systems, whereas in the breeding sows category a trend from liquid systems to composting, anaerobic digestion and 'other 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).

As recommended by the ERT (ARR 2013, para 49), since NIR 2014 the fractions of livestock manure per animal category handled in different AWMS are included for all reporting years in Annex 6.

In 2016 a new investigation on Austria's agriculture practice has been started and the implementation to Austria's emission inventory is planned for submission 2019.

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 177: Liquid slurry – percentage storage in cold and warm season according to TIHALO.

Livestock category	**Liquid slurry storage**	
	warm season [%]	**cold season [%]**
Dairy cattle	21.4	78.6
Suckling cows	18.7	81.3
Cattle < 1 year	21.9	78.1
Breeding heifers 1–2 years	20.0	80.0
Fattening heifers, bulls and oxen 1–2 years	22.4	77.6
Non-dairy cattle > 2 years	20.1	79.9
Breeding sows	19.6	80.4
Young and fattening pigs	19.6	80.4

Derivation of the share of manure digested in biogas plants

Data basis for the estimation are published numbers of biogas plants under contract for electricity supply and average amounts of manure digested in Austrian biogas plants derived from official Austrian reports. Below additional information on the derivation of the share 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 (E-CONTROL, Ökostromberichte 2006–2017). Plant numbers between the years 2000 and 2005 have been derived by interpolation.

1990 data on the average amounts of digested manure per plant was obtained from (AMON et al 2002). Data for 2007, 2009, 2011, 2014 and 2015 was derived from detailed raw material and energy balances reported by E-Control (E-CONTROL 2008, 2011, 2013 & 2017). Data for the years in between was derived by interpolation. Digested amounts of animal manures for the year 2016 were calculated on the basis of average amounts of manures per biogas plant in the year 2015 and the number of operating biogas plants in the year 2016.

In Austrian biogas plants the most important feedstock is corn-based silage and grass-based silage. Only a comparatively small part of the energy production is based on animal manures (mainly cattle, swine and chicken). Information on energy production per ton fresh matter has been obtained from KTBL (2005) and FNR (2006).

The shares of anaerobic digested manures have been calculated from the total manure excretion per relevant animal category (mainly cattle, swine and chicken). Data on average animal manure excretion has been obtained from national peer reviewed studies (GRUBER & STEINWIDDER 1996, GRUBER & PÖTSCH 2006) and Richtlinien Sachgerechter Düngung (BMLFUW 2006c).

Table 178: Numbers of biogas plants and amounts of digested manure 1990–2016.

Year	Biogas plant	Digested manure/plant	Annually digested manure
	[number]	[t /yr]	[t /yr]
1990	5	2 070	10 350
1991	7	2 013	14 091
1992	8	1 956	15 649
1993	11	1 899	20 891
1994	32	1 842	58 953
1995	38	1 785	67 843
1996	43	1 728	74 322
1997	57	1 671	95 274
1998	70	1 615	113 018
1999	100	1 558	155 761
2000	120	1 501	180 081
2001	142	1 444	205 301
2002	164	1 387	227 992
2003	187	1 330	248 156
2004	209	1 273	265 792
2005	231	1 216	280 900
2006	253	1 159	293 249
2007	294	1 102	324 033
2008	293	1 122	328 774
2009	291	1 142	332 333

Year	Biogas plant	Digested manure/plant	Annually digested manure
	[number]	[t /yr]	[t /yr]
2010	289	1 162	335 812
2011	288	1 182	340 393
2012	291	1 239	360 641
2013	293	1 297	379 937
2014	289	1 354	391 338
2015	291	1 372	399 358
2016	287	1 372	393 868

Table 178 shows an increase in biogas plant numbers and a decrease in the average amounts of digested manure. This trend can be explained by the provisions of the Austrian Ökostromgesetz (Eco Electricity Act) which promotes the use of feedstock with high energy content (corn) in order to enable the operators a cost effective operation of the biogas plants.

Activity data

(STATISTIK AUSTRIA 2017b) provides national data of annual livestock numbers on a very detailed level (see Table 161, Table 162, Table 163). These data are basis for the estimation.

Young and Fattening Pigs

The emission factors for breeding sows already include nursery and growing pigs (SCHECHTNER 1991). Thus, the animal number of piglets up to 20 kg is not taken into account.

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 the manner in which manure is managed. The following formula has been used (2006 IPCC GL, Equation 10.23):

$$EF_T = (VS_{(T)} * 365\ days\ yr^{-1}) * [B_{0(T)} * 0.67\ kg\ m^{-3} * \Sigma_{S,k}\ MCF_{S,k}/100 * MS_{(T,S,k)}]$$

$EF_{(T)}$ = 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, m³ CH_4 kg^{-1} of VS excreted

0,67 = conversion factor of m³ 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

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 179: 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 179). 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 significantly methane formation 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 2016.

Table 180: Average MCFs for liquid systems 1990 and 2016.

Animal Category	1990 [%]	2016 [%]
Dairy Cattle	8.7	8.7
Other Cattle	8.7	8.5
Swine	3.4	3.4

The following table presents the average MCFs for other systems for the years 1990 and 2016.

Table 181: Average MCFs for other systems 1990 and 2016.

Animal Category	1990 [%]	2016 [%]
Dairy Cattle	10.3	7.5
Other Cattle	16.0	15.2
Swine	16.3	14.2

As a result of the comprehensive survey on animal husbandry (AMON et al. 2007) in submission 2010 deep litter systems were introduced to the Austrian AWMS distribution.

In Austria manure from deep litter systems 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.

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 dairy cows are calculated dependent on annual milk yields and corresponding feed intake data (gross energy intake, feed digestibility, ash content, see Table 165 and Table 182).

Feed intake was worked out by (ERICH PÖTSCH 2005) based on (GRUBER & STEINWIDDER 1996). Calculation of VS excretion rates follows equation 10.24 of the 2006 IPCC GL.

Table 182: Feed intake and VS excretion of Austrian dairy cattle

Milk yield	[kg/yr]	3 000	3 500	4 000	4 500	5 000	5 500	6 000	6 500	7 000
GE intake	[MJ/day]	235.32	242.55	249.77	259.23	268.68	280.72	292.32	304.21	315.7
feed digestibility	[%]	65.7	66.0	66.3	67.3	68.2	69.1	70.0	70.6	71.2
ash content	[%]	11	11	11	11	11	11	11	11	11
VS excretion [kg $cow^{-1}day^{-1}$]		4.35	4.45	4.54	4.59	4.64	4.73	4.79	4.90	5.00

A time series was generated by adjusting these data to the yearly milk yields (see Table 183).

Table 183: VS excretion of Austrian dairy cows for the period 1990–2016.

Year	Milk yield *[kg yr^{-1}]*	*VS excretion* [kg/cow*day]	Year	Milk yield *[kg yr^{-1}]*	*VS excretion* [kg/cow*day]
1990	3 791	4 .50	2004	5 802	4 .77
1991	3 848	4 .51	2005	5 783	4 .76
1992	3 908	4 .52	2006	5 903	4 .78
1993	3 997	4 .54	2007	5 997	4 .79
1994	4 076	4 .55	2008	6 059	4 .81
1995	4 619	4 .60	2009	6 068	4 .81
1996	4 670	4 .61	2010	6 100	4 .82
1997	4 787	4 .62	2011	6 227	4 .84
1998	4 924	4 .63	2012	6 418	4 .88
1999	5 062	4 .65	2013	6 460	4 .89
2000	5 210	4 .68	2014	6 542	4 .91
2001	5 394	4 .71	2015	6 579	4 .92
2002	5 487	4 .72	2016	6 759	4 .95
2003	5 638	4 .74			

[1)] *From 1995 onwards data have been revised by Statistik Austria*

Volatile solid (VS) excretion – suckling cows

For the year 1990 an average milk yield of 3 000 kg was assumed, resulting in a daily VS excretion of 4.35 kg. From 2004 to 2008 a new study (STEINWIDDER et al. 2006) with Austrian suckling cows (Simmental) was carried out, determining 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. The results of this study and a calculated demand of 3 500kg milk per calve resulted in an increased milk yield for suckling cows: From 2004 onwards, a milk yield of 3 500 kg has been assumed, resulting in a daily VS excretion of 4.45 kg. Values between 1990 and 2004 have been derived by interpolation (see Table 184).

Table 184: VS excretion of Austrian suckling cows for the period 1990–2016.

Year	Milk yield *[kg yr^{-1}]*	*VS excretion* [kg/cow*day]	Year	Milk yield *[kg yr^{-1}]*	*VS excretion* [kg/cow*day]
1990	3 000	4 .35	2004	3 500	4 .45
1991	3 036	4 .35	2005	3 500	4 .45

Year	Milk yield *[kg yr^{-1}]*	*VS excretion* [kg/cow*day]	Year	Milk yield *[kg yr^{-1}]*	*VS excretion* [kg/cow*day]
1992	3 071	4 .36	2006	3 500	4 .45
1993	3 107	4 .37	2007	3 500	4 .45
1994	3 143	4 .38	2008	3 500	4 .45
1995	3 179	4 .38	2009	3 500	4 .45
1996	3 214	4 .39	2010	3 500	4 .45
1997	3 250	4 .40	2011	3 500	4 .45
1998	3 286	4 .40	2012	3 500	4 .45
1999	3 321	4 .41	2013	3 500	4 .45
2000	3 357	4 .42	2014	3 500	4 .45
2001	3 393	4 .42	2015	3 500	4 .45
2002	3 429	4 .43	2016	3 500	4 .45
2003	3 464	4 .44			

Volatile solid (VS) excretion – other non-dairy cattle

Austrian specific values on VS excretion for all other non-dairy cattle categories were calculated from typical Austrian diets under organic and conventional management (see Table 168).

As no major changes in diets of *Non-Dairy Cattle* occurred in the period from 1990–2016, methane emissions from manure management of *Non-Dairy Cattle* are calculated with a constant gross energy intake and thus constant VS excretion rate for the whole time series.

VS excretion rates for cattle were calculated on the basis of country specific feed intake and equation 10.24 from the 2006 IPCC GL:

$$VS = [GE * (1 - DE\%/100) + (UE * GE)] * [(1 - ASH)/18.45]$$

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 feed in percent (e.g. 75%)*
*(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).*

Table 185 presents data for the calculation of VS excretion of the livestock categories *Non-Dairy Cattle*.

Table 185: Feed intake and VS excretion of non-dairy cattle, conventional and organic production system.

	cattle < 1 year		**cattle 1–2 years**		**n.-dairy cattle > 2 years**	
	Conv.	**Org.**	**Conv.**	**Org.**	**Conv.**	**Org.**
feed digestibility [%]	76	75	73	73	73	73
ash content [%]	12.0	12.0	11.5	11.5	11.0	11.0
Gross energy intake [MJ GE (kg dry matter)$^{-1}$]	84.36	72.06	166.96	151.14	163.44	159.93
VS excretion [kg head^{-1} day^{-1}]	1.13	1.00	2.48	2.25	2.44	2.39
	cattle < 1 year		**cattle 1–2 years**		**n.-dairy cattle > 2 years**	
	Conv.	**Org.**	**Conv.**	**Org.**	**Conv.**	**Org.**

	cattle < 1 year		cattle 1–2 years		n.-dairy cattle > 2 years	
	Conv.	**Org.**	**Conv.**	**Org.**	**Conv.**	**Org.**
feed digestibility [%]	76	75	73	73	73	73
ash content [%]	12.0	12.0	11.5	11.5	11.0	11.0
Gross energy intake [MJ GE (kg dry matter)$^{-1}$]	84.36	72.06	166.96	151.14	163.44	159.93
VS excretion [kg head^{-1} day^{-1}]	1.13	1.00	2.48	2.25	2.44	2.39

The VS values of organic systems are not significantly different from those of the conventional systems. Uncertainty is estimated to be ± 20%.

5.3.2.1.2 Swine (3.B.1.3)

Key Source: No

Volatile solid (VS) excretion – swine

VS excretion of swine was derived from country-specific data on VS content in the manure (SCHECHTNER 1991). Changes in animal performance of swine are not reported for Austria. Thus, VS excretion rates of swine were kept constant for the whole time series.

Table 186: VS excretion from Austrian swine, calculated with (SCHECHTNER 1991).

Livestock category	Manure Production given in Schechtner (1991)	Calculated manure production [t head^{-1} yr^{-1}]	VS content in manure [kg (t manure)$^{-1}$]	VS excretion [kg head^{-1} day^{-1}]
breeding sows	4 t sow^{-1}yr^{-1}	4.00	75	0.82
fattening pigs	0.63 t pig^{-1} 120 days^{-1}	1.92	55	0.29

Piglets were not taken into account because the emission factors for breeding sows already include nursery and growing pigs (SCHECHTNER 1991).

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 from manure management for sheep, poultry, horses, goats and deer are estimated with the Tier 1 approach.

Default emission factors were taken from the IPCC 2006 Guidelines (Table 10.15). CH_4 emissions were estimated multiplying these emission factors by national animal numbers.

Table 187: IPCC default CH_4 emission factors for sheep, goats, horses, layers, broilers, other poultry and deer in Austria.

Livestock category	Emission Factor [kg CH_4 per head per yr]	Livestock category	Emission Factor [kg CH_4 per head per yr]
Sheep	0.19	Layers	0.03*
Goats	0.13	Broilers	0.02
Horses	1.56	Turkeys	0.09
Deer	0.19	Other Poultry (ducks, geese,..)	0.02

** Layers (dry): liquid systems/poultry not used in Austria (OLIVER BERNHAUSER 2014)*

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 manure of horses were estimated with the default emission factors for horses.

The deer category (3.B.4.4) is very inhomogeneous 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 furred game were estimated applying the default emission factor of sheep because sheep is the most similar animal category to deer (which dominates this category).

5.3.2.2 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).

<u>N excretion per animal waste management system:</u>

$$Nex_{(AWMS)} = \sum_{(T)}[N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}]$$

$Nex_{(AWMS)}$ = N excretion per animal waste management system [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}]
$AWMS_{(T)}$ = fraction of $Nex_{(T)}$ that is managed in one of the different distinguished animal waste management systems for animals of type T in the country
T = type of animal category

<u>N_2O emission per animal waste management system:</u>

$$N_2O_{(AWMS)} = \sum[Nex_{(AWMS)} \times EF_{3(AWMS)}]$$

$N_2O_{(AWMS)}$= N_2O emissions from all animal waste management systems in the country [kg N yr^{-1}]
$Nex_{(AWMS)}$= N excretion per animal waste management system [kg yr^{-1}]

$EF_{3(AWMS)}$= N_2O emissions factor for an AWMS [kg N_2O-N per kg of Nex in AWMS]

AWMS

The animal waste management systems 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 176).

N excretion

As recommended in the Centralized Review 2004, in the year 2005 Austrian N excretion values were reviewed and recalculated. The revision resulted in higher N excretion rates of dairy and suckling cows (see Table 188).

Table 188: Austria specific N excretion values of dairy cows for the period 1990–2016.

Year	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]	Year	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]
1990	3 791	76.62	2004	5 802	94.72
1991	3 848	77.13	2005	5 783	94.55
1992	3 908	77.67	2006	5 903	95.63
1993	3 997	78.48	2007	5 997	96.48
1994	4 076	79.18	2008	6 059	97.03
1995	4 619	84.07	2009	6 068	97.11
1996	4 670	84.53	2010	6 100	97.40
1997	4 787	85.58	2011	6 227	98.54
1998	4 924	86.82	2012	6 418	100.26
1999	5 062	88.06	2013	6 460	100.64
2000	5 210	89.39	2014	6 542	101.38
2001	5 394	91.04	2015	6 579	101.71
2002	5 487	91.89	2016	6 759	103.33
2003	5 638	93.24			

[1)] *From 1995 onwards data have been revised by Statistik Austria, which led to significant higher milk yield data of Austrian dairy cows.*

N excretion values as shown in Table 188 and Table 189 are based on the following literature: (GRUBER & PÖTSCH 2006, PÖTSCH et al. 2005, STEINWIDDER & GUGGENBERGER 2003, UNTERARBEITSGRUPPE N-ADHOC 2004 and ZAR 2004).

According to the requirements of the European nitrate directive, the Austrian N excretion data were recalculated following the guidelines of the European Commission. The revised nitrogen excretion coefficients were calculated based on following input parameters:

Cattle: Feed rations represent data of commercial farms consulting representatives of the working groups „Dairy production". These groups are managed by well-trained advisors. Their members, i.e. farmers, regularly exchange their knowledge and experience. Forage quality is based on field studies, carried out in representative grassland and dairy farm areas. The calculations depend on feeding ration, gain of weight, nitrogen and energy uptake, efficiency, duration of livestock keeping etc.

Sheep and goats: life weight, daily gain of weight, degree of pregnancy or lactating, feeding rations.

Pigs: breeding pigs, piglets, boars, fattening pigs: number and weight of piglets, daily gain of weight, energy content of feeding, energy and nitrogen uptake, N-reduced feeding.

Poultry: feeding ration, duration of keeping, nitrogen uptake, nitrogen efficiency.

Horses: feeding ration per horse category, weight of horses.

Table 189: Austria specific N excretion values of other livestock categories.

Livestock category	Nitrogen excretion [kg/animal*yr]
suckling cows1) (1990)	69.5
suckling cows2) (2016)	74.0
cattle 1–2 years	53.6
cattle < 1 year	25.7
cattle > 2 years	68.4
breeding sows	29.1
fattening pigs	10.3
sheep	13.1
goats	12.3
horses	47.9
layers	0.73
broilers	0.28
turkeys	1.18
other poultry3)	0.48
deer/furred game4)	13.1

1) *Annual milk yield: 3 000 kg*

2) *Annual milk yield: 3 500 kg*

3) *ducks, gooses etc.*

4) *N-ex value of sheep applied*

Livestock numbers per category can be found in Table 161, Table 162 and Table 163. Data on manure management system distribution is presented in Table 175 and Table 176.

Emission factors

N_2O emission factors of the 2006 IPCC Guidelines have been used for all AWMS.

Emission factors applied in the Austrian inventory are listed in the following table.

Table 190: 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	~0.003*	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,	0.010	IPCC 2006, Table 11.1

Animal Waste Management System	Emission factor [kg N_2O-N per kg N excreted]	Reference
goats, horses and deer)		
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 (no mixing)	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 waste management systems distribution in Austria (see Table 175 and Table 176). 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 191: N_2O emission factors used for the calculation of N_2O from yards 1990–2016.

Year	Dairy	Non-Dairy	Swine
		[kg N_2O-N per kg N excreted]	
1990	0.004	0.004	0.004
1991	0.004	0.004	0.004
1992	0.004	0.004	0.004
1993	0.004	0.004	0.004
1994	0.004	0.004	0.004
1995	0.004	0.004	0.003
1996	0.004	0.004	0.003
1997	0.004	0.005	0.003
1998	0.004	0.005	0.003
1999	0.004	0.005	0.003
2000	0.004	0.005	0.003
2001	0.004	0.005	0.003
2002	0.004	0.005	0.003
2003	0.004	0.005	0.003

Year	Dairy	Non-Dairy	Swine
		[kg N_2O-N per kg N excreted]	
2004	0.004	0.005	0.003
2005	0.004	0.005	0.003
2006	0.004	0.005	0.003
2007	0.004	0.005	0.003
2008	0.004	0.005	0.003
2009	0.004	0.005	0.003
2010	0.004	0.005	0.003
2011	0.004	0.005	0.003
2012	0.004	0.005	0.003
2013	0.004	0.005	0.003
2014	0.004	0.005	0.003
2015	0.004	0.005	0.003
2016	0.004	0.005	0.003

For the calculation of the losses of gaseous N species (NH_3-N and NO_x-N) the mass-flow procedure pursuant to EMEP/EEA methodologies (EEA 2013, EEA 2016) has been applied. A brief description of methodologies and emission factors applied in the Austrian NH_3 and NO_x inventory under the UNECE/LRTAP convention is provided in chapter5.4.2.1.

5.3.2.3 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 runoff 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[79] 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 tight-

[79] http://www.oib.or.at/

ness 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).

$$N_{volatilisation\text{-}MMS} = \sum_S[\sum_T[(N_{(T)} * Nex_{(T)} * MS_{(T,S)} * (Frac_{GasMS}/100)_{(T,S)}]] * EF$$

$N_{(T)}$ = 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 192: NH_3-N and NO_x-N volatilisation losses of manure management systems 1990 to 2016.

Year	N losses from manure management systems	$Frac_{GASMS}$
	[t N/yr]	(N_{losses}/N_{ex})
1990	22.836	0.13
1991	23.332	0.14
1992	22.991	0.14
1993	23.663	0.14
1994	23.731	0.14
1995	24.238	0.14
1996	23.933	0.14
1997	24.266	0.14
1998	24.386	0.15
1999	23.823	0.15
2000	23.346	0.14
2001	23.689	0.15
2002	23.420	0.15
2003	23.479	0.15
2004	23.439	0.15

Year	N losses from manure management systems	$Frac_{GASMS}$
	[t N/yr]	(N_{losses}/N_{ex})
2005	23.597	0.15
2006	23.742	0.15
2007	24.315	0.15
2008	24.164	0.15
2009	24.557	0.15
2010	24.569	0.15
2011	24.317	0.15
2012	24.249	0.15
2013	24.272	0.15
2014	24.274	0.15
2015	24.297	0.15
2016	24.312	0.15

5.3.3 Source 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;
- ✓ Survey on AWMS 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),
- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ External review of the revised agricultural model according to the IPCC 2006 GL by Austrian agricultural experts (stakeholder meeting) in 2014
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources will be performed in 2018.

Sector specific routine control procedures are provided in chapter5.1.4.

5.3.4 Uncertainties

Uncertainties are presented in Table 157.

5.3.5 Recalculations

Update of activity data

Milk yield data for dairy cows for the years 1991−1993 and 2001 was updated on the basis of official data from the Ministry of Agriculture (BMLFUW 2017). The revision resulted in slightly higher emissions for the years 1991−1993 and slightly lower emissions for 2001.

In 2017 new information on input materials for Austria's biogas plants became available (raw material balances for 2014 and 2015). The updated data were taken from (E-Control 2017) and resulted in revised amounts of digested manure and energy crops from 2012 to 2015 (latest available raw material balance used in a previous inventory was for 2011).

Improvements of methodologies and emission factors

3.B Manure Management (CH_4)

Minor revisions in the chicken and horse category resulted in slightly increased emissions of CH_4 (+0.01 kt CH_4 in 2015).

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 2016 83.0% of total N_2O emissions from agriculture (59.4% of total Austrian N_2O emissions) originated from agricultural soils, the rest originates from manure management and a very small share from field burning of agricultural residues.

Emissions from this category (N_2O) contributed 2.7% (2 146.63 kt CO_2 equivalents) to Austria's total greenhouse gas emissions in the year 2016. This is 29.5% of total GHG emissions of the sector agriculture.

The trend of N_2O emissions from this category is decreasing: in 2016 emissions were 4,5% below 1990 levels.

Table 193 presents N_2O emissions of agricultural soils by sub-category as well as their trends and their share in total N_2O emissions.

Table 193: N_2O emissions from agricultural soils, 1990–2016.

	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	7.54	6.32	2.15	2.32	2.30	0.02	0.00	0.50	1.18	0.01	0.17	1.22	0.54	0.67
1991	7.90	6.63	2.52	2.30	2.28	0.02	0.01	0.48	1.15	0.01	0.17	1.27	0.56	0.71
1992	7.21	6.03	2.13	2.24	2.21	0.02	0.01	0.45	1.04	0.01	0.17	1.17	0.53	0.64
1993	6.74	5.62	1.69	2.28	2.25	0.03	0.01	0.44	1.03	0.01	0.17	1.12	0.52	0.60
1994	7.56	6.34	2.36	2.29	2.24	0.02	0.02	0.43	1.08	0.01	0.17	1.23	0.55	0.68
1995	7.68	6.43	2.40	2.34	2.29	0.03	0.03	0.44	1.08	0.01	0.17	1.25	0.55	0.69
1996	7.15	5.98	1.99	2.31	2.25	0.03	0.03	0.42	1.08	0.01	0.17	1.17	0.53	0.64
1997	7.30	6.11	2.02	2.30	2.24	0.03	0.04	0.41	1.21	0.01	0.17	1.19	0.53	0.66
1998	7.31	6.12	2.04	2.31	2.24	0.03	0.04	0.39	1.21	0.01	0.17	1.19	0.53	0.66

	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**
1999	7.16	6.00	1.94	2.27	2.19	0.03	0.05	0.37	1.24	0.01	0.17	1.17	0.52	0.64
2000	6.97	5.83	1.89	2.25	2.16	0.03	0.06	0.36	1.15	0.01	0.17	1.14	0.51	0.63
2001	7.00	5.86	1.88	2.25	2.16	0.03	0.07	0.34	1.22	0.01	0.17	1.13	0.50	0.63
2002	6.98	5.85	1.92	2.22	2.12	0.02	0.08	0.32	1.22	0.01	0.17	1.13	0.50	0.63
2003	6.66	5.57	1.74	2.21	2.10	0.02	0.08	0.31	1.12	0.01	0.17	1.09	0.49	0.60
2004	6.60	5.52	1.53	2.20	2.09	0.02	0.09	0.30	1.31	0.01	0.17	1.08	0.48	0.60
2005	6.57	5.49	1.58	2.19	2.08	0.02	0.09	0.29	1.26	0.01	0.17	1.08	0.48	0.59
2006	6.52	5.45	1.60	2.20	2.08	0.02	0.10	0.27	1.20	0.01	0.17	1.07	0.49	0.59
2007	6.57	5.48	1.63	2.23	2.10	0.02	0.10	0.26	1.18	0.01	0.17	1.09	0.50	0.59
2008	6.99	5.85	1.87	2.23	2.08	0.02	0.12	0.25	1.33	0.01	0.17	1.14	0.50	0.64
2009	6.81	5.69	1.73	2.28	2.12	0.02	0.14	0.25	1.25	0.01	0.17	1.13	0.51	0.62
2010	6.36	5.29	1.39	2.27	2.11	0.03	0.13	0.25	1.21	0.01	0.17	1.07	0.50	0.57
2011	6.76	5.65	1.63	2.24	2.08	0.03	0.13	0.25	1.36	0.01	0.17	1.11	0.50	0.61
2012	6.64	5.54	1.69	2.23	2.07	0.03	0.14	0.25	1.20	0.01	0.17	1.10	0.50	0.60
2013	6.57	5.48	1.65	2.24	2.07	0.02	0.14	0.24	1.17	0.01	0.17	1.10	0.50	0.59
2014	6.92	5.78	1.76	2.25	2.08	0.02	0.15	0.24	1.36	0.01	0.17	1.14	0.51	0.63
2015	6.90	5.76	1.90	2.26	2.08	0.03	0.15	0.24	1.19	0.01	0.17	1.15	0.52	0.63
2016	7.20	6.02	1.99	2.26	2.08	0.03	0.15	0.25	1.35	0.01	0.17	1.19	0.53	0.66
Share 2016	***100%***	***83.5%***	***27.6%***	***31.4%***	***28.9%***	***0.4%***	***2.1%***	***3.4%***	***18.8%***	***0.1%***	***2.3%***	***16.5%***	***7.4%***	***9.1%***
1990–2016	***–4.5%***	***–4.8%***	***-7.6%***	***-2.5%***	***-9.3%***	***53.0%***	***3941.5%***	***-51.0%***	***14.8%***	***-18.3%***	***0.0%***	***–2.7%***	***–2.6%***	***–2.8%***

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 6).

Table 194: 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 195: 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" (BMLFUW 2000–2017)[1]. Specific data on urea application: Ministry of Sustainability and Tourism,expert judgement based on sales data (RWA – Raiffeisen Ware Austria), AMA statistics
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, 2013a, 2014a, 2015a, 2016b, 2017b)
Other organic fertilizers applied to soils	Energy crops from biogas plants: Ökostromberichte 2008, 2011, 2013 & 2017; raw material balances for 2007, 2009, 2011, 2014 & 2015 (E-CONTROL 2008, 2011, 2013, 2017) Compost application: AD elaborated from treated amounts in composting plants (chapter waste, Table 286) 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 (BMLFUW 2000–2017)[1]
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: (BMLFUW 2000–2017) and (AMA 2017)
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 (BMLFUW 2000–2017) (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 Sustainability and Tourism in its official reports (BMLFUW 2000–2017).

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: Fertilizers have a high elasticity to prices. 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 196, 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).

The time series for fertilizer consumption is presented in Table 196.

Table 196: Mineral fertilizer N consumption in Austria 1990–2016 and arithmetic average of each two years.

Year	Annual Nutrient Sales Data [t N/yr]	of which Urea	Data Source	Weighted Nutrient Consumption [t N/yr]	Weighted Urea Consumption [t N/yr]
1989	133 304	1 700	FAO		
1990	140 379	3 965	estimated GB	136 842	2 833
1991	180 388	3 965	GB	160 384	3 965
1992	91 154	3 886	GB	135 771	3 926
1993	123 634	3 478	GB	107 394	3 682
1994	177 266	4 917	GB	150 450	4 198
1995	128 000	5 198	RWA	152 633	5 058
1996	125 300	4 600	RWA	126 650	4 899
1997	131 800	6 440	RWA	128 550	5 520
1998	127 500	6 440	RWA	129 650	6 440
1999	119 500	6 808	RWA	123 500	6 624
2000	121 600	3 848	GB/AMA, RWA	120 550	5 328
2001	117 100	3 329	GB/AMA, RWA	119 350	3 589
2002	127 600	4 470	GB/AMA, RWA	122 350	3 900
2003	94 400	6 506	GB/AMA, RWA	111 000	5 488
2004	100 800	7 293	GB/AMA, RWA	97 600	6 900
2005	99 700	7 673	GB/AMA, RWA	100 250	7 483
2006	103 700	11 310	GB/AMA, RWA	101 700	9 491
2007	103 300	11 500	GB/AMA, RWA	103 500	11 405
2008	134 400	9 568	GB/AMA, RWA	118 850	10 534
2009	86 300	18 400	GB/AMA, RWA	110 350	13 984
2010	90 629	6 500	GB/AMA, RWA	88 465	12 450
2011	116 751	16 867	GB/AMA, RWA	103 690	11 683
2012	97 721	10 733	GB/AMA, RWA	107 236	13 800
2013	112 005	16 638	GB/AMA,BMLFUW	104 863	13 685
2014	111 615	15 741	GB/AMA,BMLFUW	111 810	16 189
2015	130 252	17 955	AMA	120 934	16 848
2016	122 623	21 879	AMA	126 438	19 917

GB: AMA data published in (BMLFUW 2000–2015): www.gruenerbericht.at

RWA: Raiffeisen Ware Austria, sales company: www.rwa.at

BMLFUW: Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft; in 2018 it has become the Federal Ministry of Sustainability and Tourism (BMNT): www.bmnt.gv.at

AMA: Agrarmarkt Austria (AMA 2017): www.ama.at

Urea application:

Detailed data of different kind of fertilizers were available until 1994, because until then, a fertilizer tax („Düngemittelabgabe") had been collected. From 1995 to 2012 approximated values were provided by Austria's leading fertilizer trading firm (RWA). For the years 2013 and 2014 national data on urea amounts were provided by the Austrian Federal Ministry of Sustainability and Tourism. In 2016 Austria improved its official mineral fertilizer statistics by collecting more detailed information on specific fertilizer types applied in Austria. Consequently, from 2015 onwards urea fertilizer data used in emission calculations are obtained from the official AMA statistics.

Legume cropping areas

The yearly numbers of the legume cropping areas were taken from official statistics (BMLFUW 2000–2017) and (Statistik Austria).

Table 197: Cropped area legume production and others, 1990–2016.

			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	37 880	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

	Areas [ha]						
Year	peas	soja beans	horse/field beans	clover hey, lucerne, …	Other forage renewed annually*	Meadows ploughed every four years**	Cover crops***
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

* *value for 1990 is interpolated as no data is available*

** *(BMLFUW 2000–2017), 1991–1994 and 1996 (STATSTIK AUSTRIA 1990–2014)*

*** *greening variants A+B+C+D until 2014. From 2015 onwards a new funding period started (BMLFUW 2000–2017). Only small amounts before 1995.*

Harvest Data

Harvest data and data of the cultivated area were taken from (BMLFUW 2000–2017) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT 2017) and are presented in Table 198 and Table 199.

Table 198: Harvest Data I, 1990–2016.

	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	3 133	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	2 739	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

Harvest [1 000 t]										
Year	corn	wheat	rye	barley	oats	maize (corn)	Other* cereals	potato	sugar beet	fodder beet
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	2 836	7
2016	5 642	1 970	188	860	95	2 180	349	767	3 614	8

** mixed grain, triticale*

Table 199: Harvest Data II, 1990–2016.

Harvest [1 000 t]									
Year	silo-green maize	clover-hey	rape	Sun-flower	soja bean	horse-/fodder bean	peas	vege-tables	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
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

Table 200: Cultivation Area I, 1990–2016.

	Area [ha]									
Year	**corn**	**wheat**	**rye**	**barley**	**oats**	**maize (corn)**	**Other* cereals**	**potato**	**sugar beet**	**fodder beet**
1990	948 437	278 226	93 041	292 424	61 956	198 073	24 717	31 760	49 758	3 845
1991	923 443	271 068	85 070	296 905	61 053	185 302	24 045	33 421	51 430	3 783
1992	837 703	245 728	69 114	274 972	54 695	172 557	20 637	33 036	53 846	2 952
1993	825 036	240 971	73 701	265 348	52 869	169 935	22 212	31 090	53 398	2 836
1994	821 403	240 961	77 021	252 746	49 357	179 465	21 853	29 738	52 019	2 241
1995	807 670	255 910	76 826	229 099	40 778	173 352	31 705	27 036	51 643	1 759
1996	832 066	247 602	51 222	259 648	41 609	201 342	30 643	26 335	53 082	1 203
1997	846 063	259 832	57 807	260 641	46 083	188 311	33 389	23 476	51 569	1 166
1998	837 333	264 405	59 282	265 622	40 514	171 239	36 271	22 854	49 598	1 322
1999	807 806	260 579	55 901	243 886	35 503	177 077	34 860	23 180	46 473	1 275
2000	828 048	293 806	52 473	223 762	32 981	187 802	37 224	23 737	42 836	1 036
2001	822 639	287 777	51 219	217 473	31 449	194 904	39 817	23 123	44 704	923
2002	811 021	288 764	47 145	200 948	32 103	195 922	46 139	22 523	44 464	817
2003	805 296	272 001	40 003	212 308	34 387	196 409	50 189	21 122	43 223	732
2004	810 692	290 174	45 664	191 333	30 284	201 451	51 787	21 925	44 737	692
2005	791 510	288 960	42 847	191 740	30 218	189 637	48 108	22 186	44 211	296
2006	771 660	284 577	26 924	206 443	35 151	181 196	37 369	21 920	39 401	400
2007	804 686	292 976	46 702	193 331	31 125	193 419	47 132	22 675	42 012	260
2008	832 654	296 775	53 171	185 857	26 571	216 354	53 926	22 800	43 032	238
2009	825 315	309 034	48 528	181 525	27 600	200 276	58 352	22 222	43 860	214
2010	802 152	302 852	45 699	168 891	26 576	201 137	56 997	21 973	44 841	193
2011	799 305	304 334	45 943	153 286	25 029	217 100	53 613	22 851	46 580	179
2012	803 189	308 179	48 525	150 576	24 815	219 702	51 392	21 782	49 263	170
2013	773 270	297 286	56 108	142 574	23 165	201 917	52 221	21 128	50 849	168
2014	796 670	304 645	48 241	145 825	23 297	216 316	58 347	21 384	50 604	169
2015	766 461	302 965	39 563	151 769	23 501	188 728	59 934	20 368	45 284	134
2016	770 950	315 088	37 312	140 425	22 512	195 252	60 360	21 221	43 353	133

** mixed grain, triticale*

Table 201: Cultivation Area II, 1990–2016.

	Area [ha]								
Year	**silo-green maize**	**clover-hey**	**rape**	**Sun-flower**	**soja bean**	**horse-/fodder bean**	**peas**	**vege-tables**	**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

	Area [ha]								
Year	silo-green maize	clover-hey	rape	Sun-flower	soja bean	horse-/fodder bean	peas	vege-tables	oil pumkin
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
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

Sewage sludge application on fields

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, 2013a, 2014a, 2015a, 2016b, 2017b).

Table 202: Amount of sewage sludge (dry matter) produced in Austria, 1990–2016.

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

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied sewage sludge N [t N]
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
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

Application of compost on fields

Total amounts of compost (composting plants and home composting) were taken from Table 286 (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 203: Amount of compost (dry matter) produced in Austria, 1990–2016.

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	342 284	69 031	20.2	966

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
2002	390 128	75 023	19.2	1 050
2003	432 221	78 427	18.1	1 098
2004	472 354	80 949	17.1	1 133
2005	474 990	81 236	17.1	1 137
2006	470 750	78 641	16.7	1 101
2007	473 800	79 575	16.8	1 114
2008	483 450	82 744	17.1	1 158
2009	496 492	87 971	17.7	1 232
2010	504 530	93 140	18.5	1 304
2011	521 839	100 612	19.3	1 409
2012	546 948	111 488	20.4	1 561
2013	533 965	105 092	19.7	1 471
2014	545 256	109 334	20.1	1 531
2015	543 623	107 489	19.8	1 505
2016	568 005	116 967	20.6	1 638

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*. 83.5% (6.02 kt in 2016) of N_2O emissions from agricultural soils arise from this sub-category (see Table 193).

N_2O emissions from the following sub-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 the emissions is IPCC Tier 1 (IPCC 2006, Equation 11.1).

$F_{SN} = N_{FERT} * EF_1$

F_{SN} = *Annual amount of synthetic fertilizer nitrogen applied to soils [kg N yr^{-1}]*
N_{FERT} = *Annual amount of nitrogen in synthetic fertilizers (mineral and urea) applied to soils [kg N] – (see* Table 196)
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 include the following N-inputs to soils:

- Nitrogen input through application of animal manure (excluding grazing),
- Nitrogen input through use of sewage sludge and
- Nitrogen input from other organic fertilizers (energy crops from biogas plants and compost) to soils.

N_2O emissions of this source are calculated by using equation 11.3 (IPCC 2006).

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 and N_2O-N 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 housing,
- NH_3-N losses during manure storage,
- NO_x-N losses from manure management,
- N_2O-N losses from manure management,
- The remaining N is applied to agricultural soils.

Table 204: Animal manure left for spreading on agricultural soils per livestock category 1990–2016 (I).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	dairy cattle	suckling cows	all other cattle	breeding sows	young & fattening pigs
1990	146 233	55 832	2 614	51 062	8 884	19 298

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	dairy cattle	suckling cows	all other cattle	breeding sows	young & fattening pigs
1991	144 958	54 617	3 190	50 535	8 758	19 053
1992	140 910	53 031	3 369	47 561	8 949	19 498
1993	142 883	52 904	3 864	47 841	9 185	19 999
1994	142 721	52 391	5 021	47 482	9 155	19 540
1995	145 483	48 685	11 752	47 072	9 301	19 466
1996	143 285	48 497	11 885	45 588	9 230	19 111
1997	142 628	50 885	9 536	44 205	9 204	19 279
1998	142 779	52 397	8 632	43 395	8 933	20 344
1999	139 578	51 071	9 892	43 165	7 946	18 451
2000	137 544	46 289	14 162	42 905	7 722	17 920
2001	137 273	45 553	14 447	42 019	8 085	18 437
2002	134 791	45 435	13 739	41 228	7 869	17 840
2003	133 927	43 819	13 642	42 351	7 709	17 676
2004	133 084	43 067	14 683	42 364	7 306	16 781
2005	132 337	42 849	15 126	40 655	7 272	17 422
2006	132 134	42 915	15 114	40 625	7 408	16 995
2007	133 829	43 199	15 055	40 679	7 324	18 123
2008	132 626	44 069	14 727	40 574	6 848	16 902
2009	134 619	44 332	14 622	41 773	6 758	17 403
2010	134 409	44 444	14 419	41 627	6 546	17 415
2011	132 658	44 515	14 195	40 607	6 343	16 799
2012	131 898	44 946	13 731	40 009	6 052	16 715
2013	131 965	45 649	13 080	40 414	5 849	16 346
2014	132 273	46 695	12 712	40 429	5 677	16 110
2015	132 266	46 531	12 400	40 844	5 741	15 975
2016	132 606	47 783	11 976	40 580	5 536	15 800

Table 205: Animal manure left for spreading on agricultural soils per livestock category 1990–2016 (II).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	poultry	sheep	goats	horses/solipeds	deer
1990	146 233	5 397	1 576	178	1 317	75
1991	144 958	5 328	1 658	195	1 548	76
1992	140 910	5 009	1 586	188	1 644	76
1993	142 883	5 353	1 697	226	1 738	76
1994	142 721	5 292	1 739	237	1 787	77
1995	145 483	5 068	1 857	259	1 941	82
1996	143 285	4 733	1 936	260	1 961	84
1997	142 628	5 191	1 950	278	1 986	114
1998	142 779	4 864	1 834	259	2 018	102
1999	139 578	4 720	1 791	277	2 184	79
2000	137 544	4 252	1 725	268	2 221	80
2001	137 273	4 479	1 629	284	2 258	82

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	poultry	sheep	goats	horses/solipeds	deer
2002	134 791	4 479	1 547	276	2 295	83
2003	133 927	4 399	1 655	261	2 332	84
2004	133 084	4 463	1 663	265	2 405	86
2005	132 337	4 528	1 656	263	2 479	87
2006	132 134	4 593	1 588	253	2 552	89
2007	133 829	4 657	1 786	289	2 626	91
2008	132 626	4 722	1 694	298	2 699	93
2009	134 619	4 786	1 752	325	2 773	95
2010	134 409	4 851	1 822	343	2 846	97
2011	132 658	5 006	1 836	345	2 919	93
2012	131 898	5 160	1 854	349	2 993	89
2013	131 965	5 315	1 817	344	3 066	85
2014	132 273	5 315	1 775	337	3 139	85
2015	132 266	5 315	1 798	366	3 213	85
2016	132 606	5 315	1 924	395	3 213	85

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 2018 – 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 2018). 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 2016).

NH_3 emissions from housing (cattle and swine)

Table 206 gives NH_3 emission factors for emissions from animal housing. Swiss and German technology specific NH_3-N emission factors of the EMEP/CORINAIR Emission Inventory Guidebook 2007, Table 5E, were taken. For cattle they differentiate between loose housing and tied housing systems, which is relevant for Austria.

Table 206: 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
Fattening pigs, liquid slurry system	0.150
Fattening pigs, solid storage system	15% of total N + 30% of the remaining TAN
Sows plus litter, liquid slurry system	0.167

Manure management system	kg NH_3-N (kg N excreted)$^{-1}$
Sows plus litter, solid storage system	0.167

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

NH_3-N losses are estimated by using the emission factors given in Table 207.

Table 207: 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

** 15% + 0.3% of remaining TAN for deep litter (as used for fattening pigs in agriculture), otherwise 15% for daily removal of solid manure*

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 208: 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

Table 209 shows correction factors (CF) to emission factors (EF) for a range of manure treatment options. Untreated variants systems, for example uncomposted solid manure, give the reference value '1'. EF for other treatment options, managements and systems get an associated CF, e.g. +20% for the composting of solid manure (CF = 1.2). The CF is multiplied with the EF. Factors were taken from the Swiss ammonia inventory which is calculated with the computer based programme 'DYNAMO' (MENZI et al. 2003, REIDY et al. 2007, REIDY & MENZI 2005). Due to similar management strategies and geographic structures, Swiss animal husbandry is closest to Austrian animal husbandry.

DYNAMO is based on the N flow model and estimates ammonia emissions for each stage of the manure management continuum. Animal categories, manure management systems and a range of additional parameters are considered within DYNAMO. DYNAMO parameters were adapted to Austrian specific conditions. The DYNAMO model is peer reviewed by the EAGER[80] group and published in (REIDY et al. 2008, 2009).

Table 209: Correction factors (CF) for NH_3 emissions from manure storage.

Manure storage	[CF]
Uncomposted solid manure	1
Composted solid manure	1.2
Uncovered tank	1
Solid cover – liquid system	0.2
Aerated open tank – liquid system	1.1
Straw cover – liquid system	0.6
Plastic foil cover – liquid system	0.4
Natural crust – liquid system	0.6

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 2016). Table 210 presents the recommended ammonia default emission factors and associated parameters for the different livestock categories given in the EMEP/EEA Emission Inventory Guidebook (EEA 2016).

Table 210: Default Tier 2 NH_3-N EF and associated parameters for the Tier 2 methodology.

NFR	Livestock category	proportion of TAN	Housing period [days]*)	EF housing	EF storage	EF spreading
3.B.2	Sheep	0.50	183	0.22	0.28	0.90
3.B.4.d	Goats	0.50	183	0.22	0.28	0.90
3.B.4.e	Horses (mules, asses)	0.60	292	0.22	0.35	0.90
3.B.4.g.i	Laying hens	0.70	365	0.41	0.14	0.69
3.B.4.g.ii	Broilers	0.70	365	0.28	0.17	0.66
3.B.4.g.iii	Turkeys	0.70	365	0.35	0.24	0.54
3.B.4.g.iv	Other Poultry (ducks, geese, turkeys)	0.70	365	0.35(**)	0.21(**)	0.51(**)
3.B.4.h	Other animals	0.50	73	0.22	0.28	0.90

*) *values of housing period are country specific (ALFRED PÖLLINGER 2008)*

**) *EF = weighted mean of ducks & geese 2003-2016*

The EMEP/EEA Guidebook does not give default values for NH_3 emissions from the livestock category 'deer'. As sheep is the most similar livestock category to deer, the NH_3 emission factors of sheep have been used.

NO_x emissions from manure management

NO_x-N-losses from manure management were calculated using the default Tier 1 emission fac-

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tors per animal category as outlined in the EMEP/EEA Emission Inventory Guidebook 2016 (EEA 2016, Table 3.3).

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 use of sewage sludge

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 2016 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 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 202)

The annual agricultural consumption of sewage sludge is presented in Table 202.

Other organic fertilizers applied to soils (energy crops from biogas plants and compost)

In addition to N from digested manure, which has been already accounted for in previous submissions, additional N inputs from energy crops applied to soils as fertilizer after the digestion process in biogas plants have been implemented in submission 2015.

N inputs from compost applied to agricultural soils have been included for the first time in submission 2016.

Activity data

Energy crops

The calculation of N from anaerobically digested energy crops was done on the basis of raw material and energy balances reported by E-Control (E-CONTROL 2008, 2011, 2013 & 2017).

N content of digested energy crops was derived from specific literature (RESCH et al. 2006; DLG 1997; LANDESBETRIEB LANDWIRTSCHAFT HESSEN 2013).

Amounts of digested manure N are calculated in sector manure management. N amounts of digested energy crops were derived on the basis of digested manure N amounts and the share of energy crop N (digested manure N amount/ digested crop-N amount).

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 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. N-content of dry matter of 1.4% was derived from (AMLINGER et al. 2005).

Table 211: N from biogas slurry (vegetable part) and compost.

Year	manure anaerobically digested [kg N $year^{-1}$]	N from biogas slurry [kg N $year^{-1}$]	N from compost [kg N $year^{-1}$]
1990	49 840	175 293	60 236
1991	67 870	238 707	98 742
1992	75 306	264 858	172 251
1993	100 226	352 505	386 072
1994	283 275	996 309	558 816
1995	327 613	1 152 251	694 352
1996	359 014	1 262 692	778 047
1997	460 707	1 620 357	732 696
1998	546 005	1 920 361	761 553
1999	752 947	2 648 198	785 463
2000	871 032	3 063 517	875 945
2001	996 188	3 503 702	966 428
2002	1 108 080	3 897 238	1 050 323
2003	1 209 113	4 252 582	1 097 984
2004	1 296 492	4 559 906	1 133 292
2005	1 365 534	4 802 732	1 137 307
2006	1 429 936	5 029 242	1 100 971
2007	1 577 004	5 546 496	1 114 044
2008	1 610 693	6 478 924	1 158 411
2009	1 635 722	7 614 425	1 231 597
2010	1 660 440	7 102 316	1 303 964
2011	1 694 441	6 687 875	1 408 564
2012	1 803 969	7 120 179	1 560 827
2013	1 908 988	7 534 683	1 471 292
2014	1 975 075	7 795 524	1 530 673

Year	manure anaerobically digested [kg N year^{-1}]	N from biogas slurry [kg N year^{-1}]	N from compost [kg N year^{-1}]
2015	2 021 188	7 977 531	1 504 839
2016	1 996 823	7 881 364	1 637 533

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*.

$$F_{PRP} = N_{exPRP} * EF_{PRP}$$

F_{PRP} = N_2O emissions induced by nitrogen excreted from grazing animals, expressed as N_2O-N [t N].

N_{exPRP} = Nitrogen excreted during grazing (amount of animal manure nitrogen produced by grazing animals and directly dropped on agricultural soils during grazing) [t N] – see Table 212

EF_{PRP} = Default emission factors for N_2O from manure of grazing animals have been used [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 212: Nitrogen excreted during grazing on pasture, range and paddock (N_{exPRP}) 1990–2016.

Year	N excretion grazing [t]	Year	N excretion grazing [t]
1990	17 458	2004	11 558
1991	17 017	2005	11 087
1992	15 908	2006	10 577
1993	15 884	2007	10 463
1994	15 513	2008	9 945
1995	15 910	2009	10 105
1996	15 461	2010	10 198
1997	15 069	2011	10 154
1998	14 245	2012	10 080
1999	13 762	2013	9 947
2000	13 480	2014	9 881
2001	12 820	2015	9 937
2002	12 078	2016	10 085
2003	11 770		

5.4.2.1.4 Nitrogen input from incorporation of crop residues

Within submission 2015 the methodology for the estimation of N_2O emissions from crop residues was revised in accordance with the IPCC 2006 GL. 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 from inventory submission 2015 onwards:

- 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 (BMLFUW 2000–2017). The average N content of residues was derived on the basis of the assumption (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c) that 25% of plants are legume forages and 75% are non-legume forages. 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 (BMLFUW 2000–2017).

The average N content of residues was derived on the basis of the assumption (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c) that 25% of plants are legume forages and 75% are non-legume forages. 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 2006). Activity data (areas with cover crops) were taken from Austria's Green Reports (BMLFUW 2000–2017).

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 213.

Table 213: 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 1998a) 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 (BMLFUW 2000–2017) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT 2017) and are presented in Table 198 and Table 199. Legume cropping areas were available from official statistics (BMLFUW 2000–2017) and (STATISTIK AUSTRIA 1990–2017) and can be found in Table 197.

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 6.2.1).

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 whole Austrian grassland area.

The estimation resulted in a total area of 12 954 ha organic grassland soils.

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 and by nitrogen leaching and run-off 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

$$N_2O_{(ATD)}\text{-}N = [(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})] * EF_{AD}$$

$N_2O_{(ATD)}$-N = N_2O emissions from atmospheric deposition, expressed as N_2O-N [t N]

F_{SN} = annual amount of synthetic fertilizer N applied to soils [t N] (see Table 196)

$Frac_{GASF}$ = 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_{AD} = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, kg N-N_2O (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 application on 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 application on agricultural soils
- NH_3-N and NO_x-N losses from biogas-slurry application on agricultural soils (digested energy crops)
- NH_3-N and NO_x-N losses from compost application on agricultural soils

Table 214: NH_3-N and NO_x-N volatilisation losses from synthetic fertilizers and organic N fertilizers (including grazing) 1990 to 2016.

Year	N losses mineral fertilizer (incl. urea)	$Frac_{GASF}$	N losses from applied organic N fertilizer materials and grazing	$Frac_{GASM}$
	[N/yr]	(N_{losses}/N_{FERT})	[t N/yr]	($N_{losses}/N_{FON+FPRP}$)
1990	5 603	0.04	29 057	0.18
1991	6 639	0.04	28 820	0.18
1992	5 683	0.04	27 943	0.18
1993	4 558	0.04	28 496	0.18
1994	6 280	0.04	28 424	0.18
1995	6 459	0.04	28 834	0.17
1996	5 437	0.04	28 348	0.17
1997	5 579	0.04	28 294	0.17
1998	5 723	0.04	28 249	0.18
1999	5 506	0.04	27 680	0.17
2000	5 249	0.04	27 104	0.17
2001	5 010	0.04	27 023	0.17
2002	5 161	0.04	26 532	0.17
2003	4 897	0.04	26 404	0.17
2004	4 534	0.05	26 211	0.17
2005	4 701	0.05	26 049	0.17
2006	4 979	0.05	26 005	0.17
2007	5 259	0.05	26 382	0.17
2008	5 757	0.05	26 211	0.17
2009	5 808	0.05	26 739	0.17

Year	N losses mineral fertilizer (incl. urea)	$Frac_{GASF}$	N losses from applied organic N fertilizer materials and grazing	$Frac_{GASM}$
	[N/yr]	(N_{losses}/N_{FERT})	[t N/yr]	($N_{losses}/N_{FON+FPRP}$)
2010	4 793	0.05	26 738	0.17
2011	5 297	0.05	26 416	0.17
2012	5 668	0.05	26 345	0.17
2013	5 563	0.05	26 409	0.17
2014	6 108	0.05	26 512	0.17
2015	6 533	0.05	26 593	0.17
2016	7 085	0.06	26 688	0.17

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 Report 2018 – 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 2018).

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 Emission Inventory Guidebook (EEA 2016). For the calculation of NH_3-N losses from synthetic fertilizers the detailed methodology was applied. This method uses specific NH_3 emission factors for different types of synthetic fertilizers and for different climatic conditions. For urea the weighted average of the default emission factors for normal pH soils (1.55 kg NH_3/kg N applied) and high pH soils (0.164 kg NH_3/kg N applied) (EEA 2016, table 3.2) has been calculated, resulting in an emission factor for urea of 0.158 kg NH_3 per kg of fertilizer-N applied. As calcium-ammonium-nitrate and ammonium-nitrate fertilizers represent the dominant form of non-urea synthetic fertilizers being used in Europe (FREIBAUER & KALTSCHMITT 2001), an average emission factor of 0.02 kg NH_3-N per kg of fertilizer-N is applied for fertilizers other than urea (STREBL et al. 2003).

For the calculation of NO_x-N losses the Tier 1 methodology according to the EMEP/EEA GB 2016 is applied. Emissions are calculated as a fixed percentage of total fertilizer nitrogen applied to soil. For all mineral fertilizer types the default emission factor of 4% (i.e. 0.04 kg NO per kg applied fertilizer-N) is used.

NH_3-N volatilization losses occurring during manure application

Default NH_3 emission factors for spreading of slurry and farmyard manure (expressed as share of TAN) have been applied (EEA 2009):

Table 215: 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

Table 216 presents the correction factor (CF) for band spreading. The CF is multiplied with the EF of broadcast spreading (reference value: 1). Factors were taken from the Swiss computer based programme „DYNAMO" (MENZI et al. 2003, REIDY et al. 2007, REIDY & MENZI 2005).

Table 216: Correction factors for NH_3 emissions from animal waste application.

Application technique	[CF]
Broadcast spreading	1
Band spreading	0.7

NO_x-N emissions from animal manure spreading

The Tier 1 methodology according to the EMEP/EEA GB 2016 and the default emission factor of 0.04 kg NO per kg of organic fertilizer-N spread on agricultural soils was used (EEA 2016, Table 3.1).

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 2016, Annex 1).

NO_x-N losses were calculated by applying the default Tier 1 EF for sewage sludge of 0.04 kg NO_2/kg N (EEA 2016, Annex 2).

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 2016, 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 2016, 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 2016, 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 2016, 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 run-off was used.

New 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 $Frac_{LEACH}$.

The emission calculation follows the following formula (equation 11.10, IPCC 2006 GL):

$$E\text{-}N_2O_{LL} = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) * Frac_{LEACH} * EF\text{-}N_2O_{LL}$$

$E\text{-}N_2O_{LL}$ = 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 196)
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 animal manure nitrogen 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)
$EF\text{-}N_2O_{LL}$ = Emission factor for N_2O from leaching, expressed as N_2O-N (0.0075 [kg/kg] following 2006 IPCC GL TABLE 11.3)

5.4.3 Source specific QA/QC

In the categories 3.D the following source specific QA/QC procedures have been carried out:

- ✓ NH_3-N and NO_x-N losses calculated in compliance to the obligations under UNECE/CLRTAP;
- ✓ Methods and emission factors reviewed by the EAGER[81] network;
- ✓ Plausibility of CRF N-fractions checked;
- ✓ Differences to IPCC default values explained and documented;
- ✓ External review by Austrian agricultural experts (stakeholder meetings);
- ✓ expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ External review of the revised agriculture inventory according to the 2006 IPCC GL by Austrian agricultural experts (stakeholder meeting) in 2014
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised source (e.g. crop residues, energy crops) will be performed in 2018.

Sector specific routine control procedures are provided in chapter 5.1.4.

[81] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

5.4.4 Uncertainties

Uncertainties are presented in Table 157.

5.4.5 Recalculations

Update of activity data

Milk yield data for dairy cows for the years 1991−1993 and 2001 was updated on the basis of official data from the Ministry of Agriculture (BMLFUW 2017). The revision resulted in slightly higher emissions for the years 1991−1993 and slightly lower emissions for 2001.

In 2017 new information on input materials for Austria's biogas plants became available (raw material balances for 2014 and 2015). The updated data were taken from (E-Control 2017) and resulted in revised amounts of digested manure and energy crops from 2012 to 2015 (latest available raw material balance used in a previous inventory was for 2011).

Revisions of land-use data within sector LULUCF resulted in slightly decreased N_2O emissions in all reported years (−0.002 kt N_2O in 2015).

Improvements of methodologies and emission factors

3.D Agricultural Soils (N_2O)

3.D.b Agricultural Soils (indirect soil emissions – N_2O)

Austria's agriculture model is based on the N-flow concept. Thus, revisions within Austria's air emission inventory affect calculations of Austria's GHG inventory.

The correction of a linkage error in the calculation of NO-N losses from sewage sludge application resulted in slightly increased indirect N_2O emissions from atmospheric deposition of managed soils for the whole time series. The higher amount of urea fertilizers in 2015 as well as the revised activity data, as described before (milk yields and input to digesters), are other reasons for the slight increase of indirect emissions (both, atmospheric deposition and N leaching from managed soils) in the years 1991−1993 and 2012− 2015 (+0.01 kt N_2O 2015).

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 2016 total emissions from this category amounted to 0.67 kt CO_2 equivalent, this is a share of 0.01% in total GHG emissions from sector agriculture. CH_4 and N_2O emissions for the years from 1990 to 2016 are presented in Table 217.

Table 217: Emissions from field burning (3.F) 1990–2016.

Year	CH_4 [kt]	N_2O [kt]
1990	0.05	0.001
1991	0.05	0.001
1992	0.05	0.001
1993	0.05	0.001
1994	0.05	0.001
1995	0.05	0.001
1996	0.05	0.001
1997	0.05	0.001
1998	0.05	0.001
1999	0.05	0.001
2000	0.05	0.001
2001	0.05	0.001
2002	0.05	0.001
2003	0.05	0.001
2004	0.07	0.001
2005	0.04	0.001
2006	0.04	0.001
2007	0.04	0.001
2008	0.04	0.001
2009	0.04	0.001
2010	0.04	0.001
2011	0.03	0.001
2012	0.02	0.000
2013	0.02	0.000
2014	0.02	0.000
2015	0.02	0.000
2016	0.02	0.000
Trend 1990–2016	***–57.4%***	***–69.0%***
Share in Agriculture	***0.01%***	***0.004%***

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.

For submission 2016 the calculation has been updated according to the 2006 IPCC GL, equation 2.27. 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 5.4.2.1.4) were applied. Parameters are presented in the following table:

Table 218: 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	1.25
Barley	0.90	0.86	1.09
Oats	0.90	0.86	1.16
Rye	0.90	0.86	1.29
Other cereals*	0.90	0.86	1.27

**mixed grain, triticale*

According to the *Presidential Conference of the Austrian Chambers of Agriculture* (personal communication to Mag. Längauer), in Austria about 390 ha were burnt in 2016. This value corresponds to about 0.1% of the relevant cereal area in 2016.

5.5.2.2 Other (3.F.5)

Key Source: No

This category comprises burning residual wood of vinicultures on open fields in Austria.

A simple method (Emission = Activity x Emission Factor) using country specific emission factors was applied.

Activity data (viniculture area) is taken from (STATISTIK AUSTRIA 1990–2017) and is harmonized with sector LULUCF to be consistent within the Austrian Inventory. Data for vineyards were taken from full Farm Structure Surveys (FSS) (1990, 1995, 1999 and 2010) and random sample FSS (1993, 1997, 2003, 2005, 2007, 2013 and 2016). The intermediate years were interpolated.

Further details are given in chapter *6.3 Cropland (Category 4.B)*

According to an expert judgement from the *Federal Association of Viniculture* (Bundesweinbauverband 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 219: Activity data for field burning of agricultural residues 1990–2016.

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377
1991	57 981	4 349
1992	57 599	4 320
1993	57 216	4 291
1994	56 422	4 232
1995	55 627	4 172
1996	54 061	4 055
1997	52 494	3 937
1998	51 854	3 889
1999	51 214	3 841
2000	50 304	3 773

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
2001	49 393	3 704
2002	48 483	3 636
2003	47 572	3 568
2004	48 846	3 663
2005	50 119	3 759
2006	49 981	3 749
2007	49 842	3 738
2008	47 688	3 577
2009	45 533	3 415
2010	45 480	3 411
2011	45 427	3 407
2012	45 373	3 403
2013	45 320	3 399
2014	45 320	3 399
2015	45 439	3 408
2016	46 757	3 507

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) by a calorific value of 7.1 MJ/kg burnt wood which corresponds to burning wood logs in poor operation furnace systems.

5.5.3 Source specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.5.4 Recalculations

No recalculations have been carried out.

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 220: Emissions from Liming (3.G) 1990–2016.

Year	CO_2 emissions [kt]	Year	CO_2 emissions [kt]
1990	89.97	2005	91.19
1991	91.06	2006	89.85
1992	91.09	2007	89.05
1993	90.81	2008	88.33
1994	91.39	2009	88.03
1995	91.85	2010	87.68
1996	92.49	2011	87.24
1997	92.08	2012	86.73
1998	91.45	2013	86.36
1999	90.87	2014	85.99
2000	90.19	2015	85.50
2001	90.10	2016	84.90
2002	90.06	***Trend 1990–2016***	***–5.6%***
2003	90.09	***Share in Agriculture***	***73.1%***
2004	91.17		

5.6.2 Methodological issues

There is no detailed data of lime application in Austria. Therefore, the estimated amount is based on assumptions described in the section *Activity data* below. Assumptions were reviewed within the external review of the revised agricultural model according to the IPCC 2006 GL by Austrian agricultural experts (UMWELTBUNDESAMT 2014c).

Activity data

The area for the calculation of liming comprises cropland and intensively used grassland (two and more cut meadows and cultivated pastures) (BMLFUW 2006c; Term of reference for the appropriate fertilization, made by the consulting committee for soil fertility at the Federal Ministry of Sustainability and Tourism). Cropland areas were harmonized with sector LULUCF to be consistent within the Austrian Inventory. Data were derived from the national FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System). As full Farm Structure Survey (FSS) data are only available for the years 1990, 1995, 1999 and 2010 and complemented with random sample FSS which were undertaken in 1993, 1997, 2003, 2005, 2007, 2013 and 2016, adjusted IACS data has been used for the intermediate years.

Table 221: Area with potential lime application in ha.

Year	Landuse (ha)		
	Cropland	Grassland (intensive used)	Potential agricultural area for limestone use
1990	1 405 141	877 024	2 282 165
1991	1 423 377	886 354	2 309 731
1992	1 414 742	895 683	2 310 425
1993	1 398 526	905 013	2 303 539
1994	1 402 750	915 331	2 318 081
1995	1 404 248	925 649	2 329 897

Year	Landuse (ha)		
	Cropland	Grassland (intensive used)	Potential agricultural area for limestone use
1996	1 414 005	931 984	2 345 988
1997	1 397 357	938 318	2 335 675
1998	1 395 643	924 036	2 319 679
1999	1 395 274	909 754	2 305 028
2000	1 377 934	909 667	2 287 601
2001	1 375 899	909 581	2 285 479
2002	1 374 930	909 494	2 284 423
2003	1 375 823	909 407	2 285 230
2004	1 403 797	908 656	2 312 452
2005	1 405 234	907 904	2 313 138
2006	1 389 960	889 008	2 278 968
2007	1 388 741	870 112	2 258 853
2008	1 376 689	863 879	2 240 568
2009	1 375 326	857 645	2 232 971
2010	1 372 530	851 412	2 223 942
2011	1 369 819	843 095	2 212 914
2012	1 365 214	834 779	2 199 992
2013	1 364 057	826 462	2 190 519
2014	1 361 678	819 522	2 181 201
2015	1 356 234	812 583	2 168 816
2016	1 346 400	807 017	2 153 417

The following assumptions were made:

- the recommended amount of lime that should be applied to cropland and grassland according to the Austrian advisory committee for good agricultural practices („Fachbeirat für Bodenfruchtbarkeit") is 0.7 t ha^{-1} a^{-1}.
- a pilot study on waste management in agriculture (UMWELTBUNDESAMT 2004b) showed that only 32% of this recommended amount is actually applied (0.224 t ha^{-1} a^{-1})
- additionally it has to be considered that about 60% of Austrian cropland and grassland need no liming as they are based on carbonate parent material

The area with actual lime application (considering that only 40% of cropland and grassland need liming) is shown in the following table, as recommended by the ERT.

Table 222: Area with actual lime application in ha.

Year	Landuse (ha)		
	Cropland	Grassland	Total area for actual lime application
1990	562 056	350 810	912 866
1991	569 351	354 541	923 892
1992	565 897	358 273	924 170
1993	559 410	362 005	921 416

Year	Landuse (ha)		
	Cropland	Grassland	Total area for actual lime application
1994	561 100	366 132	927 232
1995	561 699	370 260	931 959
1996	565 602	372 793	938 395
1997	558 943	375 327	934 270
1998	558 257	369 614	927 872
1999	558 110	363 902	922 011
2000	551 174	363 867	915 040
2001	550 360	363 832	914 192
2002	549 972	363 798	913 769
2003	550 329	363 763	914 092
2004	561 519	363 462	924 981
2005	562 094	363 162	925 255
2006	555 984	355 603	911 587
2007	555 496	348 045	903 541
2008	550 676	345 551	896 227
2009	550 130	343 058	893 189
2010	549 012	340 565	889 577
2011	547 927	337 238	885 166
2012	546 085	333 911	879 997
2013	545 623	330 585	876 208
2014	544 671	327 809	872 480
2015	542 494	325 033	867 527
2016	538 560	322 807	861 367

Methodology

The Tier 1 methodology following equation 11.12 (IPCC 2006) for calculating the CO_2 emissions has been applied.

$$CO_2\text{–C Emission} = (M_{Limestone} \cdot EF_{Limestone})$$

CO_2–C Emission = annual C emissions from lime application, tonnes C yr^{-1}

M = annual amount of calcic limestone (CaCO3). Dolomite is not applied in Austria.

EF = emission factor, tonne of C (tonne of limestone)$^{-1}$.

Emission Factors

The IPCC default emission factor for calcic limestone has been applied (0.12), which is equivalent to the carbonate carbon content of $CaCO_3$ (12%).

5.6.3 Source specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.6.4 Recalculations

The cropland and grassland areas for the years 2014 and 2015 were revised according to the results of the farm structure survey 2016 resulting in higher CO_2 emissions for 2014 (+0.1 kt CO_2) and lower CO_2 emissions for 2015 (−0.2 kt CO_2).

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 223: Emissions from Urea Application (3.H) 1990–2016.

Year	CO_2 emissions [kt]	Year	CO_2 emissions [kt]
1990	4.45	2005	11.76
1991	6.23	2006	14.91
1992	6.17	2007	17.92
1993	5.79	2008	16.55
1994	6.60	2009	21.97
1995	7.95	2010	19.56
1996	7.70	2011	18.36
1997	8.67	2012	21.69
1998	10.12	2013	21.51
1999	10.41	2014	25.44
2000	8.37	2015	26.48
2001	5.64	2016	31.30
2002	6.13	***Trend 1990–2016***	**603.2%**
2003	8.62	***Share in Agriculture***	**26.9%**
2004	10.84		

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 • 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 196).

Table 224: 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	2 833	6 070	2004	6 900	14 785
1991	3 965	8 496	2005	7 483	16 035
1992	3 926	8 412	2006	9 491	20 338
1993	3 682	7 890	2007	11 405	24 439
1994	4 198	8 995	2008	10 534	22 573
1995	5 058	10 838	2009	13 984	29 966
1996	4 899	10 498	2010	12 450	26 679
1997	5 520	11 829	2011	11 683	25 036
1998	6 440	13 800	2012	13 800	29 571
1999	6 624	14 194	2013	13 685	29 326
2000	5 328	11 417	2014	16 189	34 692
2001	3 589	7 690	2015	16 848	36 103
2002	3 900	8 356	2016	19 917	42 679
2003	5 488	11 760			

RWA: Raiffeisen Ware Austria, sales company

5.7.3 Source specific QA/QC

Sector specific routine control procedures are provided in chapter5.1.4.

5.7.4 Recalculations

Revised 2015 data on urea consumption (AMA 2017) resulted in higher CO_2 emissions for the respective year (+2.9 kt CO_2).

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 225 presents subcategory emissions and removals from this sector subcategories.

Table 225: Emissions and removals (+/-) from Sector 4 LULUCF by sub-categories[1] kt CO_2 equivalents.

	Greenhouse gas emissions/removals [kt CO_2e]							
Year	**4 Total**	**A Forest land**	**B Crop land**	**C Grass land**	**D Wet lands[2]**	**E Settle ments[2]**	**F Other land[2]**	**G Harvested Wood Products**
1990	-11 982	-10 858	191	650	42	657	458	-3 122
1991	-16 685	-16 585	183	645	42	660	469	-2 098
1992	-11 663	-11 819	171	640	42	664	479	-1 840
1993	-11 962	-12 289	161	635	42	667	490	-1 667
1994	-11 839	-11 228	163	635	42	663	490	-2 604
1995	-13 261	-12 212	24	468	30	607	392	-2 569
1996	-10 644	-9 197	24	469	36	601	388	-2 964
1997	-19 124	-17 952	29	471	36	595	383	-2 686
1998	-17 222	-16 141	38	473	36	589	379	-2 595
1999	-19 497	-19 061	32	473	36	586	380	-1 943
2000	-16 364	-15 972	24	472	36	584	381	-1 889
2001	-19 202	-17 925	-47	472	36	581	382	-2 701
2002	-14 166	-12 231	-40	680	47	662	351	-3 635
2003	-4 789	-2 239	-64	676	47	662	352	-4 223
2004	-9 118	-7 320	-77	677	47	660	343	-3 448
2005	-10 597	-8 771	-82	679	47	657	335	-3 461
2006	-5 116	-2 956	-78	678	37	653	326	-3 776
2007	-5 510	-1 928	-198	677	39	628	317	-5 046
2008	-4 276	-1 033	-183	672	51	664	308	-4 756
2009	-4 544	-4 471	-213	378	68	572	223	-1 102
2010	-5 878	-4 438	-218	377	69	545	215	-2 427
2011	-6 106	-4 406	-222	376	73	525	207	-2 659
2012	-5 476	-4 373	-225	375	70	536	198	-2 058
2013	-4 524	-4 340	-205	376	101	493	190	-1 141
2014	-4 725	-4 307	-171	377	71	497	182	-1 375
2015	-4 445	-4 299	33	375	59	466	178	-1 257
2016	-4 208	-4 292	65	357	77	452	174	-1 042
1990–2016	***-65%***	***-60%***	***-66%***	***-45%***	***83%***	***-31%***	***-62%***	***-67%***

[1] Other GHG are also considered, therefore the totals are different compared to the totals in the CRF tables.

[2] Only land use conversions are reported

Table 225 shows that land use, land use change and forestry is a net sink in Austria. For the years after 2002 a significant increase in biomass drain in 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 totals of the LULUCF sector.

The most important subcategory is forest land, in particular its subcategory forest land remaining forest land which is a net sink for CO_2. In the years 2007 and 2008 also the subcategory forest land remaining forest land represents a net emission source. Since the second commitment period, harvested wood products are reported as well. This subcategory is the second largest sink for CO_2. The cropland category represents also a sink in the last years, whereas the other subcategories are consistent sources of GHG emissions.

6.1.1 Emission Trends

In 2016, net removals from sector 4 amount to 4 208 kt CO_2 equivalents which corresponds to 5.3% of total GHG in Austria (without LULUCF), compared to 15% in 1990. The removals of the LULUCF sector decreased by 65% between 1990 and 2016.

The most important subcategory is forest land (*4.A*) with net removals of 4 292 kt CO_2 equivalents in 2016, followed by harvested wood products (*4.G*) with net removals of 1 402 kt CO_2 equivalents. The total emissions from the other subcategories amount to 1 126 kt CO_2 equivalents in 2016.

The net carbon stock changes in forest biomass (category *4.A.1*) demonstrates 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 occurance of windthrow and other disturbance events (e.g. very low increment in 2003, very high harvest rates in 2007 and 2008). These dynamics explain the high annual variations as well as single outlier years in the CO_2 net removals of this sector. The rather constant values from 2009 on are due to the use of averages for the forest biomass gains and losses from the last national forest inventory (NFI (2007/09) for the annual estimates after 2008. The results of the NFI 2007/09 show that the annual harvest in the years after 2002 has been much (on average 38%) higher than in the period before 2002. Consequently, the reported net sink of the sector for the years after 2002 is much lower.

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 key category analysis is presented in Chapter 1.5. Key categories within this sector are shown in Table 226.

Table 226: 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; TA
4.A.2	Land converted to forest land	CO_2	LA; TA
4.B.2	Land converted to cropland	CO_2	LA 2016
4.C.1	Grassland remaining grassland	CO_2	LA

IPCC Category	Source Categories	Key Categories	
		GHG	**KS-Assessment***
4.C.2	Land converted to grassland	CO_2	LA 1990; TA
4.E.2	Land converted to settlements	CO_2	LA
4.F.2	Land converted to other land	CO_2	LA 1990
4.G	HWP	CO_2	LA; TA

LA = Level Assessment (if not further specified – for the years 1990 and 2016)

TA = Trend Assessment 1990–2016

6.1.3 Methodology

The methodologies for estimating emissions from LUC from and to these land use categories are described in detail in the sub chapters 6.1 to 0. 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 used methods for the LULUCF emissions/removals.

6.1.3.1 Activity data

For the complete time series from 1990 to 2016 on areas remaining in a land use category and areas affected by LUC since 1970 (1960 for perennial cropland) activity data had to be compiled from data from different (statistical) 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). 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 information from the NFIs. In addition, a detailed assessment of the ARD activities under Article 3.3 of the Kyoto Protocol was carried out in the years 2011–2013.

Data for the total cropland area are available from STATISTIK Austria based on FSS (Farm Structure Surveys) (STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013 & 2014, 2017b) and IACS (Integrated Administration and Control System) data (STATISTIK AUSTRIA 1990–2017A). 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 calculated by linear interpolation. In 2015 (submission 2015), the time series of areas of alpine pastures was revised (see chapter 6.4.2). Estimates on the land use changes between cropland and grassland were derived from the data of the IACS (Integrated Administrative Control System, see also 6.6.2).

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 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 data for the settlement area are provided annually since 2006. As the database was previously updated irregularly, pre-2006 settlement area were interpolated (see 0). The increases of settlement area derive mainly 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 (area sum of all land use categories) except „Other Land" and the official total area of Austria. This calculation helps to avoid double counting or area ommissions. The LUC areas from forest land to other land are based on the NFIs. Other LUC to other land are not occuring.

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 227). 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.

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 area sum 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 data bases for all land uses) give an accurate picture of how the total Austrian area is distributed between the land use categories

Table 227 presents land use data and data for land use changes for the years 1990 and 2016 for the total area of Austria as used for the calculations. On basis of the ARD NFI 2011/2013 results the LUC areas to and from forests were estimated.

Table 227: Land use and LUC data for Austria for the years 1990 and 2016.

Area in ha	1990	2016	Diff 1990–2016

Area in ha	1990	2016	Diff 1990–2016
4.A Forest land – total area	3 891 333	4 035 000	143667
1 Forest land remaining forest land – total area	3 631 514	3 882 937	251423
1.1.a Forest land remaining forest land: coniferous	2 468 466	2 403 734	-64732
1.1.b Forest land remaining forest land: deciduous	748 475	925 537	177062
1.1.c Forest land remaining forest land: forest not in yield	414 573	553 665	139092
2. Land converted to forest land	259 819	152 063	-107756
2.1 Cropland converted to forest land	30 962	11 625	-19337
2.2 Grassland converted to forest land	144 197	77 613	-66584
2.3 Wetland converted to forest land	12 534	9 576	-2957
2.4 Settlement converted to forest land	17 122	7 128	-9994
2.5 Other Land converted to forest land	55 004	46 121	-8883
4.B Cropland – total area	1 500 824	1 417 321	-83503
1. Cropland remaining cropland	1 464 319	1 355 017	-109302
1.a Annual remaining annual	1 358 200	1 276 898	-81302
1.b Perennial remaining perennial	83 496	58 870	-24626
1.c Perennial converted to annual	11 141	9 101	-2040
1.d Annual converted to perennial	11 483	10 148	-1334
2. Land converted to cropland	36 505	62 304	25798
2.1 Forest Land converted to cropland	4 125	3 046	-1080
2.2 Grassland converted to cropland	32 380	59 258	26878
2.2.a Grassland converted to annual cropland	31 675	57 355	25680
2.2.b Grassland converted to perennial cropland	705	1 903	1198
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	1 714 917	1 449 678	-265239
1. Grassland remaining grassland	1 669 743	1 389 475	-280268
2. Land converted to grassland	45 173	60 203	15029
2.1 Forest land converted to grassland	32 467	28 032	-4435
2.2 Cropland converted to grassland	12 706	32 170	19464
2.2.a annual cropland converted to grass-land	12 621	31 932	19311
2.2.b perennial cropland converted to grassland	85	238	153
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	151 849	19233
1. Wetlands remaining wetlands	127 105	126 011	-1095
2. Land converted to wetlands	5 511	25 838	20328

Area in ha	1990	2016	Diff 1990–2016
2.1 Forest land converted to wetlands	1 706	2 747	1041
2.2 Cropland converted to wetlands	NO	NO	NO
2.3 Grassland converted to wetlands	3 804	23 091	19287
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	559 699	179644
1. Settlements remaining settlements	230 483	413 747	183264
2. Land converted to settlements	149 572	145 952	-3620
2.1 Forest land converted to settlements	9 792	8 329	-1463
2.2 Cropland converted to settlements	54 163	67 165	13002
2.3 Grassland converted to settlements	85 617	70 459	-15159
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	767 254	773 453	6199
1. Other land remaining other land	749 120	764 307	15187
2. Land converted to other land	18 134	9 146	-8988
2.1 Forest land converted to other land	18 134	9 146	-8988
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 Other land 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 228: 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. 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 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

Pools	Description
	cm (all other land uses and LUC).

6.1.3.3 Emission factors

The calculations of the emissions very closely follow the methods described in the IPCC 2006 GL. Wherever possible, higher tier methods are used and the emission factors are derived from national data. Austria is consistently closing gaps of 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 and studies for the cropland and grassland biomass as well as studies for 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 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

For the 2012 submission a complete uncertainty analysis for the whole LULUCF sector and time series was carried out 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. Only the source of wildfires in forests was not included in the uncertainty analysis. It has only a negligible share in the total LULUCF emissions/removals of Austria, so any uncertainty of this source would not contribute in a visible way to the total uncertainty of the LULUCF sector. 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.

The uncertainty of the total LULUCF sector emissions/removals is approx. ±19 000 kt CO_2. This represents on average ±132% of the total LULUCF emissions/removals in the years 1990 to 2002 which were years with a significant net sink of the LULUCF sector. In the years after 2002 with a much smaller net sink or source, the relative uncertainty of the total LULUCF emissions/removals is clearly higher (up to a few hundred %).

It is important to note that the majority (70%) of this total LULUCF uncertainty can be attributed to the C stock changes of two pools of one subcategory, namely to the results of the litter/soil pool of forest land remaining forest land (*4.A.1*). If the uncertainties of the C stock changes of the pools of subcategory *4.A.1* are deleted from the uncertainty simulation, the average uncertainties for the single years of the total LULUCF emissions/removals come to approx. ±5 600 kt CO_2 (with higher absolute uncertainties in the 90ies due to more uncertain input data in previous years).

The litter/soil C pool of *4.A. 1* is therefore a significant source of uncertainty in the estimated total GHG emissions for LULUCF. Austria uses very good tools to estimate the changes of these pools: litter input data on basis of a detailed forest inventory, results from two forest soil surveys and an internationally approved model to simulate the C stock changes (Yasso). Therefore significant reductions in the uncertainties of these are unlikely to be achieved in the short run; however, in the longer term significant improvements are very likely, when repeated soil inventories allow a thorough assessment of the soil C stock changes.

It is important to note that half of Austria is forest land and that the change of the litter/soil C pool of subcategory *4.A.1* (which represents emissions of about 2 600 kt CO_2 per year) constitutes a significant share in the total LULUCF emissions/removals of Austria.

The biomass changes of *4.A.1* have in most years had the highest impact on the total emissions/removals of the LULUCF sector, at least in the years 1990 to 2002. As a consequence, the uncertainty of these emissions/removals (around 40%) also has 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 extremely high relative uncertainties (in %) in their respective total emissions/removals (e.g. grassland, settlements and other land).

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 of pools and subcategories). 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

4.A Forest land

The wildfire area and emission estimates for the year 2014 required a minor adjustment on basis of the latest available statistics.

4.B Cropland

The estimate of the (shares of) land-use changes between annual cropland, perennial cropland and grassland on basis of the IACS system was slightly changed. The estimate is now based entirely on a subset of land parcels in IACS which show constant areas and codes throughout the time series. This led to changes of the LUC areas between annual, perennial cropland and grassland and consequently to changes in the related emissions and removals from biomass and soil.

The measurements of country specific orchard biomass and vineyard biomass were completed and the significantly too high default values of perennial biomass growth rates, stocks and turn-over periods were replaced by these country specific values. Consequently, the emissions and removals by perennial biomass in cropland changed.

The assessment of the soil C stock changes in cropland remaining cropland was improved. The results of the C stock change rates for the agricultural experimental plots and their allocations to different management types (management factors) like tillage types and input types were revisited and revised. The methodological regime for separating cropland into the different tillage and input types was further adjusted, e.g. by separating into combinations of three tillage types and variations of the input types and input combinations of low/high plant residues input, with/without manure input and with/without input from cover crops. These improvements led to lower C stock changes in the mineral soil of cropland compared to the last submission.

The 2014 and 2015 values of the cropland areas had to be updated according to the most recent agricultural statistics.

All the recalculations in the cropland category led to changes in the time series of annual emissions/removals of this subcategory in the range of −61 to 59 kt CO_2e per year.

4.C Grassland

The estimate of the (shares of) land-use changes between annual cropland, perennial cropland and grassland on basis of the IACS system was slightly changed. The estimate is now based entirely on a subset of land parcels in IACS which show constant areas and codes throughout the time series. This led to changes of the LUC areas between annual, perennial cropland and grassland and consequently to changes in the related emissions and removals from biomass and soil in the subcategory LUC from cropland to grassland.

The measurements of country specific orchard biomass and vineyard biomass were completed and the significantly too high default values of perennial biomass growth rates, stocks and turn-over periods were replaced by these country specific values. Consequently, the emissions by perennial biomass in the LUC subcategory perennial cropland to grassland changed.

The 2014 and 2015 values of the grassland areas had to be updated according to the most recent agricultural statistics.

All the recalculations in the grassland category reduced the annual emissions of this subcategory by -23 to −1 kt CO_2e per year.

4.D Wetlands

No revisions of the time series.

4.E Settlements

The estimates of the LUC shares from cropland and grassland to settlements were adjusted and led to minor changes in the emissions of the settlement subcategory (higher annual emissions of this subcategory by 0.1 to 17 kt CO_2e per year).

4.F Other lands

No revisions of the time series.

4.G HWPs

A calculation error in the HWP estimates related to veneer sheets was corrected and led to minor changes in the removals from HWPs.

The HWP production figures for 2015 were updated in the most recent FAO statistic. Consequently, the removal figures for this year had to be updated accordingly.

The estimate of paper production from domestic wood was expanded by the wood pulp production/import/export according to equations 2.8.2 and 2.8.4 of the IPCC (2014) KP Supplement and the HWP time series was recalculated accordingly.

All the recalculations in the HWP category led to changes in the time series of annual removals of this subcategory in the range of −182 to 342 kt CO_2e per year.

6.1.7 Completeness

Table 229 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 229: IPCC categories according to the IPCC 2006 Guidelines.

IPCC categories[82]/ 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 of carbon stock	✓	
Deciduous	Increase, decrease, net change of carbon stock	✓	
Forest not in yield	Increase, decrease, net change of carbon stock	NE/NO	
	Net carbon stock change in dead organic matter	✓	
	Net carbon stock change in soils	✓	
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	✓	

[82] IPCC categories – applied according to the 2006 IPCC 2006 Guidelines for National Greenhouse Gas Inventories

IPCC categories[82]/ Sub division for calculation	Description	Status for CO_2	Other GHG
	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	
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	✓	

IPCC categories[82]/ Sub division for calculation	Description	Status for CO_2	Other GHG
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		
4.G.1	Solid wood	✓	
4.G.1.1	Sawn wood	✓	
4.G.1.2	Wood panels	✓	

IPCC categories[82]/ Sub division for calculation	Description	Status for CO_2	Other GHG
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 (1)	✓ N_2O ✓ CH_4
4(V) 4 B 1 BiomassBurn_controlled	Biomass burning: controlled: residues of perennial cropland	IE (2)	IE (3) N_2O, CH_4
4(G)	C stock changes in Harvested Wood Products	✓	

1) *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 2016.*

2) *Included in the harvest of perennial cropland biomass*

3) *Included in Sector 3.F estimates – field burning of agricultural residues*

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:

- Improvement of estimates for C-stock changes in forests not in yield as recommended by the ERT during the ICR 2013. A new NFI started in 2016. The new NFI will provide estimates for the forest not in yield.
- The estimates of carbon stocks in mineral soils of "annual cropland remaining annual cropland" are based on shares of management types from IACS data for the year 2016. For the next submission further years will be analysed with IACS to improve the robustness of the time series.
- For soil organic carbon in grassland estimates a refined time resolution will be prepared.
- An analysis of existing urban tree data bases will be carried out in order to estimate CSC in biomass in settlements remaining settlements.
- An in-depth analysis of existing cropland and grassland activity data for the most recent years will be conducted to ensure time series consistency with historical years.

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 2014). 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 the Austrian forests in the past has helped to maintain an important carbon stock in the Austrian landscape and to 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).

Emission/Removal trends of forest land

In Austria, the area of forest land has been constantly increasing since 1990 (Figure 31). However, the land converted to forest land categories show a decreasing trend with exception of other land to forest land which is stagnating (Figure 32).

The annual net CO_2 removals under sector *4.A* of the reported period 1990–2016[83] range from 1 060 kt CO_2 to 19 088 kt CO_2 (mean: 9 196 kt CO_2). The most important subcategory is forest land remaining forest land (*4.A.1*), whereas land use changes to forests (*4.A.2*) and from forests (*4.B.2* to *4.F.2*) have only minor influence on the net CO_2 balance.

The year 2008 is the median year of the last national forest inventory period, which was carried out between 2007 and 2009. For the years since 2008 the means (e.g. total forest area, land use changes, increment/drain) for the last period (2007 to 2009) of the National Forest Inventory (NFI) have been reported (except for the land use changes to and from forests for which the ARD NFI 2011 to 2013 provided accurate figures for the last years up to 2013).

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 11 081 kt CO_2 (from 4 324 kt CO_2 to 16 385 kt CO_2).

Between 1990 and 2016 the net carbon sink of the forest land category ranges between 1% and 24% of the total CO_2 equivalent emissions without LULUCF of the GHGs CO_2, CH_4 and N_2O in this period.

For the reported period 1990 to 2016 the total annual net CO_2 removals from land use changes to forest range from about 1 741 kt CO_2 to 3 370 kt CO_2. The total annual emissions from land use changes from forests (conversion of forest land) vary between 511 kt CO_2 and 1 186 kt CO_2eq.

[83] For the years since 2009 the means for the last period (2007 to 2009) of the National Forest Inventory (NFI) have been reported.

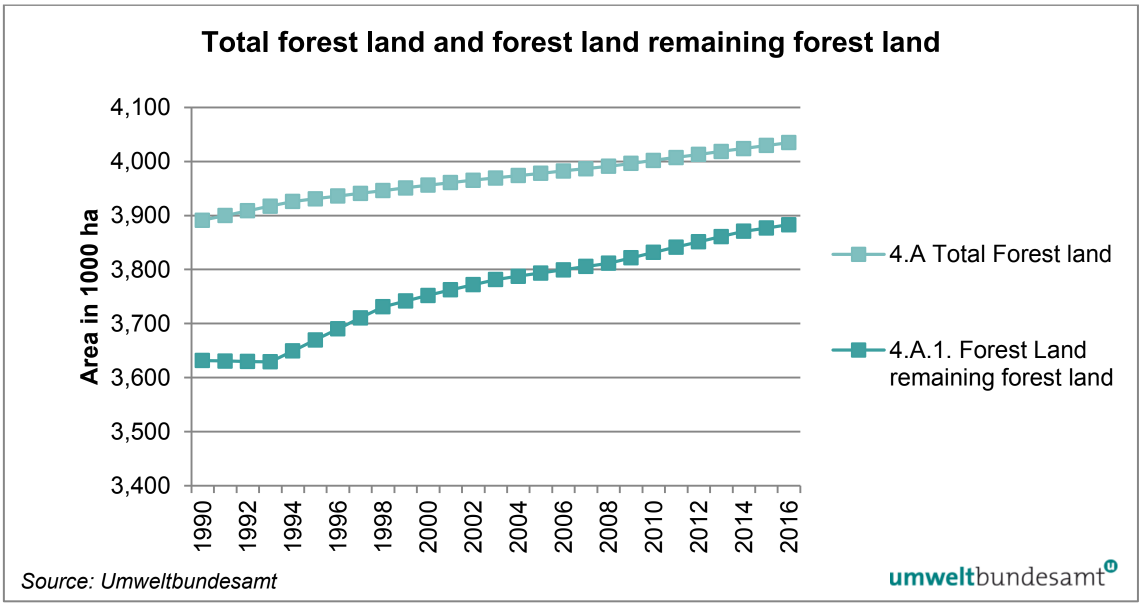

Figure 31: Trend of total forest land and forest land remaining forest land.

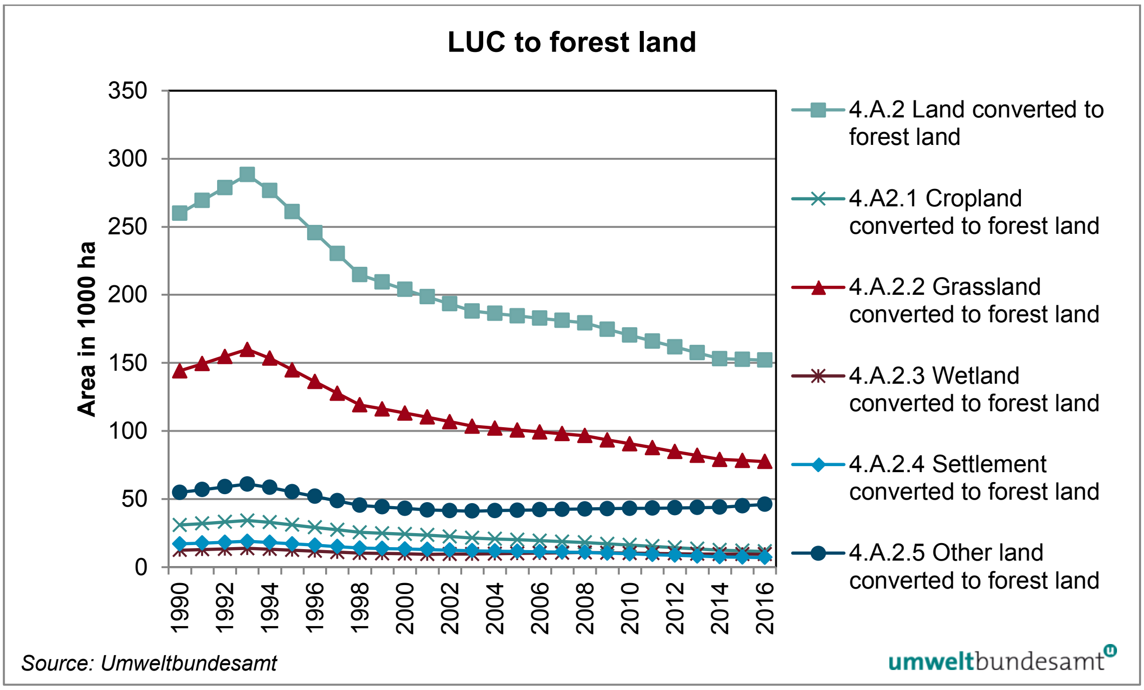

Figure 32: Trend of LUC to forest land (below) covering a conversion period of 20 years from 1990 to 2016 in 1 000 ha (Total forest land includes also forest out of yield).

The net carbon stock changes of category *4.A* vary considerable between single years and outliers exist. The reason 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 (e.g. very low increment in 2003, very high harvest rates in 2007 and 2008). The forest biomass changes in category *4.A.1* have a major impact on the overall results in category 4.*A* (and sector 4 as a whole). Therefore, such reasons for different growth and different harvest in single years explain the high annual variations as well as single outlier years in the CO_2 net removals of this sector. The rather constant values from 2009 on are due the use of average values of the last NFI (2007/09) for the estimates of the years after 2008.

The variation within the time trend for LUCs 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 230: CO_2 removals/emissions (+/-) from IPCC Category 4.A Forest Land from 1990–2016 kt CO_2 and CO_2 equiv.).

	4.A Total Forest land_CO_2eq	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	-10 892	-7 849	-3 043	-422	-1 033	-93	-330	-1 165	30	3.430	IE	0.465	0.307
1991	-16 620	-13 472	-3 148	-437	-1 068	-96	-342	-1 206	31	3.555	IE	0.123	0.081
1992	-11 856	-8 602	-3 254	-451	-1 102	-99	-354	-1 247	32	3.680	IE	0.307	0.203
1993	-12 327	-8 957	-3 370	-468	-1 143	-103	-366	-1 291	33	3.804	IE	0.261	0.172
1994	-11 264	-8 035	-3 229	-448	-1 094	-98	-351	-1 238	32	3.651	IE	0.135	0.089
1995	-12 246	-9 218	-3 028	-421	-1 022	-92	-330	-1 164	30	3.447	IE	0.074	0.049
1996	-9 229	-6 369	-2 860	-397	-967	-87	-311	-1 098	29	3.243	IE	0.067	0.044
1997	-17 982	-15 291	-2 691	-373	-913	-82	-292	-1 031	27	3.039	IE	0.047	0.031
1998	-16 169	-13 647	-2 523	-350	-858	-77	-274	-964	25	2.835	IE	0.216	0.143
1999	-19 088	-16 631	-2 457	-341	-835	-75	-267	-940	24	2.764	IE	0.019	0.012
2000	-15 999	-13 607	-2 391	-332	-812	-73	-260	-915	24	2.692	IE	0.098	0.064
2001	-17 951	-15 625	-2 326	-323	-790	-71	-253	-890	23	2.621	IE	0.056	0.037
2002	-12 257	-9 997	-2 260	-305	-759	-73	-243	-880	23	2.598	IE	0.447	0.295
2003	-2 264	-73	-2 191	-292	-731	-72	-234	-863	23	2.574	IE	0.426	0.281
2004	-7 345	-5 180	-2 165	-284	-718	-72	-229	-863	23	2.597	IE	0.040	0.026
2005	-8 797	-6 658	-2 139	-277	-704	-72	-225	-862	23	2.619	IE	0.072	0.048
2006	-2 982	-869	-2 114	-267	-689	-74	-219	-864	23	2.642	IE	0.172	0.114
2007	-1 954	134	-2 088	-257	-674	-76	-214	-867	23	2.664	IE	0.086	0.057
2008	-1 060	1 003	-2 063	-247	-659	-77	-209	-870	24	2.687	IE	0.116	0.077
2009	-4 498	-2 494	-2 003	-234	-628	-74	-197	-870	24	2.681	IE	0.130	0.086
2010	-4 465	-2 510	-1 955	-222	-602	-74	-187	-869	24	2.680	IE	0.114	0.075
2011	-4 432	-2 526	-1 906	-210	-576	-74	-178	-868	24	2.679	IE	0.102	0.068
2012	-4 399	-2 542	-1 857	-198	-551	-74	-168	-867	24	2.679	IE	0.128	0.084
2013	-4 366	-2 561	-1 805	-185	-523	-73	-157	-867	24	2.678	IE	0.210	0.139
2014	-4 333	-2 580	-1 753	-173	-495	-71	-146	-868	24	2.677	IE	0.131	0.086
2015	-4 326	-2 579	-1 747	-167	-483	-71	-140	-886	24	2.726	IE	0.323	0.213
2016	-4 320	-2 579	-1 741	-161	-471	-71	-134	-903	24	2.775	IE	0.045	0.030

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 2013; 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 and 2007-09 covering the total forest area. In the period 2011-2013 a reduced ARD NFI was carried out at the previous LUC areas from and to forests and at new LUC areas since the NFI period 2007-09.

The NFI uses a permanently below ground marked 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 Figure 23 in UMWELTBUNDESAMT 2010a or at BFW 2005[84]). 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. This is also of relevance for the reporting of the Austrian Art. 3.3 areas which are also based on the NFI data only.

The NFI assessments related to the UNFCCC- and Kyoto-Protocol-reporting-period were carried out so far in the periods 1986/90, 1992/96, 2000/02, 2007/09 and at ARD areas in 2011/13. The forest areas measured for these periods were located in the mean year of the NFI 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 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: 3 217 kha. This is the sum of the figures of 1.1.a and 1.1.b in Table 227
2) The result of step 1 is split according to the area-distribution of coniferous and deciduous trees. e.g. for 1990: coniferous 2 468 kha + deciduous 748 kha = 3 217 kha (see Table 227 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: 415 kha (see 1.1.c in Table *227*).
4) Total forest land remaining forest land in CRF table is the sum of step 1 and 3 (For 1990 3 631kha).

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: 3 631 kha + 260 kha = 3 891 kha).

The calculations of C-losses and C-gains for FL remaining FL consider only the area of **productive forest (forest in yield)**. The rationale for excluding non-productive forests is explained by

[84] http://www.bfw.ac.at/rz/bfwcms.web?dok=2384

the following conservative working assumptions: There is a balance between C-losses due to decay and C-gains due to biomass increment. There is neither extraction of biomass nor planting measures due to the limited access to these forests. The NFI 2007/09 carried out for the first time an assessment of the standing stocks in the non-productive forests. So, with subsequent NFIs and a re-assessment of these stocks, an estimate of emissions/removals in the non-productive forests will be possible in future NIR submissions.

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 ARD NFI 2011/13 (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 2011/13). Due to a lack of data, relative distributions of the total LUC areas into the LUC subcategories 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 neighbouring 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 231).

In the years 2011 to 2013 a reduced NFI was carried out only at all NFI plots which had according to previous NFIs recorded ARD activities. In addition, all NFI grid points and plots were inspected which were suspicious for a potential LUC to/from forests on basis of an assessment of latest aerial images for Austria for the period after the last NFI 2007/09. The NFI grid points and plots were checked in these latest aerial images for a potential LUC to/from forests since NFI 2007/09. In clear or suspicious cases for a current LUC at site inspections of the NFI plots were carried out for clarification if a recent LUC to/from forests in the period since the last NFI 2007/09 occurred or not and related measurements of the new LUC areas were carried out. The ARD NFI 2011/13 had also the purpose to measure and to assess for the first time and in detail the biomass stock changes and the dead wood stock changes at all old and new plots with LUCs to/from forests for the Kyoto-period 2008 to 2012. In previous submissions, rough estimates of the biomass stock changes at such LUC areas on basis of NFI results were carried out and used.

With the ARD NFI 2011/13 also a thorough inspection of all ARD areas was carried out for the appropriateness of the classification as ARD areas. Areas previously accounted as ARD 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 (see chapter 10.4.1.2)

could be identified and were deleted as ARD areas. On the basis of the results of these thorough inspections of each ARD plot, the ARD areas of submissions before 2014 were reduced by these misclassified ARD areas. The LUC areas to/from forests were reduced accordingly.

Table 231: LU-classification systems (IPCC 2006 Guidelines and NFI 2000/02, 2007/09 and ARD NFI 2011/13).

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 ARD NFI 2011/13)
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 232: Land use changes to forest (% and ha) observed from 1990 to 2012 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and the ARD NFI 2011/13; based on BFW 2013).

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 – ARD NFI 2011/13	
	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	6.2	1.8
Grassland (4.A.2.2)	55.5	32.0	55.5	30.1	50.2	27.8	48.9	14.1
Wetlands (4.A.2.3)	4.8	2.8	4.8	2.6	8.7	4.8	4.9	1.4
Settlements (4.A.2.4)	6.6	3.8	6.6	3.6	5.0	2.8	3.1	0.9
Others (4.A.2.5)	21.2	12.2	21.2	11.5	29.9	16.6	36.9	10.7
Total	**100.0**	**57.7**	**100.0**	**54.3**	**100.0**	**55.4**	**100.0**	**28.9**

Table 233: Land use changes from forest (% and ha) observed from 1990 to 2012 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and the ARD NFI 2011/13; based on BFW 2013).

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 – ARD NFI 2011/13	
	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	5.4	0.4
Grassland (4.A.2.2)	49.0	9.5	49.0	8.5	56.7	14.5	55.9	3.7
Wetlands (4.A.2.3)	2.6	0.5	2.6	0.4	2.2	0.6	14.0	0.9
Settlements (4.A.2.4)	14.8	2.9	14.8	2.6	20.0	5.1	10.3	0.7
Others (4.A.2.5)	27.4	5.3	27.4	4.7	15.0	3.8	14.4	1.0
Total	**100.0**	**19.4**	**100.0**	**17.3**	**100.0**	**25.6**	**100.0**	**6.6**

As shown in Table 232 and Table 233 the land use changes to and from forests mainly appear to be from/to grassland sites (49–56% or 49–57%, respectively).

For the years 1994 back to 1970 it was assumed that the measured land use changes between two NFI observation periods show the same ratio of distribution between land use change subcategories as between the NFI period 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 could be applied directly to split the total LUC areas of NFIs 1986/90 and 1992/96 between 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.

In response to the recommendations of the ERT during the ICR 2013 a detailed assessment of the NFI data was carried out for the years 1989 to 1994 covered by the NFIs 1986/90 and 1992/96 in order to provide better estimates for ARD activities that occurred after the 1st of January 1990 (see chapter KP-LULUCF). The result showed slightly higher LUC activities from and to forests in the year 1989 than for the following years 1990–94. The time series 1989 to 1994 of both the LUC areas and the ARD areas, were adjusted accordingly.

Figure 33 gives an overview of the LUCs to and from forests from 1970 to 1990 and from 1990 onwards. LUC 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 ones of the single years of the observation period. Interpolations across NFI periods would thus be unsuitable. These stepwise LUC area changes have implications on the emissions/removals which – as a consequence - also change stepwise for certain LUC categories from forests (e.g. FL to CL, FL to GL) and for certain pools (e.g. biomass).

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 ARD NFI 2011/23. The results are finally summed up according to the areas of LUC as shown in Table 232 and Table 233. The specific carbon stocks for litter and soil for each forest growth region are shown in Table 244.

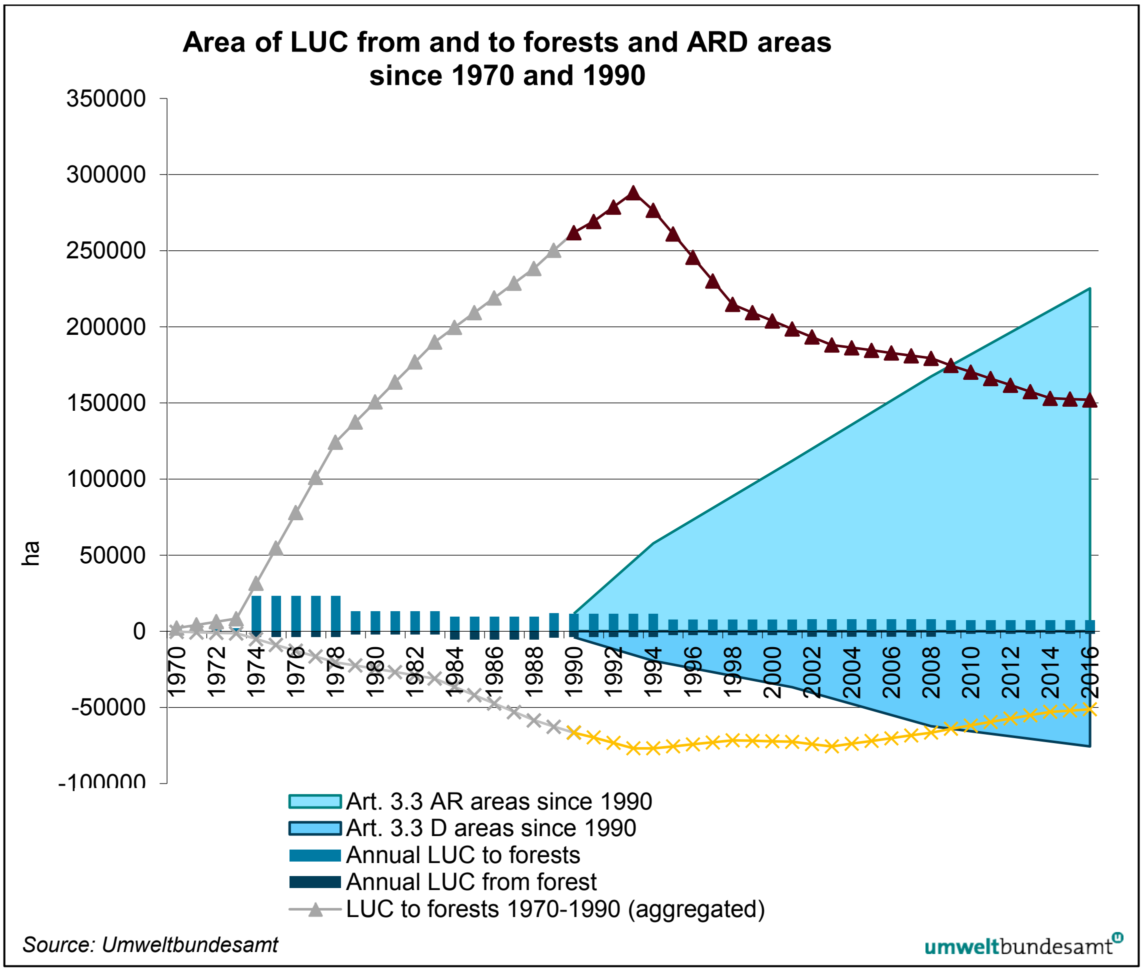

Figure 33: Areas of LUC from and to forests and ARD areas since 1970 and 1990, respectively.

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 the greenhouse gas reporting. 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 forestal 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 2013; 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 and 2007–09. An additional NFI that is limited to ARD plots was carried out in the period 2011/13.

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[85] are used to distribute NFI drain and increment more realistically between the years based on the relative harvest indices and relative increment indices.

In addition to the NFI drain data which are based on measurements in the forests further harvest statistics exist (Table 234): the annually reported records of timber harvest and the Austrian wood balance (BITTERMANN & GERHOLD 1995. BMLFUW 1964–2011). While it is assumed that the NFI provides more accurate figures on the total stemwood drain between inventories, these annual statistics 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 period. The annual average drain from the NFI for the inter-inventory period is therefore adjusted by multpying by the annual harvest index. In the same fashion, representative Austrian sets of tree ring cores (HASENAUER et al. 1999a, b; BFW 2011a, pers. comm.) are used to calculate the relative indices for adjusting NFI annual increment.

[85] Values for the relative variation in the individual years of the time series

Table 234: 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.	m³ 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).	m³ 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	m³ extracted stemwood under bark

The above methods allow accurate estimates for individual years for the category *4.A.1* (Table 235). 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, very high harvest rates in 2007 and 2008). 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 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 2009, constant average annual increment and average annual drain values from the last NFI have been reported. Once the next NFI data are available, the average annual increment and drain values from 2009 onwards will of course be replaced and adjusted by the respective relative indices. These constant values have been used instead of extrapolating recent increment/drain trends to reduce the size of the potential revisions once new NFI data become available. Previous experience with extrapolation of trends for increment and drain between inventory periods in 1980s led to figures in the 1990s, which had to be strongly revised downwards after the inventory period 1992/96.

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Table 235: Increment and drain in the Austrian forests on basis of NFIs and interpolated on basis of relative indices[86]. Italic years represent the annual average of the previous NFI period. Equally shaded cells represent the same observation period.

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	**31 416**	**32 243**	**19 846**	**19 358**
1986		**30 314**		**20 201**
1987		**31 416**		**19 583**
1988		**31 416**		**21 275**
1989		29 180		20 265
1990		28 945		23 034
1991	27 337	28 004	19 521	16 849
1992		25 180		17 958
1993		25 415		17 969
1994		27 298		21 052
1995		**27 872**		**18 461**
1996		**26 897**		**20 071**
1997	**31 255**	**34 109**	**18 797**	**19 690**
1998		**31 835**		**18 766**
1999		**34 434**		**18 832**
2000		**30 828**		**17 752**
2001		**32 810**		**18 007**
2002		31 720		21 166
2003		26 093		24 317
2004		29 845		23 500
2005	30 371	31 151	25 888	23 483
2006		29 878		27 281
2007		31 955		30 395
2008		31 955		31 076
2009		***30 371***		***25 888***
2010		***30 371***		***25 888***
2011		***30 371***		***25 888***
2012		***30 371***		***25 888***
2013		***30 371***		***25 888***
2014		***30 371***		***25 888***
2015		***30 371***		***25 888***
2016		***30371***		***25 888***

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 (wildfires) and other damages are represented in the NFI increment and drain data.

[86] 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.

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.

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 m^3 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 236 represent aggregated values on basis of the species composition of increment and drain in Austria (see example in Table 237 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 236: 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 237: Share of tree species in total stemwood increment and drain of the NFIs 2007/09 and 2000/02. (BFW 2011a).

Tree species	% in total increment NFI 07/09	% in total drain t NFI 07/09	% in total increment NFI 00/02	% in total drain NFI 00/12
Spruce	66.4	68.7	64.5	66.0
Fir	4.2	4.0	3.8	4.7
Larch	3.9	4.0	4.9	4.9
pine (pinus sylvestris)	4.0	6.3	5.2	8.2
pine (pinus nigra)	0.2	0.6	0.5	0.7
pinus cembra	0.2	0.1	0.2	0.1
Weymouth pine (pinus strobus)	0.0	0.0	0.0	0.1
douglas fir	0.1	0.0	0.1	0.0
Total coniferous	**79**	**84**	**79**	**85**
beech (fagus sylvatica)	9.1	6.8	8.3	6.7
oak	2.2	2.2	2.5	2.0
hornbeam	0.8	0.5	1.0	0.7
ash	2.7	1.2	2.5	1.0
maple	1.4	0.7	1.3	0.7

Tree species	% in total increment NFI 07/09	% in total drain t NFI 07/09	% in total increment NFI 00/02	% in total drain NFI 00/12
elm	0.2	0.2	0.2	0.3
chestnut	0.2	0.2	0.2	0.1
robinia	0.3	0.3	0.4	0.3
Sorbus. Prunus	0.3	0.3	0.4	0.2
birch	0.7	0.9	0.7	0.8
alder	1.3	1.3	1.4	1.3
lime tree (Tilia)	0.4	0.2	0.4	0.2
poplar (Populus alba, Populus tremula)	0.5	0.5	0.5	0.4
poplar (Populus nigra. populus canadensis)	0.4	0.8	0.6	0.5
willow (Salix)	0.4	0.4	0.4	0.5
Total decidous	**21**	**16**	**21**	**15**
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 238) 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 238 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 238: 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)

Tree species	Tree parts	Input parameter	Literature
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 239 for total tree biomass/stemwood biomass were derived. The aggregated expansion factors in Table 239 are not used for the estimates but are provided as additional information for transparency reasons and to allow comparisons.

Since the submission 2012 partly new biomass functions were applied. It was realized that the previously used function for the root biomass from WIRTH et al. (2004) leads to unrealistic high root biomasses for dimensions with higher DBH. This had a significant impact on the results for increment biomass, but also on the results for drain biomass. So, a different root function from WIRTH et al. (2004) was selected which includes besides DBH also the tree age as an model input and leads to more realistic estimates for the root biomass. The use of the new functions leads to approximately 12% lower net biomass removals of category *4.A.1* for the whole time series compared to the estimates of submissions before the submission 2012. The changes of the average expansion ratios due to the use of the improved functions is given in Table 239 (old vs. new i.e. „submissions before 2012" vs. „since submission 2012").

Table 239: 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	
	old	new	old	new
increment	1.75	1.62	1.77	1.63
drain	1.62	1.60	1.63	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).

In addition, the area of forests out of yield is reported. This part of the Austrian forests has limited access and there is no management of timber harvesting. We assume that there is no change in the C-stocks of these forests, so they have no impact on the GHG balance of sector LULUCF. The NFI 2007/09 carried out for the first time an assessment of the standing stocks in the non-productive forests. Therefore, with the next NFI and a re-assessment of these stocks an estimate of the biomass stock changes in the non-productive forests will be possible.

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 and 8.4 m^3 ha^{-1} for the inventory period 2007/09. Between the two periods 1986/90 to 1992/96 an increase of 10% of dead wood is estimated.

Based on the new ARD NFI 2011/13 stock changes in dead wood are available at land use change areas from and to forests for the first time (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 accounting, 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 236 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 results of the NFI demonstrate an increase of dead wood in Austria. While not always a major contributor to the total C-balance of sector 4, the associated annual net C-stock changes, which range between 221 kt CO_2 and 844 kt CO_2, are nonetheless significant.

6.2.4.1.3 Litter and soil

The dynamics of soil carbon in Austrian forest ecosystems were estimated with the simulation model Yasso07 (see FINNISH ENVIRONMENT INSTITUTE 2011 for details and references). 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. These data were used to validate the model results.

The aboveground and belowground flux of carbon to the soil and the chemical quality of the carbon input was estimated on 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 accounting all these compartments are not accounted in the estimates of the dead wood stock pool, but only the changes in standing dead wood.

The estimated aboveground and belowground litter input was validated against data from Austrian long-time monitoring sites.

The needed meteorological parameters for the simulation sites (temperature and precipitation for the time series of the used NFIs) were taken from the regionalization of the results of the Austrian Hydrographic Service for the NFI plots. The model was applied for each NFI plot using annual averages of input data of each plot (biomass. temperature and precipitation) for the model simulation. For the Austrian simulation Yasso was run 10 times for each used NFI data set (1986/90, 1992/96, 2000/02 and 2007/09) in order to account for the uncertainty about the parameter values. The simulations were carried out by the Austrian Federal Research Centre for Forests.

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 "FL remaining FL" are reported under the mineral soil C pool changes in the CRFs.

According to the simulations at all NFI plots for the time period between NFI 86/90 and NFI 07/09, the average annual change in the total soil C stock for forest land remaining forest land (in-yield) was a decrease of 0.2 t C per ha per year. The yearly time series of total area of forest land remaining forest land (in-yield) was multiplied by this factor to derive the respective total soil CO_2 removal/emission for the subcategory *4.A.1.* 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 purposed 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 140 t C per ha of productive forest, a given yearly incease in forest road area is associated with a net soil C loss of 110 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.

According to the Yasso model results plus the estimates of the soil C losses due to the increase in forest roads, litter and soil of the subcategory *4.A.1* were an emission source for the whole time series since 1990 with an annual average emission of 2 600 kt CO_2 per year. About 10% of these emissions are caused by the increase in forest roads.

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)*

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 annual area affected by wildfires are available for the years 1990 to 2014 from the statistics of the Forest Ministry (BMLFUW) 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, ranging between 0.031 and 0.77 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 ARD NFI 2011/2013 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, 2013) The data are available for coniferous and deciduous trees (diameter at breast height (dbh) ≥ 5cm) and for two age classes of the ARD lands (long-term ARD areas which had the LUC already in previous NFI periods and short term ARD areas which had the LUC in the most recent period of assessment). 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 240 and Table 241.

Table 240: 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)	
	coniferous	deciduous	coniferous	deciduous
long term AR areas	1.88	2.01	0.35	0.97
short term AR areas	2.83	1.85	0.00	0.00
long term D areas	0.16	0.32	0.24	0.09
short term D areas	0.48	1.13	38.96	48.94

Table 241: 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	0.03	0.11	0.004	0.012
short term AR areas	0.04	0.29	0.006	0.032
long term D areas	0.001	0.060	0.0003	0.007
short term D areas	0.0003	0.116	0.00004	0.013

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 240 and Table 241.

Conversion factors (BF, C)

The detailed biomass assessment at the ARD areas between NFI 2007/09 and ARD NFI 2011/13 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 242: C-conversion factors for forest biomass land use changes areas from and to forest land.

Conversion factors	**increment**		**harvest**	
t dm to t C	**coniferous**	**deciduous**	**coniferous**	**deciduous**
Above ground – stem	0.490	0.483	0.492	0.483
other tree compartments – branches. roots	0.473	0.480	0.473	0.481

Between 1990 and 2014 the average annual net C stock change in living biomass (DBH>0) per ha for areas with LUC to forests amounts to:

$\Delta C_{BM} = 1.203$ t C ha^{-1} a^{-1}

For areas with LUC from forests to other land uses the calculations lead to the following result of average annual C stock change in living biomass (DBH>0cm) per ha and year for the time series 1990 to 2014:

$\Delta C_{BM} = -1.663$ t C ha^{-1} a^{-1}

In the year of LUC from forests to other land uses, the following annual C stock drain in living biomass (DBH>0cm) per ha and year results:

$\Delta C_{BM\ drain} = -45.7$ t C ha^{-1} a^{-1}

An overview of the emissions/removals from land use changes from and to forests is given in Table 230.

6.2.4.2.2 Dead wood

Based on ARD NFI 2011/2013 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 (BFW, 2013). The stock changes are listed in Table 243. As with living biomass, the change in dead wood biomass per ha is given for short- and long term ARD LUC areas and is calculated over the 20 year transition period as described above.

Table 243: Annual stock changes of dead wood at ARD areas based on the ARD NFI 2011/13 (BFW 2013).

	Stock changes – dead wood (t/ha/a)

long term AR areas	0.032
short term AR areas	0.123
long term D areas	0.01
short term D areas	-0.26

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 244). 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 new assessment of the share of sealed area in settlements is provided and how the soil carbon stocks in settlements were updated for submission 2017). 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 244: 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**	**Calcare-ous alps**	**Foot-hills**	**Alpine Ridge**	
		t C ha^{-1} (0–50 cm)					
Forest – lit-ter	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[87] below
	Vineyards	58	58	58	58	58	Gerzabek et al. 2005
	Orchards/gard en land	78	78	78	78	78	Gerzabek et al. 2005
Grassland	grassland in-tensive use	75	95	100	79	94	Umweltbundes-amt– see footnote 87 below
	grassland ex-tensive use	132	130	120	139	139	Umweltbundes-amt– see footnote 87 below
Wetlands	Surface waters and reed beds:	0	0	0	0	0	expert judgement
Settlements	Settlements and traffic area	54	54	54	54	54	Umweltbun-desamt– see foot-note 87 below and chapter 6.6.4.1.2
	Industrial and mining areas. dumps	30	30	30	30	30	Umweltbun-desamt– see foot-note 87 below and chapter 6.6.4.1.2
Other land	Alpine shrub lands	119	119	119	119	119	Körner et al. 1993
	Rocks and sto-ne slopes:	0	0	0	0	0	expert judgement
	Other land u-ses	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 for-

[87] 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 STEIER¬MÄRKISCHEN 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.

ests.The NFIs 2000/02, 2007/09 and the ARD NFI 2011/13 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 244). 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 ARD NFI 2011/13). 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 245, Table 246 and Table 247).

Table 245: 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 246: 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	91	128	117	87	130	56	-	-	68	88
Grassland	-	-	-	-	-	75	128	114	124	128
Wetlands	45	-	54	34	38	-	-	-	-	-
Settlements	39	46	49	30	49	35	54	47	41	48
Other land	-	-	-	-	-	-	53	22	13	41

[1] - no LUC from/to forest could be observed in these regions

Table 247: 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 ARD NFI period 2011/13.

	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	-	76	65	77	-	-	-	70	90
Grassland	75	130	115	88	130	75	117	113	106	132
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	-	38	54	30	54	54	54	54	38	30
Other land	-	35	32	21	81	-	-	79	14	33

[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 244) and mineral soil (see Table 245, Table 246 and Table 247) 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 245 were applied; between 2002 and 2008, Table 246; and from 2009 onwards, Table 247.

Annual carbon stock changes in soils at LUC areas from and to forest land

$$\Delta SOC = A*(SOC_O - SOC_{O-T})/20$$

Δ SOC = 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 246)

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 246).

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 246)

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 since submission 2014. 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 (–62.6 kt C in 2016). To estimate the associated N_2O emissions the tier 2 method as provided in the IPCC 2006 GL is applied:

$N_2O\text{-}N = F_{SOM} * EF_1$ (Eq.11.1)

$N_2O\text{-}N = F_{SOM} * (1\text{-}Frac_{LEACH}) * EF_1$ (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[87]) and multiplied by the default emission factor (EF_1) from Table11.1 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:

$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5$ (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[88] 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 and from 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 lands with LUC to and from forests and with the related uncertainty of this total net change. For this reason the absolute values of the uncertainties of the single LULUCF subcategories cannot be compared with the reported emissions/removals of the individual subcategories, but as an approximation the relative uncertainties of the subcategories can be compared with the related emissions/removals. For the totals of the LULUCF sector the uncertainty is of course consistent with its emissions/removals.

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%).

The forest litter/soil simulations for the single plots show a standard deviation of 0.7 t C ha^{-1} a^{-1}, which is over 3 times the simulated average annual soil C stock change (emission) of 0.2 t C ha^{-1} a^{-1}. Note however, that according to the IPCC the uncertainty is represented by ± 2 standard deviations i.e. 7 times the estimated emission.

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}.

Due to these uncertainty values for the input parameters, the uncertainty of the C stock changes in the litter/soil pool of *4.A.1* is very high. The Monte-Carlo-simulations show that these two pools of *4.A.1* have by far the highest contributions (75% and 70%. respectively) to the total uncertainties of the emissions/removals of the total forest land subcategory and total LULUCF sector. For the LUC lands to and from forests the following uncertainties of the input parameters were used. Table 248 shows the uncertainties for the areas of the subcategories with LUC to and from forests:

[88] It should be noted that the estimated and reported biomass C stock changes for single years have higher uncertainties than the annual average for the NFI period due to the additional methodological approaches and input data to adjust the annual average out of the NFI to specific values for single years. However, these single year values are estimated in a way that its average for a NFI period gives exactly the annual average based on the NFI results. Therefore, we consider this problem to be of minor relevance.

Table 248: 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 249 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 244 (other land) or on expert judgment based on information from related studies.

Table 249: Uncertainties of the litter/soil C stocks in the forest growth regions according to Table 244.

IPCC LU categories	National LU categories	Forest growth regions					Austria
		Bohemian Massif	Inner alps	Calcareous alps	Foothills	Alpine Ridge	
		%					
Forest – litter	Forest	±118	±140	±196	±144	±147	±162
Forest – mineral soil	Forest	±110	±78	±93	±102	±85	±95
Cropland	Annual cropland. fallows	±62	±100	±89	±71	±100	±79
	Vineyards. Orchards/garden land	±49	±127	±100	±65	±127	±79
Grassland	grassland intensive use	±66	±90	±76	±59	±70	±87
	grassland extensive use	±103	±105	±81	±98	±88	
Wetlands	Surface waters and reed beds	Uniform distribution 0–190 t C ha^{-1}					
Settlements	Settlements and traffic area	Triangle distribution 10–60–75 t C ha^{-1}					
	Industrial and mining areas.	Uniform distribution 0–20 t C ha^{-1}					

IPCC LU categories	National LU categories	Forest growth regions					Austria
		Bohe-mian Massif	Inner alps	Calcareous alps	Foot-hills	Alpine Ridge	
		%					
	dumps						
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 Monte-Carlo simulations with all these distributions gave an uncertainty of the total emissions/removals of the complete forest land category of approximately ±18 700 kt CO_2. This represents on average an uncertainty of ±139% between1990 and 2002 with significant annual net sinks in category *4.A.* Uncertanties were much higher (between 215 and 1790%) after 2002 when the net removals/emissions were very low (higher relative uncertainties in the years of lower net removals/emissions). If the significant uncertainty of litter/soil C stock changes of subcategory *4.A.1* (see above) is neglected during the simulations, the total uncertainty of category *4.A* is ¾ lower, on average ±4 764 kt CO_2 with higher absolute uncertainty values in the 90s and lower uncertainty values in the recent years due to more accurate input area data in recent years.

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 QA/QC and Verification

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 chapter6.1.4).

6.2.7 Recalculations

- The wildfire area and emission estimates for the year 2014 required a minor adjustment on basis of the latest available statistics.

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 2016. 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 250.

Table 250: 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
- 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[89] due to LUC from forest land to cropland
- carbon stock change in SOM[90] 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 2016 1.42 million ha were identified as cropland including annual and perennial crops (STATISTIK AUSTRIA 2017a, 2017b). The total cropland area in Austria is decreasing for the whole reported time series.

The total emissions and removals of cropland range between -244 and 175 Gg CO_2, with emissions reported during the 90s, removals since 2001, and low emissions again since 2015 (Table 251). The main reason for the trend up to 2014 is the increase of soil carbon in cropland remaining cropland, due to specific management measures implemented by the Austrian agri-

[89] DOM = Dead Organic Matter

[90] SOM = Soil Organic Matter

environmental program ÖPUL. This program was introduced in 1995, when Austria joined the EU. The emissions during the 90s were mainly caused by the soil C loss caused by conversion from grassland to annual cropland. In this submission new emission factors for biomass of viticulture and orchards from a national survey are used. This leads to significant lower emissions (or increased removals) for the subcategorys 4.B.1.b and c compared to last year's submission (see table Table 252).

In 2016 the land use change area to cropland was 62 304 ha. The annual emissions of land converted to cropland from 1990–2016 range from 167 kt CO_2 to 224 kt CO_2 (Table 252).

Table 251: Total areas and land-use change areas of cropland (1990–2016) 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 perennial	b. perennial cropland converted to annual cropland	c. annual cropland converted to perennial 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	1 464 319	1 441 696	11 141	11 483	36 505	4 125	32 380	31 675	705	NO	NO	NO
1991	1 518 095	1 481 586	1 459 057	11 094	11 435	36 509	4 346	32 163	31 463	700	NO	NO	NO
1992	1 508 493	1 471 966	1 449 538	11 044	11 383	36 527	4 567	31 961	31 265	696	NO	NO	NO
1993	1 491 311	1 454 751	1 432 380	11 016	11 354	36 561	4 787	31 774	31 082	692	NO	NO	NO
1994	1 493 619	1 457 205	1 434 889	10 989	11 326	36 414	4 792	31 622	30 933	688	NO	NO	NO
1995	1 493 201	1 457 026	1 434 763	10 963	11 300	36 175	4 710	31 464	30 780	685	NO	NO	NO
1996	1 501 055	1 465 125	1 442 914	10 938	11 273	35 930	4 628	31 302	30 621	681	NO	NO	NO
1997	1 482 505	1 446 824	1 424 685	10 902	11 237	35 681	4 546	31 135	30 457	678	NO	NO	NO
1998	1 478 519	1 443 033	1 420 982	10 859	11 192	35 486	4 463	31 023	30 348	675	NO	NO	NO
1999	1 475 877	1 440 474	1 418 495	10 823	11 155	35 403	4 483	30 920	30 247	673	NO	NO	NO
2000	1 457 352	1 422 023	1 400 115	10 788	11 119	35 329	4 504	30 825	30 154	671	NO	NO	NO
2001	1 454 132	1 418 856	1 397 039	10 744	11 073	35 276	4 524	30 752	30 083	669	NO	NO	NO
2002	1 451 978	1 416 677	1 394 957	10 696	11 024	35 301	4 612	30 689	30 021	668	NO	NO	NO
2003	1 451 686	1 416 210	1 393 867	11 135	11 207	35 476	4 699	30 777	30 113	663	NO	NO	NO
2004	1 480 198	1 445 316	1 422 968	11 116	11 232	34 882	4 581	30 301	29 651	650	NO	NO	NO
2005	1 482 174	1 447 197	1 425 126	10 950	11 121	34 977	4 463	30 514	29 882	632	NO	NO	NO
2006	1 465 895	1 428 939	1 406 883	11 021	11 034	36 956	4 345	32 612	31 945	667	NO	NO	NO
2007	1 463 670	1 423 358	1 401 164	10 983	11 211	40 312	4 226	36 086	35 361	725	NO	NO	NO
2008	1 448 961	1 405 401	1 383 561	10 692	11 148	43 560	4 108	39 453	38 688	765	NO	NO	NO
2009	1 444 941	1 400 876	1 379 240	10 619	11 016	44 065	3 934	40 131	39 329	801	NO	NO	NO
2010	1 441 589	1 397 222	1 375 861	10 518	10 843	44 366	3 782	40 584	39 701	883	NO	NO	NO

2011	1 439 068	1 394 139	1 373 177	10 301	10 661	44 929	3 630	41 299	40 283	1 016	NO	NO	NO
2012	1 434 654	1 388 257	1 367 825	10 037	10 395	46 398	3 478	42 919	41 789	1 131	NO	NO	NO
2013	1 433 689	1 385 758	1 365 876	9 769	10 114	47 931	3 326	44 604	43 385	1 219	NO	NO	NO
2014	1 431 740	1 381 326	1 361 857	9 551	9 918	50 414	3 174	47 239	45 932	1 308	NO	NO	NO
2015	1 426 725	1 370 340	1 350 978	9 421	9 941	56 385	3 110	53 275	51 658	1 617	NO	NO	NO
2016	1 417 321	1 355 017	1 335 768	9 101	10 148	62 304	3 046	59 258	57 355	1 903	NO	NO	NO

Table 252: Emissions /removals (+/-) from cropland (1990–2016) 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	175.07	-18.47	-18.93	13.16	-12.69	193.54	81.09	112.45	110.78	1.67	15.44	1.58
1991	167.79	-25.92	-26.58	13.08	-12.42	193.72	82.02	111.70	110.03	1.66	15.43	1.57
1992	155.96	-37.95	-38.59	13.03	-12.39	193.91	82.94	110.97	109.31	1.66	15.42	1.57
1993	145.80	-48.39	-48.91	13.00	-12.48	194.19	83.90	110.29	108.64	1.65	15.42	1.57
1994	147.19	-46.41	-46.98	12.97	-12.40	193.60	83.92	109.68	108.02	1.66	15.35	1.57
1995	8.86	-161.18	-161.77	12.93	-12.34	170.04	60.87	109.17	107.53	1.64	15.26	1.56
1996	8.82	-160.30	-160.98	12.90	-12.21	169.12	60.47	108.65	107.02	1.63	15.16	1.55
1997	14.43	-153.75	-154.32	12.86	-12.29	168.18	60.07	108.10	106.49	1.61	15.06	1.54
1998	22.73	-144.52	-145.11	12.81	-12.23	167.26	59.68	107.58	105.95	1.63	14.98	1.53
1999	17.22	-149.77	-150.37	12.77	-12.17	166.99	59.77	107.22	105.60	1.62	14.94	1.52
2000	9.04	-157.71	-158.20	12.74	-12.25	166.75	59.85	106.90	105.28	1.62	14.91	1.52
2001	-61.70	-228.26	-228.76	12.68	-12.17	166.56	59.94	106.62	105.00	1.62	14.88	1.52
2002	-54.95	-232.87	-233.41	12.62	-12.08	177.91	71.54	106.37	104.75	1.62	14.85	1.52
2003	-78.87	-256.46	-261.25	12.20	-7.41	177.60	71.50	106.10	104.56	1.54	14.89	1.52
2004	-91.94	-268.69	-270.55	13.15	-11.29	176.75	70.55	106.20	104.86	1.34	14.61	1.49
2005	-96.96	-271.01	-269.90	13.24	-14.35	174.04	69.60	104.44	103.24	1.20	14.63	1.49
2006	-93.90	-269.17	-268.35	12.84	-13.66	175.26	68.63	106.64	104.27	2.37	15.46	1.58
2007	-214.71	-397.26	-402.66	13.02	-7.62	182.55	67.65	114.90	111.97	2.93	16.88	1.72
2008	-201.02	-394.82	-394.83	13.18	-13.16	193.80	66.68	127.12	124.52	2.60	18.26	1.86
2009	-231.10	-405.28	-403.38	12.61	-14.52	174.18	35.09	139.10	136.51	2.58	18.47	1.89

2010	-236.23	-412.90	-410.01	12.57	-15.46	176.67	34.17	142.50	138.88	3.63	18.59	1.90
2011	-241.11	-419.53	-416.93	12.53	-15.12	178.42	33.25	145.17	140.29	4.87	18.81	1.92
2012	-244.13	-423.63	-419.28	12.30	-16.65	179.50	32.33	147.17	142.51	4.66	19.43	1.98
2013	-224.81	-408.56	-404.01	11.97	-16.52	183.74	31.46	152.28	148.04	4.24	20.08	2.05
2014	-192.50	-381.36	-378.98	11.59	-13.97	188.86	30.60	158.27	153.91	4.36	21.14	2.16
2015	9.27	-193.85	-196.39	11.23	-8.69	203.11	30.12	173.00	163.60	9.39	23.68	2.42
2016	39.11	-184.49	-191.13	11.22	-4.57	223.60	29.64	193.96	184.67	9.29	26.20	2.67

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 1960–2017a, STATISTIK AUSTRIA 2017b). 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 a combination of FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System) data. In the years when the full FFS was conducted (1990, 1995, 1999 and 2010) these data were taken (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013). 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, 2017b), and these data for cropland area were also taken. 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 of farms that receive support under the CAP (which, however, is almost all cropland area in Austria). 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 are included in FSS compared to IACS. For the intermediate years between FSS the annual cropland area has been estimated on the basis of the IACS data which was adjusted by a factor representing the average relative FSS-IACS discrepancy (= FSS/IACS).

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; however, in contrast to the above 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.

Areas for land use change between and within grassland and cropland were estimated on basis of IACS data. IACS is the most important system for the management and control of EU payments from the CAP to farmers established by the Member States. Thus, it provides a unique identification system covering all agricultural areas (Land Parcel Identification System (LPIS)). 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 96% of the total agricultural area according to the FSS (2016: IACS: 2 601 085 ha, FSS (preliminary data): 2 699 000 ha, BMLFUW, 2017). LPIS is a part of IACS and represents GIS-based agricultural administration of the land uses 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 identified at the plot level (graphically and digitally) using farm maps (cartographic documents which comprise an air photograph and the graphical data of the individual parcels).

By means of these data, detailed information on land uses and land use changes of cropland (annual, perennial) and grassland between 2002 and 2016 is provided. Land use change from and to wetland is insufficiently collected in IACS. Land use change from and to settlement and other land is not provided by IACS.

Annual conversions between grassland and cropland, so called "short time oscillating changes", are not taken into account and only a subsample is analysed to derive the permanent conversions representing land use changes. This subsample of IACS data has to comply with the following criteria:

a. continuity of area,
b. constancy of area and
c. initial homogeneity of the land unit: units have to be entirely either grassland or cropland in 2002 (first year of IACS data base). This way, any spatial increase of one land use category could unambiguously be ascribed to a conversion from the other.

Restrictions a–c were retained about one third of the grassland units available in IACS for further analysis (=subsample).

Each unit's composition was calculated for all of the years 2002–2016. A permanent conversion to either grass- or cropland in a unit was assumed, if the category's share in this unit increased at least once and never decreased during 2002–2013.

Further differentiation of LUCs within the cropland area in the two subcategories "annual cropland" and "perennial cropland" were derived from the IACS database. For this submission a new additional criterion of area constancy was introduced for the data extraction. This shall ensure that only "real" land use changes are tracked, as in 2015 many parcel IDs changed due to the separate assessment of landscape elements within IACS (see more details below).

The years before 2002 are not sufficiently reflected in the IACS database to derive LUC between cropland and grassland. In order to receive reliable activity data for the years before 2002 the LUC areas between cropland and grassland for these years were extrapolated based on an average land use change share of the total cropland and grassland area derived from the LUC areas between 2002 and 2005. The LUC activity data of these years are rather stable and it is assumed that LUC before 2002 followed the same trend. This is the reason for the rather stable values between 1990 and 2002 and for higher fluctuations after 2002 which are caused by the area (activity) data for the subcategory for LUCs from grassland to cropland.

In 2016 the annual LUC area from grassland to cropland derived by this method amounts to 4.2 % of the total cropland area across a LUC transition period of 20 years, and the annual land use change for 2016 is 0.5 % of the total cropland area. On the other hand, in 2016 the LUC area from cropland to grassland is 2.2 % of the total grassland area across a LUC transition period of 20 years and the annual land use change for 2016 is 0.4 % of the total grassland area.

The historic total cropland area before 2002 is based on IPCC Approach 1 (Vol 4, Ch.3) and the figures for the years after 2002 and the land use changes between cropland and grassland are based on IPCC Approach 3 (IACS) (IPCC 2006, Vol4, ch.3). In addition, the estimates of land use changes from CL and GL to wetlands and settlement are approximated (because they are not documented) in order to fully account for the year-to-year increases of the total wetland and settlement area (which are documented in real estate database BEV). Consequently, there are some inconsistencies in the initial areas and final areas (estimated with the land-use change areas) of total cropland and grassland in the land transition matrix (CRF table 4.1) from year to year (while the trend over longer time periods (several years) is rather consistent) and inconsistencies regarding the initial areas between CRF tables 4.1 and 4.B and 4.C, respectively. This is because priority was given to consistency within the reported year itself (proper allocation of land use changes between all categories based on Approach 3 data from IACS) rather than consistency of these area datasets between the single years. This has no consequences on the emission/removal estimates of the cropland and grassland subcategory because they are estimated on the basis of areas of subcategories of land-use (change) and management which result from Approach 3 assessments.

In 2015 a new ÖPUL funding period started and digitalized information on landscape elements was collected separately for the first time in the IACS database. For this reason some parcel-ID-numbers (unique Identification numbers for each parcel) were automatically changed in the IACS database. IDs of cropland and also grassland areas were assigned to such new landscape elements and the previous areas received new IDs. This resulted in artificial "land use change" categorisations without any change in the land-scape. Therefore, for the selection of the IACS data a second criterion, namely area consistency over time, was introduced to ensure that only "real" land use changes were considered in the area statistics. The LUC shares of the analysed sample were extrapolated to the total cropland or grassland to estimate the total LUCs between cropland and grassland.

The areas of the LUC subcategory FL to CL are measured by the NFIs and by the ARD assessment.

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:

1) Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas.
2) Settlement areas and soils – once converted – cannot usually be used for cropland cultivation.
3) 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.
4) Other lands are located in high altitude or very steep areas and therefore have unfavorable ecological conditions for cropland use.

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 6.3.4.1.2 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).

For the current submission the above- and belowground biomass stock and stock changes of orchards and vineyards were for the first time 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 soil carbon stock changes (CSC) in annual cropland remaining annual cropland and perennial cropland remaining perennial cropland was further improved for the 2018 submission. The refinement is based on revisiting 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 refinement assignes 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, with/without manure input and low/high crop residues input). These improvements led to lower C stock changes in the mineral soil of cropland remaining compared to the last submission.

The total annual removals of *4.B.1* range between 423.6 kt CO_2 and 18.5 kt CO_2 (see Table 252).

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 and yearly agricultural statistics (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014, 2017b and STATISTIK AUSTRIA, 1960–2017a). 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.

Table 253: Estimated total area of perennial crops from 1990–2016 in ha (including areas of LUC to perennial cropland).

	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	48 846	18 075	5 924	1 711	1 846	76 402
2005	50 119	17 882	5 191	1 700	2 048	76 940
2006	49 981	17 171	4 818	1 518	2 449	75 935
2007	49 842	16 459	4 444	1 335	2 849	74 929
2008	47 688	16 530	3 821	1 667	2 567	72 272
2009	45 533	16 600	3 199	1 998	2 284	69 615
2010	45 480	16 671	2 576	2 330	2 002	69 059
2011	45 427	16 928	2 393	2 299	2 204	69 250
2012	45 373	17 185	2 209	2 267	2 406	69 441
2013	45 320	17 442	2 026	2 236	2 608	69 632
2014	45 799	17 502	1 971	2 236	2 553	70 062
2015	46 278	17 563	1 917	2 236	2 498	70 491
2016	46 757	17 623	1 862	2 236	2 443	70 921

Figure 34 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 dyanmics 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.

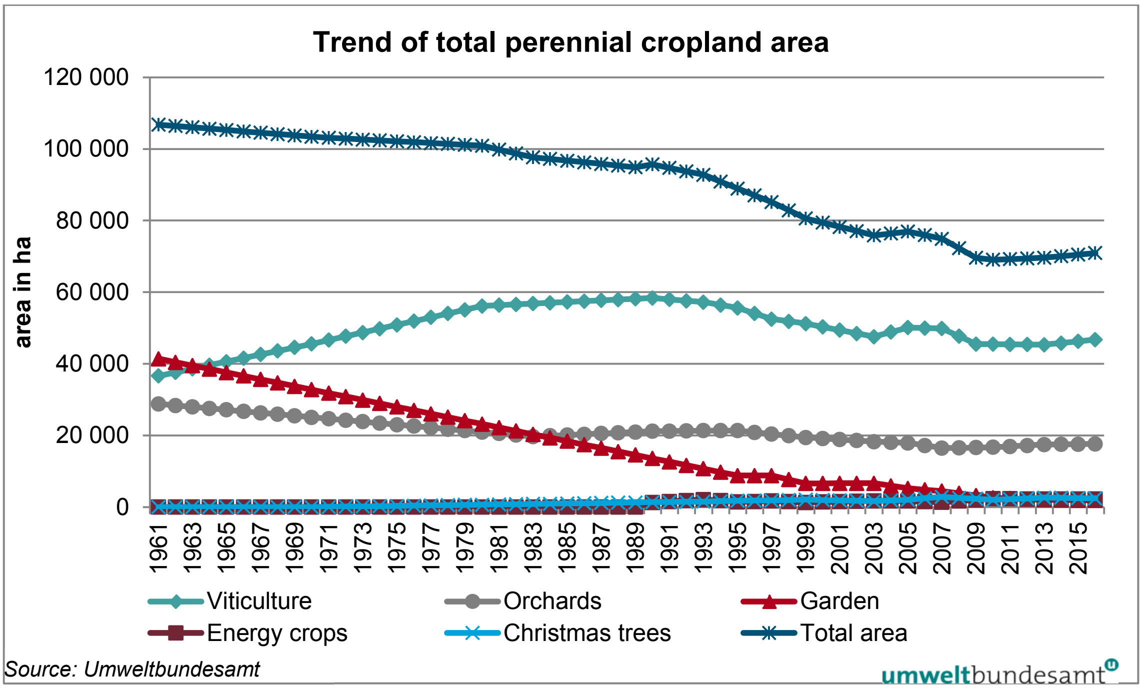

Figure 34: Trend of total perennial cropland area (ha) from 1960–2016 (including LUC areas to perennial cropland).

In 2016 and 2017, a survey to estimate the national 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 weighed 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 rotation period, annual biomass growth rates and the the average rotation periods for these perennial cultures were derived (Table 254). 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 carbon accumulation rate of perennial crops of 0.27 t C $ha^{-1}a^{-1}$.

Christmas trees and 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 energy crops a country specific steady state of biomass increase over 10 years and 6 years of rotation period, respectively, was assumed. The energy 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 crops cause gross emissions parallel to the removals in the growing biomass.

For christmas trees and energy 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 AR-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 254: 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 belowground biomass carbon stock (t C ha^{-1} a^{-1})	Rotation period (years)	Method
Vineyards	3.37	0.096	35	country specific values
Orchards	13.71	0.745	18	country specific values
House gardens	13.71	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 was 10 148 ha in 2016.

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". 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). This approach 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.

For the calculation of the annual change in carbon stocks in living biomass of land converted to 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. Root/shoot ratios 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 cropland was multiplied with the root/shoot ratio to provide an estimate of the below-ground biomass. The means of the annual aboveground and below ground biomass of the crops (resulting from data for a time-period of 10 years) were calculated and weighted by the related area of these crops in Austria to get the average annual cropland biomass.

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 was 9 101 ha in 2016.

The rationale for these estimates and the used methods are described in chapter 6.3.4.1.2. 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 6.3.4.1.2 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 6.3.4.1.2; 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 and their allocations to different management types (management factors) like tillage types and input types were revisited and revised for the 2018 submission:

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 255: shows the revised national factors used for this submission compared to the IPCC default values (for cool, temperate, moist regime).

Table 255: 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 was further adjusted.

As a starting point (equal to previous submissions), the annual cropland area per year was splitted into four Agri-Environmental-Climate-Measures (AECM) according to the Austrian ÖPUL program for subsidy payments in the agriculture. ÖPUL started in 1995 but these single management types 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, EBM)
- 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 35) and were taken from the agricultural statistics (which are based on IACS since 2002).

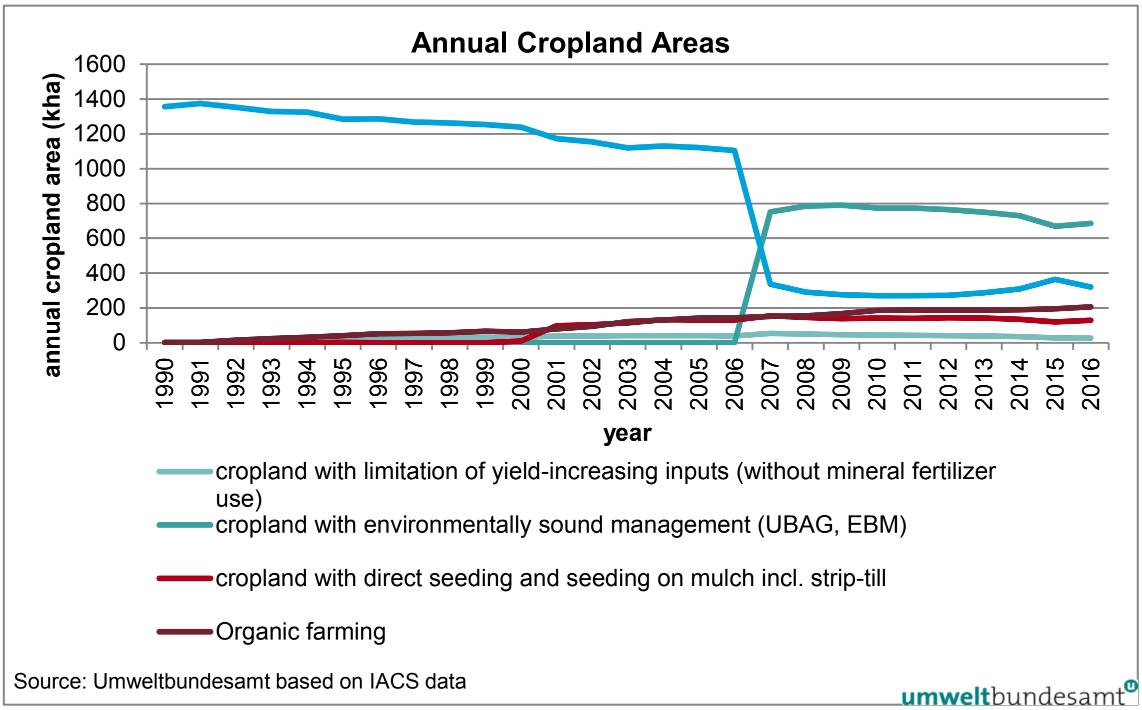

Figure 35:Trend of annual cropland areas in Austria with Agri-Environmental-Climate-Measures (kha).

Each of the annual areas of these five management types 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 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 measures of the AECM (Agri-Environmental Climate Measure, ÖPUL, BMLFUW 2016) of the Rural Development Programme: "Cover crops at arable land – intermediate crops (cover crops between two main crops)" and " Cover crops at arable land – Evergreen system".
   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).

An IACS analysis on basis of 2016 data was carried out to assess the area shares of the combinations of these input types in the cropland areas of each of the five management types as listed above.

The possible combinations and related soil C stock change factors are shown in Table 256.

Table 256: 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

Tillage	Cover crops	Manure	Crop resi-dues	F_{LU}	F_{MG}	F_I	Average equi-librium cropland soil C stock in 1990 (from soil inventories) (t C ha^{-1} for 0 - 30 cm)	Estimated ref-erence 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	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
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

Tillage	Cover crops	Manure	Crop resi-dues	F_{LU}	F_{MG}	F_I	Average equi-librium cropland soil C stock in 1990 (from soil inventories) (t C ha^{-1} for 0 - 30 cm)	Estimated ref-erence 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})
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 2016 data, this splitting of cropland area within the individual five management types was carried out and the relative share of areas with different input combinations and related management factors was assumed to be constant and was applied regressively backwards until 1990 related to the area trend of the five management types. For the next submission further IACS analyses for other years are planned to increase the robustness of the results.

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 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 255) 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 tillaged (F_{MG} = 1.0, see Table 255).

For the areas with the soil erosion measure a management factor for input F_I of 1.05 is applied, which is the Austrian value for high input – without manure, see Table 255. 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 the agricultural statistics.

Table 257: 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: 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 scheme – ÖPUL (relevant ÖPUL measures are cover crops, input reduction, organic farming, tillage reduction). The agri environment 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 as part of the second pillar of the CAP (Common Agricultural Policy) 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 to 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 36) indicates also a significant decrease in the annual mineral soil C stock changes in 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 expiremental 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.

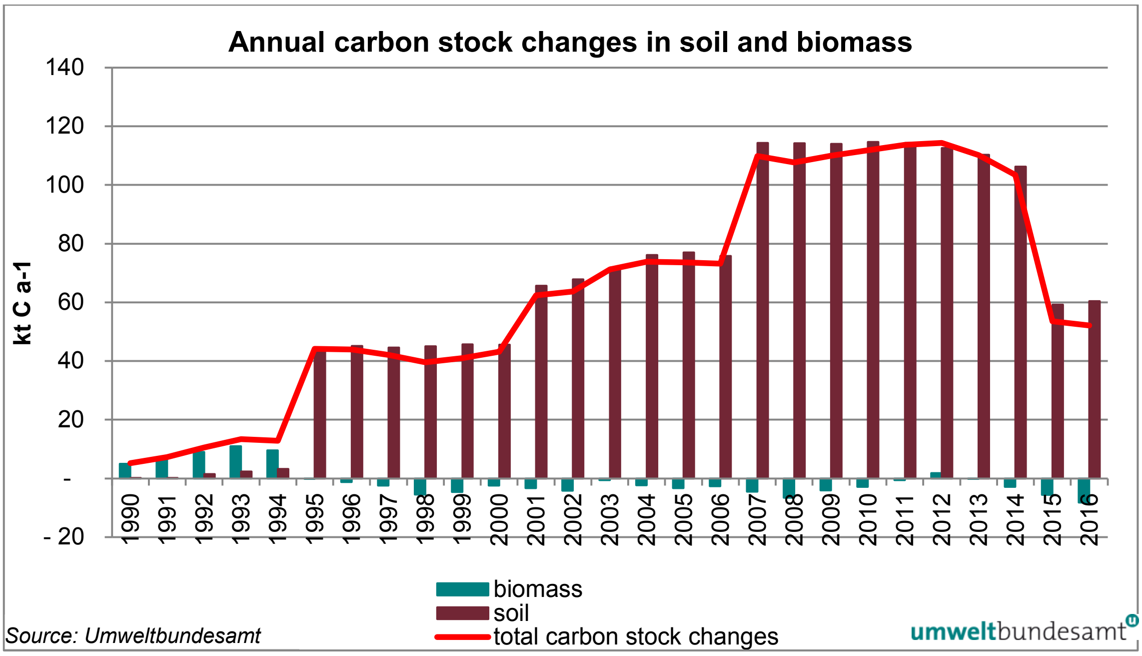

Figure 36: Annual carbon stock changes in soil and biomass of the subcategory annual cropland remaining annual cropland and perennial cropland remaining perennial cropland (kt C).

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 11 483 ha to 10 148 ha from 1990 to 2016.

The rationale for estimating the soil C stock changes of this conversion has been given in chapter 6.3.4.1.5.

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*

$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 0.35 \text{ t C ha}^{-1} \text{ a}^{-1}$

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-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 11 141 ha to 9 101 ha from 1990 to 2016.

The rationale for estimating the soil C stock changes of this LUC has been given in chapter 6.3.4.1.6

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:

$\Delta SOC_{20} = (SOC_0 - SOC_{0-T})/20 =- 0.35 \text{ t C ha}^{-1} \text{ a}^{-1}$

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 are reported in sector *3.F* agriculture.

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) ranges from 4 125 ha to 3 046 ha between 1990 and 2016 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 29.6 kt CO_2 to 83.9 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. 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 252). 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:

$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5$ (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 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

The LUCs between CL and GL of the most recent years were updated on basis of an assessment of the most recent statistics.

The average annual land use change area from grassland to annual cropland from 1990–2016 is 2 511 ha. The area in conversion status for a time period of 20 years ranges from 29 651 ha to 57 355 ha for the period 1990 to 2016, leading to annual emissions between 109 and 210 kt CO_2.

The average annual land use change area from grassland to perennial cropland from 1990–2016 is 847 ha. 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. For instance, in the years 2006 to 2008 higher conversion rates from grassland to CL could be observed. This is likely caused by the changed framework conditions due to EU regulations concerning the protection of grasslands which restricts conversions between grassland and cropland. This grassland protection regulatory framework came into force in 2002 – therefore, it is assumed that farmers converted more grassland into cropland in the years before 2002 to circumvent the loss of such management freedom for some of their lands.

Activity data of grassland converted to cropland in the 20 year conversion status are reported in Table 251. Emissions were estimated applying a country specific methodology (Tier 2) for biomass carbon stocks and for soil carbon stocks.

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).

$$\text{Annual change in biomass} = \text{annual area of currently converted land} * (L_{conversion} + \Delta C_{growth})$$

$L_{conversion} = C_{after} - C_{before}$

ΔC_{growth}= country specific value for annual carbon accumulation rate in annual crops is 6.67 t C $ha^{-1}a^{-1}$(see Chapter 6.3.4.1.2. 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:

*Annual change in biomass = conversion area for a transition period of 20 years * ΔC_{growth} + annual area of currently converted land * $L_{conversion}$*

$L_{conversion} = C_{after} – C_{before}$

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.

$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -1.0$ t C ha^{-1} a^{-1}

*annual change in carbon stock of mineral soils converted from grassland to cropland = ΔSOC * 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-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 (land in the 20 year transition period) from grassland to perennial cropland ranges from 623 ha to 1 903 ha for the period 1990–2016 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.

$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -0.65$ 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*

Δ SOC = 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-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 resulting from Grassland converted to Cropland on mineral soils (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[87]) 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 2015) 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 258: 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 248	see Chapter 6.2.5. Table 248

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 259: 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%
Perennial CL biomass (except perennial crops below)	±75%	±75%
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 249	
N_2O emission factor for soil at LUC to CL		±150%
C/N ratio grassland soils	±55%	
C/N ratio forest soils	±58%	

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
- Perennial CL biomass (except perennial crops below): 2006 IPCC GL
- 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 the study that was used (UMWELTBUNDESAMT 2010b)
- N_2O emission factor for soil at LUC to CL: WINIWARTER 2007

- C/N ratio grassland soils: assessment on basis of the soil inventory results
- C/N ratio forest soils: assessment on basis of the soil inventory results

On basis of these input uncertainties the Monte Carlo simulations led to the following range of uncertainties of the total emissions/removals of the cropland category in the single years of the time series: ±810 to ±1 106 kt CO_2[91]. This reflects the fact that the activity data of previous years have a higher uncertainty (see Table 248). The relative uncertainties in the single years are in the range from ±481 to ±3 939% depending on the net emissions or removals of the sector – net emissions and removals close to 0 lead logically to higher relative uncertainties.

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.

Several emission factors and approaches were changed in the last submission. Consequently, the related uncertainties need to be updated. Until the next submission the uncertainty analysis of the cropland category will be adjusted accordingly.

6.3.6 QA/QC and Verification

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 estimate of the (shares of) conversions between annual cropland, perennial cropland and grassland on basis of the IACS system was slightly changed. The estimate is now based entirely on a subset of land parcels in IACS which show constant areas and codes throughout the time series. This led to changes of the conversion areas between annual, perennial cropland and grassland and consequently to changes in the related emissions and removals from biomass and soil.
- The measurements of country specific orchard biomass and vineyard biomass were completed and the significantly too high default values of perennial biomass growth rates, stocks and turn-over periods were replaced by these country specific values. Consequently, the emissions and removals by perennial biomass in cropland changed.
- The assessment of the soil C stock changes in cropland remaining cropland was further improved. The results of the C stock change rates for the agricultural experimental plots and their allocations to different management types (management factors) like tillage types and input types were revisited and revised. The methodological regime for separating the cropland into the different tillage and input types was further adjusted, e.g. by separating

[91] It should be noted that due to the design of the NFI changes in forest biomass stock also include the biomass changes due to LUC to and from forests. As a consequence, the estimates of the overall uncertainty of biomass changes at all forest lands and lands with LUC to and from forests were carried out in the FL sector. For this reason the absolute values of the uncertainties of the single LULUCF subcategories cannot be compared with the reported emissions/removals of the individual subcategories, but as an approximation the relative uncertainties of the subcategories can be compared with the related emissions/removals. For the totals of the LULUCF sector the uncertainty is of course consistent with its emissions/removals.

into combinations of three tillage types and variations of the input types and input combinations of low/high plant residues input, with/without manure input and with/without input from cover crops. These improvements led to lower C stock changes in the mineral soil of cropland compared to the last submission.

- The 2014 and 2015 values of the cropland areas had to be updated according to the most recent agricultural statistics.

All the recalculations in the cropland category led to changes in the time series of annual emissions/removals of this subcategory in the range of −61 to 59 kt CO_2e per year.

6.3.8 Planned improvements

The estimates of carbon stocks in mineral soils of "annual cropland remaining annual cropland" are based on shares of management types from IACS data for the year 2016. For the next submission further years will be analysed with IACS to improve the robustness of the time series.

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 2016 1.45 million ha of Austria were grassland (STATISTIK AUSTRIA 2017). Since 1990 the area of grassland has genrally 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 grassland management was stopped and fallow grassland (grassland in good agricultural and ecological condition no longer used for production; formely called "GLÖZ").

The annual emissions from the grassland category in Austria amounted to 626 kt CO_2 in 1990 and 333 kt CO_2 in 2016. The main driver of the emissions is the LUC from forest land to grassland.

Since 2007 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 at grassland.

Table 260: 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

Table 261: Total areas and land-use change areas of grassland 1990–2016 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	1 714 917	1 669 743	45 173	32 467	12 706	12 621	85	NO	NO	NO
1991	1 708 562	1 661 670	46 892	34 203	12 689	12 604	85	NO	NO	NO
1992	1 702 207	1 653 625	48 582	35 939	12 643	12 558	85	NO	NO	NO
1993	1 710 340	1 660 072	50 268	37 675	12 593	12 509	84	NO	NO	NO
1994	1 689 668	1 639 383	50 285	37 716	12 569	12 484	84	NO	NO	NO
1995	1 668 997	1 619 383	49 614	37 069	12 545	12 461	84	NO	NO	NO
1996	1 648 636	1 599 692	48 944	36 421	12 523	12 439	84	NO	NO	NO
1997	1 671 366	1 623 092	48 274	35 773	12 501	12 417	84	NO	NO	NO
1998	1 661 034	1 613 442	47 593	35 125	12 467	12 384	84	NO	NO	NO
1999	1 650 702	1 602 994	47 708	35 284	12 424	12 341	83	NO	NO	NO
2000	1 652 301	1 604 468	47 833	35 442	12 390	12 307	83	NO	NO	NO
2001	1 653 900	1 605 942	47 958	35 601	12 357	12 274	83	NO	NO	NO
2002	1 655 499	1 606 566	48 932	36 621	12 312	12 229	83	NO	NO	NO
2003	1 657 097	1 607 359	49 738	37 640	12 098	12 009	89	NO	NO	NO
2004	1 628 997	1 580 044	48 953	37 037	11 916	11 827	89	NO	NO	NO
2005	1 608 648	1 559 981	48 667	36 433	12 233	12 136	98	NO	NO	NO
2006	1 581 383	1 533 036	48 347	35 830	12 517	12 409	107	NO	NO	NO
2007	1 554 118	1 504 969	49 149	35 227	13 922	13 803	119	NO	NO	NO
2008	1 539 169	1 486 498	52 670	34 623	18 047	17 919	129	NO	NO	NO
2009	1 524 220	1 471 711	52 509	33 477	19 032	18 900	132	NO	NO	NO
2010	1 509 271	1 456 922	52 349	32 502	19 847	19 712	135	NO	NO	NO
2011	1 493 892	1 441 725	52 167	31 527	20 640	20 481	159	NO	NO	NO
2012	1 478 512	1 426 897	51 615	30 553	21 063	20 899	164	NO	NO	NO
2013	1 463 133	1 412 119	51 014	29 578	21 437	21 259	177	NO	NO	NO
2014	1 458 648	1 407 850	50 798	28 603	22 195	22 009	186	NO	NO	NO
2015	1 454 163	1 398 653	55 510	28 318	27 192	26 965	227	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
2016	1 449 678	1 389 475	60 203	28 032	32 170	31 932	238	NO	NO	NO

Table 262: Emissions/removals (+/-) from grassland in kt CO_2 and CH_4 in CO_2eq (1990–2016).

	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	626.26	294.26	332.00	376.24	-44.25	-44.05	-0.20	NO	NO	NO	23.79
1991	621.02	294.31	326.72	370.95	-44.23	-44.03	-0.20	NO	NO	NO	23.79
1992	615.92	294.36	321.57	365.61	-44.04	-43.84	-0.20	NO	NO	NO	23.79
1993	610.96	294.32	316.64	360.51	-43.87	-43.67	-0.20	NO	NO	NO	23.79
1994	611.00	294.44	316.56	360.36	-43.80	-43.61	-0.20	NO	NO	NO	23.79
1995	443.93	294.56	149.37	193.08	-43.71	-43.52	-0.19	NO	NO	NO	23.79
1996	445.70	294.68	151.02	194.65	-43.63	-43.44	-0.19	NO	NO	NO	23.79
1997	447.23	294.54	152.69	196.23	-43.54	-43.34	-0.19	NO	NO	NO	23.79
1998	448.97	294.59	154.38	197.82	-43.44	-43.25	-0.19	NO	NO	NO	23.79
1999	448.73	294.66	154.07	197.36	-43.29	-43.10	-0.19	NO	NO	NO	23.79
2000	448.38	294.65	153.74	196.90	-43.17	-42.97	-0.19	NO	NO	NO	23.79
2001	448.01	294.64	153.37	196.45	-43.07	-42.88	-0.19	NO	NO	NO	23.79
2002	655.80	294.64	361.16	404.07	-42.91	-42.72	-0.19	NO	NO	NO	23.79
2003	651.91	294.63	357.28	400.01	-42.72	-42.53	-0.20	NO	NO	NO	23.79
2004	653.39	294.79	358.60	400.63	-42.03	-41.82	-0.21	NO	NO	NO	23.79
2005	654.75	294.91	359.84	401.24	-41.40	-41.19	-0.21	NO	NO	NO	23.79
2006	654.04	295.07	358.97	401.52	-42.55	-42.31	-0.24	NO	NO	NO	23.79
2007	653.33	295.24	358.09	401.79	-43.69	-43.43	-0.26	NO	NO	NO	23.79
2008	648.34	295.35	352.99	402.06	-49.07	-48.78	-0.29	NO	NO	NO	23.79
2009	354.40	295.44	58.96	122.83	-63.87	-63.56	-0.30	NO	NO	NO	23.79
2010	352.92	295.52	57.39	124.85	-67.46	-67.14	-0.31	NO	NO	NO	23.79
2011	351.97	295.61	56.36	126.86	-70.51	-70.17	-0.34	NO	NO	NO	23.79
2012	351.28	295.70	55.58	128.88	-73.31	-72.93	-0.38	NO	NO	NO	23.79

	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
2013	352.29	295.79	56.49	131.36	-74.87	-74.47	-0.40	NO	NO	NO	23.79
2014	353.38	295.82	57.57	133.84	-76.27	-75.85	-0.42	NO	NO	NO	23.79
2015	350.75	295.87	54.88	134.33	-79.45	-78.97	-0.48	NO	NO	NO	23.79
2016	333.06	295.92	37.13	134.82	-97.69	-97.14	-0.55	NO	NO	NO	23.79

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 minus land converted to grassland. The areas were estimated from national statistics of land use (STATISTIK AUSTRIA 1960–2016). The grassland data are collected in the Austrian Farm Structure Surveys 1993, 1995 (full survey), 1997, 1999 (full survey), 2003, 2005, 2007, 2010 (full survey) and 2016 (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2017a). 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. For the years between the full and random sample surveys the data have been interpolated. The data of the random sample farm structure survey 2016 (Statistik Austria 2017a) are considered in this submission.

In the 2015 submission an improvement of areas of alpine pastures was carried out, which led to reduced areas of alpine pastures compared to previous surveys. Figure 37 shows clearly the shift of unproductive rough grazing areas to "other land" which is caused by a different allocation of certain lands instead of a real land-use change. A detailed description of the recalculation of the alpine grassland area is included in 2015 submission (UMWELTBUNDESAMT 2015). This methodology was also used in the current submission.

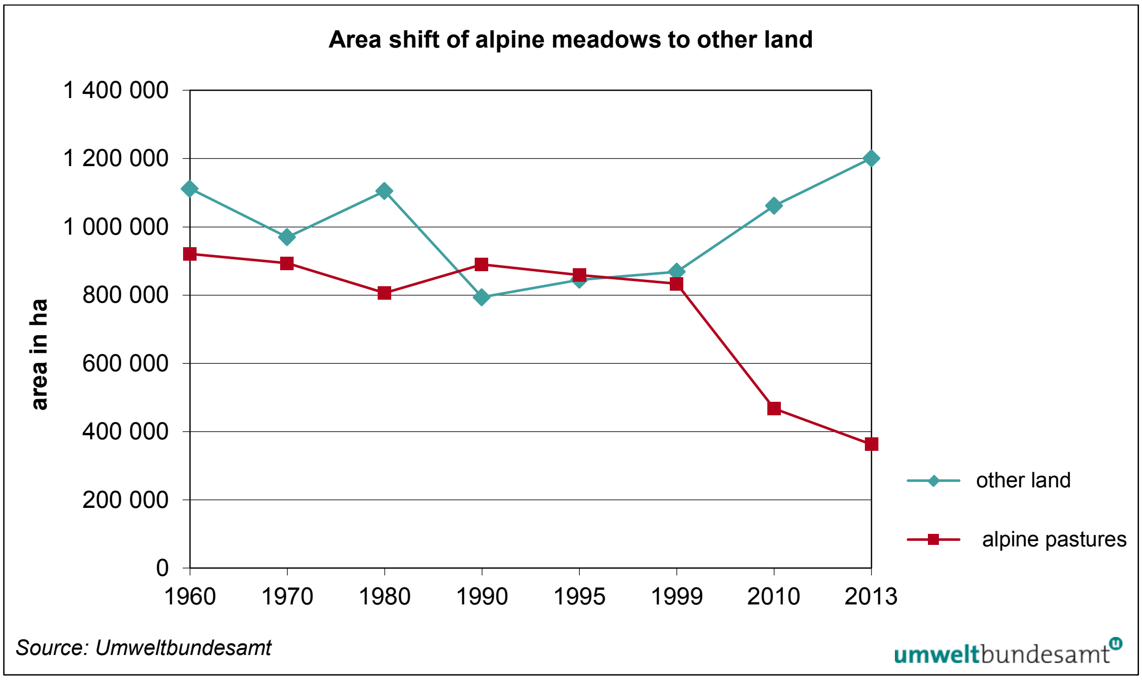

Figure 37: Area shift of alpine meadows to other land (ha) according to the reclassification of alpine meadows

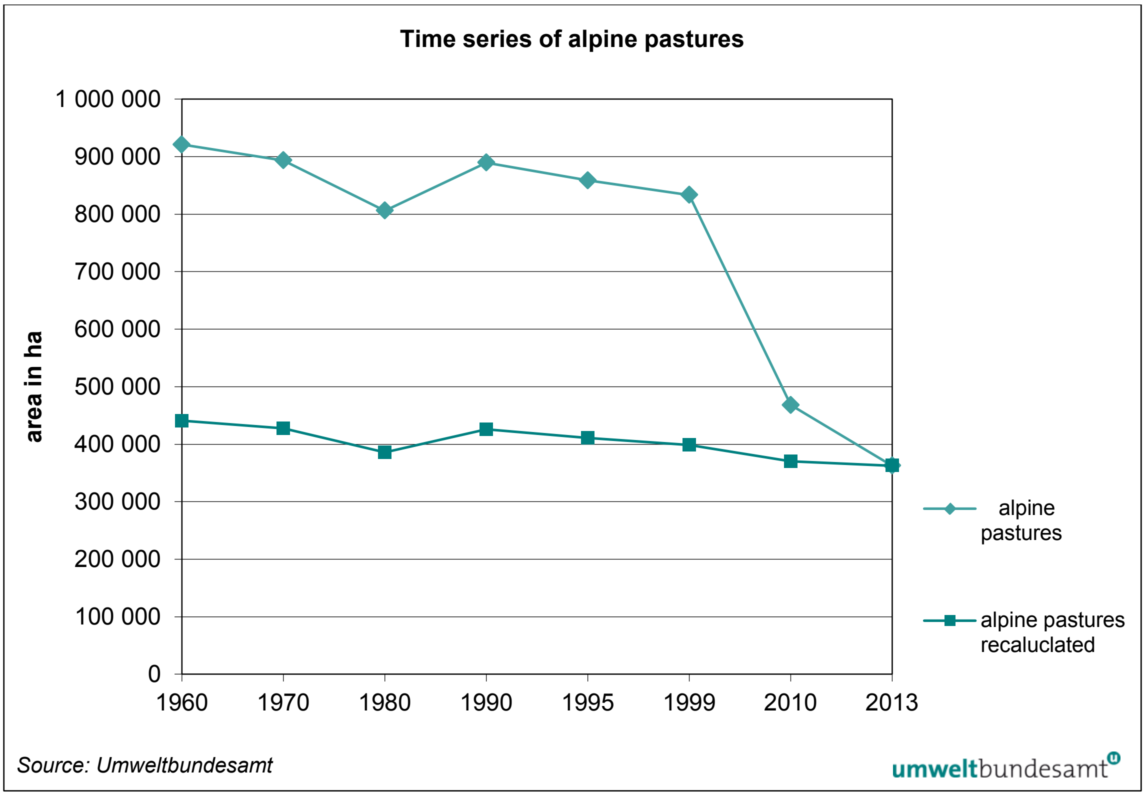

Figure 38: Time series of alpine pastures according to submission 2014 and recalculated alpine pastures according to submission 2015 (ha).

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 an update of these LUC areas for the last years on the basis of the most recent statistics (for a detailed description see Chapter 6.3.2).

In 2016 the LUC area from cropland to grassland constitutes 2.2 % of the total grassland area (across a LUC transition period of 20 years) and the annual value for 2016 is 0.4% of the total grassland area .

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:

1) Drainage of wetlands for the purpose of grassland use was carried out at some minor areas in Austria in former decades. For reasons of nature conservation this management practise stopped many years ago.
2) Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas.
3) Settlement areas and soils – once converted – cannot be used for grassland.
4) 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.
5) „Other lands" are found at the highest elevations or steepest areas of Austria. The subsequent unfavorable ecological conditions do not allow any agricultural use.

As mentioned in chapter 6.3.2 one can observe inconsistencies when comparing initial and final areas in the land transition matrix (CRF Table 4.1.) from one to another year for the total grassland area. The total grassland area is based on Approach 1 and the land use changes between cropland and grassland are based on Approach 3 (IACS). In addition, the estimates of land use changes from CL and GL to wetlands and settlement are approximated (because they are not documented) in order to fully account for the year-to-year increases of the total wetland and settlement area (which are documented in the real estate database BEV). Consequently, there are some inconsistencies in the initial areas and final areas (estimated with the land-use change areas) of total cropland and grassland in the land transition matrix (CRF table 4.1) from year to year (while the several years' trend is rather consistent) and inconsistencies regarding the initial areas between CRF tables 4.1 and 4.B and 4.C, respectively. This is because priority was given to consistency within the reported year itself (proper allocation of land use changes between all categories based on Approach 3 data from IACS) rather than consistency of these area datasets between the single years. This has no consequences on the emission/removal estimates of the cropland and grassland subcategory because they are estimated on the basis of areas of subcategories of land-use (change) and management which result from Approach 3 assessments.

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,
- 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 2016 was 1.39 million ha.

The annual emissions from grassland remaining grassland between 1990 and 2016 vary only slightly from 294.3 kt CO_2 to 295.9 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 nation-wide 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 biological agriculture) 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 1990–2016 were calculated then on basis of this annual soil C stock increase.

Annual change in carbon stock of mineral soils in grassland remaining grassland = ΔSOC_{201} ** area of grassland remaining grassland*

$\Delta SOC_{20} = (SOC_{1990+20} – SOC_{1990})/20 = 0.00162t\ C\ ha^{-1}\ a^{-1}$

The approach of the IPCC 2006 Guidelines was used to divide $(SOC_{1990+20} - SOC_{1990})$ by 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**). The carbon 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 updated in this submission and 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 for the first time 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 this 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 37 716 ha to 28 032 ha between the years 1990 and 2016. 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 122.8 kt CO_2 and 404.1 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 262). 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 1990–2016 is 1 341 ha. The average annual land use change area (1990–2016) from perennial cropland to grassland is 10 ha. The total area in conversion status for a time period of 20 years amounts to 12 706 ha in 1990 and 32 170ha in 2016. Considering the area of the 20 years transition period this leads to annual removals from 44.3 kt CO_2 in 1990 and 97.7 kt CO_2 in 2016.

The use of the IACS system for the assessment of the LUCs of other agricultural land uses to GL (see chapter 6.4.2) allows more accurate annual assessments of the activities since 2002. This leads to higher annual variations in this period than before 2002. Since the peak in 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 6.3.4.1.2).

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 263: 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 * (*$L_{conversion} + \Delta C_{growth}$*)*

$L_{conversion} = C_{after} - C_{before}$

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 6.3.4.1.2; 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 2016 is 15 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 12 621 ha and 31 932 ha in the years 1990 and 2016, 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", 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).

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 85 ha and 238 ha in the years 1990 and 2016:

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).

Δ 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 264: 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 248	see Chapter 6.2.5 Table 248
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 emissions from organic soils were revised for this submission and led to significantly higher emissions in the grassland category. The related uncertainties of the organic soils will be updated in the next submission.

The Monte Carlo simulations resulted in the following range of uncertainties for the total emissions/removals of the grassland category in the single years of the time series: ±519 to ±831 kt CO_2 with higher uncertainties in the 90s[92]. This difference is caused by the activity data of previous years which have a higher uncertainty (see Table 264). The relative uncertainties in the single years range from ±80 to ±161%. Very high relative uncertainties occur in the most recent years when the net emissions/removals were clearly lower than in the previous years.

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 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.

6.4.6 QA/QC and Verification

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 estimate of the (shares of) land-use changes between annual cropland, perennial cropland and grassland on basis of the IACS system was slightly changed. The estimate is now based entirely on a subset of land parcels in IACS which show constant areas and codes throughout the time series. This led to changes of the LUC areas between annual, perennial cropland and grassland and consequently to changes in the related emissions and removals from biomass and soil in the subcategory LUC from cropland to grassland.

The measurements of country specific orchard biomass and vineyard bio-mass were completed and the significantly too high default values of perennial biomass growth rates, stocks and turnover periods were replaced by these country specific values. Consequently, the emissions by perennial biomass in the LUC subcategory perennial cropland to grassland changed.

The 2014 and 2015 values of the grassland areas had to be updated according to the most recent agricultural statistics.

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[92] It should be noted that due to the design of the NFI changes in forest biomass stock also include the biomass changes due to LUC to and from forests. As a consequence, the estimates of the overall uncertainty of biomass changes at all forest lands and lands with LUC to and from forests were carried out in the FL sector. For this reason the absolute values of the uncertainties of the single LULUCF subcategories cannot be compared with the reported emissions/removals of the individual subcategories, however, an approximation of the relative uncertainties of the subcategories can be compared with the related emissions/removals. For the totals of the LULUCF sector the uncertainty is of course consistent with its emissions/removals.

All the recalculations in the grassland category reduced the annual emissions of this subcategory by 23 to −1 kt CO_2e per year.

6.4.8 Planned improvements

For soil organic carbon in grassland estimates in a refined time resolution will be prepared (similar to the improvement carried out for the cropland category for this submission).

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 to 151 849 ha in the years 1990–2016. Along the time series a steady increase in wetland could be observed with slightly higher increases in the last few years.

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 in the last years have driven the slightly higher emissions of this subcategory.

Table 265 und Table 266 show the land use change and removals/emissions from LUC to wetlands from 1990–2016.

Table 265: Total areas and land-use change areas of wetland 1990–2016 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

	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
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	121 561	22 704	1 752	NO	20 952	NO	NO
2010	145 084	122 211	22 872	1 884	NO	20 988	NO	NO
2011	146 123	122 861	23 262	2 016	NO	21 246	NO	NO
2012	146 989	123 512	23 477	2 148	NO	21 329	NO	NO
2013	149 360	124 162	25 198	2 279	NO	22 918	NO	NO
2014	150 292	124 813	25 479	2 411	NO	23 068	NO	NO
2015	150 626	125 280	25 346	2 579	NO	22 767	NO	NO
2016	151 849	126 011	25 838	2 747	NO	23 091	NO	NO

Table 266: Emissions/removals (+/-) of wetland 1990–2016 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	42.08	NO	42.08	23.12	NO	18.97	NO	NO
1991	42.03	NO	42.03	23.06	NO	18.97	NO	NO
1992	41.97	NO	41.97	23.01	NO	18.97	NO	NO
1993	41.93	NO	41.93	22.97	NO	18.97	NO	NO
1994	41.93	NO	41.93	22.97	NO	18.97	NO	NO
1995	30.31	NO	30.31	14.41	NO	15.90	NO	NO
1996	35.81	NO	35.81	14.41	NO	21.40	NO	NO
1997	35.81	NO	35.81	14.41	NO	21.40	NO	NO
1998	35.81	NO	35.81	14.41	NO	21.40	NO	NO
1999	35.80	NO	35.80	14.40	NO	21.40	NO	NO
2000	35.80	NO	35.80	14.40	NO	21.40	NO	NO
2001	35.80	NO	35.80	14.40	NO	21.40	NO	NO
2002	47.28	NO	47.28	19.62	NO	27.66	NO	NO
2003	47.27	NO	47.27	19.62	NO	27.66	NO	NO
2004	47.30	NO	47.30	19.65	NO	27.66	NO	NO
2005	47.33	NO	47.33	19.68	NO	27.66	NO	NO
2006	37.20	NO	37.20	19.70	NO	17.50	NO	NO
2007	39.34	NO	39.34	19.72	NO	19.62	NO	NO
2008	51.32	NO	51.32	19.75	NO	31.58	NO	NO
2009	68.13	NO	68.13	49.05	NO	19.08	NO	NO
2010	68.79	NO	68.79	49.06	NO	19.73	NO	NO
2011	73.41	NO	73.41	49.07	NO	24.34	NO	NO
2012	69.78	NO	69.78	49.07	NO	20.70	NO	NO
2013	101.17	NO	101.17	49.02	NO	52.15	NO	NO
2014	71.05	NO	71.05	48.97	NO	22.08	NO	NO
2015	58.52	NO	58.52	48.90	NO	9.62	NO	NO
2016	77.00	NO	77.00	48.83	NO	28.17	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 2016). 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 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 25 838 ha for the period 1990 to 2016.

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.

6.5.4.2 Land use changes to Wetland (4.D.2)

On the contrary to the remaining category, 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 2 747 ha between the years 1990 and 2016 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 14.4 kt CO_2 to 49.1 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 $C.a^{-1}$):

$$\Delta C_{LW\ flood} = (Sum\ A_i * (B_{after} - B_{before})) * CF$$

Ai = 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 23 091 ha between the years 1990 and 2016 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 9.6 kt CO_2 to 52.2 kt CO_2.

Changes in carbon stocks in soil of grassland converted to wetland

In response to a 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 248; 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 249 and Chapter 6.3.5. Table 259. 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 176 and 627 kt CO_2 with a steady increase across the time series or between 419 and 1 613% of the total emissions in the single years. The low absolute uncertainty (despite the high uncertainties of the input data) reflects the low LUC activity in this subcategory.

6.5.6 QA/QC and Verification

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

- No revisions of the time series.

6.5.8 Planned improvements

See Chapter 6.1.8.

6.6 Settlements (Category 4.E)

6.6.1 Category description

About 0.56 million ha of Austria's surface can be allocated to the IPCC land use category settlements (BEV 2017). 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 146 504 ha to 152 622 ha between the years 1990 and 2016 causing annual emission rates due to C stock changes of biomass, dead organic matter and soils ranging from 379 kt CO_2 to 589 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 portions 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 do not strictly mirror the trend in the total settlement area.

Table 267 and Table 268 show the land use changes and removals/emissions from LUC to settlements for the period 1990 to 2016.

Table 267: Total areas and land use change areas for the subcategory settlements 4.E for the period 1990 to 2016 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	54 163	85 617	NO	NO
1991	386 858	236 470	150 388	10 315	55 001	85 072	NO	NO
1992	393 661	242 308	151 353	10 839	55 896	84 618	NO	NO
1993	400 465	248 146	152 319	11 362	56 792	84 165	NO	NO
1994	407 268	255 375	151 893	11 375	57 351	83 168	NO	NO
1995	414 071	262 854	151 217	11 180	57 889	82 149	NO	NO
1996	420 874	270 333	150 542	10 984	58 427	81 130	NO	NO
1997	427 678	277 812	149 866	10 789	58 966	80 112	NO	NO
1998	434 481	285 290	149 191	10 593	59 504	79 093	NO	NO
1999	441 284	292 107	149 177	10 641	60 203	78 333	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
2000	448 088	298 924	149 163	10 689	60 901	77 573	NO	NO
2001	454 891	305 741	149 149	10 737	61 600	76 813	NO	NO
2002	461 694	313 012	148 682	11 151	61 935	75 596	NO	NO
2003	468 497	320 283	148 214	11 565	62 270	74 379	NO	NO
2004	475 395	327 324	148 071	11 490	62 926	73 655	NO	NO
2005	482 293	334 365	147 928	11 414	63 583	72 931	NO	NO
2006	489 190	341 406	147 784	11 339	64 239	72 207	NO	NO
2007	494 950	348 447	146 504	11 263	64 342	70 898	NO	NO
2008	502 903	355 488	147 415	11 188	65 511	70 716	NO	NO
2009	513 017	362 854	150 163	10 733	67 792	71 638	NO	NO
2010	521 598	370 196	151 402	10 330	68 590	72 482	NO	NO
2011	529 188	377 537	151 651	9 928	68 907	72 816	NO	NO
2012	537 502	384 879	152 622	9 525	69 575	73 523	NO	NO
2013	543 587	392 221	151 366	9 122	69 160	73 084	NO	NO
2014	550 122	399 563	150 559	8 719	68 964	72 876	NO	NO
2015	555 150	406 655	148 495	8 524	68 130	71 842	NO	NO
2016	559 699	413 747	145 952	8 329	67 165	70 459	NO	NO

Table 268: Emissions/removals (+/-) from land use changes to settlement for the period 1990 to 2016 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 in CO_2eq	4(IV)A2_N_2O emissions from N leaching and runoff_N_2O in CO_2eq
1990	577	231	31	316	NO	NO	80	8
1991	580	236	30	314	NO	NO	81	8
1992	583	240	30	313	NO	NO	81	8
1993	586	245	29	311	NO	NO	81	8
1994	582	245	29	308	NO	NO	81	8
1995	527	194	28	305	NO	NO	80	8
1996	521	192	28	302	NO	NO	79	8
1997	516	190	27	299	NO	NO	79	8

1998	511	188	27	296	NO	NO	78	8
1999	508	188	26	293	NO	NO	78	8
2000	506	189	26	291	NO	NO	78	8
2001	504	189	26	289	NO	NO	77	8
2002	585	283	21	281	NO	NO	77	8
2003	585	287	21	277	NO	NO	77	8
2004	584	287	21	276	NO	NO	76	8
2005	581	286	21	274	NO	NO	76	8
2006	578	286	20	272	NO	NO	76	8
2007	554	285	10	259	NO	NO	75	8
2008	589	285	29	275	NO	NO	75	8
2009	496	146	51	298	NO	NO	76	8
2010	468	143	37	289	NO	NO	76	8
2011	449	139	27	282	NO	NO	77	8
2012	459	136	34	290	NO	NO	77	8
2013	417	133	13	271	NO	NO	76	8
2014	421	129	18	274	NO	NO	76	8
2015	391	128	6	258	NO	NO	75	8
2016	379	127	4	248	NO	NO	73	7

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 2017). 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; therefore a mean annual increase of the settlement area was calculated for the years 1971–1981 with 6 461 $ha.a^{-1}$, for the years 1982–2002 with 6 803 $ha.a^{-1}$, for the years 2004–2006 with 6 898 $ha.a^{-1}$. Note that for the years before 1980, data were extrapolated following a mean annual increase/decrease between the years 1980–1990.

Obviously the annual increase of settlement area results in a decrease of other land use categories. Therefore. the following procedure was set up to distribute the total increase in settlement between the categories of land use changes to settlement:

- Land use changes from forests are based on the statistical results of the NFI.
- The residual increases of the settlement area result most likely from conversions of cropland and grassland. The size of these LUCs to SL depends on the amount of residual cropland and grassland decreases that needs to be assigned to a LUC category, after subtracting the known areas which go to forest land (data from NFI is considered first in the hierarchy) and other land use categories. In addition, land use changes from cropland and grassland to settlement are estimated to cover the full residual annual increase in settlement area (in addition to the settlement increase resulting from land-use change from forest land. Therefore, the shares of CL and GL to SL are changing from year-to-year according to the „availability" of residual land in order to ensure area consistency.

In compliance with this approach the land use changes to settlement area as shown in Table 267 were derived for the period 1990 to 2016.

In the 2015 submission the data on alpine grassland area were revised. This change has also substantially affected the areas of LUC to settlements as areas have been shifted between the categories. Major changes occurred in the categories Grassland to settlements and Cropland to settlements. For detailed information on the revision see chapter 6.4.2.

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 sub-categories 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 269: 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

For submission 2017 the share of sealed area in settlements in total Austra 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. For this reason the increase of living biomass of perennial species (trees and shrubs) at LUC areas to settlement is now calculated with 0.69 t C $ha^{-1}a^{-1}$ (previous submissions: 0.58 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 areassumed 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 ha^{-1}). Carbon stocks of sealed areas are set zero. In 2017 the share of sealed area in settlements was revised. 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 new shares for "sealed"[93] 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 ha^{-1} (= (1-0.435)* 70 t ha^{-1}) on average (0–30 cm soil depth). For the cropland and grassland categories the following values were used (0–30 cm soil depth).

- Cropland: 50 t ha^{-1}
- Grassland: 70 t 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 8 524 ha to 11 565 ha between the years 1990 and 2016, causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 127 kt CO_2 to 287 kt CO_2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise chang-

[93] 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.

es 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 23 to 109 kt CO_2 in the years 1990 to 2016.

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 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 litter range from 16 to 64 kt CO_2 in the years 1990–2016.

The annual emission rates due to C stock changes in soil range from 88 to 114 kt CO_2 in the years 1990–2016.

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 54 163 to 69 575 ha in the years 1990–2016.

Since 2006 the settlement area was taken in annual resolution while interpolations were carried out for the years before. As a consequence, the LUC areas CL to SL and the emissions show higher variations in the years after 2005. In submission 2015 the year 2012 represented an unrealistic outlier which was caused by a change of the reference date in the Real Estate Database. The settlement area data series has been corrected for this outlier in the previous submission.

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 settment 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.

In the years 1990 to 2016 the annual removal rates range from 73.1 to 124.8 kt CO_2 due to the increased biomass on settlement areas in comparison to croplands.

Changes in carbon stocks in soil of cropland converted to settlement

Due to a revision of the share of "sealed" area in settlements, the soil carbon stocks in settlement were recalculated and now differ substantially from the cropland soil carbon stock(cropland: 50 t C ha^{-1}, settlement: 40 t C ha^{-1}. see Chapter 6.3.4.1.4). Consequently since this submission, soil has become a source of net emissions during conversion of cropland to settlement (ranging from 104 to 133 kt CO_2/a).

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 70 716 ha to 85 617 ha in the years 1990–2016 resulting in annual emission rates due to C stock changes of biomass and soils from 248 kt CO_2 to 316 kt CO_2.

Since 2006 the settlement area data were provided in an annual resolution while interpolations were carried out for the years before. As a consequence, the LUC areas GL to SL and the emissions show higher variations in the years after 2006. The year 2012 represents an unrealistic outlier.

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 1990–2016 the annual removal rates (net change) range from 102 to 162 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). As described in the previous section 6.6.4.1.4 the emission factor for soil in settlements was updated. Therefore, the emissions from soil in this category have changed since last submission.

The annual emission rate due to loss of soil carbon ranges from 393 to 478 kt CO_2 in the years 1990–2016.

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 1990–2016.

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 1990–2016.

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. In the present submission, these emissions were calculated for the first time 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[87]).

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 2015) 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 248. For the area of LUC from CL to SL and GL to SL triangle distributions were defined.

The uncertainties of the emission factors were given in the Chapter 6.2.5. (Table 249) and Chapter 6.3.5. (Table 259). 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 1 817 kt CO_2 to 2 099 kt CO_2[94]. Higher values were found for the 90s when the input data had a lower accuracy. With these values, the settlement category contributes (after the forest land category) the second highest share to the uncertainty of the total emissions/removals of the total LULUCF sector. This result is not unexpected since the activity is significant and the input parameters are rather uncertain. Expressed in % of the total emissions of the settlement category, the uncertainty lies between 274 and 410% depending on the magnitude of the net emissions in the single years.

6.6.6 QA/QC and Verification

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

- The estimates of the LUC shares from cropland and grassland to settlements were adjusted and led to minor changes in the emissions of the settlement subcategory (higher annual emissions of this subcategory by 0.1 to 17 kt CO_2e per year).

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 in submission 2015 for the whole time series. Due to the update of the time series of Alpine grassland areas in submission 2015, the LUC category Grassland to Other land no longer occurs (see Chapter 6.4.2 for detailed information).

[94] It should be noted that due to the design of the NFI changes in forest biomass stock also include the biomass changes due to LUC to and from forests. As a consequence, the estimates of the overall uncertainty of biomass changes at all forest lands and lands with LUC to and from forests were carried out in the FL sector. For this reason the absolute values of the uncertainties of the single LULUCF subcategories cannot be compared with the reported emissions/removals of the individual subcategories, but as an approximation the relative uncertainties of the subcategories can be compared with the related emissions/removals. For the totals of the LULUCF sector the uncertainty is of course consistent with its emissions/removals.

Table 270: Total areas and land-use change areas for the subcategory Other Land 4.F for the period 1990 to 2016 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	767 254	749 120	18 134	18 134	NO	NO	NO	NO
1991	740 418	721 314	19 104	19 104	NO	NO	NO	NO
1992	740 453	720 379	20 073	20 073	NO	NO	NO	NO
1993	733 581	712 538	21 043	21 043	NO	NO	NO	NO
1994	736 023	714 957	21 066	21 066	NO	NO	NO	NO
1995	744 858	724 154	20 704	20 704	NO	NO	NO	NO
1996	744 848	724 505	20 343	20 343	NO	NO	NO	NO
1997	728 150	708 169	19 981	19 981	NO	NO	NO	NO
1998	729 950	710 331	19 619	19 619	NO	NO	NO	NO
1999	730 406	710 698	19 708	19 708	NO	NO	NO	NO
2000	734 815	715 018	19 796	19 796	NO	NO	NO	NO
2001	723 918	704 033	19 885	19 885	NO	NO	NO	NO
2002	712 670	692 826	19 844	19 844	NO	NO	NO	NO
2003	699 560	679 756	19 804	19 804	NO	NO	NO	NO
2004	687 250	668 393	18 857	18 857	NO	NO	NO	NO
2005	693 726	675 816	17 910	17 910	NO	NO	NO	NO
2006	725 859	708 896	16 963	16 963	NO	NO	NO	NO
2007	744 973	728 957	16 016	16 016	NO	NO	NO	NO
2008	761 490	746 421	15 069	15 069	NO	NO	NO	NO
2009	764 058	749 909	14 148	14 148	NO	NO	NO	NO
2010	767 459	754 135	13 324	13 324	NO	NO	NO	NO
2011	771 229	758 729	12 499	12 499	NO	NO	NO	NO
2012	776 343	764 668	11 675	11 675	NO	NO	NO	NO
2013	778 731	767 881	10 850	10 850	NO	NO	NO	NO
2014	772 199	762 173	10 025	10 025	NO	NO	NO	NO
2015	770 835	761 250	9 586	9 586	NO	NO	NO	NO
2016	773 453	764 307	9 146	9 146	NO	NO	NO	NO

Table 271: Emissions/removals (+/-) from land use changes to Other Land for the period 1990 to 2016 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 run-off_N_2O in CO_2eq
1990	444	444	NO	NO	NO	NO	14	1.45
1991	454	454	NO	NO	NO	NO	15	1.53
1992	463	463	NO	NO	NO	NO	16	1.60
1993	473	473	NO	NO	NO	NO	16	1.68
1994	473	473	NO	NO	NO	NO	16	1.68
1995	375	375	NO	NO	NO	NO	16	1.65
1996	372	372	NO	NO	NO	NO	16	1.63
1997	368	368	NO	NO	NO	NO	16	1.60
1998	364	364	NO	NO	NO	NO	15	1.57
1999	365	365	NO	NO	NO	NO	15	1.57
2000	366	366	NO	NO	NO	NO	15	1.58
2001	367	367	NO	NO	NO	NO	16	1.59
2002	335	335	NO	NO	NO	NO	16	1.60
2003	336	336	NO	NO	NO	NO	16	1.60
2004	328	328	NO	NO	NO	NO	15	1.54
2005	320	320	NO	NO	NO	NO	14	1.47
2006	312	312	NO	NO	NO	NO	14	1.41
2007	304	304	NO	NO	NO	NO	13	1.34
2008	296	296	NO	NO	NO	NO	13	1.28
2009	211	211	NO	NO	NO	NO	12	1.21
2010	204	204	NO	NO	NO	NO	11	1.15
2011	196	196	NO	NO	NO	NO	11	1.09
2012	188	188	NO	NO	NO	NO	10	1.03
2013	181	181	NO	NO	NO	NO	10	0.97
2014	173	173	NO	NO	NO	NO	9	0.91
2015	170	170	NO	NO	NO	NO	9	0.88
2016	166	166	NO	NO	NO	NO	8	0.85

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.

For the 2015 submission the data on the alpine grassland area were revised. This change has substantially affected the areas of LUC to other land. Since then, the subcategory grassland converted to other land is no longer occurring. For detailed information on the revision see chapter 6.4.2.

The LUC areas from forest land to other land are based on the NFIs and ARD NFI. All other LUCs to other land are assumed as not occurring. 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 geographicallyand/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).

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

Only LUCs from Forest land to Other land occur.

6.7.4.1.1 Forest Land converted to Other Land (4.F.2.1)

The methodology and activity data are described in Chapters 0 and 6.2.4.2. The area in conversion from forest land to other land for a time period of 20 years ranges from 9 146 ha to 21 066 ha in the years 1990 to 2016 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 166 kt CO_2 to 473 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 32 to 158 kt CO_2 in the years 1990–2016.

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 due to C stock changes in litter range from 21 to 96 kt CO_2 in the years 1990–2016.

The annual emission rates due to C stock changes in mineral soils range from 112 to 220 kt CO_2 in the years 1990–2016.

6.7.4.1.2 Grassland converted to Other Land (4.F.2.3)

An update of the areas of alpine grassland (see chapter 6.4.2) led to the omission of this category and it is therefore reported as NO since the 2015 submission.

6.7.4.1.3 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. In the present submission, these emissions were calculated for the first time 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.

6.7.4.1.4 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, 2015) 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 248.

The uncertainties of the emission factors were given in the Chapter 6.2.5, Table 249.

The uncertainty of the totals of the emissions/removals of the other land category across the time series ranges from 1 044 kt CO_2 to 1 659 kt CO_2[95]. Higher values were found for the 90s where the input data had a lower accuracy. Expressed in % of the total emissions of the other land category, the uncertainty lies between 337 and 599%. The amount of net emissions was in the most recent years lower. As a consequence, the relative uncertainty of these estimates was higher.

6.7.6 Recalculations

- No revisions of the time series.

6.7.7 QA/QC and Verification

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.

[95] It should be noted that due to the design of the NFI changes in forest biomass stock also include the biomass changes due to LUC to and from forests. As a consequence, the estimates of the overall uncertainty of biomass changes at all forest lands and lands with LUC to and from forests were carried out in the FL sector. For this reason the absolute values of the uncertainties of the single LULUCF subcategories cannot be compared with the reported emissions/removals of the individual subcategories, but as an approximation the relative uncertainties of the subcategories can be compared with the related emissions/removals. For the totals of the LULUCF sector the uncertainty is of course consistent with its emissions/removals.

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 2016 this category contributed to net emission removals of 1 042 kt CO_2. 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 this sink is subject to variations which are strongly influenced by market conditions. In 2009 the removals were substantially lower than in the years before. This is a consequence of the economic downturn in 2008 which resulted in a reduced HWP production based on domestic harvest in the following years in all product categories. Until now pre-2008 production levels based on domestic harvest have not yet been achieved (e.g. the sink for 2016 is even lower than the one for 2009).

Table 272: Emissions/removals from Harvested wood products for the period 1990 to 2016 in kt CO_2.

	Harvested wood products (produced and consumed domestically)	Sawn wood	Panels	Paper an 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	-3 776	-1 900	-1 532	-344	IE	NO
2007	-5 046	-2 904	-1 629	-513	IE	NO
2008	-4 756	-2 643	-1 631	-483	IE	NO
2009	-1 102	-630	-901	429	IE	NO
2010	-2 427	-1 311	-1 040	-77	IE	NO
2011	-2 659	-1 491	-1 099	-68	IE	NO
2012	-2 058	-1 052	-1 026	20	IE	NO
2013	-1 141	-566	-879	305	IE	NO
2014	-1 375	-687	-867	179	IE	NO

	Harvested wood products (produced and consumed domestically)	Sawn wood	Panels	Paper an paper board	Harvested wood products (produced and exported)	HWP in SWDS
2015	-1 257	-729	-740	212	IE	NO
2016	-1 042	-608	-675	241	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 2016. Table 273 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.

Table 273: Production of harvested wood products based on domestic harvest in Austria for the period 1990 to 2016 in cubic metres or tonnes calculated from FAO statistics.

	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	2 258 248	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	1 851 904	1 928 748
2010	5 811 867	2 019 129	2 201 453
2011	6 064 727	2 098 936	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

	Sawn wood [m³]	wood panels [m³]	Paper and paper board [t]
2016	5 096 980	1 793 208	1 853 647

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, m³ a^{-1}

$IRW_{ex,\,i}$ = Industrial roundwood – export quantity for year i, m³ a^{-1}

$IRW_{im,\,i}$ = Industrial roundwood – import quantity for year i, m³ 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 273. 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 521 to 2 523 kt CO_2.

6.8.4 Recalculations

- A calculation error in the HWP estimates related to veneer sheets was corrected and led to minor changes in the removals from HWPs.
- The HWP production figures for 2015 were updated in the most recent FAO statistic. Consequently, the removal figures for this year had to be updated accordingly.
- The estimate of paper production from domestic wood was expanded by the wood pulp production/import/export according to equations 2.8.2 and 2.8.4 of the IPCC (2014) KP Supplement and the HWP time series was recalculated accordingly.

All the recalculations in the HWP category led to changes in the time series of annual removals of this subcategory in the range of −182 to 342 kt CO_2e per year.

6.8.5 Planned Improvements

No improvements are planned.

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 2016 amounted to 1 581 kt CO_2 equivalent (1990: 3 925 kt CO_2 equivalent). These are about 2.0% of total greenhouse gas emissions in Austria in 2016 and 5.0% in 1990. In 2016, greenhouse gas emissions from the waste sector were 60% below the level of 1990.

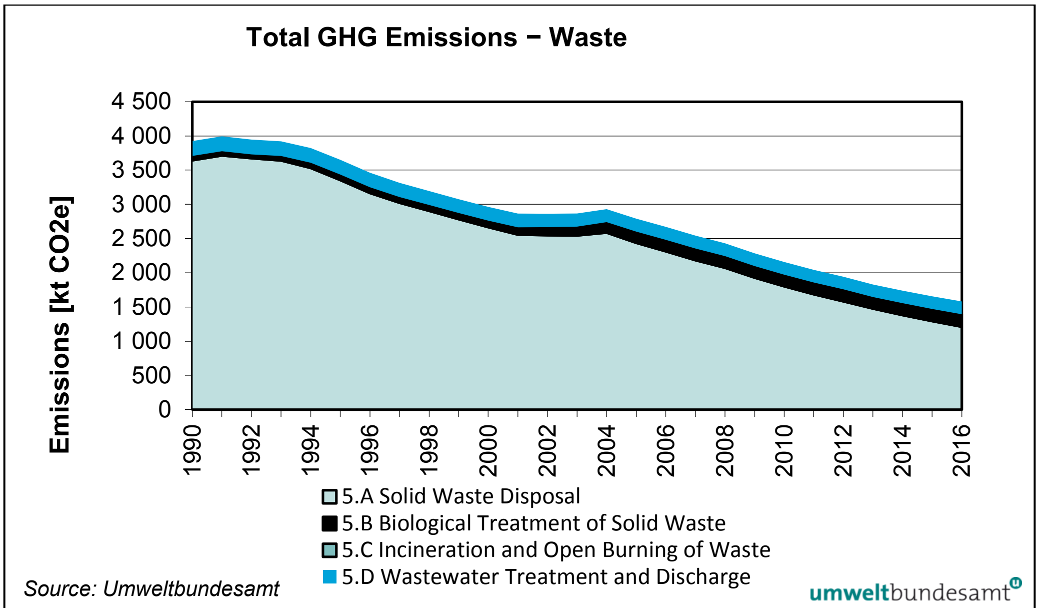

Figure 39: GHG emissions from CRF 5 Waste.

Table 274 presents the emission trend by gas. The major greenhouse gas emitted from this sector is CH_4, which represents 83.3% of all emissions from this sector in 2016, followed by N_2O (16.5%) and CO_2 (0.1%).

CH_4 emissions

CH_4 emissions from sector Waste amounted to 1 318 kt CO_2 equivalent in 2016; that is 65.1% 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 92% 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 262 kt CO_2 equivalent in 2016. Emissions increased by 119.9% since 1990.

63% of N_2O emissions originate from *5.D. Wastewater Treatment and Discharge*, 37% 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 2.05 kt CO_2 equivalent in 2016 and decreased by 92.7% 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 274: Greenhouse gas emissions from sector Waste by gas.

Year	CO_2	CH_4	N_2O	Total CRF 5
	[kt]	[kt CO_2e]	[kt CO_2e]	[kt CO_2e]
1990	27.92	3 778	118.93	3 925
1991	24.36	3 849	121.13	3 994
1992	11.13	3 808	127.02	3 946
1993	10.80	3 775	135.02	3 921
1994	10.79	3 666	146.40	3 823
1995	11.11	3 486	153.79	3 651
1996	11.43	3 290	161.14	3 463
1997	11.76	3 139	164.27	3 315
1998	12.08	3 013	169.95	3 195
1999	12.40	2 886	176.42	3 075
2000	12.40	2 765	185.49	2 963
2001	12.40	2 655	198.59	2 865
2002	12.40	2 644	206.99	2 863
2003	12.40	2 640	214.49	2 867

2004	12.40	2 688	230.00	2 930
2005	12.40	2 541	237.81	2 791
2006	10.26	2 418	242.64	2 671
2007	8.21	2 290	244.95	2 543
2008	6.16	2 179	245.62	2 431
2009	4.10	2 033	247.23	2 285
2010	2.05	1 906	249.91	2 158
2011	2.05	1 789	251.74	2 043
2012	2.05	1 686	253.88	1 942
2013	2.05	1 577	249.95	1 829
2014	2.05	1 483	253.14	1 739
2015	2.05	1 398	255.87	1 656
2016	2.05	1 318	261.58	1 581
Trend 1990–2016	**-92.7%**	**–65.1%**	**119.9%**	**–59.7%**

Table 275 presents the greenhouse gas emissions by sub-category. As can be seen, the dominant sub-category is *5.A Solid Waste Disposal*, contributing 77% to greenhouse gas emissions from sector Waste.

Table 275: Greenhouse gas emissions from sector waste by subcategories.

Year	**5.A**	**5.B**	**5.C**	**5.D**	**Total**
			[kt CO_2 e]		
1990	3 644	35.74	28.07	217.32	3 925
1991	3 714	37.47	24.50	218.14	3 994
1992	3 674	44.43	11.18	216.55	3 946
1993	3 641	55.09	10.84	214.30	3 921
1994	3 532	65.39	10.82	215.11	3 823
1995	3 355	69.09	11.15	215.81	3 651
1996	3 166	72.49	11.47	212.65	3 463
1997	3 024	71.32	11.79	208.08	3 315
1998	2 905	73.90	12.12	203.67	3 195
1999	2 784	77.72	12.44	201.42	3 075
2000	2 667	82.59	12.44	201.23	2 963
2001	2 558	93.92	12.44	201.15	2 865
2002	2 549	105.27	12.44	196.50	2 863
2003	2 545	116.77	12.44	192.23	2 867
2004	2 587	140.96	12.44	189.91	2 930
2005	2 438	151.36	12.44	189.44	2 791
2006	2 314	157.38	10.29	189.86	2 671
2007	2 184	162.50	8.23	188.66	2 543
2008	2 074	163.90	6.18	187.46	2 431
2009	1 929	164.89	4.12	186.66	2 285
2010	1 803	167.44	2.06	185.87	2 158
2011	1 686	169.62	2.06	184.79	2 043

2012	1 583	173.73	2.06	183.90	1 942
2013	1 477	166.28	2.06	183.13	1 829
2014	1 382	172.25	2.06	182.65	1 739
2015	1 294	175.15	2.06	185.07	1 656
2016	1 212	180.35	2.06	187.38	1 581
Trend 1990–2016	**–66.7%**	**404.6%**	**–92.7%**	**–13.8%**	**–59.7%**

7.1.2 Key Categories

Methodology and results of the key category analysis is presented in Chapter 1.5. Table 276 summarizes the key categories in the waste sector.

Table 276: 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 2016)

TA = Trend Assessment 1990–2016

CH_4 from solid waste disposal has been identified as the only key source in this sector applying KCA Tier 1 approach.

7.1.3 Completeness

Table 277 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 277: 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	091006 Biogas production	NA**)	✓	NA**)
5.C INCINERATION AND OPEN BURNING OF WASTE				
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		NO	NO	NO***)
5.D WASTE WATER TREATMENT AND DISCHARGE				
5.D.1 Domestic wastewater	091002 Wastewater treatment in residential/commercial sect.	NA	✓	✓
5.D.2 Industrial wastewater	091001 Wastewater treatment in industry	NA	NA	IE****)
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; N_2O: negligible according to IPCC 2006.*

****) The relevant legislation in Austria that prohibits the burning of waste outside stationary combustion facilities is the "Bundesluftreinhaltegesetz" ("BLRG, Fassung vom 26.09.2016": https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20002155*

*****) N_2O from industrial wastewater treated together with domestic wastewater in wastewater treatment plants 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 273 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).

For *CRF 5.C 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.

N_2O emissions from *CRF 5.D. Wastewater Treatment and Discharge* 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.

7.1.5 Category-specific 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 2016 emissions from 5.A Solid Waste Disposal contributed 77% to greenhouse gas emissions from sector Waste and 1.5% to total greenhouse gas emissions in Austria. From 1990 to 2016 greenhouse gas emissions from this source decreased by 66.7% (see Table 280).

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[96] 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[97]), 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 mechanical-biological treatment) and in sector 'energy' respectively, as incineration is a pre-treatment option too.

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[96] 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).

[97] Ordinance on Landfills (Landfill Ordinance 2004), Federal Law Gazette No 164/1996 as amended by Federal Law Gazette No 49/2004; Ordinance on Landfills (Landfill Ordinance 2008), Federal Law Gazette II No 39/2008 as amended by Federal Law Gazette II No 185/2009

'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 sludges.
- 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 implementing of the Waste Management Law), fat and textiles are not deposited any more (see Table 281). 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).

Table 278 presents a summary of all considered waste types and the corresponding identification numbers (list of waste).

Table 278: Considered types of waste (list of waste[98] 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
1912	wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	200101/ 200102	paper and cardboard

[98] 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
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 40 and Table 279 below are only to inform about the waste management practices in Austria, and data presented herein are not used for the calculation of GHG emissions. shows the main streams of treatment and disposal of waste from households and similar sources. It also aims to transparently show the distinction between residual and non-residual waste (with regard to municipal solid waste[99]) and to demonstrate that all relevant activity data are taken into account in the inventory.

[99] In fact non-residual waste also comprises waste from other (industrial) sources.

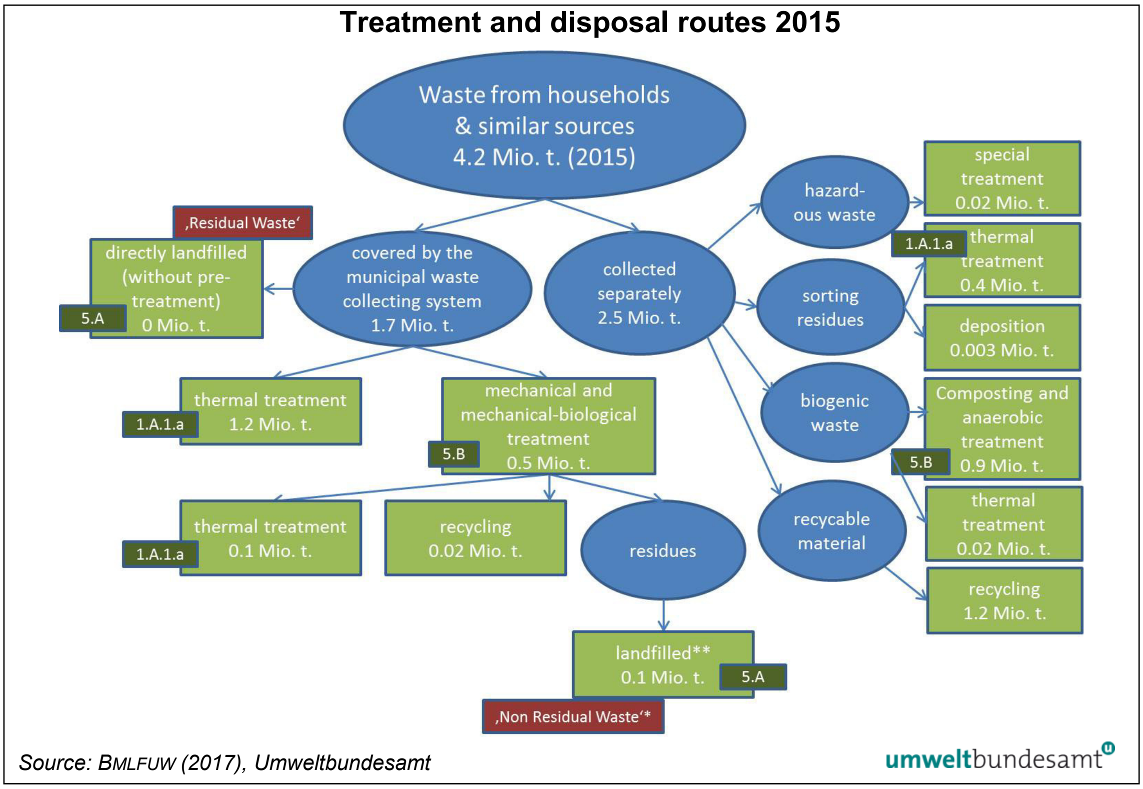

Figure 40: Waste from households and similar sources – treatment and disposal routes 2015. Please note: This illustration only covers data from households and similar sources. Waste from industrial and similar sources (e.g. wastewater treatment plants) are also included in the inventory, but not considered in Figure 2.

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.

Table 279: Recycling and treatment of waste from households and similar sources.

Treatment	1989[1)]	1999[3)]	2004[3)]	2006[4)]	2008[5)]	2009[6)]	2010[7)]	2012[8)]	2013[9)]	2014[10)]	2015[11)]
bio-technical treatment	16.7%[2)]	6.3%	11.2%	17.9%	8.8%	10.4%	8.5%	11.0%	10.9%	10.4%	7.2%
thermal treatment (incineration)	5.9%	14.7%	28.3%	23.7%	34.7%	36.4%	40.2%	38.2%	38.8%	38.6%	41.4%
treatment in plants for hazardous waste	0.4%	0.8%	1.2%	1.8%	2.3%	2.4%	2.5%	2.4%	2.1%	2.0%	2.1%
recycling	12.9%	34.3%	35.6%	34.8%	32.3%	31.7%	30.7%	26.8%	27.2%	26.9%	27.1%
Composting and anaerobic treatment	1.0%	15.4%	16.0%	17.9%	18.2%	18.7%	17.7%	21.6%	20.9%	22.0%	22.1%
direct deposition at landfills	63.1%	28.5%	7.7%	3.8%	3.7%	0.4%[*)]	0.4%[*)]	<0.1%[*)]	0.1%[*)]	0.1%[*)]	0.1%*)

1) *Federal Waste Management Plan 2001 (BMLFUW 2001)*
2) *This value also includes plants used in the past to reduce odour emissions.*
3) *Federal Waste Management Plan 2006 (BMLFUW 2006a)*
4) *Annual update (2008) of the Federal Waste Management Plan (BMLFUW 2006a)*
5) *Annual update (2009) of the Federal Waste Management Plan (BMLFUW 2006a)*
6) *Federal Waste Management Plan 2011 (BMLFUW 2011a)*
7) *Annual update (2012) of the Federal Waste Management Plan (BMLFUW 2013)*
8) *Annual update (2013) of the Federal Waste Management Plan (BMLFUW 2014b)*
9) *Annual update (2014) of the Federal Waste Management Plan (BMLFUW 2015b)*
10)*Annual update (2015) of the Federal Waste Management Plan 2015 (BMLFUW 2015c)*
11) *Federal Waste Management Plan 2017 (BMNT 2017)*

*) *deposition of (sorting-, processing-) residues from separately collected waste*

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. In 2014, 30 mass waste landfills were in operation, compared to 61 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, which is due to the introduction of disposal fees. This fee originates from an Austrian Law for cleaning up contaminated sites[100] with the objective to finance cleaning up and securing activities for contaminated site. As long as disposal fees were low, high amounts were deposited, which was especially the case in 1989.

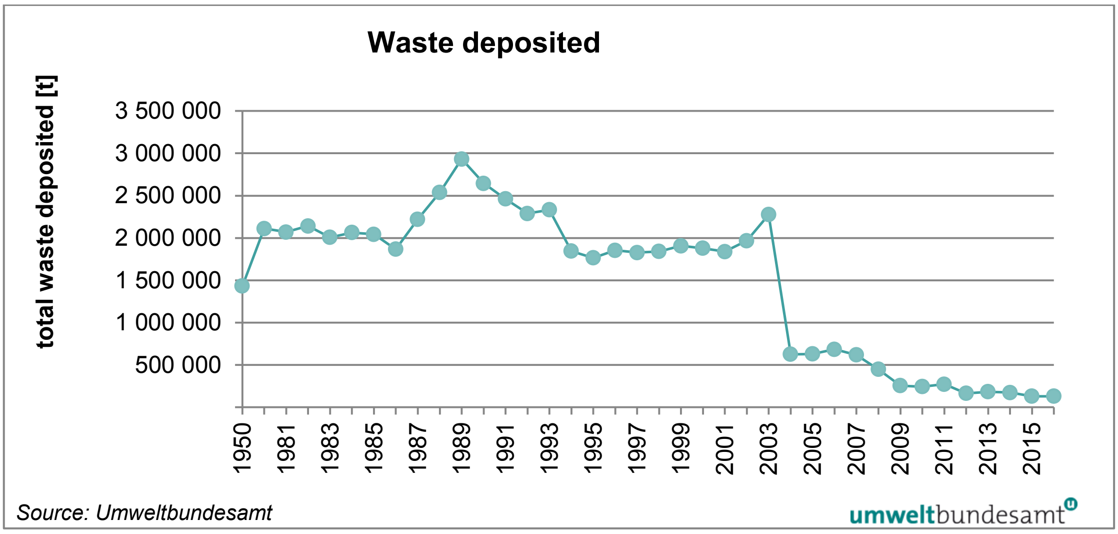

Figure 41: Waste ('residual waste' and 'non-residual waste') with a relevant share of degradable organic carbon (deposited on mass waste landfills), period 1950–2016.

In 1990 waste management was for the first time regulated by law (Austrian Waste Management Law[101]). As a result, waste separation and 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[102], which – apart from some exemptions[103] – 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.

[100] Law on the Remediation of Contaminated Sites (1989), Federal Law Gazette No 299/1989 as amended

[101] Waste Management Act of 2002, Federal Law Gazette I No 102/2002 as amended by Federal Law Gazette I No 9/2011

[102] Ordinance on Landfills (Landfill Ordinance 2004), Federal Law Gazette No 164/1996 as amended by Federal Law Gazette No 49/2004; Ordinance on Landfills (Landfill Ordinance 2008), Federal Law Gazette II No 39/2008 as amended by Federal Law Gazette II No 185/2009

[103] 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.

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 data on historical and current waste amounts is available. Parameters used are partly country-specific (e.g. landfill gas recovery), 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 2008–2016 have been taken from the EDM[104], 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[105] (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 2008–2015 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 280 presents activity data and CH_4 emissions from managed waste disposal on land for the period 1990–2016.

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[104] Electronic Data Management

[105] Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

Table 280: Activity data for 'residual waste' and 'non residual waste', greenhouse gas emissions and implied emission factors 1990–2016

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		0.06
1991	661 676	1 799 718	2 461 394	-6.9%	148 568	1.9%	0.06
1992	674 909	1 614 157	2 289 067	-7.0%	146 970	-1.1%	0.07
1993	688 407	1 644 718	2 333 126	1.9%	145 630	-0.9%	0.07
1994	702 175	1 142 067	1 844 242	-21.0%	141 273	-3.0%	0.08
1995	716 219	1 049 709	1 765 928	-4.2%	134 204	-5.0%	0.08
1996	730 543	1 124 169	1 854 713	5.0%	126 643	-5.6%	0.08
1997	745 154	1 082 634	1 827 788	-1.5%	120 946	-4.5%	0.08
1998	760 057	1 081 114	1 841 171	0.7%	116 208	-3.9%	0.07
1999	822 179	1 084 625	1 906 804	3.6%	111 348	-4.2%	0.07
2000	826 874	1 052 061	1 878 935	-1.5%	106 674	-4.2%	0.07
2001	772 786	1 065 592	1 838 378	-2.2%	102 319	-4.1%	0.07
2002	792 753	1 174 543	1 967 296	7.0%	101 956	-0.4%	0.06
2003	890 640	1 385 944	2 276 584	15.7%	101 805	-0.1%	0.05
2004	344 747	282 656	627 403	-72.4%	103 466	1.6%	0.19
2005	389 660	241 733	631 393	0.6%	97 510	-5.8%	0.18
2006	425 091	260 068	685 159	8.5%	92 547	-5.1%	0.15
2007	464 109	154 517	618 626	-9.7%	87 357	-5.6%	0.16
2008	319 927	129 324	449 251	-27.4%	82 943	-5.1%	0.21
2009	256 340	0	256 340	-42.9%	77 162	-7.0%	0.34
2010	244 969	0	244 969	-4.4%	72 104	-6.6%	0.33
2011	273 313	0	273 313	11.6%	67 447	-6.5%	0.28
2012	166 263	0	166 263	-39.2%	63 304	-6.1%	0.42
2013	185 156	0	185 156	11.4%	59 083	-6.7%	0.35
2014	174 500	0	174 500	-5.8%	55 268	-6.5%	0.35
2015	131 959	0	131 959	-24.4%	51 758	-6.4%	0.43
2016	132 183	0	132 183	0.2%	48 467	-6.4%	0.40

* *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 absolut numbers) in 2011/2012 is caused by the shutdown of 2 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 waste deposited in the respective year, 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 2015 only 132 kt were landfilled resulting in an IEF of 0.4 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 281: 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	239.49	2.99	6.92	7.80	36.11	1.87	0.45	1.45	0.00
1991	205.17	3.05	7.06	7.95	36.83	1.91	0.46	1.48	0.00
1992	174.33	3.11	7.20	8.11	37.57	1.95	0.47	1.51	0.00
1993	167.76	3.18	7.34	8.27	38.32	1.98	0.48	1.54	0.00
1994	109.64	3.24	7.49	8.44	39.09	2.02	0.49	1.57	0.00
1995	94.47	3.31	7.64	8.61	39.87	2.06	0.50	1.60	0.00
1996	94.43	3.37	7.79	8.78	40.67	2.11	0.51	1.64	0.00
1997	84.45	3.44	7.95	8.96	41.48	2.15	0.52	1.67	0.00
1998	84.33	3.51	8.10	9.14	42.31	2.19	0.53	1.70	0.00
1999	78.09	2.61	6.81	8.34	47.41	3.60	1.41	2.15	0.01
2000	81.45	1.72	5.18	6.25	53.66	1.25	0.98	2.66	0.02
2001	88.28	1.19	7.23	6.95	46.39	2.08	0.86	2.55	0.01
2002	103.68	1.55	5.30	8.03	50.31	1.16	0.81	1.54	0.00
2003	129.86	1.72	6.15	21.97	38.12	1.94	0.68	1.15	0.00
2004	28.02	1.06	0.04	4.30	22.09	0.28	0.02	0.68	0.00
2005	24.10	0.42	0.06	0.53	31.79	0.08	0.02	0.78	0.00
2006	26.08	1.02	0.82	0.50	33.71	0.21	0.02	1.02	0.00
2007	15.59	0.92	0.25	0.37	38.46	0.07	0.00	0.68	0.00
2008	13.12	0.00	0.27	0.44	27.06	0.01	0.00	0.16	0.00
2009	0.00	0.00	0.01	0.30	22.09	0.00	0.00	0.02	0.00
2010	0.00	0.01	0.02	0.11	21.33	0.00	0.00	0.02	0.00
2011	0.00	0.01	0.00	0.14	23.79	0.00	0.00	0.03	0.00
2012	0.00	0.00	0.00	0.19	14.33	0.00	0.00	0.01	0.00
2013	0.00	0.00	0.00	0.54	15.45	0.00	0.00	0.0	0.00
2014	0.00	0.00	0.00	0.35	14.80	0.00	0.00	0.0	0.00
2015	0.00	0.00	0.13	0.14	11.33	0.00	0.00	0.0	0.00
2016	0.00	0.00	0.00	0.34	11.14	0.00	0.00	0.0	0.00

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 282: Parameters for calculating CH_4 emissions from SWDS.

Waste category/ Parameters	residual waste	wood	paper	sludges	Sorting residues	Bio-waste	textiles	Constructio n 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 283	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)	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 43 (UMWELTBUNDESAMT 2004c, 2008a, 2014b)								
Process start (M)	13 Delay time of 6 months, with an average residence time of 6 months (IPCC default)								

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 282. These are clearly defined (wood, paper, sludge, etc.) and quite 'homogenous'.

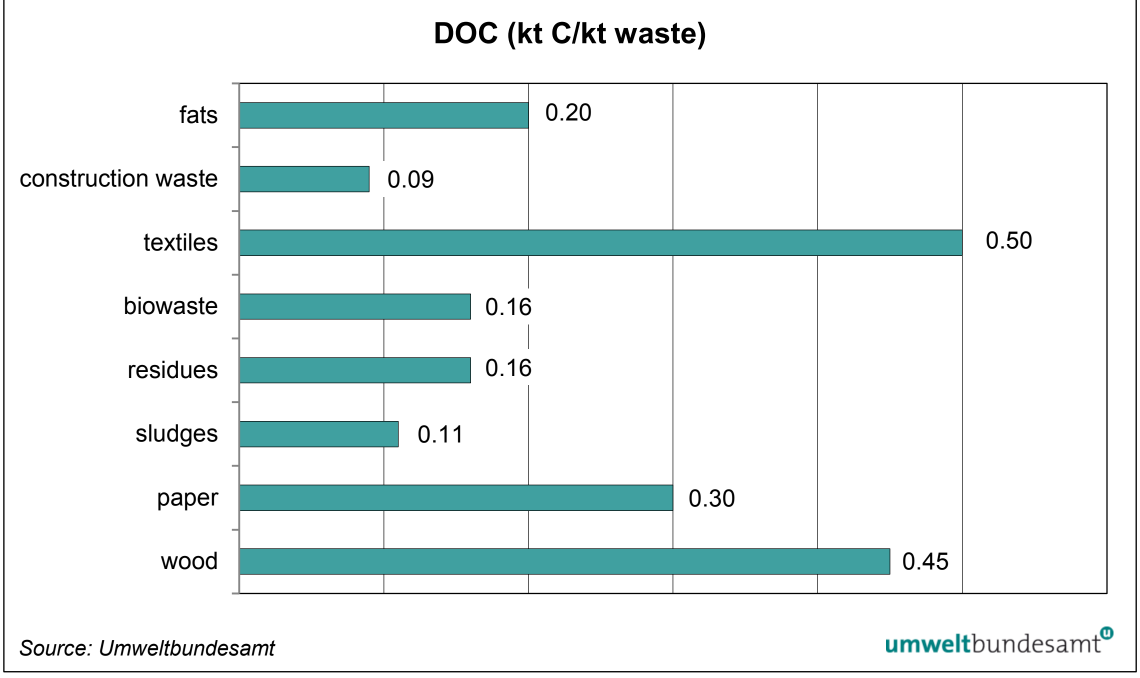

Figure 42: DOC of non-residual waste fractions.

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 283: Time series of bio-degradable organic carbon content of residual waste (mixed MSW, directly deposited).

Year	kt C/kt Residual Waste	Year	kt C/kt 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 *)

Year	kt C/kt Residual Waste	Year	kt C/kt Residual Waste
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)
1997	0.13 2)	2009–2016	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 Updateof 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 284).

Table 284: 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 282.

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 adapting the default DOCf (0.5) as provided by the IPCC 2006 GL 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. The DOCf for fats is set to 0.77 as lignin C is excluded here.

The higher DOCf values used compared to the bulk DOCf can be justified by the fact that in Austria a high share of e.g. garden or park waste (i.a branches from trees and bushes) is treated biologically in composting plants (considered under 5.B.1 composting).

Fraction of CH_4 in generated landfill gas (F)

Austria uses a 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 is slightly higher than the default from the IPCC 2006 Guidelines (0.5). The methane concentration in the generated landfill gas changes over time. After a few month already before the so called "stable methane phase" commences, the methane concentration increases to about 55%. During the stable methane phase (this phase lasts for 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 protein show substantially higher concentrations than carbohydrates (WEILAND, P. 2001). In biogas plants, fats and oil show very high methane concentrations (about 68%), legumes show concentrations between 52% and 65%, food waste about 60% (LFL 2017). Seperately collected biowaste includes also proteins and fats, kitchen and cateen waste even higher shares.

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 and 2013 further surveys were conducted (UMWELTBUNDESAMT 2008a, UMWELTBUNDESAMT 2014b) to get new data on collected landfill gas as well as information on its use from landfill operators. Results show that from 2002 on, the amount of landfill gas recovered 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[106] – 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 recovered decreased by 73% by 2016.

[106]a methane concentration of 55% (default) is used for the estimation of the landfill gas **produced** ('F') over the whole time-series.

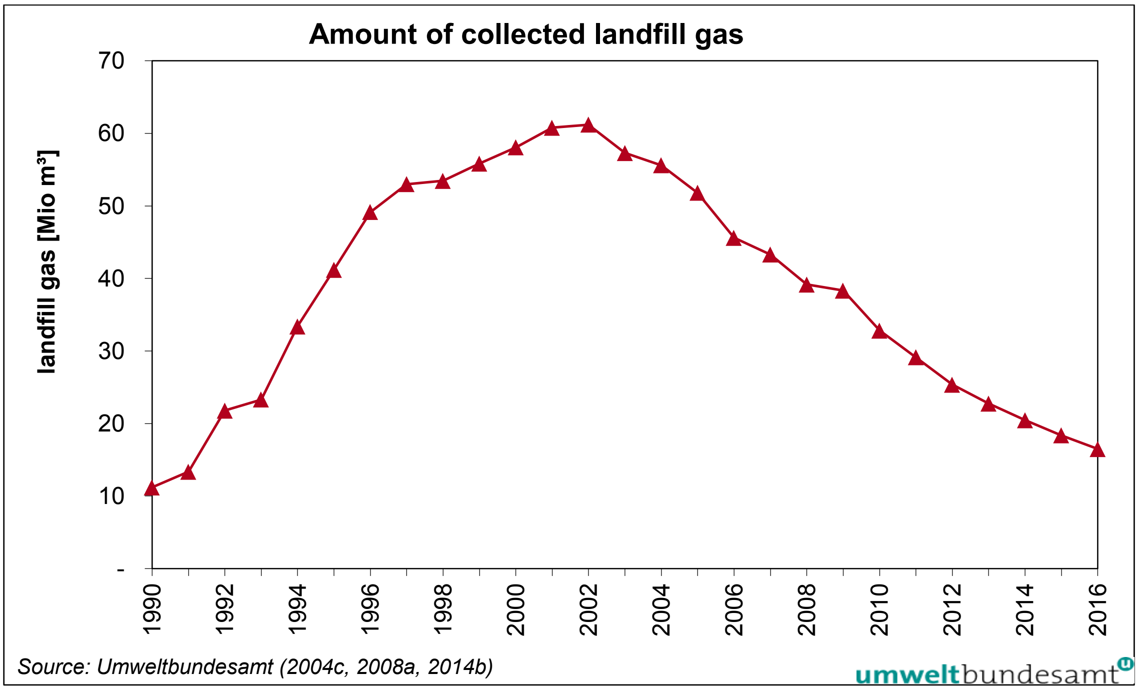

Figure 43: Amount of collected landfill gas 1990 to 2016.

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 285: 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 and verification

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). 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[107] 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 Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. 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 (Department 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 Category-specific recalculations

No recalculations were undertaken.

7.2.5 Category-specific planned improvements

A further survey on landfill gas recovery at landfill gas operators to update this parameter will be carried out in 2018.

[107] According to § 41 (1) Landfill Ordinance

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)

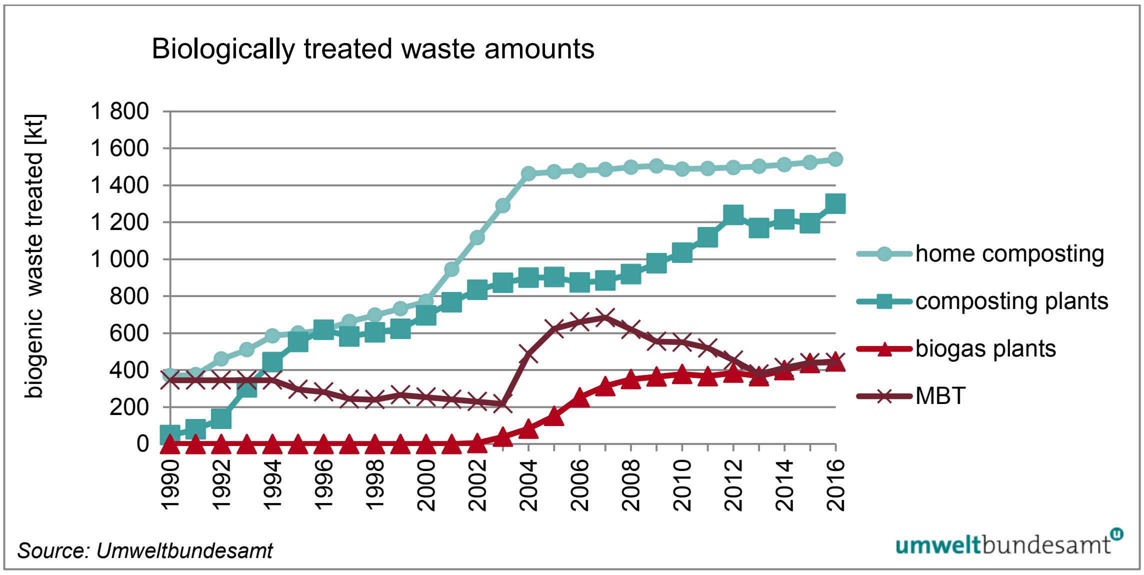

Figure 44: Amounts of waste treated (mechanical-) biologically.

Emissions increased by 400% over time as the result of the increasing amount of composted as well as mechanical-biologically treated waste.

7.3.2 Methodological issues

Emissions from mechanical-biological 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 *emissions* $= M_i * EF_i$

N_2O *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)*

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 2016 to 2030 it is assumed that the leakage will gradually decrease to stabilise at a leakage rate of 1%. The reasoning for this continouse 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.

$$CH_4 \text{ emissions} = M * L_0 * F * CH_4 \text{ density} * EF$$

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)*

7.3.2.1 Activity data

Historical activity data were taken from national publications and regional sources as listed in Table 286.

In most recent years the 'Electronic Data Management' (EDM) is the primary data basis[108], providing data for the 'Federal Waste Management Plan' 'BAWP' (BMLFUW 2006a, BMLFUW 2011a, BMNT 2017), which is (in part) updated annually ('Status Reports' 2007, 2008, 2009, 2012, 2013, 2014, 2015). For years where no reliable data were available inter- or extrapolation was done.

The EDM is an information network operated by Umweltbundesamt. It is a central *eGovernment* initiative by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (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.

Home composted amounts are calculated based on a per-capita value of 215 kg/person/a, whereas for Vienna only 15% of the population is considered due to the lower number of gardens in this urban area. This approach is in line with the method applied for the BAWP (BMNT 2017).

Mechanical-biologically treated waste for most recent years is taken directly from the EDM.

The EDM is also the main data source of biogenic waste treated in composting and anaerobic treatment plants. Regarding EDM data on composting plants, research by waste experts at the 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

[108] In subcategory *5.A Solid Waste Disposal* waste amounts have been taken from EDM reports already since 2008.

expected that reporting irregularities will be further decreased. The 5% assumption is continued for 2015 and 2016 as still reporting irregularities are expected.

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 on 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.

Table 286: 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 1998	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	**1 953**	242		767		944	interpolated	0	
2002	**2 186**	230		834		1 117		5	intrapolated based on EJ by Umweltbundesamt (2015)
2003	**2 418**	218	UMWELTBUNDESAMT 2008b	871		1 290		39	
2004	**2 932**	488		899		1 462	calculated based on BMLFUW 2008a	83	
2005	**3 150**	623		903		1 472		152	
2006	**3 266**	660		874		1 480		252	
2007	**3 367**	684		884		1 485	BMLFUW 2008a	314	
2008	**3 387**	619	interpolated	919		1 498	BMLFUW 2011a	350	
2009	**3 401**	555	EDM	977		1 505		364	
2010	**3 452**	551		1 035		1 488	calculated on basis of BMLFUW 2011a	378	
2011	**3 495**	519		1 118	EDM + EJ UMWELTBUNDESAMT (2015)	1 491		367	EDM
2012	**3 573**	453		1 239		1 496		385	
2013	**3 416**	379		1 168		1 502		367	
2014	**3 538**	413		1 215		1 511		399	
2015	**3 596**	439		1 194		1 524		438	
2016	**3 728**	442		1 300		1 540		447	

7.3.2.2 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 287: 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 et al. 2003, 2005) (ANGERER & FRÖHLICH 2002) (DOEDENS et al. 1999)
Composting (bio-waste, loppings, home composting)	0.75	0.1	(AMLINGER et al. 2003, 2005)

Table 288: Emission parameters used for 'Anaerobic digestion at biogas plants' (5.B.2).

Parameter			References
L_0	CH_4 generation potential	110 m^3/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 from 2016 to 2030 gradually decreasing, as Austrian approval authorities require "zero" leakage from new biogasplants. For this reason, the leakage of 5% is gradually decreasing to 1% until 2030, considering the average lifetime of a biogas plant with 15 years.

A CH_4 density (D) of 0.65 kg/m^3 is applied.

7.3.3 Uncertainties and time-series consistency

The following uncertainties are considered in the Uncertainty Analysis:

Table 289: 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 Category-specific recalculations

No recalculation was done in this years' submission.

7.3.5 Category-specific QA/QC and verification

See7.1.5.

All QA/QC steps have been taken 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 subcategory as the data basis (EDM) is the same.

7.3.5.1 Composted amounts

For the years 2011-2014 activity data 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 62 kt in 2016) have to be considered additionally to achieve time-series consistency (Expert judgement by Umweltbundesamt 2015).

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 kg vs 54 kg CH_4/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 Category-specific planned improvements

No further improvements are currently planned for this category.

7.4 Incineration and Open Burning of Waste (Category 5.C)

The Austrian federal clean air act (Bundesluftreinhaltegesetz, BGBl. I Nr. 137/2002)[109] prohibits the burning of waste outside stationary combustion facilities with the general exception of fire drills, bonfires and barbecue as well as activities which needs a specific permit (e.g. burning of agricultural residues). Therefore emissions of category *5.C.2 Open burning of waste* has been set as 'NO'.

7.4.1 Source Category Description

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. in total emissions from waste is 0.7% for the year 1990 and 0.1% for the year 2016.

In Austria waste oil has been incinerated in especially designed so called „USK-facilities" (**U**m-welt**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 incin-

[109] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20002155

eration regulation[110] came into force, introducing ambitious emission limits (from 2005 on[111]) 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 5 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 290: Greenhouse gas emissions from Category 5.C.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	27.92	0.0009	0.0004	28.07
1991	24.36	0.0008	0.0004	24.50
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
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	12.12
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	6.18
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

[110] 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.

[111] 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]
2016	2.05	0.0001	0.0000	2.06
Trend 1990–2016	**-93%**	**-94%**	**-96%**	**-93%**

7.4.2 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.

7.4.2.1 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 291. 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 291: Emission factors and parameters of IPCC Category 5.C 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'.*

7.4.2.2 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.

Table 292: 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
2010-2016	NO	500	500

The following table shows activity data of waste incineration with energy recovery.

Table 293: 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

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]
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	10 333
2006	1.180.898	113.695	60.216	436.596	21.697	11 585
2007	1.124.139	109.724	62.376	514.071	23.996	11 000
2008	1.146.547	95.548	60.082	359.879	22.206	12 634
2009	1.348.681	96.505	54.243	336.691	14.881	10 412
2010	1.418.176	109.772	57.002	359.589	21.911	11 172
2011	1.456.520	108.220	164.636	393.857	19.597	12 916
2012	1.438.921	98.227	176.809	388.235	12.662	11 880
2013	1.516.986	143.848	173.637	428.759	10.365	12 660
2014	1.830.935	112.587	177.894	462.892	11.963	13 723
2015	1.850.216	114.110	201.061	481.311	15.370	14 414
2016	1 783 095	196 125	203 723	478 954	20 396	14 078

[1) *Umweltbundesamt, Statistik Austria 2008.*

[2) *(HACKL & MAUSCHITZ 1995, 1997, 2001, 2003, 2007, MAUSCHITZ 2004), From 2005 onwards ETS data us used*

[3) *1.A.2.f other fuels – activity data*

[4) *including waste oil and clinical waste*

7.4.2.3 Recalculations

No recalculations hav been carried out since the previous submission.

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 wastewater as well as direct and indirect N_2O emissions from wastewater of domestic and industrial origin. Septic tanks are characterised by anaerobic conditions (resulting in CH_4 emissions), whereas wastewater treatment plants use aerobic procedures with nitrification and denitrification steps (resulting in N_2O emissions). In addition to wastewater treatment, also the discharge of wastewater (nitrogen effluent) into aquatic environments causes N_2O emissions. N_2O emissions are only reported under *5.D.1 domestic and commercial wastewater treatment*, where also some industrial wastewater ('co-discharger') is included.

In the year 2016, greenhouse gas emissions from *5.D Wastewater Treatment and Discharge* contributed 12% to greenhouse gas emissions from sector Waste and 0.2% to total greenhouse gas emissions in Austria. From 1990 to 2016, greenhouse gas emissions from this category decreased by 14%. 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 are strongly increasing in line with the growing share of population connected to modern centralized wastewater treatment plants. The share of plant emissions in total greenhouse gas emissions from sub-category *5.D Wastewater Treatment and Discharge* has grown from 0% (1990)[112] to 70% (2016).

Table 294: Greenhouse gas emissions from domestic and commercial wastewater treatment (5.D.1) 1990–2016.

	CH_4		**N_2O**				**GHG**
Source	**septic systems**		**N_2O indirect effluent plants**	**effluent population**	**N_2O direct plants**	**total**	**total**
	[t CH_4]	**[t CO_2e]**	**[t N_2O]**	**[t N_2O]**	**[t N_2O]**	**[t CO_2e]**	**[t CO_2e]**
1990	4 850	121 248	205.03	117.36	0.00	96 072	217 319
1991	4 837	120 920	210.59	115.65	0.00	97 220	218 140
1992	4 705	117 622	224.90	107.06	0.00	98 925	216 547
1993	4 557	113 922	238.84	98.00	0.00	100 378	214 300
1994	4 387	109 668	228.56	88.39	36.88	105 442	215 110
1995	4 205	105 137	215.45	78.53	77.43	110 677	215 813
1996	3 867	96 680	197.64	71.31	120.20	115 967	212 647
1997	3 527	88 181	187.53	64.07	150.75	119 897	208 078
1998	3 186	79 659	176.33	56.80	183.03	124 014	203 674
1999	2 934	73 350	162.68	51.85	215.23	128 068	201 418
2000	2 682	67 047	137.55	46.89	265.84	134 187	201 234

[112] In the early 1990s there has been hardly nitrification/denitrification in Austria, thus no N_2O emissions are expected until 1994.

	CH_4		N_2O				GHG
Source	septic systems		N_2O indirect effluent plants	effluent population	N_2O direct plants	total	total
	[t CH_4]	[t CO_2e]	[t N_2O]	[t N_2O]	[t N_2O]	[t CO_2e]	[t CO_2e]
2001	2 432	60 799	110.02	41.98	318.99	140 356	201 155
2002	2 181	54 516	112.68	37.82	325.98	141 988	196 504
2003	1 946	48 660	115.33	33.60	332.86	143 574	192 235
2004	1 794	44 854	117.99	33.81	334.96	145 054	189 908
2005	1 641	41 019	100.60	34.04	363.42	148 422	189 441
2006	1 483	37 069	83.22	25.59	403.93	152 796	189 865
2007	1 389	34 721	78.83	23.97	413.78	153 940	188 662
2008	1 294	32 354	74.44	22.34	423.72	155 106	187 459
2009	1 198	29 954	74.85	20.68	430.34	156 710	186 664
2010	1 102	27 541	75.26	19.01	437.02	158 324	185 866
2011	1 051	26 273	73.93	18.14	439.85	158 513	184 786
2012	1 001	25 026	72.60	17.28	443.24	158 871	183 897
2013	961	24 033	70.19	16.59	447.10	159 096	183 129
2014	923	23 068	67.77	15.93	451.81	159 580	182 648
2015	932	23 300	70.45	16.09	456.33	161 774	185 073
2016	944	23 597	71.14	16.29	462.16	163 779	187 376
1990–2016	***−81%***		***−65%***	***−86%***	***-***	***+70%***	***−14%***
2015-2016	***+1.3%***		***1.0%***	***+1.3%***	***+1.3%***	***+1.2%***	***+1.2%***

7.5.2 Methodological issues

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). Industrial wastewater treatment does not result in CH_4 emissions due to the well-managed, mainly aerobic treatment, and is thus reported as not applicable. N_2O emissions from the treatment and discharge of domestic and commercial wastewater (including industrial sources) are calculated applying a country-specific method, as described in chapter 7.5.2.2.

For calculation of CH_4 emissions only the share of population disposing the wastewater to septic systems (anaerobic conditions) is considered.

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 2016 the connection rate to wastewater treatment plants increased from 59% to 95%.

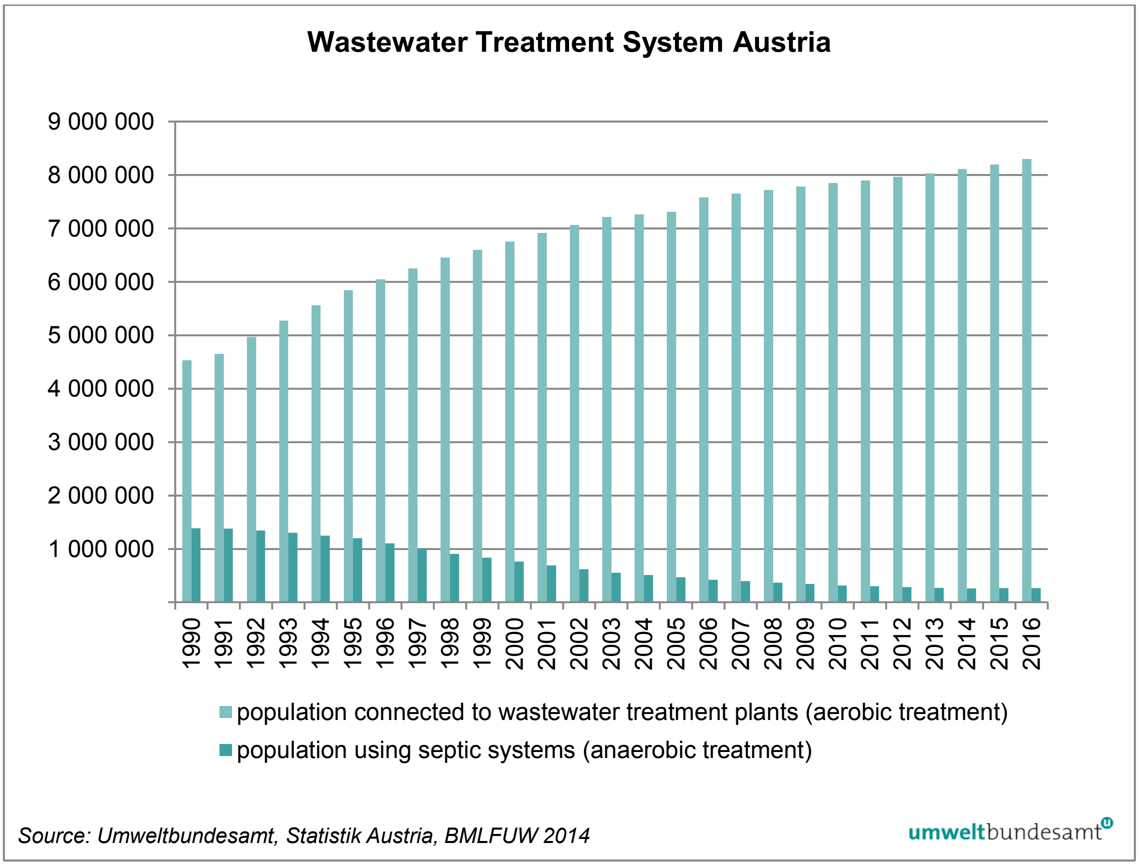

Figure 45: Domestic Wastewater Treatment in Austria.

In Austria sewage sludge treatment is carried out by aerobic stabilisation and anaerobic digestion. Under aerobic conditions (stabilisation), only a negligible amount of methane is produced. Methane gas produced in the digestion process is usually used for energy recovery or is flared. In order to prevent uncontrolled putrefaction, the sludge is stabilized. In smaller facilities such stabilization is usually carried out aerobically (open pool with oxygen input), in bigger plants stabilization is carried out anaerobically (in a digestion tower). The methane gas produced in the course of the anaerobic treatment is used for energy recovery in combined heat/power generation systems (CHP). In case of technical disruptions or overloads the methane gas is flared off. In both treatment methods, no significant amounts of methane emissions are released into the environment. Most of sewage sludge is incinerated (included in 1.A) or treated another way, in Austria mainly in composting and to a minor part in mechanical-biological treatment plants (included in 5.B). Smaller amounts are put on agricultural soils (included in 3.D). Small amounts are deposited after pre-treatment (included in 5.A).

7.5.2.1 CH_4 emissions

CH_4 emissions reported under *CRF 5.D Wastewater Treatment and Discharge* originate from 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 295: Share of population using septic tanks (1991–2014).

1991	2001	2003	2006	2008	2010	2012	2014
17.8%	8.6%	6.8%	5.1%	4.4%	3.8%	3.4%	3.1%

In the year 2014[113] 95.0% of the Austrian population is connected to municipal wastewater treatment plants. The remaining wastewater is treated either in septic tanks (3.1%), domestic wastewater handling systems (1.7%), 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 2016d). Data are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010, 2012 and 2014. The missing data was inter extrapolated, and after 2014 the value is considered constant, until new data will be available.

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*

7.5.2.2 N_2O emissions

N_2O emissions from *CRF 5.D. Wastewater Treatment and Discharge* are calculated using a

[113] the latest year for which data on connection rate is currently available

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 46.
- 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.

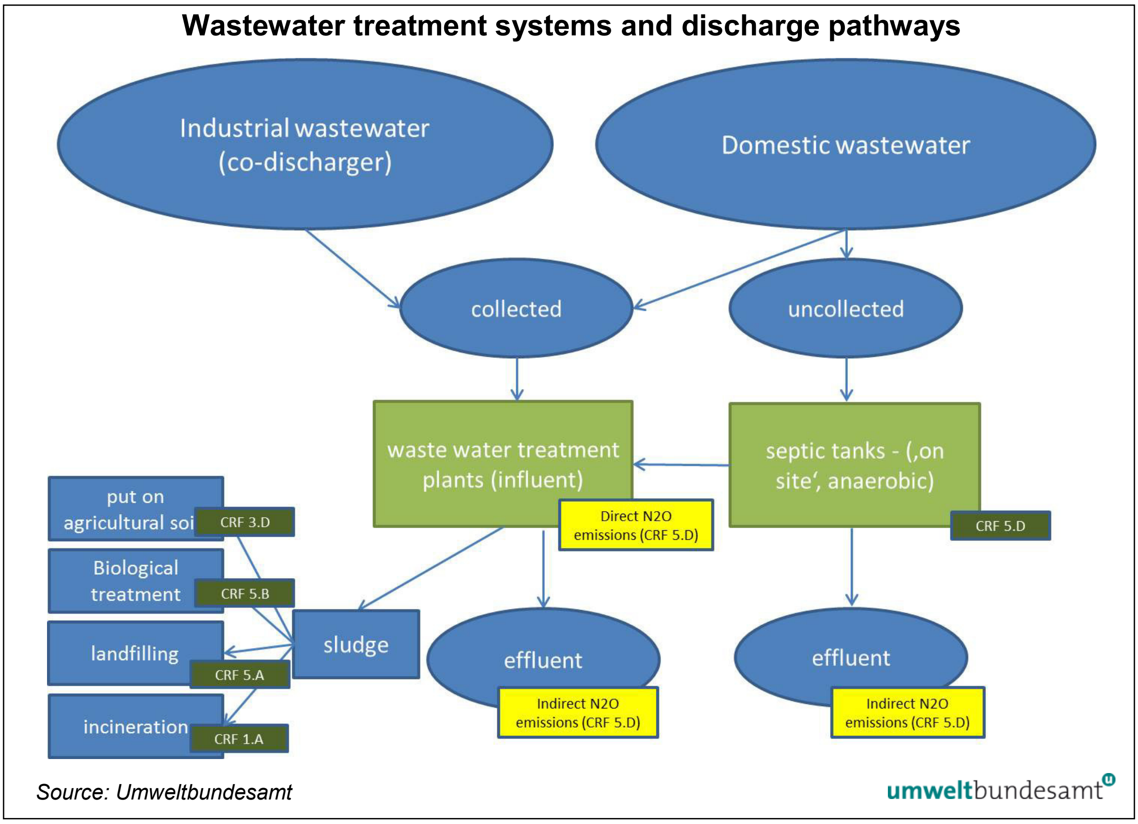

Figure 46: Wastewater treatment systems and discharge pathways (schematic illustration).

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)

$F_{IND\text{-}COM}$= 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. 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 2014, BMLFUW 2016d). Data are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010, 2012 and 2014; missing data were inter- or extrapolated. In the year 2014 – the latest year for which data on connection rate is currently available – 95.0% of the Austrian population was connected to municipal wastewater treatment plants. 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 2014 the denitrification rate reached a level of 82%, and in 2016 81%. This minor fluctuation is 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 (expert judgement by Umweltbundesamt (2015)). The $T_{CND-PLANTS}$ was calculated on basis of connection rates to the public sewage system (national statistics) and the assessed share of CND-plants in Austria.

Table 296: Activity data for calculation of direct N_2O emissions (plants).

	population	$T_{CND-PLANTS}$		Denitrification rate
		connection rate plants	share CND-plants	
	no.	[%]	[%]	[%]
1990	7 677 850	59%	0%	10%
1991	7 754 891	60%	0%	10%
1992	7 840 709	63%	0%	10%
1993	7 905 632	67%	0%	10%
1994	7 936 118	70%	12%	18%
1995	7 948 278	74%	24%	27%
1996	7 959 016	76%	36%	35%
1997	7 968 041	78%	43%	40%
1998	7 976 789	81%	51%	46%
1999	7 992 323	83%	59%	51%
2000	8 011 566	84%	71%	60%
2001	8 042 293	86%	83%	68%
2002	8 082 121	87%	83%	68%
2003	8 118 245	89%	83%	68%
2004	8 169 441	89%	83%	68%
2005	8 225 278	89%	89%	73%
2006	8 267 948	92%	96%	77%
2007	8 295 189	92%	97%	78%
2008	8 321 541	93%	99%	79%
2009	8 341 483	93%	99%	80%
2010	8 361 069	94%	100%	80%
2011	8 388 534	94%	100%	80%
2012	8 426 311	95%	100%	80%
2013	8 477 230	95%	100%	81%
2014	8 543 932	95%	100%	82%
2015	8 629 519	95%	100%	81%
2016	8 739 806	95%	100%	81%

$F_{IND-COM}$: 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. In 1990 only 10% of the nitrogen was removed, until 2014 this value has increased to 82% (BMLFUW 2016d).

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 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"[114]), an electronic register of material emissions to surface water bodies from point sources, especially municipal sewage treatment plants. It is administered by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) 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 and 2015. Data for the years in between had to be interpolated. For the years before 2001 as well as for 2013 and 2016 the $N_{EFFLUENT}$ was estimated using the connected population as an indicator.

$N_{EFFLUENT\ POPULATION}$ 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.

[114] 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)

Table 297: Activity data for calculation of N_2O from wastewater effluent.

	$N_{EFFLUENT\ PLANTS}$ [t N/yr]	$N_{EFFLUENT\ POPULATION}$ [t N/yr]	$N_{EFFLUENT\ TOTAL}$ [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
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	2.047	11.013
2016	9.054	2.074	11.127

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.

7.5.3 Uncertainties and time-series consistency

The uncertainty, originally based on ORTHOFER et al (1995), was reevaluated 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 298: Uncertainty assessment for CRF 5.D Wastewater Treatment and Discharge.

	CH_4	N_2O
Activity data	20%	20%
Emission factor	50%	100%

7.5.4 Category-specific QA/QC and verification

7.5.4.1 CH_4

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[115]. As the measurements have been carried out under conditions (air temperatures) similar to the average temperature of Austria the results can directly be compared 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

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, 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)[116] and published as a scientific article in Energy Procedia (Parravicini, V. et al 2016[117]).

Verification EF_{PLANTS}

As a QA and verification measure Austria plans to regularly evaluate plant specific N flows (in-

[115] A MCF value of 0.22 was calculated using the mean methane emission value measured for the septic tanks from this project

[116] 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.

[117] Parravicini V., Svardal K., Krampe J. (2016). Greenhouse Gas Emissions from Wastewater Treatment Plants. Energy Procedia, 97 (2016), S. 246 – 253.

fluent 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 Category-specific recalculations

For the year 2015, actual data for the nitrogen content in the effluent from waste water treatment plants became available (based on EMREG), which have been used to update the 2015 data. The revision of 2015 data resulted in +0.002 kt N2O.

Table 299: Recalculations with respect to previous submission for CRF 5.D Wastewater Treatment and Discharge.

Difference	1990	1991	1992	1993	1994	1995	1996	1997	1998
N_2O [kt CO_2e]	0	0	0	0	0.0	0	0	0	0
CH_4 [kt CO_2e]	0	0	0	0	0	0	0	0	0

Difference	1999	2000	2001	2002	2003	2004	2005	2006	2007
N_2O [kt CO_2e]	0	0	0	0	0	0	0	0	0
CH_4 [kt CO_2e]	0	0	0	0	0	0	0	0	0

Difference	2008	2009	2010	2011	2012	2013	2014	2015
N_2O [kt CO_2e]	0	0	0	0	0	0	0	0.002
CH_4 [kt CO_2e]	0	0	0	0	0	0	0	0

7.5.6 Category-specific planned improvements

No further improvements are currently planned for this category.

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 report any indirect CO_2 or N_2O emissions in CRF Table 6.

Indirect CO_2 from the atmospheric oxidation of CH_4, CO and NMVOC is only reported as NMVOC from *2.D.3 Solvent Use* in CRF Table 2(I)s2. Thus Austria continues to report indirect CO_2 in the sectoral report for solvents and other product use (previous CRF Table 3). For details please refer to chapter 4.5.2.3.

10 RECALCULATIONS AND IMPROVEMENTS

Recalculations of previously submitted inventory data are performed with the only 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.

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

In previous versions of the energy balance the category 1.A.4.a has been used as a 'residual' sector for the amount of fuels which could not be attributed to sectors by default. For the years 2012 to 2015 a new systematic has been applied by Statistik Austria for gas oil, residual fuel oil, LPG, natural gas, wood pellets and briquettes. The new systematic considers the amount of fuel which is not covered by bottom up statistics or census data in a different way. These amounts of fuels are now distributed to final energy consumption of 1.A.2 Manufacturing industries and

1.A.4 'other sectors' subcategories, depending on the estimated incompleteness (e.g. small companies which are not obliged to report energy consumption) or uncertainty (census data) of the fuel consumption in these sectors. These methodological changes do not affect total final consumption but imply shifts between 1.A.2 and 1.A.4 subcategories.

The energy balance was revised by Statistik Austria for the years 2003 to 2015 with the following main implications on energy consumption and CO_2 emissions:

- Natural gas has been shifted between final energy consumption, other energy industries and transformation input to power plants for the years 2011−2015 (between −0.1 to 3.1 PJ). As a result of the 2015 energy data revision this leads to -141 kt CO_2 from '1.A.1.c other energy industries', -29 kt CO_2 from '1.A.1.a public electricity and heat', +298 kt CO_2 from '1.A.2 manufacturing industries' and -129 kt CO_2 from '1.A.4 Other sectors'. Total 1.A natural gas consumption has not been affected in any year.
- For liquid fuels minor revisions have been made 2005 to 2015 (mainly shifts between 1.A.2 and 1.A.4 subcategories). As a result of the 2015 energy data revision, this leads to -36 kt CO_2 from '1.A.2 manufacturing industries' and +37 kt CO_2 from '1.A.4 Other sectors'.

  For 1999−2004, up to 81 kt CO_2 from liquid fuels have been shifted to gaseous fuels within category 1.A.1.b refinery because of the revision of refinery fuels within the energy balance.
- For solid fuels minor revisions have been made for the years 2002−2004 and category '1.A.1.a public electricity and heat production' (between +2 and +5 kt of CO_2). For 2005-2015 minor revisions have been made for category '1.A.2 manufacturing industries' (-74 kt CO_2 in 2015, of which about 41 kt have been shifted to category '2.C.1 Iron and Steel'), and category '1.A.4 Other sectors' (-16 kt CO_2 in 2015).
- For 'other fuels' the major revision of the energy balance took place for the years 2005 to 2013, which resulted in +48 kt higher CO_2 emissions from 'other fuels' in category 1.A.1.a public electricity and heat production in 2013. Other revisions of the energy balance resulted in +81 kt higher CO_2 emissions from 1.A.2.c Chemicals Industries – other fuels for the year 2015 and -129 kt lower CO_2 emissions for the year 2009.

Other methodological improvements

Other fuels (industrial waste) have been shifted from category 1.A.4.a to category 1.A.1.a for the years 1990 to 2000 in order to increase time series consistency of those sectors.

For 1.A.4.c – biomass the IPCC default CH_4 emission factor has been selected (previously a country specific factor has been used), which leads to +28 kt CO_2-equivalent in 1990 and +34 kt CO_2-equivalent in 2015.

CH_4 emissions from 1.A.4.a and 1.A.4.b – biomass are now based on a new energy demand model for space heating. The model considers more detailed technologies (boilers, ovens) and provides an improved time series consistency. The change in emissions is about -139 kt CO_2-equivalent in 1990 and +22 kt CO_2-equivalent in 2015.

10.1.1.2 Mobile sources

Update/Improvement of methodology, activity data and emission factors

Aviation (1.A.3.a)

Update of the aviation emission model for calculating emissions of 2016 including the newest

EMEP/EEA 2016 (Annex 5) emission factors. Flight movement data and the calculation of distances between airport pairs have been improved.

As a recalculation of the whole time series (1990-2015) with the updated emission model is not possible due to a lack of detailed data needed from now on and budgetary resources the result for 2016 cannot be compared with the result for 2015 of the submission 2017. An application of the updated emission model to all inventory years or a calibration to ensure a consistent time series is planned for the next submission in 2019.

Revision 2015: -0.13 kt CO_2e

Road transport (1.A.3.b)

Refined calibration of specific CO_2 emissions of newly registered PCs and LDVs registrations of all years by taking into account the special characteristics of fuels used in the type approval process. Increase in inland driving performance (on average +1%) due to an increase in specific moped mileage. From 2010 onwards revision of specific passenger car mileage for cars based on the latest statistical national survey.

For the year 2015 marginal changes in emissions are caused by a downward revision of the levels for liquefied petroleum gas (LPG) in the national energy balance.

The mentioned improvements lead to an overall increase of emissions (+17 kt CO_2e) for the year 2015.

Rail transport (1.A.3.c)

For the year 2015 changes in emissions (−12.7 kt CO2eq) are caused by revised levels for diesel in the national energy balance.

Fugitive emissions (1.B)

1.B.2.b.2 production

Recalculations in CO_2 emissions in the category 1.B.2.b.2 (production) for the years 2003-2015 are due to revision of data reported *by the Association of the Austrian Petroleum Industry*. Since 2003 emissions from this source were erroneously reported including not only fugitive emissions but also pyrogenic emissions by one company. This error was corrected and led to a total reduction of CO_2e emissions from this source of -52.5 kt CO_2e in 2015 (cumulative 680 kt CO_2e between 2003 and 2015).

10.1.2 Industrial Processes and Other Product Use (Sector 2)

Update of activity data

2.B.1 Ammonia Production

Due to updated data of urea used in traffic (see below, 2.D.3) as well as in agriculture (3.H) from 2005–2015, the time series for CO_2 emissions in sector 2.B.1 also changed to +5.2 kt CO_2e in 2015.

2. B.10.2 Other Chemical Industry

Due to a transcription error emissions for 2015 changed (-7.1 kt CO_2e).

2.C.3. Aluminium Production

Plant specific data have been updated from 2008 on. This lead to an improvement in the IEF from 2013 backwards. No changes in the emissions for 2014 and 2015.

2.B.10.i Chemical Industry – Other: Production of bulk chemicals

Due to a transcription error emissions for 2015 changed (−7.1 kt CO_2e).

2.D.3. Other

Carbon dioxide emissions from the use of urea in selective catalytic reduction in the transport sector, which had previously been reported under 2.G.4, are now reported under 2.D.3, in line with footnote 6 in CRF Table2 (I).A-Hs2. The revision resulted in 2015 in +21.7 kt CO_2e. The slight changes in CO_2 emissions from this use (marginal increases up to 2011, reductions from 2011 onwards) are not caused by changes in vehicle technology but by the use of the latest NEMO version. The use of the newest NEMO version (4.0.0 from November 2016) results in slight shifts between fuel consumption in inland and fuel export, which causes revised AdBlue© consumptions in fuel export due to the fact of the specific fleet composition in fuel export.

2.F.1. Refrigeration and Air Conditioning

Due to information provided by railway and tramway companies, refills of air conditioning with 134a during the lifetime of the equipment happens on a regular basis. Thus, 134a used for refills during the lifetime of equipment of railed vehicles was subtracted from total R 134a use, which affected amounts used in refrigeration and air conditioning (Commercial Refrigeration as well as Industrial Refrigeration). The change amounts to -41.6 kt CO_2e in 2015, and – 129.3 kt CO_2e in 2011).

2.F.1.d Transport Refrigeration

A transcription error was amended, which led to an increase of emissions in 2015 of 17.1 kt CO2e.

2.F.4. Aerosols – Metered Dose Inhalers

Updated producer information provided information on two types of inhalers that contain R 227ea instead of R134a. Thus, numbers of units with R 227ea were re-allocated and the exact amount of gas used per inhaler used. Emissions in 2015 were updated by 0.1 kt CO_2e.

2.G.2 Other product manufacture and use

Updated numbers on SF6 use for particle accelerators for 2015 led to an update of emissions in 2015 by +0.2 kt CO_2e.

2.G.4 Other

Carbon dioxide emissions from the use of urea in selective catalytic reduction are no longer reported under this category, but in category 2.D.3 instead, cf. above. For this reason emissions in 2015 are -26.5 kt CO_2e lower.

Improvements of methodologies and emission factors

2.C.3. Aluminium Production

Plant specific data have been updated from 2008 on. This lead to an improvement in the IEF from 2013 backwards. No change of 2014 and 2015 emissions.

2.C.1. Iron and Steel Production

The allocation for 2015 changed due to an update of the emissions, which were formerly occurring in the sector 1.A.2.a are now allocated to 2.C.1.a. This resulted in +41.1 kt CO_2e in 2015.

10.1.3 Agriculture (Sector 3)

Update of activity data

3.A Enteric Fermentation, 3.B Manure Management, 3.D Agricultural Soils

Milk yield data for dairy cows for the years 1991-1993 and 2001 was updated on the basis of official data from the Ministry of Agriculture (BMLFUW 2017). The revision resulted in slightly higher emissions for the years 1991-1993 and slightly lower emissions for 2001.

In 2017 new information on input materials for Austria's biogas plants became available (raw material balances for 2014 and 2015). The updated data were taken from (E-Control 2017) and resulted in revised amounts of digested manure and energy crops from 2012 to 2015 (latest available raw material balance used in a previous inventory was for 2011).

3.D.a.5 Mineralization/immobilization

Revisions of land-use data within sector LULUCF resulted in slightly decreased N_2O emissions in all reported years (-0.002 kt N_2Oe in 2015).

3.G Liming

The cropland and grassland areas for the years 2014 and 2015 were revised according to the results of the farm structure survey 2016 resulting in higher CO_2 emissions for 2014 (+0.1 kt CO_2) and lower CO_2 emissions for 2015 (- 0.2 kt CO_2).

3.H Urea Application

Revised 2015 data on urea consumption (AMA 2017) resulted in higher CO_2 emissions for the respective year (+2.9 kt CO_2).

Improvements of methodologies and emission factors

3.B Manure Management (CH_4)

Revised Tier 1 calculations of chicken and horses resulted in slightly increased emissions of CH_4 (+0.01 kt CH_4 in 2015)

3.D Agricultural Soils (N_2O)

3.D.b Agricultural Soils (indirect soil emissions – N_2O)

Austria's agriculture model is based on the N-flow concept. Thus, revisions within Austria's air emission inventory affect calculations of Austria's GHG inventory.

The correction of a linkage error in the calculation of NO-N losses from sewage sludge application resulted in slightly increased indirect N_2O emissions from atmospheric deposition of managed soils for the whole time series. The higher amount of urea fertilizers in 2015 as well as the revised activity data, as described before (milk yields and input to digesters), are other reasons for the slight increase of indirect emissions (both, atmospheric deposition and N leaching from managed soils) in the years 1991-1993 and 2012-2015 (+0.01 kt N_2O 2015).

10.1.4 LULUCF (Sector 4)

Revisions of the data series for LULUCF are due to the following changes:

4.A Forest land

The wildfire area and emission estimates for the year 2014 required a minor adjustment on basis of the latest available statistics.

4.B Cropland

The estimate of the (shares of) land-use changes between annual cropland, perennial cropland and grassland on basis of the IACS system was slightly changed. The estimate is now based entirely on a subset of land parcels in IACS which show constant areas and codes throughout the time series. This led to changes of the LUC areas between annual, perennial cropland and grassland and consequently to changes in the related emissions and removals from biomass and soil.

The measurements of country specific orchard biomass and vineyard biomass were completed and the significantly too high default values of perennial biomass growth rates, stocks and turn-over periods were replaced by these country specific values. Consequently, the emissions and removals by perennial biomass in cropland changed.

The assessment of the soil C stock changes in cropland remaining cropland was improved. The results of the C stock change rates for the agricultural experimental plots and their allocations to different management types (management factors) like tillage types and input types were revisited and revised. The methodological regime for separating the cropland into the different tillage and input types was further adjusted, e.g. by separating into combinations of three tillage types and variations of the input types and input combinations of low/high plant residues input, with/without manure input and with/without input from cover crops. These improvements led to lower C stock changes in the mineral soil of cropland compared to the last submission.

The 2014 and 2015 values of the cropland areas had to be updated according to the most recent agricultural statistics.

All the recalculations in the cropland category led to changes in the time series of annual emissions/removals of this subcategory in the range of -61 to 59 kt CO_2e per year.

4.C Grassland

The estimate of the (shares of) land-use changes between annual cropland, perennial cropland and grassland on basis of the IACS system was slightly changed. The estimate is now based entirely on a subset of land parcels in IACS which show constant areas and codes throughout the time series. This led to changes of the LUC areas between annual, perennial cropland and grassland and consequently to changes in the related emissions and removals from biomass and soil in the subcategory LUC from cropland to grassland.

The measurements of country specific orchard biomass and vineyard biomass were completed and the significantly too high default values of perennial biomass growth rates, stocks and turn-over periods were replaced by these country specific values. Consequently, the emissions by perennial biomass in the LUC subcategory perennial cropland to grassland changed.

The 2014 and 2015 values of the grassland areas had to be updated according to the most recent agricultural statistics.

All the recalculations in the grassland category reduced the annual emissions of this subcategory by -23 to -1 kt CO_2e per year.

4.D Wetlands

No revisions of the time series.

4.E Settlements

The estimates of the LUC shares from cropland and grassland to settlements were adjusted and led to minor changes in the emissions of the settlement subcategory (higher annual emissions of this subcategory by 0.1 to 17 kt CO_2e per year).

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4.F Other lands

No revisions of the time series.

4.G HWPs

A calculation error in the HWP estimates related to veneer sheets was corrected and led to minor changes in the removals from HWPs.

The HWP production figures for 2015 were updated in the most recent FAO statistic. Consequently, the removal figures for this year had to be updated accordingly.

The estimate of paper production from domestic wood was expanded by the wood pulp production/import/export according to equations 2.8.2 and 2.8.4 of the IPCC (2014) KP Supplement and the HWP time series was recalculated accordingly.

All the recalculations in the HWP category led to changes in the time series of annual removals of this subcategory in the range of -182 to 342 kt CO_2e per year.

LULUCF KP estimates

The wildfire area and emission estimates for the year 2014 required a minor adjustment on basis of the newest statistics.

A calculation error in the HWP estimates related to veneer sheets was corrected and led to minor changes in the removals from HWPs.

The HWP production figures for 2015 were updated in the most recent FAO statistics. Consequently, the removal figures for this year had to be updated accordingly.

The estimate of paper production from domestic wood was expanded by the wood pulp production/import/export according to equations 2.8.2 and 2.8.4 of the IPCC (2014) KP Supplement and the HWP time series was recalculated accordingly.

All these recalculations led to changes in the annual removals of forest management for the years 2013 to 2015 in the range of -46 to 333 kt CO_2e per year.

10.1.5 Waste (Sector 5)

Update of activity data

5.D Wastewater Treatment and Discharge

For the year 2015, actual data for the nitrogen content in the effluent from waste water treatment plants became available (based on EMREG), which have been used to update the 2015 data. The revision of 2015 data resulted in +0.002 kt N_2O.

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, thus emission data for 1990 to 2015 which are submitted this year differ slightly from data reported previously.

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).

2015 emissions of N_2O, CH_4 and fluorinated compounds were revised upwards, whereas emissions of CO_2 and fluoriated compounds were revised slightly downwards.

Table 300: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission.

	1990	2015
	Recalculation Difference [%]	
Total	**−0.15%**	**0.01%**
CO_2	0.00%	−0.03%
CH_4	−1.03%	0.86%
N_2O	−0.12%	0.28%
HFC, PFC, SF_6, NF_3	0.00%	−2.04%

without emissions fromLULUCF

Table 301: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission by sector

	Submission 2018		Submission 2017		Recalculation Difference	
THG	**1990**	**2015**	**1990**	**2015**	**1990**	**2015**
	[Mt CO_2e]		[Mt CO_2e]		[Mt CO_2e]	
Total	**78.69**	**78.86**	**78.80**	**78.85**	**-0.115**	**0.005**
Energy	52.91	53.35	53.03	53.35	-0.11	0.00
IPPU	13.66	16.67	13.66	16.68	0.00	-0.01
Agriculture	8.19	7.18	8.19	7.17	0.00	0.01
Waste	3.93	1.66	3.93	1.66	0.00	0.00

National total emissions (excluding LULUCF) for the base year **1990** have been slightly revised downwards since last years' submission (−115 kt CO_2e), mainly because of the revised estimate submitted for *Energy* due to methodological improvements.

Revised total emissions for **2015** are 0.01% higher (+5 kt CO_2e) than the value submitted last year, mainly because of updated activity data in the *Agriculture* sector.

A description of all recalculations by each sector is given in Chapter 10.1 as well as the relevant sectoral methodological chapters.

Table 302 presents the recalculation differences of national total GHG emissions for all years.

Table 302: Recalculation Difference of National Total GHG Emissions.

Year	National Total GHG emissions without LULUCF			
	Submission 2017 [kt CO_2e]	Submission 2016 [kt CO_2e]	Recalculation Difference [kt CO_2e]	Recalculation Difference [%]
1990	78 690	78 805	-115	-0.15%
1991	82 496	82 631	-135	-0.16%
1992	75 796	75 925	-129	-0.17%
1993	75 855	75 968	-113	-0.15%
1994	76 393	76 501	-108	-0.14%
1995	79 730	79 815	-85	-0.11%
1996	82 924	83 031	-107	-0.13%
1997	82 461	82 494	-33	-0.04%
1998	81 757	81 790	-33	-0.04%
1999	80 055	80 171	-116	-0.14%
2000	80 432	80 534	-102	-0.13%
2001	84 510	84 584	-74	-0.09%
2002	86 199	86 251	-52	-0.06%
2003	91 817	91 908	-90	-0.10%
2004	91 575	91 674	-99	-0.11%
2005	92 655	92 642	13	0.01%
2006	89 832	89 798	33	0.04%
2007	87 103	87 072	30	0.03%
2008	86 951	86 923	28	0.03%
2009	80 119	80 249	-129.9	-0.16%
2010	84 931	85 059	-128	-0.15%
2011	82 450	82 697	-247	-0.30%
2012	79 917	80 038	-121	-0.15%
2013	80 178	80 150	28	0.03%
2014	76 442	76 381	60	0.08%
2015	78 856	78 851	5	0.01%

10.3 Implications for emission trends, including time series consistency

As can be seen in Figure 47, Austria's GHG emissions reported this year (2018) in sum differs only slightly from the data submitted last year (2017). The national total (excl. LULUCF) for the base year is 0.15% (115 kt CO_2e) lower than reported last year; the national total (excl. LULUCF) for 2015 is +0.01% (5 kt CO_2e) higher than the value submitted last year.

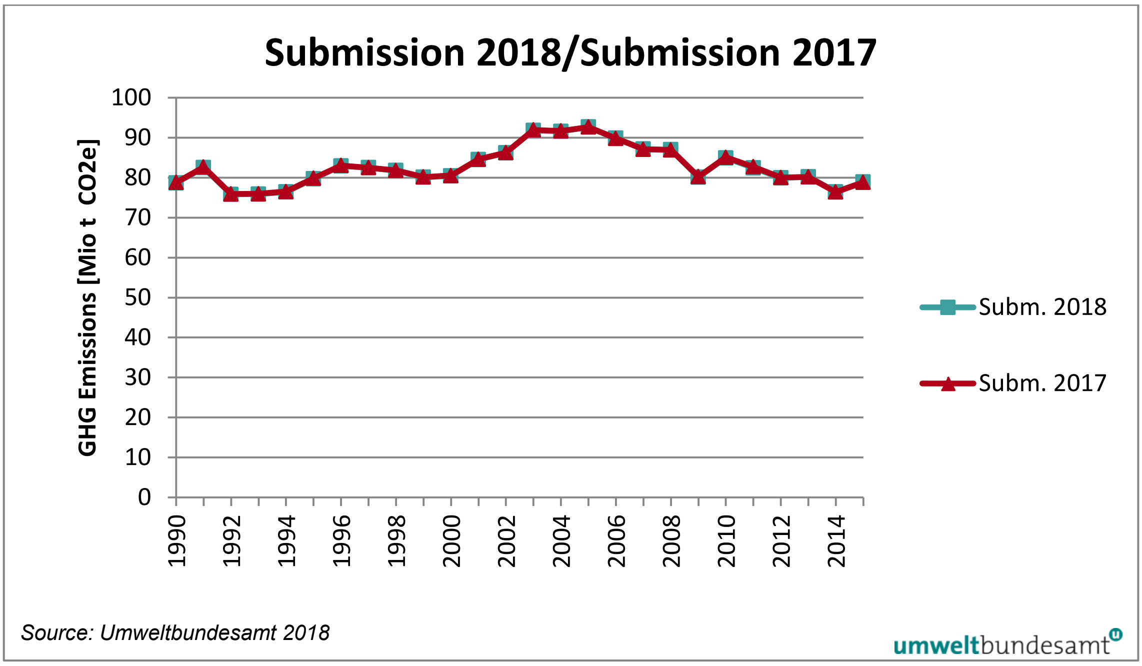


Figure 47: Comparison of GHG emissions - submission 2018/submission 2017.

10.4 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.

10.4.1 Planned improvements

Source specific planned improvements are presented in the respective subchapters of Chapters 3–7.

10.4.2 Improvements made in response to the review process

In 2017, Austria was not reviewed by the UNFCCC. The results of the centralised review conducted in 2016, were published 31 May,2017. Below the improvements made in response to the issues raised in the UNFCCC review process are summarized in Table 303.

Table 303: Improvements made in response to the UNFCCC Review.

Finding	Reference	Improvement made	Chapter
General			
Key category analysis: The Party did not include a key category analysis excluding LULUCF in its NIR (page 42, table 8)	ARR 2016	A key category analysis excl LULUCF is now not only included in the Annex, but also in chapter 1.5	Chapter 1.5
CRF: CRF table 9 (Completeness – Information on notation keys) currently provides explanations for the N2O and CH4 transportation emissions that are reported as "IE". The ERT notes that the notation key "IE" is used in other areas of the CRF tables (for example; fugitive emissions of N2O from fuel, CO2 emissions from petrochemical and carbon black production, CH4 emissions from iron and steel production and N2O emissions from industrial wastewater)	ARR 2016	The table has been updated.	CRF Table 9
CRF Summary3s1 and Summary3s2 tables for all years display the notation keys "NA" or "NO" for most cells within the table instead of the notation keys specific to the method applied or the emission factor used, as per instructions for this table. The ERT recommends the Party to complete the CRF Summary3s1 and Summary3s2 tables in its next inventory submission using the indicated notation keys to specify the method applied and the emission factor used.	ARR 2016	Summary3 should now contain the methods for all relevant sectors and pollutants.	CRF Table 3s1 and 3s2
QA/QC and verification: The ERT notes several inconsistencies found between the NIR and the CRF tables, and therefore recommends that the Party enhance its QC practices, or the application of its existing practices, in order to ensure consistency between the NIR and the CRF tables in the next submission.	ARR 2016	Sector experts and the report coordinator have been made aware of these inconsistencies. Checks will be enhanced for the NIR 2018 to ensure consistency between CRF tables and the report.	Chapters 3-7
Energy			

1.A.1.a Public electricity and heat production – CO2: Austria used an IPCC 2006 tier 2 methodology to estimate emissions using emission factors from country studies by the Federal Ministry for Economic Affairs and Labour (1990, 1996) and the Austrian Environment Agency (2002). The CO2 emission factor used for CO2 emissions from industrial waste incineration was 104.17 t/TJ (1990–1999), 78.11 t/TJ (2014). The 2006 IPCC Guidelines default emission factor is 143.0 t/TJ with a 95% confidence interval from 110.0 t/TJ to 183.0 t/TJ. To estimate CO2 emissions from other waste, an emission factor of 52.09 t/TJ was used. However, the default emission factor is 91.7 t/TJ with a range from 73.3 t/TJ to 121.0 t/TJ. During the review, the Party explained that it considered 90% carbon content and 10% biomass content as the reason for the lower emission factor The ERT notes the explanation provided by Austria and recommends that such explanatory notes be provided to improve transparency	ARR 2016	A new unpublished study for has shown that the selected C-contents are valid.	Chapter 3.2.9.3 in NIR 2017 and NIR 2018
1.A.1.c Manufacture of solid fuels and other energy industries – CO2, CH4: The emission estimate for CH4 and CO2 is based on the default carbon content from the Revised 1996 IPCC Guidelines for peat, sewage sludge, black liquor, biogas, sewage sludge gas and landfill gas (non-fossil), as reported in the 2016 NIR (pages 86 and 87). During the review, Austria explained to the ERT that the 2006 IPCC Guidelines will be used from the 2017 submission onwards The ERT recommends that Austria use the 2006 IPCC Guidelines default carbon content if country specific or plant/fuel level studies are not available and report the estimates	ARR 2016	For peat and all types of biomass the IPCC 2006 default emission factors have been applied.	NIR 2017 and NIR 2018, chapter 3.2.10.3

1.A.2.c Chemicals – Industrial waste and other waste – CO2: Austria used an IPCC 2006 tier 2 methodology to estimate emissions using emission factors from country studies by the Federal Ministry for Economic Affairs and Labour (1990, 1996) and the Austrian Environment Agency (2002). The CO2 emission factor used for CO2 emissions from industrial waste incineration was 104.17 t/TJ (1990–1999), 78.11 t/TJ (2014). The 2006 IPCC Guidelines default emission factor is 143.0 t/TJ with a 95% confidence interval from 110.0 t/TJ to 183.0 t/TJ. To estimate CO2 emissions from other waste, an emission factor of 52.09 t/TJ was used. However, the default emission factor is 91.7 t/TJ with a range from 73.3 t/TJ to 121.0 t/TJ. During the review, the Party explained that it considered 90% carbon content and 10% biomass content as the reason for the lower emission factor The ERT notes the explanation provided by Austria and recommends that such explanatory notes be provided to improve transparency	ARR 2016	The explanation provided during the review has been added to the respective chapter.	NIR 2018, chapter 3.2.11.3
1.A.2.a Iron and steel – CO2: Austria explained in the NIR (page 76) that the emissions from residual fuel oil used in blast furnaces were included in the metal industry category (2.c). There was further information from Austria that 10.1 Mt CO2 emissions were reported under iron and steel production (2.c.1) in the IPPU sector, while 1.4 Mt of CO2 emissions were reported in the energy sector (1.A.2.a). During the review, Austria informed the ERT that the emissions allocated in iron and steel production were from fuels used as reductants in blast furnaces The ERT notes the justification of the emission allocation and encourages Austria to provide explanations	ARR 2016	Additional information has been added to the NIR.	NIR 2018, chapter 3.2.11.1
1.A.3.b Road transportation – biomass – CH4 and N2O: Report N2O and CH4 emissions from biomass separately: Report N2O and CH4 emissions from biomass separately	ARR 2016	From the submission 2018 onwards CH4 und N2O from biofuels are separately reported in the CRF tables.	Chapter 3.2.12, CRF table 1.A(a)s3
Fugitive Emissions			
No recommendations were raised during the Centralized Review 2016			
IPPU	ARR 2016		

2.A.3 Glas Production-CO2: The Party reported in its NIR (chapter 4.2.3.2, page 193) that it uses the default emission factors for soda ash, limestone and dolomite for the calculation of the emissions from 1990 to 2004. The emission factors were based on the 2006 IPCC Guidelines (table 2.1, page 2.7), and those used for the calculation and reported in the NIR are rounded compared with the default emission factors and did not agree with the exact values The ERT recommends that Austria use the exact default emission factors from the 2006 IPCC Guidelines to improve accuracy	ARR 2016	Austria now applies the detailed default EFs of the IPCC 2006 Guidelines in its calculations.	Chapter 4.2.3.2
2.A.4 Other process uses of carbonates – CO2: Austria reported magnesia sinter production in the wrong part of the CRF table (2.A.4.d). In response to a question by the ERT, Austria explained that the allocation was an error and should in fact be reported under 2.A.4.c The ERT recommends that Austria reallocate the emissions from magnesia sinter production to 2A.4.c	ARR 2016	This recommendation was implemented as discussed - sintered magnesium is now reported under 2.A.4c.	CRF table 2(I).A-Hs1, Chapter 4.2.4.3
2.A.4 Other process uses of carbonates – CO2: The Party reported emissions from the production of bricks and tiles, but noted that there is no methodology for estimating emissions from brick production in the 2006 IPCC Guidelines. However, the 2006 IPCC Guidelines do provide a general method which can also be used for bricks (chapter 2.5, other process uses of carbonates). The Party informed the ERT during the review that from 2005 onwards, verified CO2 emissions reported under the EU ETS were used and for 1998 to 2001 emissions were calculated based on carbon contents in raw material used in the various facilities. For the intermediate years, the same IEF was applied The ERT recommends that for more transparency Austria implement this information in its next NIR and explain and identify which method from the 2006 IPCC Guidelines was used to calculate these emissions	ARR 2016	Information on the Tier method used is now included in the respective NIR chapter.	Chapter 4.2.4.12

2.A.4.a Other process uses of carbonates – CO2: The Party reported emissions from the production of bricks and tiles, but noted that there is no methodology for estimating emissions from brick production in the 2006 IPCC Guidelines. However, the 2006 IPCC Guidelines do provide a general method which can also be used for bricks (chapter 2.5, other process uses of carbonates). The Party informed the ERT during the review that from 2005 onwards, verified CO2 emissions reported under the EU ETS were used and for 1998 to 2001 emissions were calculated based on carbon contents in raw material used in the various facilities. For the intermediate years, the same IEF was applied. The ERT recommends that for more transparency Austria implement this information in its next NIR and explain and identify which method from the 2006 IPCC Guidelines was used to calculate these emissions	ARR 2016	Additional information has already been included in the National Inventory Report 2017.	Chapter 4.2.4.1
2.B.1 Ammonia production – CO2: […] The ERT recommends that Austria explain how the CO2 emissions from fertilizer production are allocated. Furthermore, the ERT encourages the Party to include in the description of products contained in the chapter on ammonia production, links to the relevant chapters or to include an explanation of the emissions of CO2 from urea, nitric acid and fertilizer production	ARR 2016	Austria included in the chapter for ammonia production a description of the different products produced, and also implements information on the occurance of CO_2 emissions from fertilizer production.	Chapter 4.3.1, Figure 23
2.B.1 Ammonia production – recovered CO2: […] The ERT recommends that Austria change the notation key for the recovery of CO2 from ammonia production from "NO" to the sum of CO2 bound in these three products (melamine, fertilizer and urea)	ARR 2016	As discussed with the ERT, the sum was not included, as it contains confidential data, and is a downstream process rather than a recovery. There is no CO_2 recovered as such, thus these emissions are continued to be reported as NO.	Chapter 4.3.1.2, Table 131

2.B.8 Petrochemical and carbon black production – CO2: Austria reported only ethylene production for petrochemical production under category 2.B.8. All other petrochemicals are reported as "NO". Austria explained in the 2016 NIR that: "all by-products are returned to the refinery. As the refinery and its related emissions are covered under sector 1, all CO2 emissions related to by-products of ethylene production are reported in this sector" The ERT recommends that the Party contact the producer to confirm that only ethylene is produced or to use publicly available information. The ERT also recommends that Austria implement a transparent explanation as to why only ethylene is produced in this refinery and no other products such as propylene, or that it provide estimates if new information is available	ARR 2016	An explanation is included in the NIR.	Chapters 4.3.4.1 and 4.3.4.2
2.C.3 Aluminium production – SF6: The Party still reports in chapter 4.4.4 of the 2016 NIR (SF6 used in aluminium and magnesium foundries (2.C.4)) SF6 emissions from secondary aluminium production and magnesium production, in accordance with the Revised 1996 IPCC Guidelines; however, according to the 2006 IPCC Guidelines and the 2006 IPCC Guidelines secondary aluminium production must be reported under CRF category 2.C.3, production of aluminium. The Party further reported the SF6 emissions from secondary aluminium production under CRF category 2.C.7 (as Aluminium casting). The ERT notes that in CRF table 2(II).B under source category 2.C.3 there is a subcategory "F-gases used in foundries" with a footnote indicating that according to the 2006 IPCC Guidelines, possible SF6 emissions from casting are to be included under magnesium production The ERT recommends that Austria reallocate the SF6 emissions from CRF category 2.C.7 to CRF category 2.C 3, production of aluminium/F-gases used in foundries, for more transparency and comparability. The ERT also recommends that Austria amend its reporting in chapter 4.4.4 as it still includes the old nomenclature and improve chapter 2.C.3	ARR 2016	Austria has adapted its reporting and amended the relevant chapters in the NIR accordingly.	Chapters 4.4.3

2.C.4 Magnesium production – SF6: The Party reported on magnesium production on page 220 of the 2016 NIR that "Industry introduced alternative cover gases in the last years" but reported only SF6 emissions. During the review, Austria explained to the ERT that this information is misleading. The company producing magnesium is now producing less than before and has optimized its furnace. Therefore less or no SF6 is needed, as fewer fires break out The ERT recommends that Austria obtain confirmation from the company producing magnesium that no other gases are used, and include this information in the NIR for more transparency. Furthermore, the ERT recommends that Austria explain in its next NIR why for some years the company had reported no consumption of SF6		Austria has included more detailed information on this, including on the decreasing trend of SF_6, in its NIR 2017.	Chapter 4.4.4
2.F.1 Refrigeration and air conditioning – HFCs: Include a more detailed and transparent description as to where emissions of HFC-23 are included	ARR 2016	The description has been improved in the National Inventory Report 2017.	Chapters 4.7.2.1 and 4.7.2.3.
Agriculture			
<u>3.D.Direct and indirect N2O emissions from agricultural soils – N2O</u>: Austria used weighted annual nitrogen sales data for each of the years 1989 and 1990 as the basis for calculating the weighted values of 1990. During the review, questions were raised about this and about the use of fertilizer sale prices. Austria explained that it had previously used statistics on fertilizer use without employing a smoothing algorithm, resulting in high inter-annual variations in N2O emissions. In response to the questions raised during the review, Austria stated that the weighted nutrient consumption (t N/year) and the weighted urea consumption (t N/year) figures were developed by calculating the simple average of the two years. The sales figures for 1989 and 1990 were used as the basis for calculating the weighted values for 1990. Austria explained that the method was chosen in order to reduce the effects of storage due to the high elasticity of annual sales figures to marked prices In the 2012 recommendation, Austria indicated that the use of fertilizer sales is fully in line with the 2006 IPCC Guidelines (11.2.1.3) and stated that weighting nutrient consumption data based on official statistics is a reasonable approach The ERT found the explanation provided by Austria to be acceptable; however, it underlined the need for enhancing the transparency of the methodologies used. The ERT recommends that Austria provide an explanation (including information provided during the review) of the methodology in the NIR	ARR 2016	The explanation in the NIR has been improved.	Chapter 5.4.2

LULUCF			
4. General (LULUCF): Use the results of the uncertainty analysis to prioritize the aspects of the inventory that require refinement, in order to improve the accuracy and possibly to reduce the overall uncertainty of the LULUCF inventory	ARR 2016	Austria uses almost exclusively country-specific methods and emission factors. The most relevant LULUCF subcategories are estimated with Tier 3 methods. Therefore, further improvements are hardly possible.	NA
4.A.1 Forest land remaining forest land – CO2: Enhance the description of the method used to report carbon stock changes in litter and dead wood separately in the dead organic matter and soil pools categories in the annual submission. For example, by including references in the documentation box in the CRF tables, in order to improve the transparency of the reporting	ARR 2016	Information has been added in the documentation box of CRF table 4.A and in the NIR	CRF table 4.A, Chapter 6.2.4.1
4.B.1 Cropland remaining cropland – CO2: Austria has refined the methodology for the calculation of soil carbon stock change in annual cropland remaining annual cropland and perennial cropland remaining perennial cropland. The new approach calculates the soil carbon stock change for five different cropland management types with impact on the removals in some years of the temporal series. The Party has included detailed information on the emission factor for different cropland management; however, for transparency, the ERT considers it necessary to include information on activity data of different cropland management types The ERT recommends that Austria include information on the activity data of the different cropland management types	ARR 2016	Additional information on activity data has been included in the NIR.	Chapter 6.3.4.1.4

4.D.1 Wetlands remaining wetlands – Gen: The ERT noted a brief description of the subcategory other wetland remaining other wetland, and this subcategory contains the information on flooded land remaining flooded land, bogs, and rivers and lakes. However, the ERT observed a lack of consistency in the information on notation keys in flooded land remaining flooded land. The Party indicated in its NIR the use of the notation key "IE" of flooded land remaining flooded land, because activity data are contained in the subcategory other wetland remaining other wetland and CRF tables contain the notation key "NE". The Party has information only on activity data and the 2006 IPCC Guidelines indicate that the notation key "IE" is used for emissions by sources and removals by sinks of GHGs estimated but included elsewhere in the inventory instead of under the expected source/sink category The ERT recommends that Austria improve the description of the category wetlands remaining wetlands, obtain the activity data for flooded land remaining flooded land and use the correct notation in its next NIR and the CRF tables	ARR 2016	The description has been improved in 2018, as well the correct use of notation keys in the CRF Table 4.D has been checked.	Chapter 4.D.1, CRF Table 4.D
Waste			
5.A.1 Managed waste disposal sites – CH4: Austria uses a value of 0.55 for the fraction of CH4 in generated landfill gas (fluorine), according to table 268 in the 2016 NIR (page 441). As a reference for this value, Austria refers to "mean value cited in literature, also within the IPCC range". There is no range included in the 2006 IPCC Guidelines, only a default value of 0.50. In response to a question from the ERT, Austria confirmed that the sentence in the NIR was referring to the range of the default value in the Revised 1996 IPCC Guidelines The ERT recommends that Austria include the references from which the country-specific value was derived in the description in the NIR (references were provided during the review). The ERT also recommends that Austria include a justification of the deviation from the 2006 IPCC Guidelines default percentage and recommends that it provide a source for the figure of 0.55 cited or provide revised estimates using the IPCC defaults	ARR 2016	References for the country specific value have already been included in the NIR	Chapter 7.2.2.2. Emission Parameters

5.C.1 Waste incineration – CO_2: In response to a question on the high inter-annual change of the implied CO_2 emission factor for the incineration of non-biogenic MSW (5.C.1.B) between 1990 (162.4 kg/t waste), 1991 (143.2 kg/t waste) and 1992 (1,383.6 kg/t waste), Austria explained that the activity data for 1990 and 1991 in the CRF tables were erroneous and stated that it would correct this in its next submission. The activity data should be 31 kt for 1991, resulting in an IEF of 754 kg CO_2/t waste. Austria explained that the increase in the IEF between 1992 and 1993 was caused by the change in the composition waste streams that were incinerated between 1991 (including MSW, clinical waste and waste oil) and 1992 (including clinical waste and waste oil but excluding MSW) The ERT recommends that Austria correct the AD for 1990 and 1991	ARR 2016	The activity data für 1990 and 1991 have been corrected in the CRF.	CRF 5.C
5.C.2 Open burning of waste – CO_2, CH_4 and N_2O: Austria did not provide information on the use of the notation key "NO" for emissions of open burning of waste in the NIR. In response to a question raised during the review, Austria explained that national legislation includes the prohibition of burning outside stationary combustion facilities The ERT recommends that the Party include a paragraph in the NIR with information on the national prohibition of open burning with references to the national legislation	ARR 2016	Austria did not provide information on the use of the notation key "NO" for emissions of open burning of waste in the NIR. In response to a question raised during the review, Austria explained that national legislation includes the prohibition of burning outside stationary combustion facilities The ERT recommends that the Party include a paragraph in the NIR with information on the national prohibition of open burning with references to the national legislation	Chapter 7.4.1
Forest Management			
Forest management – CO_2: Austria intends to apply the provisions to exclude emissions from natural disturbances for the accounting on forest management under Article 3, paragraph 4, of the Kyoto Protocol. The Party calculated the background level and the margin considering all natural disturbances, without details of different types of natural disturbances. For transparency, the ERT considers it important to provide information on the types of natural disturbance. During the review, the Party provided the information on natural disturbances (wildfires, insects, and snow and storms) and noted this will be included in the next submission The ERT recommends that Austria provide information on natural disturbance types whose emissions the Party wishes to exclude from accounting during the commitment period	ARR 2016	A figure on 'Annual natural disturbance emissions in Austria' has already been included in the National Inventory Report 2017.	Chapter 11.5.2.4 Information related to the natural disturbances provision under Art. 3.4

Forest management – CO_2: The description of the technical correction of "updated expansion ratios" is not clear. During the review, the Party provided a detailed explanation and noted that this description will be included in its next NIR The ERT recommends that Austria enhance the description of the technical correction of "updated expansion ratios"	ARR 2016	Additional information has already been included in the National Inventory Report 2017	Chapter 11.5.2.3 Technical corrections of FMRL
KP-LULUCF: KL.1 Article 3, paragraph 3, activities – CO_2: Explain the approach used and the time period threshold to show how harvesting or disturbances, and replanting or regrowth are distinguished from deforestation	ARR 2016	Further explanation will be provided in the NIR.	Chapter 11.4

PART 2: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 KP-LULUCF

11.1 General information

GHG emissions and removals arising from land use, land use change and forestry activities reported under the Kyoto Protocol (incl. HWP) are presented in Table 304.

Table 304: Emissions and removals (+/-) reported under the Kyoto-Protocol (incl. HWP).

	Greenhouse gas emissions/removals [kt CO_2e]			
Activity	**2013**	**2014**	**2015**	**2016**
Afforestation/reforestation	-2 018	-2 032	-2 065	-2 097
Deforestation	536	525	518	512
Forest management	-3 480	-3 672	-3 518	-3 270

11.1.1 Definition of forest and any other criteria

The National Forest Inventory (NFI) of Austria constitutes the main source of input data for calculating LULUCF greenhouse emissions/removals. Consequently, for the purpose of consistency, the applied forest definition for reporting follows the definitions used within the NFI (Table 305).

Table 305: Selected parameters defining forest in Austria for the reporting which are the same as according to the NFI of Austria (FBVA 2001).

Parameter	**Range**	**Selected value**
Minimum land area	0.05–1 ha	0.05 ha
Minimum crown cover	10–30%	30%[1]
Minimum height	2–5 m	2 m[1]
Average width		> 10 m

[1] (*in situ*, i.e. potential of the standing stock to reach this threshold)

In addition to areas satisfying the criteria in Table 305, permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades, forest roads) also represent forests.

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 considered as forests but represent rather cropland. Rows of trees and areas with woody plants in a park structure are also not considered forest land.

In accordance with the Austrian Forest Act all forests are managed in Austria. Natural forests in sense of the decisions for the 2nd commitment period do not exist in Austria. Therefore, conversion from natural forests to plantations do not occur in Austria.

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

As reported in the Initial Report[118] Austria decided not to elect any of the activities under Article 3.4 of the Kyoto Protocol. However, for the second commitment period reporting of forest management (FM) under Art. 3.4. has become mandatory.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each mandatory and elected activity under Article 3.4 have been implemented and applied consistently over time

The area of forest land reported as *Afforestation/Reforestation, Deforestation and Forest Management* (ARD) under the Kyoto Protocol has the same basis as the area reported for the land use changes (LUCs) from and to forests in the UNFCCC greenhouse gas inventory, though taking the different time frame (ARD areas starting with 1990) as well as the permanence of ARD areas into account. All LUC from and to forests are considered to be direct human-induced ARD. Afforestation and reforestation (AR) activities are reported together. A justification for that is given in Chapter 11.4.1. The *Forest Management* (FM) areas and FM emissions/removals represent the total forest land area in Austria minus the ARD areas and their respective emissions/removals.

The data on ARD and FM areas is calculated from the NFIs and the ARD NFI 2011/13 (an extension of the NFI for the purpose of KP reporting) and is available for the whole time series to be reported (see chapter 11.2.1). Since the NFI period 1981–85 the NFI uses a permanently marked grid system (see next chapter). For this reason ARD and FM activities are assessed at the same grid points and sample plots at each inventory period. Definitions and the methods of assessment have remained stable since 1990. This guarantees consistency in the statistical approach and in the assessment over time. The most recent assessment regarding ARD activities/lands and their emissions was the ARD NFI 2011–13.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

Austria has not chosen any voluntary Art. 3.4 activity. So, only the mandatory Art. 3.4 activity FM is reported by Austria.

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3 and Article 3.4

The information on ARD and FM areas is based on the assessments of the Austrian NFI and the ARD NFI (NFI – (BFW 2013, 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 and 2007–09 covering the total forest area. In the period 2011-2013 a re-

[118] http://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/pdf/at-initial-report-200611-corr.pdf

duced ARD NFI was carried out at the previous ARD areas and at the new ARD areas since the NFI period 2007-09. The NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and the ARD NFI period 2011/13 are the relevant ones for reporting the ARD and FM activities and their emissions/removals. The ARD NFI assessment 2011/13 was finalised in 2014. On basis of these new ARD NFI results, the ARD activity data, emission factors and emission/removal estimates were revised for the 2014 submission. It is important to note that the ARD NFI is not a full forest inventory but rather a resampling at plots where af-/reforestation and deforestation took place. Therefore the ARD NFI does not provide input data for FM.

A statistical approach is used to estimate the total area of ARD and FM units following Reporting Method 1 of the IPCC (2014) KP Supplement.

The NFI uses since NFI 1981-85 a permanently below ground marked 4 x 4 km grid across all of Austria (see Figure 33 in UMWELTBUNDESAMT 2010a or at BFW 2005, http://www.bfw.ac.at/rz/bfwcms.web?dok=2384) with four permanent 300 m^2 sample plots at each grid point (see Figure 34 in UMWELTBUNDESAMT 2010a or „Abbildung 1" in the download of HAUK & SCHADAUER 2009). Details are described in HAUK & SCHADAUER (2009). 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. 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%. Each grid point shown in Figure 33 in UMWELTBUNDESAMT (2010a) or at BFW (2005, http://www.bfw.ac.at/rz/bfwcms.web?dok=2384) is terrestrially inspected during each NFI assessment for a potential af-/reforestation, except grid points that are not suited to cover forests (e.g. grid points at glaciers or at permanent surface water bodies). Therefore, the spatial assessment unit for the submission of the Kyoto Protocol LULUCF tables covers the entire territory of Austria. NFIs with a grid of permanent sample plots (which allow a separate assessment of LUCs to forests and LUCs from forests) were carried out in the periods 1981–85, 1986–90, 1992–96, 2000–02, 2007–09 and – as ARD NFI – in the period 2011–13 (in the period 2011–13 no full NFI, but only a survey at NFI plots with ARD was carried out – see below). This means that starting with the results of NFI 1986-90 the ARD-areas are explicitly measured and known.

In the years 2011 to 2013 a reduced NFI was carried out only at all NFI plots which had ARD activities according to previous NFIs. In addition, all NFI grid points and plots were inspected which indicated potential ARD activity on the basis of an assessment of latest aerial images for Austria for the period after the last NFI (2007/09). The NFI grid points and plots were checked in these latest aerial images for potential ARD activity since NFI 2007/09. In clear or suspicious cases for a current ARD activity at-site-inspections of the NFI plots were carried out for clarification if a recent ARD activity in the period since the last NFI 2007/09 had occurred and related measurement of the new ARD areas were carried out. The ARD NFI 2011/13 had also the purpose to measure and to assess for the first time the biomass stock changes and the dead wood stock changes at all old and new ARD plots for the Kyoto-period 2008 to 2012. In previous submissions, only preliminary and rough estimates of the biomass stock changes at ARD areas on basis of NFI results were carried out and used. Within the scope of the ARD NFI 2011/13, a much more detailed assement of these stocks was carried out.

With the ARD NFI 2011/13 also a thorough inspection of all ARD areas was carried out for the appropriateness of the classification as ARD areas. Areas previously accounted as ARD areas due to

- Measurement or assessment errors,
- Different classifications for unchanged plots by different NFI inspection teams in different NFIs or
- Short time oscillations in activities below the legal time frames for accounting as afforestation or deforestation (see chapter 11.4.1.1)

could be identified and were deleted as ARD areas. On basis of the results of these thorough inspections, the ARD areas of previous submissions were corrected in the 2014 submission (reduced) for these misclassified ARD areas.

At ARD areas the forest definitions of the NFI are applied (see chapters 0 and 0). At permanent sample plots with ARDs adjacent to existing forests any ARD area is accounted, even at ARD areas smaller than 0.05 ha but larger than the minimum assessment size (see below). At each permanent sample plot the ARD area is assessed. The minimum size of the sub-area with a different land use within one permanent sample plot needs to be larger than 1/10 of the total sample plot area to be assessed (> 30 m^2). If this pre-condition is met the polygon that divides the different areas of land uses within the sub-plot is measured using polar-coordinates (see examples in Figure 35 in UMWELTBUNDESAMT 2010a or 'Abbildung 5' in the download of HAUK & SCHADAUER 2009). This does not mean that the sample plot is further subdivided into parcels of 30 m^2, but the 30 m^2 only represent the minimum area threshold for the measurement of a plot division in two different land uses. At site, sketches are drawn and the polygon data are entered into the geographic information system of the portable NFI input devices. If the former border line can be recognized in the follow-up NFI, it is kept. A new measurement of the border line is carried out if a minimum distance of 2 m between corner points of the lines is exceeded.

Due to its representativeness and coverage the NFI data allow unbiased reporting of the complete Austrian forest area, forest land remaining forest land and LUCs from and to forests. This is of relevance for the reporting of the Austrian Art. 3.3 and Art. 3.4 Forest Management areas which are based on the NFI data only.

In case a land use change has been observed at a sample plot of the NFI the type of the neighbouring non-forest land was recorded (see chapter 11.2.2 for the assessed land use types). This specification of different land use types is however only available since the NFI 2000/02 (since the observation period between NFI 1992/96 and NFI 2000/02). For the years before the observation period between NFI 1992/96 and NFI 2000/02 (as represented by the results of NFI 2000/02), i.e. for the years 1990 to 1994 only the total areas of AR-lands and D-lands are available from NFIs (observation period between 1986/90 and NFI 1992/96 as represented by the results of NFI 1992/96), but no further distribution into the different LUC subcategories. It was assumed that the total measured AR- and D-areas in the years 1990 to 1994 (as assessed by the observation period between NFI 1986/90 and NFI 1992/96) show the same relative ratio of distribution in AR- and D-subcategories as assessed by the NFI 2000/02. So, the area ratios of AR- and D-subcategories according to NFI 2000/02 could be applied directly to split the total AR- and D-areas according to the NFIs 1986/90 and 1992/96 to individual AR- and D-categories.

Furthermore, in response to the recommendations of the ERT during the ICR 2013 a detailed assessment of the NFI data was carried out for the years 1989 to 1994 covered by the NFIs 1986/90 and 1992/96 in order to provide better estimates for ARD activities that occurred after the 1st of January 1990. The data sets and LUC information from these NFIs were split to account for the activities before 1990 and since 1990. The result showed slightly higher LUC activities from and to forests in the year 1989 than for the following years 1990-94.The time series 1990 to 1994 of the ARD areas was adjusted accordingly.

Table 306: Land use changes to forest (%, ha) observed form 1990 to 2012 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and the ARD NFI 2011/13; based on BFW 2013).

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 – ARD NFI 2011/13**	
	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	6.2	1.8
Grassland (4.A.2.2)	55.5	32.0	55.5	30.1	50.2	27.8	48.9	14.1
Wetlands (4.A.2.3)	4.8	2.8	4.8	2.6	8.7	4.8	4.9	1.4
Settlements (4.A.2.4)	6.6	3.8	6.6	3.6	5.0	2.8	3.1	0.9
Others (4.A.2.5)	21.2	12.2	21.2	11.5	29.9	16.6	36.9	10.7
Total	**100.0**	**57.7**	**100.0**	**54.3**	**100.0**	**55.4**	**100.0**	**28.9**

Table 307: Land use changes from forest (%, ha) observed form 1990 to 2012 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and the ARD NFI 2011/13; based on BFW 2013).

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- ARD NFI 2011/13**	
	LUC from forest land (%)	**LUC from forest land [1 000 ha]**	**LUC from forest land (%)**	**LUC from forest land [1 000 ha]**	**LUC from forest land (%)**	**LUC from forest land [1 000 ha]**	**LUC from forest land (%)**	**LUC from forest land [1 000 ha]**
Cropland (4 A.2.1)	6.2	1.2	6.2	1.1	6.1	1.6	5.4	0.4
Grassland (4 A.2.2)	49.0	9.5	49.0	8.5	56.7	14.5	55.9	3.7
Wetlands (4 A.2.3)	2.6	0.5	2.6	0.4	2.2	0.6	14.0	0.9
Settlements (4 A.2.4)	14.8	2.9	14.8	2.6	20.0	5.1	10.3	0.7
Others (4 A.2.5)	27.4	5.3	27.4	4.7	15.0	3.8	14.4	1.0
Total	**100.0**	**19.4**	**100.0**	**17.3**	**100.0**	**25.6**	**100.0**	**6.6**

As shown in Table 306 and Table 307 ARDs mainly occur from or to grassland sites (49–56% or 49–57%, respectively)..

For reasons of accuracy and uncertainty Austria reports separately for different types of ARD activities. In addition, for estimating changes in litter and soil carbon stocks the ARD areas were further stratified according to five forest growth regions (Bohemian Massif, Inner Alps, Calcareous Alps, Foothills and Alpine ridge). The distribution of the AR- and D-areas in these forest growth regions is also based on the NFI results 2000/02 and 2007/09 and the ARD NFI assessment 2011/13. The AR- and D-areas for the period 1990 to 1994 are accordingly distributed into forest growth regions on basis of the shares from the results of NFI 2000/02. The results are finally summed up according to the areas of LUCs as shown in Table 306 and Table 307.

Figure 48 gives an overview of the ARD areas.

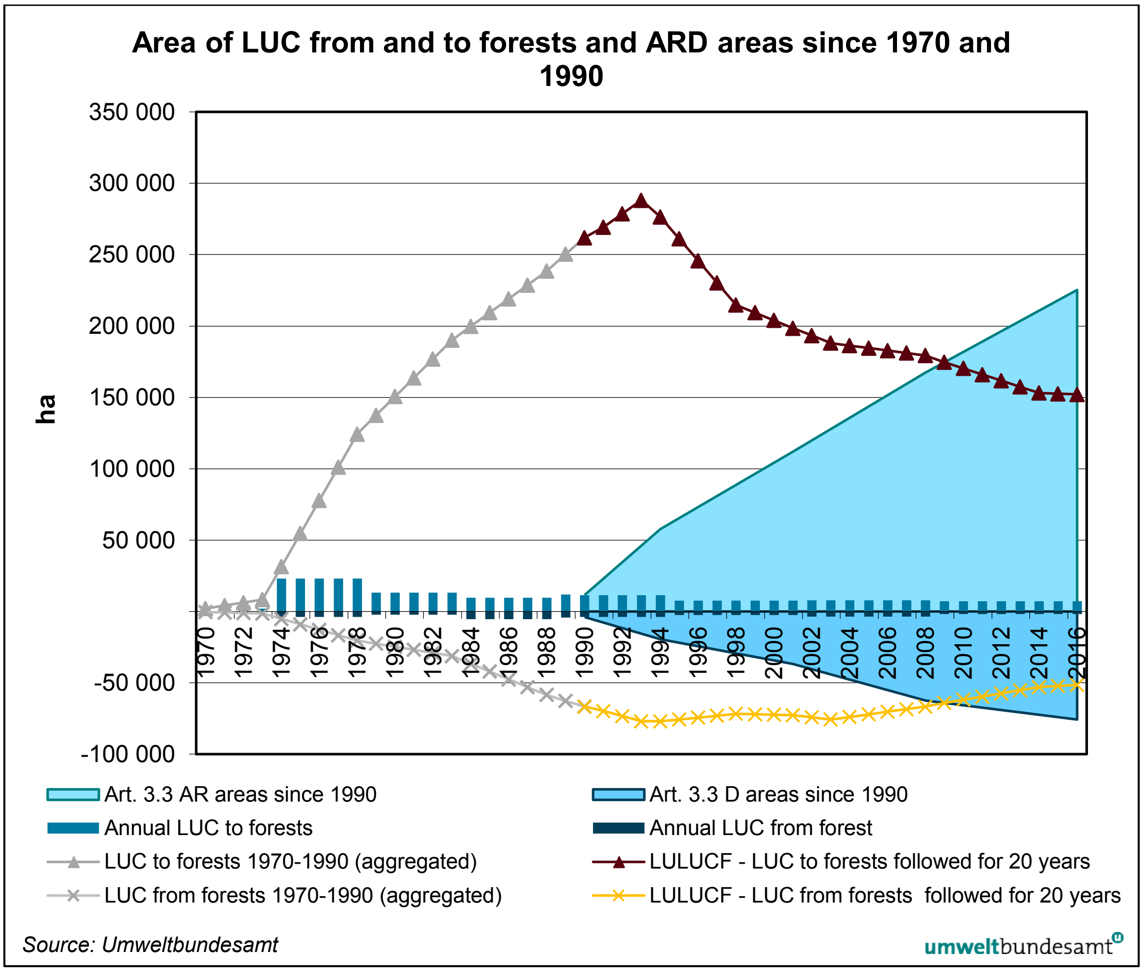


Figure 48: Areas of LUC from and to forests and ARD areas since 1970 and 1990, respectively.

Table 308: Comparison of ARD and FM areas reported under KP and areas of forest land remaining forest land and LUC to/from forests reported under UNFCCC (1 000 ha). For the year 2009 (20 years of transition since 1990) the areas are the same under both reporting schemes.

	KP reporting					Reporting under the Convention		
Year	**Annual AR areas**	**Total AR areas 1990**	**Annual D areas**	**Total D areas 1990**	**Total FM areas**	**4.A.1 Forest land remaining forest land**	**4.A.2 LUC to forests, 20 yr transition period**	**LUC from forests 4.B.2 - 4.F.2, 20 yr transition period**
	1 000 ha							
1990	11.5	12	3.9	4	3 880	3 632	260	66
1991	11.5	23	3.9	8	3 877	3 631	269	70
1992	11.5	35	3.9	12	3 874	3 630	279	73
1993	11.5	46	3.9	16	3 871	3 629	288	77
1994	11.5	58	3.9	19	3 868	3 649	277	77
1995	7.8	65	2.5	22	3 866	3 670	261	76
1996	7.8	73	2.5	24	3 863	3 690	246	74
1997	7.8	81	2.5	27	3 860	3 711	230	73
1998	7.8	89	2.5	29	3 857	3 731	215	72

	KP reporting					Reporting under the Convention		
Year	Annual AR areas	Total AR areas 1990	Annual D areas	Total D areas 1990	Total FM areas	4.A.1 Forest land remaining forest land	4.A.2 LUC to forests, 20 yr transition period	LUC from forests 4.B.2 - 4.F.2, 20 yr transition period
1999	7.8	97	2.5	32	3 854	3 742	209	72
2000	7.8	104	2.5	34	3 852	3 752	204	72
2001	7.8	112	2.5	37	3 849	3 762	199	73
2002	7.9	120	3.7	40	3 845	3 772	193	74
2003	7.9	128	3.7	44	3 842	3 781	188	76
2004	7.9	136	3.7	48	3 838	3 788	186	74
2005	7.9	144	3.7	51	3 834	3 794	185	72
2006	7.9	152	3.7	55	3 831	3 800	183	70
2007	7.9	160	3.7	59	3 827	3 806	181	68
2008	7.9	167	3.7	62	3 824	3 812	179	67
2009	7.2	175	1.7	64	3 822	3 822	175	64
2010	7.2	182	1.7	66	3 820	3 832	170	62
2011	7.2	189	1.7	67	3 818	3 841	166	60
2012	7.2	196	1.7	69	3 817	3 851	162	57
2013	7.2	204	1.7	71	3 815	3 861	157	55
2014	7.2	211	1.7	72	3 813	3 871	153	53
2015	7.2	218	1.7	74	3 811	3 877	153	52
2016	7.2	225	1.7	76	3 810	3 883	152	51

There is a slight inconsistency in tables 4.1 and NIR2 of the forest land and FM area from one year to the next year (final to intitial): The reason for this difference is a rounding issue. The total forest areas from the NFIs (and consequently those derived for forest management) are taken with an accuracy rounded to kha, while the ARD areas are estimated on basis of accuracy at the ha level. Please note that this slight inconsistency in Table NIR2 has no effect on the GHG results.

11.2.2 Methodology used to develop the land transition matrix

The land transition matrix is based on the results of land use changes from and to forest derived from the NFIs of the periods 1986/90, 1992/96, 2000/02, 2007/09 and the ARD-NFI 2011/13. The assessment methods at the NFI grid points are described in chapter 11.2.2. The land uses at the sub-areas of the permanent sample plots are assessed according to the following subcategories (forests with its sub-specifications; cropland: cropland, fallow, orchards and vineyards, biomass plantations for energy use, Christmas tree cultures; grassland: cut pastures, grazing land and alpine pastures; wetlands: inshore waters, reeds, bogs/fens; other natural areas: shrublands, screes and gravel areas, rocks, landslide areas; settlements: trade, industry and mining, traffic areas, landfills, touristic areas, houses and parking places, garden and parks). The results of the measured land-use change areas from and to forests at the sample plots within an NFI are extrapolated statistically assuming representativeness of the NFI system for the whole area of Austria. The FM area for a given year represents the total forest area as assessed by the NFIs (or extrapolated beyond the last NFI results) minus the cumulative AR area since 1990.

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The database and system to identify the geographical locations of the ARD areas represents the NFI assessment system with its systematic statistical grid across the whole area of Austria (see chapters 11.2.1 and 0). This system allows accurate identification of the geographical locations of the sampled ARD activities. The geographical result of ARD activities between the NFI periods 1992/96 and 2000/02 is given in Figure 37 in UMWELTBUNDESAMT (2010a) or in the download of RUSS (2004). ARD areas are spread across the whole country. Areas with less ARD activity are typically due to less forest cover rather than reduced ARD activity *per se*..

11.3 Activity-specific information

11.3.1 Methods for carbon stock changes and GHG emission and removal estimates for the ARD activities

11.3.1.1 Description of the methodologies and the underlying assumptions used

The methodologies and assumptions used for the GHG estimates under the Kyoto Protocol Art. 3.3 are consistent wth those applied when calculating the emissions/removals from LUCs from and to forests as part of UNFCCC LULUCF reporting (see Chapter 6.2.2 Land Use Changes to Forest Land – *4.A.2*). The only difference in the two methodologies is how the LUCs to and from forests are reflected in the estimates i.e. a 20 year conversion status for reporting under UNFCCC vs. cumulative AR and D areas since 1990 under KP (see Table 308).

For the 2014 submission estimates of the biomass and dead wood stock changes at ARD lands on basis of the detailed assessments of the ARD activities under Article 3.3 of the Kyoto Protocol were carried out. The ARD assessment was carried out in the years 2011 to 2013. These assessments were used to revise the ARD areas, the emission factors at these lands and thus the estimates of the emissions/removals.

The methods to derive the activity data were described before in chapter 11.2.

The emission factors were estimated in the following manner:

Biomass

Based on the results of the ARD NFI 2011/2013 the experts of the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW) provided detailed, measured values for biomass increment and drain at the ARD areas (BFW, 2013) The data are available for coniferous and deciduous trees (dbh ≥ 5cm) and for two age classes of the ARD lands (long-term ARD where the ARD activity already occured in the previous NFI periods and short term ARD areas where ARD activity was discovered in the most recent period of assessment). For tree biomass with a dbh < 5 cm the stock changes were estimated. The detailed data for biomass increment and biomass drain, and biomass stock changes respectively, are summarised in Table 309 and Table 310.

Table 309: 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)	
	coniferous	deciduous	coniferous	deciduous
long term AR areas	1.88	2.01	0.35	0.97
short term AR areas	2.83	1.85	0.00	0.00
long term D areas	0.16	0.32	0.24	0.09
short term D areas	0.48	1.13	38.96	48.94

Table 310: 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	0.03	0.11	0.004	0.012
short term AR areas	0.04	0.29	0.006	0.032
long term D areas	0.001	0.060	0.0003	0.007
short term D areas	0.0003	0.116	0.00004	0.013

The biomass stock changes at the ARD lands presented in Table 309 and Table 310 were used for calculating emissions/removals from ARD activities for the whole time series.

Conversion factors (BEF)

The detailed biomass assessment at the ARD areas between NFI 2007/09 and ARD NFI 2011/13 allowed the application of the same densities of single tree species and biomass functions as used in sector 5.A.1. (see chapter 7.2.4.1.1) to derive biomass increment and biomass harvest of the single trees at ARD lands with a DBH ≥ 5cm. The stock changes of biomass < 5 cm at ARD land is calculated by measuring and comparing stocks between the last two NFI periods.

Table 311: Carbon conversion factors for forest biomass land use changes areas from and to forest land.

Conversion factors (t C/t d.m.)	increment		harvest	
	coniferous	deciduous	coniferous	deciduous
Above ground - stem	0.490	0.483	0.492	0.483
other tree compartments - branches, roots	0.473	0.480	0.473	0.481

For AR areas the calculations lead on average for 2008 to 2012 to the following result of annual net C stock change in living biomass (DBH>0cm) per ha and year:

$\Delta C_{BM} = 1.207 \text{ t C ha}^{-1} \text{ a}^{-1}$

For D areas the calculations lead to the following result of average annual C stock change in living biomass (DBH>0cm) per ha and year for the time series 2008 to 2012:

$\Delta C_{BM} = -1.237 \text{ t C ha}^{-1} \text{ a}^{-1}$

In the year the D occurs, the following annual C stock drain in living biomass (DBH>0cm) per ha and year results:

$\Delta C_{BM\ drain} = -42.6\ t\ C\ ha^{-1}\ a^{-1}$

Dead wood

Based on ARD NFI 2011/2013 the experts of the Federal Research and Training Centre for Forests, Natural Hazards and Landscape provided detailed, measured values for stock changes of standing dead wood at ARD areas (BFW, 2013). The stock changes are summarised in Table 312.

Table 312: Annual stock changes of dead wood at ARD areas based on the ARD NFI 2011/13 (BFW 2013).

	stock changes – dead wood (t/ha/a)
long term AR areas	0.032
short term AR areas	0.123
long term D areas	0.01
short term D areas	-0.26

Litter and soil

The soil C stock changes were stratified according to 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). The calculations for the regionalised land-use-specific agricultural soil C stocks are based on Austrian soil inventories (same sources as the results for the national values used in previous submissions). The calculations for the stratified 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 land use categories other than forest, cropland and grassland, national estimates were applied. Table 313 gives an overview of the estimates of C stocks in mineral soils (0–50 cm) and litter according to different land uses and forest growth regions.

In response to review findings the estimates of the emissions/removals in the mineral soils of ARD lands with wetlands were revised. In previous submissions wetlands (flooded land) were assumed to have a 0 soil C stock. 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 such lands. Due to a lack of information in literature no C-stock changes in mineral soil are assumed at ARD lands with wetland. The AR lands WL to FL are higher than the D lands FL to WL and FL can be expected to have higher C stocks in soil. Therefore, this approach represents a conservative estimate and underestimates ARD net removals at such lands.

Table 313: 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	Foot-hills	Alpine Ridge	
		t C ha^{-1} (0–50 cm)					
Forest – litter	Forest	40	24	24	19	26	BFW, in prep.
Forest – mineral soil	Forest	88	91	109	77	117	BFW, in prep.
Cropland	Cropland	56	90	80	65	90	Umweltbundesamt, in prep.
	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, in prep.
	grassland extensive use	132	130	120	139	139	Umweltbundesamt, in prep.
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 belowand chapter 6.6.4.1.2
	Industrial and mining areas, dumps	30	30	30	30	30	Umweltbundesamt– see belowand 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

The values for forests, cropland and grassland represent regional averages which are based on Austrian soil inventories for forests (BFW 2009) and 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 (BFW, Umweltbundesamt).

Minor LUC areas between bogs/fens and forests were observed during the last two NFIs (annual changes between 9 and 50 ha). A thorough assessment of these areas shows that these land use changes always occur along forest boundaries and are related to a change in tree cover but not in soil conditions and management (bogs/fens are protected in Austria). So, it is assumed that the soil carbon stocks at these lands do not change.

The estimate 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 and were revised in the previous submission. 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.

The NFIs 2000/02, 2007/09 and the ARD NFI 2011/13 specify the LUC from and to forests in a broader range of LUC categories than the existing six major IPCC land use categories (see Table 313). Consequently, for each IPCC land use change category from and to forest an area weighted mean value of soil C-stocks for each subcategory and growth region was calculated for each NFI period (NFI 1992/96 to 2000/02, NFI 2000/02 to 2007/09 and NFI 2007/09 to ARD NFI 2011/13). The area weighted mean C-stock values used to estimate emissions and removals from soil and litter at LUC areas from and to forest are shown in Table 314, Table 315 and Table 316.

Table 314: 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 –2006 GL)	**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**	**Foothills**	**Alpine Ridge**
Forest	91	117	109	77	88	91	117	109	77	88
Cropland	90	73	77	65	56	-	90	71	65	56
Grassland	123	125	117	85	77	116	128	115	88	75
Wetlands	0	0	0	0	0	0	0	0	0	0
Settlements	54	40	54	41	34	54	48	54	38	54
Other land	53	51	21	27	30	73	25	40	30	30

[1]- no LUC from/to forest could be observed in these regions

Table 315: 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 – 2006 GL)	**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**	**Foothills**	**Alpine Ridge**
Forest	91	117	109	77	88	91	117	109	77	88
Cropland	90	81	78	65	57	-	88	-	68	56
Grassland	128	130	117	87	91	128	128	114	124	75
Wetlands	0	0	0	0	0	0	0	0	0	0
Settlements	-	38	54	34	45	54	48	47	41	35
Other land	46	49	49	30	39	53	41	22	13	-

[1] - no LUC from/to forest could be observed in these regions

Table 316: 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 ARD NFI period 2011/13.

	C-stocks (t ha^{-1}) in soils (0–50 cm)[1]									
Land use categories (IPCC – 2006 GL)	**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**	**Foothills**	**Alpine Ridge**
Forest	91	117	109	77	88	91	117	109	77	88
Cropland	-	77	76	65	56	-	90	-	70	-
Grassland	130	130	115	88	75	117	132	113	106	75
Wetlands	0	0	0	0	0	0	0	0	0	0
Settlements	38	54	54	30	-	54	30	54	38	54
Other land	35	81	32	21	-	-	33	79	14	-

[1] - no LUC from/to forest could be observed in these regions

The estimates of the soil C stock changes at ARD areas were split into litter (humus layer, see Table 313) and mineral soil (see Table 314, Table 315 and Table 316).

and follow the equations below. The changes are estimated annually and have been summed up for each AR- and D-subcategory in the CRF tables. For these estimates, the ARD areas consistent with the NFI results were also stratified according to the forest growth regions and the different previous or subsequent land-uses (see chapter 6.2.2.2).

Annual carbon stock changes in soils at ARD areas:

$$\Delta\ SOC = A^*(SOC_O - SOC_{O\text{-}T})/20$$

Δ SOC = average annual carbon stock change in soils (t C a^{-1}) over the LUC transition period of 20 years

A = ARD area 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 316)

$SOC_{O\text{-}T}$ = 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 316).

Annual carbon stock changes in litter at ARD areas:

$$\Delta\ C_{LT} = A^*\ (C_{LTo} - C_{LTo\text{-}t})/T$$

$\Delta\ C_{LT}$ = average annual carbon stock change in litter (t C a^{-1})

A = annual D area, respectively the AR area 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 316)

$C_{LTo\text{-}t}$ = carbon stock in litter before conversion, respectively

T = transition period for the litter carbon stock changes (1 year for D areas, 20 years for AR areas)

Harvested Wood Products

The methodology applied for estimating emissions/removals of HWPs under the KP is identical with the methodology used under the UNFCCC (see chapter 6.8). To allocate the carbon stock changes to the particular forest activities under Art. 3.3 and Art. 3.4a the default method (equation 2.8.3 of the KP Supplement) has been applied:

$$f_j(i) = \frac{harvest_j(i)}{harvest_{Total}(i)}$$

Where:

$f_j(i)$ = share of harvest originating from the particular activity j in year i

j = activity FM or AR or D in year i

Table 317: Share of harvest originating from a particular activity.

	2013	2014	2015	2016
activity	f_j	f_j	f_j	f_j
FM	0.9770	0.9765	0.9759	0.9753
AR	0.0142	0.0147	0.0153	0.0159
D	0.0088	0.0088	0.0088	0.0088

The HWP removals and emissions for Af-/Reforestation are estimated on basis of the total HWP results according to UNFCCC (see chapter 6.8) multiplied with the AR share of total harvest according to Table 317. For D activities HWP emissions or removals are not estimated.

N_2O emissions from disturbance associated with soil C stock losses due to ARD

Direct N_2O emissions from mineral soil due to D to cropland, settlements and other land and AR from grassland were estimated using exactly the proposed method in the IPCC 2006 GL (Tier 2, see table 11.1, using equation 11.2 and country specific C/N soil ratios).The used activity data represent the total AR and D areas of these subcategories since 1990. The estimates are based on the related annual C stock changes in soil across 20 years transition period using the C stocks in mineral soils as given above. For the C/N ratio in the mineral soils Austrian specific values of 19 for forest soils derived from the Austrian forest soil survey (BFW 1992) and 12 for grassland soils derived from the Austrian agricultural soil inventories were taken[119].

Indirect N_2O emissions related to leaching and run-off of N due to these soil C stock losses were also estimated with the tier 2 methodology of Chapter 11 of the IPCC 2006 Guidelines (see chapter 1.2.4.2.2).

Planned improvements

An update of activity data and emission factors at ARD lands on the basis of the recently started new NFI is planned for the 2nd CP.

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3

No carbon pool is omitted.

[119] 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.

There is no practice of biomass burning at ARD areas in Austria. The area affected from wild fires in the total Austrian forests is very small, ranging between 56 and 139 ha in the years 2013-2015 (source: statistics of the Forest Ministry, BMLFUW). In the first KP period no NFI plot at ARD sites was affected by wild fires (this would have been observed and noted by the NFI team during the surveys 2011/13). Therefore, wildfire emissions at ARD lands are reported as "NO". If the next NFI identifies that ARD plots have been affected by forest fire, related emissions will be estimated and reported in the subsequent submission.

Furthermore, forests are not fertilised in Austria. So, fertilisation at AR areas does not occur and are thus reported as "NO".

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Due to a lack of available methods in the IPCC GPG and elsewhere, indirect and natural GHG emissions/removals have not been factored out.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

- A calculation error in the HWP estimates related to veneer sheets was corrected and led to minor changes in the removals from HWPs.
- The HWP production figures for 2015 were updated in the most recent FAO statistics. Consequently, the removal figures for this year had to be updated accordingly.
- The estimate of paper production from domestic wood was expanded by the wood pulp production/import/export according to equations 2.8.2 and 2.8.4 of the IPCC (2014) KP Supplement and the HWP time series was recalculated accordingly.
- All these recalculations led also to minor changes in the annual removals of ARD for the years 2013 to 2015.

11.3.1.5 Uncertainty estimates

On the basis of the data of the ARD NFI 2011/13 the uncertainty estimate for the emissions/removals of the Art. 3.3 ARD activities was carried out.

The uncertainties of the NFI design, measurement errors and input parameters result in an uncertainty of the net C stock changes of the biomass and dead wood at ARD areas of ±55%. Furthermore, the uncertainties of the areas of LUCs to/from forests and the uncertainties of the litter and soil C stocks as described in chapter 6.2.5 were used to derive the overall uncertainty of the emissions/removals of the ARD activities.

The Monte-Carlo-Simulations as described in chapter 6.1.5 provided the following uncertainties for the net removals of the ARD activities in the Kyoto-Protocol-Period 2008-12: ±7 857 kt CO_2 equiv. which equals a relative uncertainty of ±116%.

Similar to sector *4.A.1*, a majority of this uncertainty is attributable to the uncertainty of the soil C stock changes at ARD lands in period 2008-12 which represents (in absolute terms) almost the same as the uncertainty of the ARD net removals in this time (±7 084 kt CO_2). The changes in the litter pool represent also a very high absolute uncertainty which is about one third of the overall uncertainty of the ARD net removals (± 2 812 kt CO_2). Clearly lower is the uncertainty of the net removals due to biomass changes at ARD lands in 2008-12 (±1 406 kt CO_2).

A revision of the uncertainty estimate will be carried out in a future submission on the basis of new NFI results, once they become available.

11.3.1.6 Information on other methodological issues

The methods used to estimate emissions/removals from ARD activities are of the same tier as the methods used for the UNFCCC reporting.

11.3.1.7 The year of the onset of an activity, if after 2013.

In 2016 the following ARD activities were presumed: AR at 7 233 ha, D at 1 661 ha. The annual AR and D areas are thus considered since the last NFI 2011-2013.

11.3.2 Methods for carbon stock changes and GHG emission and removal estimates for Forest Management

11.3.2.1 Description of the methodologies and the underlying assumptions used

The methodologies, assumptions and emission factors used for the GHG estimates under Kyoto Protocol Art. 3.4. activity Forest Management follow completely those for Forest Land remaining Forest Land *4.A.1* (see chapter 6.2.4.1). The only difference in the two methodologies is how the LUCs to and from forests (which are subtracted from the total forest area) are reflected in the estimates i.e. a 20 year conversion status for reporting under UNFCCC vs. cumulative AR and D areas since 1990 under KP (see chapter 11.2.1).

The methods to derive the activity data were described before in chapter 11.2.

The emission factors were estimated according to the description in the following chapters for Forest Land remaining Forest Land:

Biomass

See chapter 6.2.4.1.1

Dead wood

See chapter 6.2.4.2.2

Litter and soil

See chapter 6.2.4.2.3

Forest fires

The emissions of forest fires in Austria occur only in FM lands and are fully accounted under Forest Management. The method of the estimates is the same as described for biomass burning in Forest Land remaining Forest Land in Chapter 6.2.4.1.4.

Harvested Wood Products

The methodology applied for estimating emissions/removals of HWPs under the KP is identical with the methodology used under the UNFCCC (see chapter 6.8). To allocate the carbon stock changes to the particular forest activities under Art. 3.3 and Art. 3.4a default method (equation

2.8.3 of the KP Supplement) has been applied:

$$f_j(i) = \frac{harvest_j(i)}{harvest_{Total}(i)}$$

Where:

$f_j(i)$ = share of harvest originating from the particular activity j in year i

j = activity FM or AR or D in year i

The HWP removals and emissions for Forest Management are estimated on basis of the total HWP results according to UNFCCC (see chapter 6.8) multiplied with the FM share of total harvest according to Table 317.

Planned improvements

An update of activity data and emission factors at FM lands on the basis of the recently started new NFI is planned for submissions towards the end of the 2nd CP. In addition, estimates for the GHG emissions and removals of forests not in yield will be possible with the results of the coming NFI. Such estimates for these forests are not yet possible because their stocks were only assessed once in the last NFI.

The methodological improvements in the estimates resulting from paper (see chapter 11.3.2.4, second but last bullet point) requires a related technical correction of the FMRL which will be carried out for the next submission.

11.3.2.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.4 Forest Management

No carbon pool is omitted.

Estimates for the GHG emissions and removals of forests not in yield in Austria are not yet possible because their stocks were only assessed once in the last NFI. These estimates will be carried out in the end 2nd CP with the results of the new NFI which started 2016. There is no harvest in these forests due to the lack of access, but planting measures are carried out for sustaining the forest cover and their frequent feature as protective forests (both are requirements according to the Austrian Forest Act). Consequently, it is assumed that these forests represent a missing net C sink in the current emissions/removals estimates.

11.3.2.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Due to a lack of available methods in the IPCC GPG and elsewhere, indirect and natural GHG emissions/removals have not been factored out.

11.3.2.4 Changes in data and methods since the previous submission (recalculations)

- The wildfire area and emission estimates for the year 2014 required a minor adjustment on basis of the newest statistics.
- A calculation error in the HWP estimates related to veneer sheets was corrected and led to minor changes in the removals from HWPs.

- The HWP production figures for 2015 were updated in the most recent FAO statistics. Consequently, the removal figures for this year had to be updated accordingly.
- The estimate of paper production from domestic wood was expanded by the wood pulp production/import/export according to equations 2.8.2 and 2.8.4 of the IPCC (2014) KP Supplement and the HWP time series was recalculated accordingly.
- All these recalculations led to changes in the annual removals of forest management for the years 2013 to 2015 in the range of −46 to 333 kt CO2e per year.

11.3.2.5 Uncertainty estimates

Due to the insignificant difference in the estimates and input data (slightly different FM activity area compared to the areas of Forest Land remaining Forest Land) the results for FM uncertainty can be considered the same as for Forest Land remaining Forest Land. See chapter 6.2.4.1 for details.

11.3.2.6 Information on other methodological issues

The methods used to estimate emissions/removals from FM activities are of the same tier as the methods used for the UNFCCC reporting.

11.3.2.7 The year of the onset of an activity, if after 2013.

In 2016 the FM area was 3 810 kha.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2014 and are direct human-induced.

The following Chapters (10.4.1.2–10.4.1.6) include additional information on the legal framework for forests, forest management and AR as well as a further justification related to reporting under Article 3.3 KP.

For the ARD lands since 1 January 1990 the results of land-use changes from and to forests according to the Austrian NFI in the period 1992–96 are used. The NFI 1992–96 assessed these land use changes in comparison to the results of the previous Austrian NFI 1986–90. In response to the recommendations of the ERT during the ICR 2013, a detailed assessment of the data of these two NFIs was carried out in order to provide better estimates for ARD activities that occurred after the 1st of January 1990. The data sets and LUC information out of these NFIs was split to account for the activities before 1990 and since 1990. The result showed slightly higher LUC activities from and to forests in the year 1989 than for the following years 1990–94. The time series 1990 to 1994 of the ARD areas was adjusted accordingly.

11.4.1.1 Information that demonstrates that activities under Article 3.3 are direct human-induced – 1) Legal framework on forests and af-/reforestation – overview

The main legal framework for forest land is the Austrian Forest Act. The Austrian Forest Act is valid for all forests in Austria. Specific forest implementation laws exist in most of the Federal Provinces of Austria, but they are containing only few provisions to specify some regulations of the Forest Act and do not change anything on the issue of forest, forest management and af-/reforestation as laid down by the Austrian Forest Act. Furthermore, it is important to note that no EU legislation on forests exists, hence definitions and legal understanding of forest, af/reforestation, deforestation as well as forest management differ from member state to member state.

Note the following quotations of the Austrian Forest Act represent translations of the original German text.The Austrian Forest Act §1a (BGBl. Nr 440/1975 and amendments) defines forest as follows:

§ 1a

(1) Forest within the meaning of this Federal Act consists of basal areas stocked with woody plants of the categories listed in the Appendix (forestal plant cover), where the growing stock reaches an area of at least 1,000 m^2 and an average width of 10 m.

(2) Forest within the meaning of Subsection 1 also consists of basal areas of which the forestal plant cover has been temporarily reduced or removed as a result of being used for other reasons.

(3) Notwithstanding its particular use, forest within the meaning of Subsection 1 also consists of permanently unstocked basal areas where they are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades).

(4) The following are not deemed to be forest within the meaning of Subsection 1

a) *notwithstanding other provisions of this Federal Act, basal areas which serve other purposes than that of forestry and where the plant cover of an age of at least 60 years has not reached a canopy cover of three tenths,*

b) *stocked areas which, because the structure of their plant cover is that of parks, predominantly serve purposes other than that of forestry,*

c) *shrub areas not used for forestry purposes with the exception of those which have been managed as coppice or which have been classified as protection forest (§ 23) or which have been declared protective forests (§ 30),*

d) *rows of trees where they are not shelter belts (§ 2 Subsection 3),*

e) *stocked areas which serve the immediate operation of a railway that is in existence at the time at which this Federal Act comes into force,*

f) *border areas within the meaning of § 1 paragraph 2 of the National Border Act, BGBl. No. 9/1974, insofar as they are to be kept free of plant cover based on national treaties regulating the surveying and demarcation of the national borders.*

The provisions of §§ 43 to 46 shall apply.

(5) 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, where they are not planted on forest soil and their owners have reported the intended operational use to the authority within ten years of carrying out the afforestation or establishing these facilities, shall not be deemed to be forest within the meaning of Subsection 1. Should no such report be made, § 4 shall apply.

(6) The provisions of §§ 43 to 45 shall apply to the sites listed in Subsection 5, first sentence, to forest arboretums and forest seed orchards additionally those of the Forestry Propagation Act.

(7) Forest, where the plant cover has a canopy of less than three-tenths, is referred to as a sparse stand, and forest soil with no plant cover is referred to as a clear felled area.

For the assessment of an area as forest only the definition of forest according to the Austrian Forest Act is legally binding. The Austrian forest law experts comment on basis of legal decisions the meaning of the Austrian Forest Act with respect to the land use classification in more detail: The legal consequence of the Austrian Forest Act is that any area that meets this definition becomes a forest independent from an allocation of that area to a different land use category within the property tax land register, within the borders land register or within the owners land register. In addition, any priority rights from property, ownership or servitude rights cannot change the forest status of an area that has become a forest according to the Austrian Forest Act (JÄGER 2003). The relevance of this legal binding frame for management operations is the following: Any change of land use management in a way that the resulting land cover meets the forest definition represents a legally binding land use change to forest.

The Austrian Forest Act also lays down the „public interest in the sustaining of forests", which is expressed by the fundamental ban of deforestation in §17 (1). The consequence is the following: Once an area has become a forest (see above), a following land-use change would be deforestation (and the ending of an area as 'forest') in the sense of the law. However, this would be only possible under certain very limited circumstances (e.g. public interest in deforestation) and has to follow several administrative steps before being legally allowed. Therefore, the landowners have a legal need for activities to prevent an undesired re-growth of an area to a 'forest' ('forest force'). As a consequence, the re-growth of an area as 'forest' takes only place where desired and represents therefore a 'direct human induced activity'.

With respect to the technique of af-/reforestation the following points are relevant: It is a frequent and often desirable forest management strategy in Austria to use the potential of natural re-growth caused, for instance, by the seed of adjacent forests (in line with the third technique of af-/reforestation listed in the Marrakesh-Accords). Reasons for this include lower economic costs and that naturally re-grown trees (species and provenances) are better adapted to the local ecological conditions. Also here, the Austrian Forest Act qualifies such an activity as an appropriate management activity to reforest cleared areas (and, therefore, as a „direct human induced activity") and prioritizes it in comparison to other re-afforestation techniques:

The Austrian Forest Act §13 (BGBl. Nr 440/1975 and amendments):

§ 13. (3) Re-afforestation shall take place by means of natural regeneration, if there is a natural regeneration by seed, stool shoot or root sucker within a period of ten years, which gives rise to the expectation that the re-afforestation area will be fully stocked.

According to a decision by the 'Administrative Court of Austria' (June 24th, 1996, Nr. 91/10/0168) it counts as „forest use" or „forest management" if an owner or a forest manager let an area to be re-afforested by natural regeneration.

In this context it is important to recognize, that in Austria areas are also subject to the provisions of the Forest Act in the case of natural regeneration. An area afforested by means of natural regeneration is also qualified as forest to be managed under the forest law according to Z 2 of § 4 Abs. 1 of the Forest Act:

New Afforestation

§ 4. (1) Basal areas which were not previously forest are subject to the provisions of this Federal Act in the case of:

1. *afforestation (seed or planting) ten years after it has been carried out,*
2. *natural regeneration after reaching a canopy cover of five tenths of its area with a plant cover having a height of at least 3 meters.*

The provisions of Section IV should nevertheless be applied as soon as plant cover exists.

(1a) The Federal Minister for Agriculture, Forestry, Environment and Water Management can

determine, according to technical requirements in forestry, a plant cover height deviating from the provisions of Subsection 1 fig. 2

(2) Basal areas on which substitute afforestation (§ 18 Subsection 2) has been carried out shall be deemed to be forest within the meaning of § 13 Subsection 8 as soon as growth has been ensured.

(3) Basal areas for which funding has been granted for afforestation in accordance with the provisions of Section X shall be deemed to be forest soil from the time that promotional funds were paid out; in the case of afforestation at high altitude, i.e. the zone within five-hundred metres of altitude below the natural treeline, this shall not apply until the young plantation has been secured within the meaning of § 13 Subsection 8.

Timberline region, shelter belts

§2. (1) The provisions of the Federal Act shall also be applied to forest plant cover in the timberline region of the forest and to shelter belts, irrespective of the nature of use of the basal areas and the site structure of the plant cover.

(2) The timberline region of the forest shall be understood as the zone between the natural treeline and the actual line of the closed tree cover.

(3) Shelter belts are lines or rows of trees or bushes which primarily serve to protect against wind damage especially for agricultural plots and to hold snow.

Special provisions for the timberline zone and for shelterbelts

§ 25. (1) The provisions of §§ 22 to 24 shall apply analogously to the timberline zone. In addition to this the authority shall, where local circumstances require it and this does not concern salvaging timber from acute forest damage, issue a notice stating that the felling be subject to a permit or totally prohibited. In the case of a permit, the felling shall be subject to marking performed by the authority. The notice shall be withdrawn as soon as the reasons for issuing it have ceased to apply.

(2) Reductions in the plant cover of the timberline zone for longer than a temporary period shall require official approval. A permit shall be issued if and insofar as the plant cover does not offer a profound protective effect within the meaning of § 6 Subsection 2 lit. b. No permit is required for the removal of plant cover on basal areas which are classified as Alps or as basal areas used for agricultural purposes in the Border Land or Land Tax register and which have not become forest as a result of re-afforestation within the meaning of § 4, provided the plant cover does not offer a profound protective effect within the meaning of § 6 Subsection 2 lit. b.

(3) Official approval is also required for changing the location of the plant growth in the timberline zone by removing the plant cover and re-afforesting at another place if this plant growth offers a profound protective effect within the meaning of § 6 Subsection 2 lit. b. A permit shall be granted if this change does not reduce the proportion of the sheltered area and the protective effect of the plant cover is not impaired. The permit may, if necessary, be subject to conditions and requirements.

(4) The provisions of §§ 18 to 20 shall apply analogously to the procedures to be carried out in accordance with Subsections 2 and 3.

(5) Shelterbelts are to be handled in a way that their protective function is not impaired. Felling in shelterbelts requires marking performed by the authority.

In the regulation of the Federal Minister for Agriculture, Forestry, Environment and Water Management, BGBl. II Nr. 25/2003, according to § 4 Abs. *1a of the Forest Act, for species (Alnus virid-*

is, Pinus cembra, Pinus mugo), which are growing in high altitudes, the plant cover height is laid down with 1 meter.

These legal provisions out of the Austrian Forest Act are presented to demonstrate two facts:

1) It takes a defined time and/or the exceeding of defined limit values until an af-/reforestation area becomes a forest and all provisions of the Forest Act are valid for these areas, for both, AR areas that were directly planted or seeded and AR areas from natural regeneration. These provisions are also operationalized by the NFI which is the assessment system for forests and ARD. The NFI assesses forest only after exceeding defined limit values which are well in line with the legal provisions (see chapter 11.4.1.2). So, there is a time lag between the decision of stopping previous land management and the assessment as forest by the NFI as well as the counting as forest under the Austrian Forest Act. Austria does not see here any relevance with respect to „direct human induced" AR: There is no provision under Kyoto-Protocol for the AR assessment with respect to a certain (or no) time period of becoming a forest as a prerequisite for the validity as being „direct human induced" af/reforestation. On the contrary, directly planted AR-areas would also request some years before being assessed and accounted as forest and af-/reforestation. It is so, that a land owner can convert land that do not yet fall under the limit values of the Austrian Forest Act, however, until reaching these limit values this land is not counted as af-/reforestations, too. The decision of the land owner for af-/reforestation is only evident and accounted when the limit values are exceeded and the land is assessed as forest.
2) Certain management provisions of the Austrian Forest Act cover all areas where forest is expanding, even if the limit values given above are not yet met by the areas becoming forest. These are the provisions of section IV of the Austrian Forest Act: forest management obligations for protection from forest fire, forest pests and pollution are mandatory also before the qualification of an area as afforestation according to the related legal limit values are fulfilled (see paragraph 4 above). In addition, in the timberline zone any forest plant cover is under related forest management obligations by the Austrian Forest Act, even without meeting the limit values for plant cover or tree height (see § 2, 1 and § 25, 1–4).

These forestry legal circumstances in Austria and the legal overruling capacity of the Austrian Forest Act with respect to the assessment of the property of an area as forest, is the reason and the legal framework that – according to Austrian law – qualify a stop of land management and the following re-growth of a forest as a „direct human induced activity" for the conversion of an area to a forest. The nature of a 'decision' towards forest by the land owner is expressed by land owner allowing his/her land to exceed the limit values for being forest at a land previously under different land use. This regeneration would not be possible without a stop of the previous land management, so it must be desired by the land owner having in mind the automatic 'forest force' due to Austrian law (besides, the land owner loses premium payments for grassland or cropland management). The provisions in the Austrian Forest Act demonstrate a general national decision by the Austrian legislation that any Austrian land exceeding the limit values described above becomes automatically forest land with obligations for forest management. As such, the Austrian Forest Act is also a national decision that all land that is no longer cultivated (and meets the forest definition) shall be a managed forest.

Austria would also like to inform about the specific national circumstances with regard to the reward related to removal units (RMUs) from afforestation. Although land-use is decided by the land-owner any RMUs generated by afforestation do not belong to the land owner but are owned by the government. Therefore there is no additional added value for the land owner linked to afforestation. The rationale behind that rule is that usually the communities and the regions want to keep the current land use, e.g. as grassland or cropland. These rules are country-specific and might be different in other countries.

11.4.1.2 Information that demonstrates that activities under Article 3.3 are direct human-induced – 2) Forest – definition

For its reporting under the Kyoto-Protocol, Austria uses almost the same forest definition as laid down by the Austrian Forest Act (see chapter 11.4.1.1). The basis for the Austrian estimates of af-/reforestation are the results of the Austrian NFI. The NFI assesses at the plot level and within the Austrian wide grid if the forest definition according to the Austrian Forest Act § 1a is met. The assessment of all grid points of this Austrian wide grid within each NFI period ensures that the entire forest area in Austria (including all ARD activities) is adequately sampled. For the NFIs, a written technical instruction is available where all the assessed parameters are defined, including also the forest and non-forest definition (HAUK & SCHADAUER 2009, http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf., SCHIELER & HAUK 2001, http://bfw.ac.at/700/pdf/da_ges_neu.pdf). The NFI operationalizes the provisions of the Austrian Forest Act in its technical instruction with the following limit values for tree numbers per 100 m^2:

Table 318: Tree numbers per 100 m^2.

Age	Spruce, fir	Larch	Pine	Beech, oak	Poplar hybrids
Seedling stage	22–45	20–45	40–90		2–4
Juvenile stage	21–37	20–35	36–80	70–130	

Any land that was not forest before (in the previous NFI period) and that meets these tree number ranges is detected as Af-/Reforestation area. There is only a slight difference in the definitions according to NFI: The minimum area for forest according to NFI is 500 m^2, while the Forest Act defines 1 000 m^2. Theoretically this may result in a minor over-estimation of the af-/reforestation and deforestation area compared to the legal basis of the Forest Act. According to the statistical nature of the assessment the minor over-estimation from af-/reforestation is likely to be of the same magnitude than the over-estimation for deforestation.

It should be noted that these tree number limits used by the NFI for the assessment of forest area are used since many NFIs as they represent good approximations for the secured further forest succession of the new forest lands under Austrian conditions. As such, they are also in line with the related provisions of the Austrian Forest Act. Nevertheless, the Austrian Forest Act lists also for the situation of less tree cover forest management and protection obligations (see chapter 11.4.1.1).

In Austria the National Forest Inventory is prepared by a governmental organisation and the main objective of the NFI is to assess whether or not the forest management has been sustainable. This therefore meets the requirement that the data on carbon stock changes are, according to the best available knowledge and practise, neither under- nor overestimated. This requirement is fully consistent with the requirements under the UNFCCC.

11.4.1.3 Information that demonstrates that activities under Article 3.3 are direct human-induced – 3) Forest management – definition

According to the legal framework in Austria any forest area and, as a consequence, all AR areas represent areas under forest management and are as such reported (see chapter 11.4.1.4). The reason is that all Austrian forests are under the Austrian Forest Act which implies rights and obligations with regard to forest management for the land owners. This includes for instance: The need for reforestation of forests that lost their crown cover (§ 13 of the Forest Act), the necessity for forest pest control measures (§§ 43 to 45 of the Forest Act), needs for management measures that sustain the forests (§ 22 of the Forest Act), measures that prevent visitors from accidents along public paths (§ 176 (4) of the Forest Act).

In Austria also the forests in nature protected areas are qualified as forests according to the Forest Act and therefore all the above mentioned management-obligations have also to be fulfilled in these areas, if no exceptions are permitted by the forest-public authority (§ 32a of the Forest Act). There are only few such permissions, regarding negligible areas (less than 1% of the Austrian forests), where partly exceptions have been permitted. Mostly, the provisions to af-/reafforestation and forest protection measures are only reduced but not cancelled. All forests in nature protected areas are managed to fulfill ecological and social functions and are subject to forest management.

The management of all the Austrian forests has to be consistent with the principles as defined in § 1 of the Austrian Forest Act.

§ 1 (2) of the Austrian Forest Act defines as aim of this law to secure the „sustainable forest management“. The definition of forest management in Austria follows completely the decisions of the PAN European Process of the Forest Ministers that broadly define:

„Sustainable forest management comprises the tending and use of forests in a way and at a rate, that maintains their biodiversity, productivity, regeneration capacity, their vitality and their potential to fulfill, now and in the future relevant ecological, economic and social functions at local, national, and global levels, and that does not cause damage to other ecosystems. Notably precautions have to be taken with respect to the use of forests in view of the long production period and potential planning in order to ensure that the use of forest resources will also be preserved for future generations."

This broad definition of 'forest management' is also in line with the related definitions in the IPCC 2006 GL.

It should be noted that these provisions for sustainable forest management together with the legal prioritization of natural regeneration to other re-afforestation techniques (see chapter 11.4.1.1) give evidence for a general promotion of seed sources for the af-/reforestation areas by the Austrian legislation. In case of AR areas with natural regeneration the seed sources are the forests adjacent to the AR lands, and these forests are managed forests and under the Austrian forest act (Austria has the opinion that Decision 16/CMP.1, para. 1 ('... promotion of seed sources') is not limited to the AR areas as such but is also valid for management measures at those areas where the seeds of the young trees at the AR areas origin. Austria interprets 'on lands' in the Decision 16/CMP.1, para. 1 as being related to the 'conversion of non-forested land to forested land' and not to the place of the listed activities.).

11.4.1.4 Information that demonstrates that activities under Article 3.3 are direct human-induced – 4) Reporting on forests in Austria

The forest area according to NFI is the basis for all official and international reporting of forest area in Austria. The figures may differ from report to report, but only due to different time periods under consideration and/or different definitions of forest that underlie the different reporting obligations.

As described in chapter 11.4.1.3 above, 100% of Austrian forests are under forest management. This is also reported internationally, for instance in the reports 'State of Europe's Forest 2003' and 'State of Europe's Forest 2007' under the „Ministerial Conference on The Protection of Forests in Europe" (MCPFE Liasion Unit and UNECE/FAO, 2003, 2007 http://www.foresteurope.org/filestore/foresteurope/Publications/pdf/state_of_europes_forests_2007.pdf).

Also according to the 2010 Forest Resource Assessment (FRA) of the FAO, 100% of the Austrian forested area has been reported as under sustainable forest management (FRA 2010, Country Report Austria). Furthermore, Austria reported the same figures for the increase in forested area under FRA2010 as compared to the af-/reforestation areas under Article 3.3 of the Kyoto-Protocol (taking the different definitions into account).

11.4.1.5 Information that demonstrates that activities under Article 3.3 are direct human-induced – 5) Justification for Austria's accounting under Article 3 paragraph 3

The following elements are intended to document Austria's justification for accounting all forest area increases as 'direct human induced' af-/reforestation on basis of the documentations and explanations in chapters 0 to 0:

a) The issue of forest land under management

According to chapters 0 and 0 all forest area in Austria is under forest management. Following the KP Supplement (chapter 2.1, Table 2.1.1) a change to managed forest land always represents af-/reforestation. Otherwise, unmanaged forest land would be „produced" while – in fact – unmanaged forests don't exist in Austria per definition. For the same reasons and symmetry, Austria reports every loss of forest land as deforestation under Article 3.3 of the Kyoto-Protocol (a conversion of managed forest land to a different land use must be 'direct human induced').

b) Further considerations on „direct human induced"

Besides the fundamentals as described in chapter 11.4.1.2 above, the following arguments also support our view:

Our reading of the IPCC GPG on LULUCF suggests that the use of a broad definition of 'direct human induced' af-/reforestation is valid. This is probably best expressed by the 2nd but last paragraph (Chapter 4, p. 4.52) in the IPCC GPG on LULUCF:

„It is good practice to provide documentation that all afforestation and reforestation activities included in the identified units of land are direct human-induced. Relevant documentation includes forest management records or other documentation that demonstrates that a decision had been taken to replant or to allow forest regeneration by other means."

The second sentence of this paragraph is also in line with our reported AR areas and documentation. A discontinuation of any management of land not being a forest that leads to a forest is in our view evidence 'that a decision had been taken to replant or to allow forest regeneration by other means' as there exists a legal basis which accounts for this land use change also in an administrative sense and provides obligations for its forest management (that the af-/reforestated forests are under forest management).

The question on the af-/reforestation technique is in our understanding not the relevant one: The expression'*„… to replant or to allow forest regeneration <u>by other means</u>"* is in our view a broad definition that includes also natural regeneration as an af-/reforestation technique (as does the definition of af-/reforestion in the Marrakech Accords). More relevant, however, may be the documentation around the issue (…*other <u>documentation</u> that demonstrates that a decision had been taken to replant or to allow…).*

c) Documentation material that supports Austria's approach

The following key documents were cited for Austria's justification:

The Austrian Forest Act with its definitions and implied understanding of 'forest', 'forest management' (broad definition) including afforestation/reforestation.

The cited parts of the Austrian Forest Act show that an area which meets the forest definition becomes a forest by law (independent from different assignments under other regulations). This 'Forest-Force' overrules all other regulations and protects the af-/reforested areas from deforestation. Chapter 11.4.1.3 shows that all forests in Austria are forests under the Austrian Forest Act with related rights and obligations for the land owners (including an obligation for forest management). Furthermore, all land in Austria has defined some owner. These national circumstances result in that all Austrian forests are reported to be under forest management. Chapter 11.4.1.2 informs that natural regeneration is by law an accepted and frequently desired management technique to af-/reforest land.

So, only areas are accounted as afforestation/reforestation areas that qualify as forests under the Austrian forest act and that all afforested/reforested areas that qualify as forests under the forest act are fully protected by the forest act, independent where those areas are located in Austria. In Austria all forested areas are managed forest areas: abandonment of land generally does not exist in Austria because all land has an owner who decides the land use and needs to manage the land according to the related legal obligations whereas abandoned lands according to the Revised 1996 IPCC Guidelines are by definition assumed not to be subject to ongoing human intervention (of significance to carbon stocks after abandonment). Such decision has been made by the Austrian Parliament and cannot be overruled by any authority including the land-owner. According to its general and legal nature the Austrian Forest Act is binding in its entirety. It is a mandatory requirement for any forest management plan. As such, it overrules also any forest management plan and makes it unnecessary to include in forest management plans any statement with respect to af-/reforestation. Therefore, we interpret the Austrian Forest Act as the best demonstration for a generally and permanently valid national decision regulating af-/reforestation where units of land meet the forest definition of the Austrian Forest Act after the land owner has decided for the af-/reforestation of the land. Hence, the Austrian Forest Act itself is also the national decision that no longer cultivated units of land are af-/reforestation areas and forests when they meet the forest definition of the Austrian Forest Act, and it underpins the nature of a decision for af-/reforestation by the land owner of the AR lands (otherwise the land would be managed in a way that the forest definition is not met by the plant cover).

The results of the NFI with regard to the increase in the forested area are the basis for the reported af-/reforestation area. Such assessed AR areas give also evidence for a decision by the land owners for a land-use change to forests. The NFI covers the whole territory of Austria, and identifies in a randomized way all forested land and all changes in forested land. The instruction handbook of the NFI defines all assessed parameters (see HAUK & SCHADAUER 2009, http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf., SCHIELER & HAUK 2001, http://bfw.ac.at/700/pdf/da_ges_neu.pdf) and the procedure (including training of staff) guarantees that only areas, that meet the definition of forest are recognized as forested area.

Summary

Austria believes that there is well established documentation explaining that all LUC areas to forests are 'direct human induced' AR lands in Austria. Under the Austrian law, land will be regarded as forest land wherever it meets the qualification set out in the Austrian forest act. As such a change, either by natural or artificial regeneration, is a decision taken by the land owner, and thus Austria regards this as 'direct human induced' AR activity under Article 3.3.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

In Austria temporarily unstocked areas (e.g. harvested area, disturbances) remain forests and are not accounted as deforestation. NFI teams are trained to distinguish between the results of forest management operations and land use changes.

Deforested areas

can be detected by two combined characteristics:

1. The forest definition of Austrian NFI has ceased to apply.

And:

2. There are significant visible changes in soil structure or ground vegetation which do not go with the natural succession of a forest (e.g. consequences of anthropogenic activities like ploughing, crop production, mowing or construction activities or natural abortion of the forest and its stand by e.g. landslides).

Exceptions are forest roads for forest management purposes within the forest (Private roads at the forest edge and public roads within the forest are classified as non forest). Particularly, if point 2 is not clearly fulfilled an unstocked area remains forest.

Temporarily unstocked areas

by forest management or forests with biotic and abiotic reduction of their crown coverage (windthrow, fire, beetles) maintain the natural succession of ground vegetation and soil and therefore remain part of the forest.

It must be mentioned that the Austrian Forest Act obliges land owners into guaranteeing the regeneration of the forests (according to the criteria of the forest definition) on forest areas without sufficient crown cover within a defined time span. This legal framework represents the main reason why unstocked forest areas that do not clearly fulfil point 2 above are still assessed as forests by the NFI. Consequently, there does not exist a time period threshold to distinguish harvesting or disturbances (and replanting or regrowth) from deforestation within the NFI assessments, but the criterias in point 2.

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

During the NFI assessments areas are immediately classified as being deforested or not using the criteria described in chapter 11.4.2. For the arguments given in this chapter, there exists no transition period for the assessment of a deforestation. If a LUC is visible it is accounted, but the assessment of a LUC needs more criteria than just the loss of forest cover (see above).

11.4.4 Information related to the natural disturbances provision under article 3.3

Austria will not make use of the natural disturbance provision for Article 3.3 activities.

11.4.5 Information on the equivalent forest provision

Austria will not make use of the equivalent forest provision.

11.4.6 Information on Harvested Wood Products under article 3.3

The HWP removals and emissions were estimated for AR, but not for D activities. Details for the separate estimation for all activities are provided in Chapter 11.3.1.1.

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

In Austria all forests represent managed forestsaccording to the regulations set out in the Austrian Forest Act and per definition (see Chapter 11.4.1). Austria uses a broad definition for the description of Forest Management. Consequently, with the exeption of except the emissions and removals of the ARD lands since 1.1.1990 which are accounted under the Art. 3.3 activity ARD, the emissions and removals of all lands which were forests in 1.1.1990 result from human induced activities and are accounted as Forest Management emissions and removals.

11.5.2 Information relating to Forest Management

Austria has a long tradition in forest management which is characterised by a long-term forestry policy that takes also issues of biodiversity conservation into account. It has been a guiding principle of Austrian forest management policy for more than 100 years to use forests in an economically sustainable manner, balancing the relevant ecological, economic and social functions. The principle of sustainable management of forests is laid down in § 1 of the Austrian Forest Act which is valid for all Austrian forests. This Act defines all measures which have to be taken in order to manage, protect and sustain Austrian forests. This includes regulations connected with harvest (e.g. limitations for harvest in stands below the legal minimum age for the rotation period; maximum allowed size of clearcuts), provisions for natural and artificial regeneration, regulations around deforestation (e.g. principal ban of deforestation and definition of substitute afforestation measures in approved cases), but also management measures which have to be implemented for phyto-sanitary reasons or in protective forests (see also Chapter 11.4.1). Therefore, Austria uses a broad definition for Forest Management. As a consequence of these regulations and measures, Austria is one of the most densely wooded countries in Europe with forests covering almost half of the federal territory. Since the beginning of the Austrian Forest Inventory in 1961 a continuous increase in forest area and tree biomass stock has been observed in Austria (BFW 2011a).

11.5.2.1 Conversion of natural forest to planted forest

According to the definitions laid out in the Austrian Forest Act all forests are managed in Austria. Natural forests in sense of the decisions for the 2^{nd} commitment period do not exist in Austria. Therefore, there is no conversion from natural forests to plantations in Austria. Emissions and removals in Forest Management land in Austria cover the emissions and removals of whole Austrian forests minus those resulting from AR and D (in the year of D) which are accounted under these Art. 3.3 activities.

11.5.2.2 Forest Management Reference Level (FMRL)

Austria submitted in 'Submission of information on forest management reference levels by AUSTRIA in accordance with Decision 2/CMP.6' (UNFCCC 2011a) the following national reference levels for Forest management for the period 2013-2020:

- 6.516 million t CO_2 per year in case of accounting for harvested wood products on the basis of the production approach, in line with the guidance provided in FCCC/KP/AWG/2010/CRP.4/Rev.4

- 2.121 million t CO_2 per year in case of accounting for harvested wood products on the basis of instantaneous oxidation.

This value is consistent with the value included in the draft decision on LULUCF for Austria adopted in Cancun.

The approach for estimating the FMRL used the data of the Austrian forests according to the results of the NFI 2000/02 as basis. These are also the used data for estimating the historic emissions and removals for Forest Land. The models which were used for the projections of the FMRL were developed and tuned on basis of the data of the Austrian forests from the NFIs and/or on basis of the results of FAO HWP production statistics for Austria. So, there is a high consistency between the methods in constructing the FMRL and the data used for the historical GHG emissions and removals of forests and HWPs (details of the approaches can be found in Austria's FMRL submission, UNFCCC 2011a). Some inconsistencies were already known at the time of FMRL submission and described there-in (e.g. lack of consideration of biomass drain due to mortality in the FMRL). In addition, first estimates for certain pools (litter and soil) of Forest Land were already in preparation when drafting the FMRL submission and announced in the FMRL submission. Several further improvements have been carried out since Austria's FMRL submission in 2011, partly on basis of results of the NFI 2007/09 which became available after the FMRL submission.So, with all these changes and improvements there was a need for technical corrections of Austria's FMRL in line with all the recommendations given by the technical assessment of the FMRL (UNFCCC 2011b) and in line with the methodological advice in the IPCC (2014) KP-Supplement. Details on these technical corrections are described in the following chapter.

11.5.2.3 Technical Corrections of FMRL

In accordance with the conclusions and recommendations of the „Report of the technical assessment of the forest management reference level (FMRL) submission of Austria submitted in 2011" (UNFCCC 2011b), the improvements and updates in the forest land remaining forest land category have impacts on accounting for Forest Management in the second commitment period which require the following technical corrections:

1) Inclusion of the litter and soil pools:
   According to Paragraph 30 of the 'Report of the technical assessment of the forest management reference level submission of Austria submitted in 2011' (UNFCCC 2011b) Austria indicated to make a technical correction to its FMRL as soon as national estimates for the litter and soil pools are available. The new estimates for the *4.A.1* litter and soil C pool changes represent an increase in emissions of about 2 600 kt CO_2 per year, which requires a technical correction to ensure consistency in the treatment of pools between the FMRL and the national reporting of the Austrian GHG inventory under the UNFCCC and Kyoto Protocol.
2) Updated estimates of biomass:
   Since the 2012 submission some updated biomass functions are applied for the biomass estimates in the forest category. It was realized that the previously used function for the root biomass from Wirth et al. (2004) leads to unrealistic high root biomasses for dimensions with higher DBH due to the shape of the function at larger DBHs. This had a significant impact on the results for increment biomass, but also on the results for drain biomass. So, a different root function from WIRTH et al. (2004) was selected which includes besides DBH also the tree age as an explanatory parameter and leads to more realistic estimates for root biomass. The use of the new functions leads to approximately 12% lower net biomass re-

movals of category *4.A.1* for the whole time series compared to the estimates of submissions before the submission in 2012. The changes of the average expansion ratios due to the use of the improved functions is given in Table 239 (old vs. new i.e. „submissions before 2012" vs. „since submission 2012").

Table 319: 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	
	old	new	old	new
increment	1.75	1.62	1.77	1.63
drain	1.62	1.60	1.63	1.59

This results in following changes: The expansion ratios for increment decreased by around 8%, those for drain by around 2% (Table 239). As a result of these new expansion ratios the net removals of the historic time series decreased significantly in comparison to previous submissions. This adjustment leads to a decrease in FMRL removals (based on the previously used biomass functions) of around 2 400 kt CO_2 which requires a technical correction to ensure methodological consistency between the FMRL and the national reporting of the Austrian GHG inventory under the UNFCCC and Kyoto Protocol.

3) Updated data on 'drain':

Austria already indicated in the course of the technical assessment of its FMRL, that a certain „inconsistency" arises from the fact, that the projections used to calculate the FMRL only cover emissions resulting from the harvest of 'useable' trees, whereas the NFI and subsequently the reporting under the UNFCCC covers all biomass drain, including biomass losses due to mortality, which were around 10% of the total biomass drain in the forests in yield according to the latest NFI.

The ERT concluded that the FMRL should in principle take account the most recent data available at the time of estimation and suggested that Austria should assess whether including the NFI 2007–2009 data would make a significant difference to the FMRL. The losses due to mortality represent an increase in emissions of around 2 200 kt CO_2, which requires a technical correction to ensure methodological consistency between the FMRL and the national reporting of the Austrian GHG inventory under the UN-FCCC and Kyoto Protocol.

4) Updated dead wood pool:

The gains in the dead wood pool have been recalculated on the basis of the new NFI results. The annual removals in this pool changed from approx. 600 to 800 kt CO_2. The changes in the dead wood pool represent an increase in removals of around 200 kt CO_2, which requires a technical correction to ensure methodological consistency between the FMRL and the national reporting of the Austrian GHG inventory under the UN-FCCC and Kyoto Protocol.

5) Corrections in the calculations of the 'increment'

As indicated in the 'Report of the technical assessment of the forest management reference level submission of Austria submitted in 2011' Austria assumed a constant stemwood increment of 29.8 million m³ o.b. per year, based on the weighted average of the last NFIs available at the time of compiling the FMRL submission. An error occurred in this estimate, which requires a correction. In addition results of the new NFI 2007/09 were taken up in the calculation of the weighted average. This correction results in a change of the projected annual stemwood increment from 29.9 to 30.1 million m^3 o.b. This change represents an increase in removals of around 200 kt CO_2 which requires a technical correction to ensure methodological consistency in the calculations of the FMRL and the national forest inventory.

6) Update of harvested wood products:
   Due to the unavailability of FAO data the time series from 1900 to 1960 was gap-filled by calculating a mean value of the data from the early 60s. To be in line with the 2006 IPCC Guidelines this methodology has been updated accordingly. Pre-1960 values have been estimated by a degression which reflects the development of economic growth for this period. This change represents an increase in removals of around 900 kt CO_2 which requires a technical correction to ensure methodological consistency in the calculations of the FMRL and the national forest inventory.

The sum of all the technical corrections result in a 'calculatory' difference between the FMRLs adopted for Austria pursuant to Decision 2/CMP.7 of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (as listed in FCCC/KP/CMP/2011/10/Add.1 to Decision 2/CMP.7 (UNFCCC 2012)) and the national reporting of the Austrian GHG inventory under the UNFCCC and Kyoto Protocol of 6 759 kt CO_2 p.a (with HWP on basis of instantaneous oxidation) and 5 823 kt CO_2 p.a (with HWP on the basis of delayed emissions).

The application of these technical corrections led to a revision of the FMRL from -2 121 to 4 638 kt CO_2 (with HWP on basis of instantaneous oxidation), and from -6 516 to -693 kt CO_2 (with HWP on the basis of delayed emissions).

These technical corrections are furthermore in line with the provisions of Paragraph 14 of the Annex to decision 2/CMP.7 which requires parties to demonstrate methodological consistency between the FMRL and reporting for forest management.

The methodological improvements in the estimates resulting from paper (see chapter 11.3.2.4, second but last bullet point) requires a further related technical correction of the FMRL which will be carried out for the next submission.

11.5.2.4 Information related to the natural disturbances provision under article 3.4

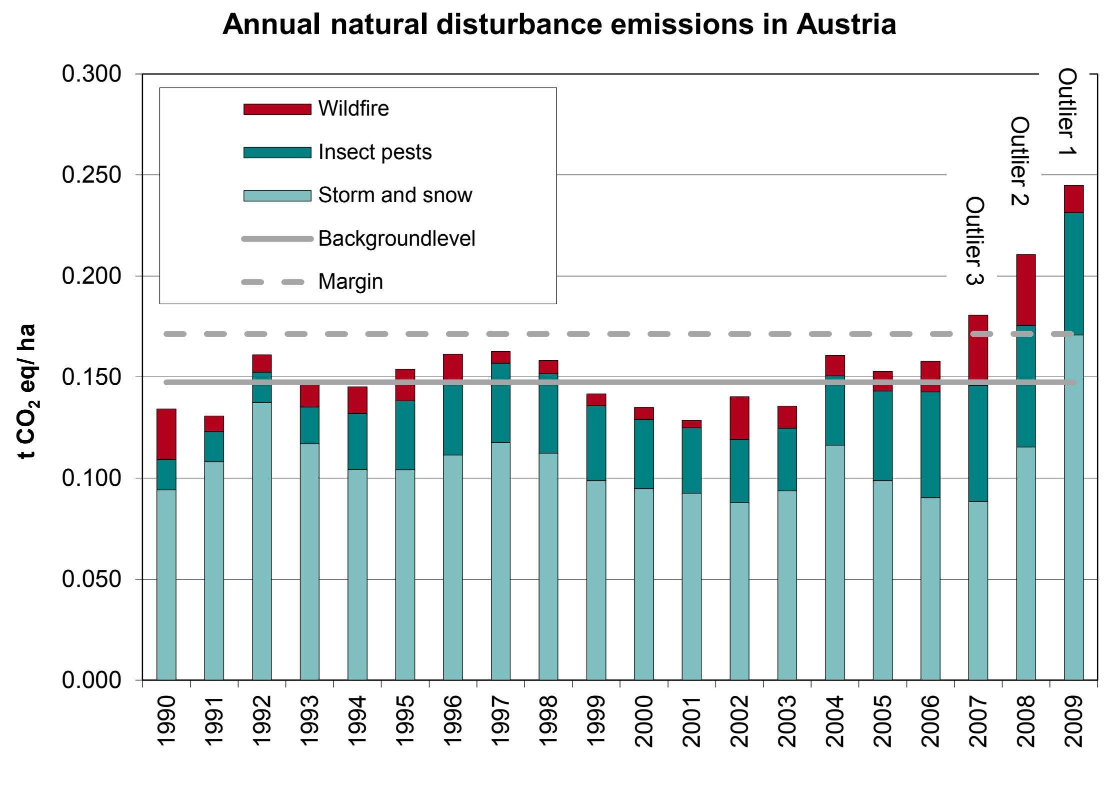
Austria intends to apply the provisions to exclude emissions from peaks in natural disturbances (ND) for the accounting for Forest Management under Article 3.4 of the Kyoto Protocol during the second commitment period in accordance with Paragraph 33 of the Annex to decision 2/CMP.7.

The background level for the natural disturbance emissions of forest management is 0.147 t CO_2eq/ha, including the margin it amounts to 0.171 t CO_2eq/ha.

The ND estimates were carried out at the Federal Research and Training Centre for Forests, Natural Hazards and Landscape which run the used statistics for estimating the ND (BFW 2014). National forest statistics (Dokumentation der Waldschädigungsfaktoren – DWF) provide annual data for natural disturbances in Austrian forests. This information is complemented with data provided by the National Forest Inventory.

The background level was determined in line with the provisions given in Annex E to decision 2/CMP.7. All (types of) natural disturbances are considered in this calculation for which the emission time series has been established from 1990-2009. The chosen Tier 3 method applies a decay model for emissions from all ND except for forest fires whose methodology is the same as described in Chapter 6.2.4.1.4 for biomass burning in forest land remaining forest land. The Yasso model (see chapter 6.2.4.1.3) calculates annual emissions from the biomass decay of all ND biomass remaining at site which is not associated with salvage logging. For Austria this implies that only wood and biomass which is non-merchantable (small affected plots, heavily destroyed stems, trees with small diameters, trees which are economically not interesting and trees which are from an forest-entomological point of view not relevant) or wood and biomass lying on remote and inaccessible areas is considered for the background level calculation. In addition, deadwood which is not a result of the ND event was not included.

The background level and the margin have been determined by applying the IPCC (2014) default method, which is twice the standard deviation of the mean of the emission time series (1990-2009) without outliers which were above twice the SD (those were removed until no outliers occur anymore).



Source: BFW 2014

Figure 49: Annual natural disturbance emissions in Austria according to natural disturbance type, background level, margin and excluded annual emissions for the Background Level based on the DWF data (Source: BFW 2014)

The background level and margin for this time series were also estimated with an independent Austrian statistic on ND (Austrian timber harvest reports). The results for background level and margin were almost the same as those on basis of DWF data, but the DWF statistic has a more accurate resolution of the various ND types (BFW 2014). So, Austria decided to use the DWF statistic as the data source for the ND assessment.

It is not expected that net credits or debits occur due to the provisions explained above. In addition, it is ensured by the monitoring system of all non-accounted ND sites that removals due to re-growth on these areas will not be accounted.

11.5.2.5 Information on Harvested Wood Products under article 3.4

2/CMP8, para g

(i) Information on activity data for the HWP categories

The HWP estimates for the KP activities follow the same approach as those for the HWP estimates under the UNFCCC. Detailed information on the activity data is provided in 0.

(ii) Information on half-lives, information on methodologies used

The HWP estimates for the KP activities follow the same approach as those for the HWP estimates under the UNFCCC (production approach from domestic harvest). Detailed information on the half-lives and methodology is provided in chapter 6.8.

(iii) If FMRL is based on a projection, information on whether emissions from HWP originating from forests prior to the start of the second CP have been included in the accounting

The estimates of the HWP share in the FMRL and those of the HWP emissions and removals under FM are fully consistent. The projections of the HWP emissions and removals include also those from the forests prior to the start of the 2nd CP.

(iv) Information on how emissions from HWP pool that have been accounted for during the first CP on the basis of instantaneous oxidation have been excluded from the accounting of the 2nd CP

Austria did not elect Forest Management for the 1st CP.

(v) Demonstrate that HWP from D have been accounted as instantaneous oxidation

The HWP removals and emissions are estimated and reported separately for all three activities (AR, D, FM), which ensures that those for D are not accounted. Details for the separate estimation for all activities are provided in chapters 11.3.1.1 and 11.3.2.1.

(vi) *Showing that CO_2 emissions from SWDS are separately accounted, and wood for energy purposes accounted on the basis of instantaneous oxidation*

Depositing of organic material is forbidden by law in Austria. Consequently, CO_2 emissions from SWDS do not occur. The used activity data (FAO wood products data) ensure that only delayed emissions from wood products are accounted under HWP, but not harvested wood which is immediately used for energy purposes.

(vii) Information showing that emissions/removals from HWPs which are accounted do not include imported HWP

The methodological details of the used approach are described in chapter 6.8 of the UNFCCC part of the NIR. The description there provides evidence that the IPCC (2014) approach has been implemented to separate the HWP production originating from domestic harvest in Austria from the total HWP production.

11.5.3 Information relating to Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage and Rewetting if elected, for the base year

These activities were not elected by Austria.

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

According to the chapter 2.3.6 of the KP Supplement the key categories for Kyoto Protocol activities can be derived from the identified key categories in the UNFCCC inventory. The GL state that 'whenever a category is identified as key in the UNFCCC inventory, it is good practice that the associated activity under the KP also be treated as a Key Category'. In case of Austria according to this approach, all of the categories under Articles 3.3 of the Kyoto Protocol (afforestation and reforestation, deforestation and forest management) can be regarded as key categories (see Table 8).

11.7 Information related to Article 6

There are no Article 6 activities concerning the LULUCF sector in Austria.

12 INFORMATION ON ACCOUNTING OF KYOTO PROTOCOL UNITS

12.1 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.

12.2 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 2017 has been reported as separate file ('SEF_AT_CP2_2017_20180222') in xls and xml format each by separate upload.

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 manually by using the SEF report tool, version 3.8.3, provided by the secretariat at 26th January 2018.

The SEF for CP2 2016 was generated on 22nd February 2018 with data from the Union Registry from 8th January and the SEF report tool version 3.8.3, provided by the secretariat on 26th January 2018.

Further details can be found in the electronic SEF files as mentioned above.

12.3 Discrepancies and notifications

No discrepancies occurred in 2017. Therefore, no report R-2 is submitted.

No CDM notifications occurred in 2017. Therefore, no report R-3 is submitted.

No non-replacements occurred in 2017. Therefore, no report R-4 is submitted.

No invalid units exist at the 31 December 2017. 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 2017.

12.4 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 publicly accessible information both on the website of the Austrian emissions trading registry http://www.emissionshandelsregister.at/ms/emissionshandelsregister/ehr_en/ehr_en_publicreports/ehr_en_unfcccreports/ and in the public section "Kyoto Protocol Public Reports" of the Austrian part of the Union Registry
https://ets-registry.webgate.ec.europa.eu/euregistry/AT/public/reports/publicReports.xhtml

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/

12.5 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.)

12.6 KP-LULUCF accounting

Austria selected accounting of the KP-LULUCF activities at the end of the commitment period.

12.7 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 must be first introduced into the EU legislative framework. This was done by the Annex of Commission Delegated Regulation 2015/1844.

This provision, however, will become applicable, according to Article 2 of the Delegated Regulation, on "the date of publication by the Commission in the Official Journal of the European Union of a communication on the entry into force of the Doha Amendment to the Kyoto Protocol". Consequently, for the moment and until the Doha Amendment enters into force, we are not in a position to open the PPSR account in our National Registry.

13 CHANGES IN THE NATIONAL SYSTEM

Austria has reported a description of its national system in accordance with Article 5, paragraph 1, of the Kyoto Protocol, in its Initial Report for the first commitment period and has reported on updates of its national system in its national inventory reports in accordance with the "Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol".

The national system is unchanged compared to previous submission.

14 CHANGES IN THE NATIONAL REGISTRY

14.1 Information on changes according to Decision 15/CMP.1

The following table summarises the changes to the National Registry of Austria in 2017.

Table 320: Changes to the national registry of Austria in 2017.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Neither the name and contact of the registry administrator as an institution nor the name of the registry administrator and the alternate registry administrator has changed.
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	The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. 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	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully 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 of the registry internet address occurred during the reporting period.
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	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.

14.2 Previous Annual Review recommendations

Austria was not subject to an individual inventory review in 2017.

FCCC/ARR/2016/AUT did not include any recommendations related to the registry.

There were no recommendations in SIAR Part 1 and Part 2 (SIAR/2017/AUT/1/1 and SIAR/2017/AUT/1/2), both as version 2.0 and both prepared by Markwin Pieters, UNFCCC. on 12th July 2017.

15 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

The following information is provided in accordance with the guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol (Decision 15/CMP.1, Section H.). Updates compared to previous submission of Article 3 (14) information (as included in NIR 2017) have been included regarding the information on reduction of market imperfections.

23. Each Party in Annex I shall provide information relating to how it is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement its commitments mentioned in Article 3, paragraph 1 of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention.

The Kyoto Protocol is, in principle and in general, designed to minimize adverse effects on specific sectors, specific industries or specific trade partners of a Party, including effects on international trade, and social, environmental and economic impacts on other Parties. This is due to the fact that a. o.. it does not limit action to a single gas or sector and that it requests action to support the least developed countries. By striving to implement the features of the Protocol, Austria is naturally working to minimize any adverse effects due to the reduction of greenhouse gas emissions.

Austria is acting together with other Parties in the EU to jointly fulfil the commitments under the Protocol. Key climate policies and measures (e.g. the EU Emissions Trading System and the Effort Sharing between Member States) are established at an EU level. While these policies are executed at the national level, they are not monitored and assessed by individual Member States, but by the EU as a whole. The EU reports in detail on how it strives to minimize adverse effects in its annual national inventory report in Section 15.1, to which we hereby refer for further information.

Austria also seeks to ensure that response measures designed and implemented entirely at the national level are as targeted and effective as possible. Since 2013, we have compulsory, government-wide impact assessments concerning environmental, economic and social consequences of policies and measures. The main focus of the assessments is on effects at the national level, but this does not rule out that assessments also consider international effects. In fact, economic effects of measures cannot be analysed in isolation and will necessarily address trade-related effects as well.

We note that effects (impacts) of climate change response measures can be both positive and negative, and that maximising positive economic, social and environmental impacts (co-benefits) through good policy design is an important aspect in incentivising climate action at the national, regional and global level.

24. Parties included in Annex II, and other Parties included in Annex I that are in the position to do so, shall incorporate information on how they give priority, in implementing their commitments under Article 3, paragraph 14, to the following actions, based on relevant methodologies referred to in paragraph 11 of decision 31/CMP.1

(a)The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities.

Austria strives to phase out market imperfections that run counter to the objective of the Convention and to take into account externalities. In this relation Austria, as part of the internal market of the European Union, is determined by EU policies to a considerable extent.

Market imperfections

Removing market imperfections is an important target of EU policy. Financial support provided by the Member States to undertakings is regulated at the level of the European Union. The EU Treaty pronounces a general prohibition of "State aid", but exemptions may be granted if they are in the common interest for the EU, for example in favour of environmental protection.

The EU has made significant progress in removing imperfections and taking into account externalities e. g. in the energy market and in agriculture. For details see Section 15.2 of the EU's National Inventory Report.

Austria uses fiscal incentives etc. as important instrument to advance the objectives of the Convention.

Fiscal incentives

Energy prices for road transport do not yet sufficiently reflect externalities. Mineral oil tax and fuel consumption levy are incentives to buy cars with low CO_2 emissions. Since 2011 the air traffic also has to contribute through the introduction of a flight fee.

- **Fuel consumption levy (from March, 1st, 2014)**

The car registration levy depends on the standard fuel consumption of the car. For cars with a fuel consumption corresponding to CO_2 emissions below or equal to 90 g/km the tax rate is zero, it linearly increases up to 32% for cars with emissions of 250 g/km; further 20 € are added for each g/km above 250 g/km. Electric vehicles are exempt from the levy.

- **Air Transport Levy**

In December 2010 the Air Transport Levy Act was passed within the Budget Act of the Republic of Austria. From April 2011 all flights starting from an Austrian Airport have to pay a fee at a specific amount per passenger (very few exceptions are granted, e.g. like military or humanitarian flights). An amendment of the Act in 2017 has led to the following fees:

Short distance (within Austria, as well as e.g. Sweden, Cyprus): 3,50 Euros

Medium Distance (e.g. Iraq, Sudan): 7,50 Euros

Long Distance (Brazil, Indonesia): 17,50 Euros

Agricultural subsidies

ÖPUL 2015 (Österreichisches Programm für umweltgerechte Landwirtschaft)

Austria provides subsidies for farms according to the programme for the promotion of agriculture that is extensive, appropriate to the environment, and protective of nature. The subsidised measures also lead to decreasing greenhouse gas emissions.
(https://www.bmnt.gv.at/english/agriculture/Rural-development/-pul2015until2020.html)

(b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies

No subsidies for environmentally unsound technologies have been identified.

(c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end

This technological field is not a high priority in the Austrian research policy.

(d) Cooperating in the development, diffusion and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort

Regarding the development, diffusion and transfer of technology which causes no or less greenhouse gas emissions Austria puts its focus is on renewable energy sources.

(e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

No action is taken in this context.

(f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

Austria is a member of institutions and initiatives that have the exchange of research results and transfer of technology as a main target, e. g. the International Energy Agency and the Climate Technology Initiative. Bilateral assistance projects are another important means for transfer of technology which helps countries reducing their dependence on the consumption of fossil fuels.

- **International Energy Agency (IEA)**

Austria is a founding member of the International Energy Agency (IEA), which was founded in 1974. A lot of climate change issues are processed in so-called joint Implementation Agreements, where international partners collaborate on different research topics.

- **Climate Technology Initiative**

Austria is member of the Climate Technology, which was established in 1995 at the Conference of Parties to the UNFCCC and has a new status as an IEA Implementing Agreement since 2003. Its mission is to promote the objectives of the UNFCCC by fostering international cooperation for accelerated development and diffusion of climate friendly technologies and practises for all activities and greenhouse gases. The main principles of CTI are close collaboration with developing countries and economies in transition and partner-ship with stakeholders, including the private sector, non-government organisations (NGOs), and other international organisations. CTI performs a. o. capacity building and technical assistance for technology needs assessments as well as technology implementation activities and organizes seminars, symposia and training courses. (http://www.climatetech.net)

ABBREVIATIONS

General

AMA ....Agrarmarkt Austria

BAWP ....Bundes-Abfallwirtschaftsplan
Federal Waste Management Plan

BFW......................Bundesamt und Forschungszentrum für Wald
Austrian Federal Office and Research Centre for Forest

BMLFUW ....Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft
Federal Ministry of Agriculture, Forestry, Environment and Water Management

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, now domain of Environment: BMLFUW)

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 called 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

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

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

FAO ....Food and Agricultural Organisation of the United Nations

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

IPCC ....Intergovernmental Panel on Climate Change

ICR........................In-Country Review (by the UNFCCC)

IEA........................International Energy Agency

ISO........................International Standards Organisation

LTO.......................Landing/Take-Off cycle

LULUCF................Land Use, Land-Use Change and Forestry – IPCC-CRF Category 4

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.)

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

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}

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ANNEX

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 295 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 2016.

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 2016 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 2016 44 source categories comprised > 95% of the cumulative total and were thus rated as key categories. For the year 1990 50 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 2016 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. 24 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 2016 according to Equation 5.4.1 of the GPG-LULUCF. Nine LULUCF key categories were identified by this analysis for 2016. 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 2016 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 2016, and for the trend assessment 1990-2016, 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 2016 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	CO2	7 924	10.1%	10.1%
2 C 1	Iron and Steel Production	CO2	6 610	8.4%	18.5%
1 A 1 a solid	Public Electricity and Heat Production	CO2	6 247	7.9%	26.4%
1 A 4 b liquid	Residential	CO2	5 605	7.1%	33.5%
1 A 3 b diesel oil	Road Transportation	CO2	5 378	6.8%	40.4%
3 A 1	Cattle	CH4	4 579	5.8%	46.2%
5 A	Solid Waste Disposal	CH4	3 644	4.6%	50.8%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 294	4.2%	55.0%
1 A 4 b solid	Residential	CO2	2 511	3.2%	58.2%
2 A 1	Cement Production	CO2	2 033	2.6%	60.8%
1 A 1 b liquid	Petroleum Refining	CO2	1 958	2.5%	63.3%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 884	2.4%	65.7%
1 A 4 b gaseous	Residential	CO2	1 847	2.3%	68.0%
1 A 4 a liquid	Commercial/Institutional	CO2	1 423	1.8%	69.8%
1 A 2 a solid	Iron and Steel	CO2	1 335	1.7%	71.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	1 228	1.6%	73.1%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	1 182	1.5%	74.6%
2 C 3	Aluminium Production	PFC	1 149	1.5%	76.0%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 014	1.3%	77.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	1.2%	78.5%
2 B 2	Nitric Acid Production	N2O	877	1.1%	79.6%
1 A 2 d liquid	Pulp, Paper and Print	CO2	853	1.1%	80.7%
1 A 4 a gaseous	Commercial/Institutional	CO2	707	0.9%	81.6%
1 A 2 a gaseous	Iron and Steel	CO2	650	0.8%	82.4%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	607	0.8%	83.2%
1 A 2 f gaseous	Non-Metallic Minerals	CO2	559	0.7%	83.9%
1 A 2 f solid	Non-Metallic Minerals	CO2	535	0.7%	84.6%
1 A 2 c gaseous	Chemicals	CO2	519	0.7%	85.3%
1 A 2 f liquid	Non-Metallic Minerals	CO2	508	0.6%	85.9%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	507	0.6%	86.6%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energ	CO2	506	0.6%	87.2%
2 A 4 c	Non-metallurgical Magnesium	CO2	481	0.6%	87.8%
2 B 1	Ammonia Production	CO2	467	0.6%	88.4%
1 A 1 b gaseous	Petroleum Refining	CO2	437	0.6%	89.0%
3 B 1 1	Cattle	CH4	424	0.5%	89.5%
1 A 2 d solid	Pulp, Paper and Print	CO2	398	0.5%	90.0%
2 A 2	Lime Production	CO2	396	0.5%	90.5%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	363	0.5%	91.0%
1 A 1 a other	Public Electricity and Heat Production	CO2	352	0.4%	91.4%
2 D	Non-Energy Products from Fuels and Solvei	CO2	349	0.4%	91.9%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	343	0.4%	92.3%
1 B 1 a	Coal Mining and Handling	CH4	333	0.4%	92.7%
1 B 2 b	Natural Gas	CH4	259	0.3%	93.0%
3 B 1 1	Cattle	N2O	258	0.3%	93.4%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	256	0.3%	93.7%
1 A 4 b biomass	Residential	CH4	228	0.3%	94.0%
2 C 4	Magnesium Production	SF6	228	0.3%	94.3%
1 A 3 e gaseous	Other Transportation	CO2	224	0.3%	94.6%
2 G	Other Product Manufacture and Use	N2O	224	0.3%	94.8%
1 A 4 b solid	Residential	CH4	200	0.3%	95.1%

Table A 2: Approach 1 - Level Assessment of the KCA excluding LULUCF for 2016

IPCC Category Code	IPCC Category	GHG	Year 2016 Estimate Ex,t [t CO2-e units]	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b diesel oil	Road Transportation	CO2	17 700	22.2%	22.2%
2 C 1	Iron and Steel Production	CO2	10 418	13.1%	35.3%
1 A 3 b gasoline	Road Transportation	CO2	4 779	6.0%	41.3%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 997	5.0%	46.3%
3 A 1	Cattle	CH4	3 886	4.9%	51.2%
1 A 4 b liquid	Residential	CO2	3 376	4.2%	55.4%
1 A 4 b gaseous	Residential	CO2	2 797	3.5%	58.9%
1 A 1 b liquid	Petroleum Refining	CO2	2 250	2.8%	61.8%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 793	2.3%	64.0%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 758	2.2%	66.2%
2 A 1	Cement Production	CO2	1 729	2.2%	68.4%
1 A 1 a solid	Public Electricity and Heat Production	CO2	1 587	2.0%	70.4%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 582	2.0%	72.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	1 464	1.8%	74.2%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	1 283	1.6%	75.8%
5 A	Solid Waste Disposal	CH4	1 212	1.5%	77.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	1 079	1.4%	78.7%
1 A 4 a gaseous	Commercial/Institutional	CO2	985	1.2%	79.9%
1 A 2 c gaseous	Chemicals	CO2	984	1.2%	81.2%
1 A 2 a gaseous	Iron and Steel	CO2	981	1.2%	82.4%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	785	1.0%	83.4%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	783	1.0%	84.4%
1 A 2 f gaseous	Non-Metallic Minerals	CO2	645	0.8%	85.2%
1 A 2 f other	Non-Metallic Minerals	CO2	600	0.8%	85.9%
2 A 2	Lime Production	CO2	582	0.7%	86.6%
1 A 3 e gaseous	Other Transportation	CO2	556	0.7%	87.3%
1 A 1 b gaseous	Petroleum Refining	CO2	535	0.7%	88.0%
2 B 1	Ammonia Production	CO2	527	0.7%	88.7%
1 A 4 a liquid	Commercial/Institutional	CO2	483	0.6%	89.3%
1 A 2 a solid	Iron and Steel	CO2	433	0.5%	89.8%
1 A 2 d solid	Pulp, Paper and Print	CO2	365	0.5%	90.3%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	353	0.4%	90.7%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	346	0.4%	91.2%
3 B 1 1	Cattle	CH4	336	0.4%	91.6%
1 A 2 b gaseous	Non-Ferrous Metals	CO2	332	0.4%	92.0%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	329	0.4%	92.4%
2 G 2	Other product manufacture and use - SF6 and PFCs from	SF6	319	0.4%	92.8%
2 A 4 c	Non-metallurgical Magnesium	CO2	318	0.4%	93.2%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO2	271	0.3%	93.6%
3 B 1 1	Cattle	N2O	266	0.3%	93.9%
1 B 2 b	Natural Gas	CH4	253	0.3%	94.2%
1 A 2 c other	Chemicals	CO2	230	0.3%	94.5%
1 A 2 f solid	Non-Metallic Minerals	CO2	221	0.3%	94.8%
1 A 4 b biomass	Residential	CH4	219	0.3%	95.0%

Table A 3: Approach 1 - Trend Assessment of the KCA excluding LULUCF for the trend 1990–2016.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate Ex,t	Trend Assessment $T_{x,t}$	% Contribution to Trend	Cumulative Total of $L_{x,t}$
1 A 4 b solid	Residential	CO2	2 511	80	0.970	28.5%	28.5%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2	91	0	0.420	12.3%	40.8%
1 A 2 d liquid	Pulp, Paper and Print	CO2	853	24	0.382	11.2%	52.0%
2 C 4	Magnesium Production	SF6	228	2	0.288	8.5%	60.5%
2 B 2	Nitric Acid Production	N2O	877	36	0.262	7.7%	68.2%
1 A 1 a solid	Public Electricity and Heat Production	CO2	6 247	1 587	0.233	6.8%	75.0%
5 A	Solid Waste Disposal	CH4	3 644	1 212	0.093	2.7%	77.7%
1 A 4 b solid	Residential	CH4	200	6	0.077	2.3%	80.0%
1 A 3 b gasoline	Road Transportation	CO2	7 924	4 779	0.066	1.9%	81.9%
2 C 3	Aluminium Production	CO2	150	5	0.056	1.7%	83.6%
1 A 3 b diesel oil	Road Transportation	CO2	5 378	17 700	0.048	1.4%	85.0%
1 A 4 b liquid	Residential	CO2	5 605	3 376	0.047	1.4%	86.4%
2 C 7	Aluminium Production	SF6	14	0	0.042	1.2%	87.6%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	1 228	346	0.040	1.2%	88.8%
1 A 2 a solid	Iron and Steel	CO2	1 335	433	0.035	1.0%	89.8%
1 A 4 a liquid	Commercial/Institutional	CO2	1 423	483	0.035	1.0%	90.8%
2 C 1	Iron and Steel Production	CO2	6 610	10 418	0.031	0.9%	91.7%
1 A 4 a other	Commercial/Institutional	CO2	116	6	0.025	0.7%	92.5%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 582	0.020	0.6%	93.1%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2	51	2	0.020	0.6%	93.6%
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Inc	CO2	4	0	0.016	0.5%	94.1%
1 A 2 f liquid	Non-Metallic Minerals	CO2	508	165	0.013	0.4%	94.5%
1 A 2 a liquid	Iron and Steel	CO2	75	6	0.012	0.3%	94.8%
3 A 1	Cattle	CH4	4 579	3 886	0.010	0.3%	95.1%

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 $L_{x,t}$
1 A 3 b gasoline	Road Transportation	CO2	7 924	7 924	8.4%	8.4%
4A1	Forest land remaining forest land	CO2	-7 849	7 849	8.3%	16.6%
2 C 1	Iron and Steel Production	CO2	6 610	6 610	7.0%	23.6%
1 A 1 a solid	Public Electricity and Heat Production	CO2	6 247	6 247	6.6%	30.2%
1 A 4 b liquid	Residential	CO2	5 605	5 605	5.9%	36.1%
1 A 3 b diesel oil	Road Transportation	CO2	5 378	5 378	5.7%	41.8%
3 A 1	Cattle	CH4	4 579	4 579	4.8%	46.6%
5 A	Solid Waste Disposal	CH4	3 644	3 644	3.8%	50.5%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 294	3 294	3.5%	54.0%
4G	HWP	CO2	-3 122	3 122	3.3%	57.2%
4A2	Land converted to forest land	CO2	-3 043	3 043	3.2%	60.5%
1 A 4 b solid	Residential	CO2	2 511	2 511	2.6%	63.1%
2 A 1	Cement Production	CO2	2 033	2 033	2.1%	65.2%
1 A 1 b liquid	Petroleum Refining	CO2	1 958	1 958	2.1%	67.3%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 884	1 884	2.0%	69.3%
1 A 4 b gaseous	Residential	CO2	1 847	1 847	1.9%	71.3%
1 A 4 a liquid	Commercial/Institutional	CO2	1 423	1 423	1.5%	72.8%
1 A 2 a solid	Iron and Steel	CO2	1 335	1 335	1.4%	74.2%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	1 228	1 228	1.3%	75.5%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	1 182	1 182	1.2%	76.7%
2 C 3	Aluminium Production	PFC	1 149	1 149	1.2%	77.9%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 014	1 014	1.1%	79.0%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	943	1.0%	80.0%
2 B 2	Nitric Acid Production	N2O	877	877	0.9%	80.9%
1 A 2 d liquid	Pulp, Paper and Print	CO2	853	853	0.9%	81.8%
1 A 4 a gaseous	Commercial/Institutional	CO2	707	707	0.7%	82.6%
1 A 2 a gaseous	Iron and Steel	CO2	650	650	0.7%	83.2%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	607	607	0.6%	83.9%
4E2	Land converted to Settlements	CO2	577	577	0.6%	84.5%
1 A 2 f gaseous	Non-Metallic Minerals	CO2	559	559	0.6%	85.1%
1 A 2 f solid	Non-Metallic Minerals	CO2	535	535	0.6%	85.6%
1 A 2 c gaseous	Chemicals	CO2	519	519	0.5%	86.2%
1 A 2 f liquid	Non-Metallic Minerals	CO2	508	508	0.5%	86.7%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	507	507	0.5%	87.3%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energ	CO2	506	506	0.5%	87.8%
2 A 4 c	Non-metallurgical Magnesium	CO2	481	481	0.5%	88.3%
2 B 1	Ammonia Production	CO2	467	467	0.5%	88.8%
4F2	Land converted to Other land	CO2	444	444	0.5%	89.3%
1 A 1 b gaseous	Petroleum Refining	CO2	437	437	0.5%	89.7%
3 B 1 1	Cattle	CH4	424	424	0.4%	90.2%
1 A 2 d solid	Pulp, Paper and Print	CO2	398	398	0.4%	90.6%
2 A 2	Lime Production	CO2	396	396	0.4%	91.0%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	363	363	0.4%	91.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	352	352	0.4%	91.8%
2 D	Non-Energy Products from Fuels and Solver	CO2	349	349	0.4%	92.1%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	343	343	0.4%	92.5%
1 B 1 a	Coal Mining and Handling	CH4	333	333	0.4%	92.8%
4C2	Land converted to grassland	CO2	332	332	0.4%	93.2%
4C1	Grassland remaining grassland	CO2	294	294	0.3%	93.5%
1 B 2 b	Natural Gas	CH4	259	259	0.3%	93.8%
3 B 1 1	Cattle	N2O	258	258	0.3%	94.1%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	256	256	0.3%	94.3%
1 A 4 b biomass	Residential	CH4	228	228	0.2%	94.6%
2 C 4	Magnesium Production	SF6	228	228	0.2%	94.8%
1 A 3 e gaseous	Other Transportation	CO2	224	224	0.2%	95.0%

Table A 5: Approach 1 - Level Assessment of the KCA including LULUCF for 2016.

IPCC Category Code	IPCC Category	GHG	Year 2016 Estimate $E_{x,t}$ [t CO_2-e units]	Absolute Value of Year 2016 Estimate $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b diesel oil	Road Transportation	CO2	17 700	17 700	20.4%	20.4%
2 C 1	Iron and Steel Production	CO2	10 418	10 418	12.0%	32.5%
1 A 3 b gasoline	Road Transportation	CO2	4 779	4 779	5.5%	38.0%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 997	3 997	4.6%	42.6%
3 A 1	Cattle	CH4	3 886	3 886	4.5%	47.1%
1 A 4 b liquid	Residential	CO2	3 376	3 376	3.9%	51.0%
1 A 4 b gaseous	Residential	CO2	2 797	2 797	3.2%	54.2%
4A1	Forest land remaining forest land	CO2	-2 579	2 579	3.0%	57.2%
1 A 1 b liquid	Petroleum Refining	CO2	2 250	2 250	2.6%	59.8%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 793	1 793	2.1%	61.9%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 758	1 758	2.0%	63.9%
4A2	Land converted to forest land	CO2	-1 741	1 741	2.0%	65.9%
2 A 1	Cement Production	CO2	1 729	1 729	2.0%	67.9%
1 A 1 a solid	Public Electricity and Heat Production	CO2	1 587	1 587	1.8%	69.8%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 582	1 582	1.8%	71.6%
1 A 1 a other	Public Electricity and Heat Production	CO2	1 464	1 464	1.7%	73.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	1 283	1 283	1.5%	74.8%
5 A	Solid Waste Disposal	CH4	1 212	1 212	1.4%	76.2%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	1 079	1 079	1.2%	77.4%
4G	HWP	CO2	-1 042	1 042	1.2%	78.6%
1 A 4 a gaseous	Commercial/Institutional	CO2	985	985	1.1%	79.8%
1 A 2 c gaseous	Chemicals	CO2	984	984	1.1%	80.9%
1 A 2 a gaseous	Iron and Steel	CO2	981	981	1.1%	82.0%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	785	785	0.9%	82.9%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	783	783	0.9%	83.8%
1 A 2 f gaseous	Non-Metallic Minerals	CO2	645	645	0.7%	84.6%
1 A 2 f other	Non-Metallic Minerals	CO2	600	600	0.7%	85.3%
2 A 2	Lime Production	CO2	582	582	0.7%	85.9%
1 A 3 e gaseous	Other Transportation	CO2	556	556	0.6%	86.6%
1 A 1 b gaseous	Petroleum Refining	CO2	535	535	0.6%	87.2%
2 B 1	Ammonia Production	CO2	527	527	0.6%	87.8%
1 A 4 a liquid	Commercial/Institutional	CO2	483	483	0.6%	88.4%
1 A 2 a solid	Iron and Steel	CO2	433	433	0.5%	88.9%
4E2	Land converted to Settlements	CO2	379	379	0.4%	89.3%
1 A 2 d solid	Pulp, Paper and Print	CO2	365	365	0.4%	89.7%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	353	353	0.4%	90.1%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	346	346	0.4%	90.5%
3 B 1 1	Cattle	CH4	336	336	0.4%	90.9%
1 A 2 b gaseous	Non-Ferrous Metals	CO2	332	332	0.4%	91.3%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	329	329	0.4%	91.7%
2 G 2	Other product manufacture and use - SF6 and PFCs from	SF6	319	319	0.4%	92.1%
2 A 4 c	Non-metallurgical Magnesium	CO2	318	318	0.4%	92.4%
4C1	Grassland remaining grassland	CO2	296	296	0.3%	92.8%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO2	271	271	0.3%	93.1%
3 B 1 1	Cattle	N2O	266	266	0.3%	93.4%
1 B 2 b	Natural Gas	CH4	253	253	0.3%	93.7%
1 A 2 c other	Chemicals	CO2	230	230	0.3%	94.0%
4B2	Land converted to cropland	CO2	224	224	0.3%	94.2%
1 A 2 f solid	Non-Metallic Minerals	CO2	221	221	0.3%	94.5%
1 A 4 b biomass	Residential	CH4	219	219	0.3%	94.7%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	205	205	0.2%	95.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	191	191	0.2%	95.2%

Table A 6: Approach 1 - Trend Assessment of the KCA including LULUCF for the trend 1990–2016.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate $E_{x,t}$	Trend Assessment $T_{x,t}$	% Contribution to Trend	Cumulative Total of $L_{x,t}$
1 A 4 b solid	Residential	CO2	2 511	80	0.805	27.0%	27.0%
1 A 2 d liquid	Pulp, Paper and Print	CO2	853	24	0.316	10.6%	37.6%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2	91	0	0.249	8.4%	46.0%
2 C 4	Magnesium Production	SF6	228	2	0.229	7.7%	53.7%
2 B 2	Nitric Acid Production	N2O	877	36	0.217	7.3%	61.0%
1 A 1 a solid	Public Electricity and Heat Production	CO2	6 247	1 587	0.194	6.5%	67.5%
4A1	Forest land remaining forest land	CO2	7 849	2 579	0.169	5.7%	73.2%
5 A	Solid Waste Disposal	CH4	3 644	1 212	0.077	2.6%	75.8%
4G	HWP	CO2	3 122	1 042	0.066	2.2%	78.0%
1 A 4 b solid	Residential	CH4	200	6	0.063	2.1%	80.1%
1 A 3 b gasoline	Road Transportation	CO2	7 924	4 779	0.055	1.8%	82.0%
2 C 3	Aluminium Production	CO2	150	5	0.046	1.5%	83.5%
1 A 3 b diesel oil	Road Transportation	CO2	5 378	17 700	0.040	1.3%	84.8%
1 A 4 b liquid	Residential	CO2	5 605	3 376	0.039	1.3%	86.1%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	1 228	346	0.033	1.1%	87.2%
1 A 2 a solid	Iron and Steel	CO2	1 335	433	0.029	1.0%	88.2%
1 A 4 a liquid	Commercial/Institutional	CO2	1 423	483	0.029	1.0%	89.2%
4C2	Land converted to grassland	CO2	332	37	0.028	0.9%	90.1%
2 C 1	Iron and Steel Production	CO2	6 610	10 418	0.025	0.9%	91.0%
4A2	Land converted to forest land	CO2	3 043	1 741	0.024	0.8%	91.8%
1 A 4 a other	Commercial/Institutional	CO2	116	6	0.020	0.7%	92.5%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 582	0.020	0.7%	93.2%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2	51	2	0.016	0.5%	93.7%
2 C 7	Aluminium Production	SF6	14	0	0.013	0.4%	94.1%
1 A 2 f liquid	Non-Metallic Minerals	CO2	508	165	0.011	0.4%	94.5%
1 A 2 a liquid	Iron and Steel	CO2	75	6	0.010	0.3%	94.8%
3 A 1	Cattle	CH4	4 579	3 886	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.

IPCC Category Code	IPCC Category	Greenhouse Gas	Tier 1 Level Assessment 1990	Tier 1 Level Assesment 2016	Tier 1 Trend Assessment 1990-2016	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate Ex,t	Share Latest Year (2016)
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	8	4		3 294	3 997	5.0%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	16	33	14	1 228	346	0.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	39	14		352	1 464	1.8%
1 A 1 a solid	Public Electricity and Heat Production	CO2	3	12	6	6 247	1 587	2.0%
1 A 1 b gaseous	Petroleum refining	CO2	34	27		437	535	0.7%
1 A 1 b liquid	Petroleum refining	CO2	11	8		1 958	2 250	2.8%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	31	39		506	271	0.3%
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CO2			21	4	0	0.0%
1 A 2 a gaseous	Iron and Steel	CO2	24	20		650	981	1.2%
1 A 2 a liquid	Iron and Steel	CO2			23	75	6	0.0%
1 A 2 a solid	Iron and Steel	CO2	15	30	15	1 335	433	0.5%
1 A 2 b gaseous	Non-ferrous Metals	CO2		35		75	332	0.4%
1 A 2 c gaseous	Chemicals	CO2	28	19		519	984	1.2%
1 A 2 c other	Chemicals	CO2		42		174	230	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	20	15		943	1 283	1.6%
1 A 2 d liquid	Pulp, Paper and Print	CO2	22		3	853	24	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO2	36	31		398	365	0.5%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	30	22		507	783	1.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	41			343	191	0.2%
1 A 2 f gaseous	Non-Metallic Minerals	CO2	26	23		559	645	0.8%
1 A 2 f liquid	Non-Metallic Minerals	CO2	29		22	508	165	0.2%
1 A 2 f other	Non-Metallic Minerals	CO2		24		67	600	0.8%
1 A 2 f solid	Non-Metallic Minerals	CO2	27	43		535	221	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	45	17		256	1 079	1.4%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	19	10		1 014	1 758	2.2%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	25	36		607	329	0.4%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			2	91	0	0.0%
1 A 3 b diesel oil	Road Transportation	CO2	5	1	11	5 378	17 700	22.2%
1 A 3 b gasoline	Road Transportation	CO2	1	3	9	7 924	4 779	6.0%
1 A 3 e gaseous	Other Transportation	CO2	48	26		224	556	0.7%
1 A 4 a gaseous	Commercial/Institutional	CO2	23	18		707	985	1.2%
1 A 4 a liquid	Commercial/Institutional	CO2	14	29	16	1 423	483	0.6%
1 A 4 a other	Commercial/Institutional	CO2			18	116	6	0.0%
1 A 4 b biomass	Residential	CH4	46	44		228	219	0.3%
1 A 4 b gaseous	Residential	CO2	13	7		1 847	2 797	3.5%
1 A 4 b liquid	Residential	CO2	4	6	12	5 605	3 376	4.2%
1 A 4 b solid	Residential	CO2	9		1	2 511	80	0.1%
1 A 4 b solid	Residential	CH4	50		8	200	6	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	17	21		1 182	785	1.0%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2			20	51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH4	42			333	NA	
1 B 2 b	Natural Gas	CH4	43	41		259	253	0.3%
2 A 1	Cement Production	CO2	10	11		2 033	1 729	2.2%
2 A 2	Lime Production	CO2	37	25		396	582	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO2	32	38		481	318	0.4%
2 B 1	Ammonia Production	CO2	33	28		467	527	0.7%
2 B 2	Nitric Acid Production	N2O	21		5	877	36	0.0%
2 C 1	Iron and Steel Production	CO2	2	2	17	6 610	10 418	13.1%
2 C 3	Aluminium Production	PFC	18			1 149	0	0.0%
2 C 3	Aluminium Production	CO2			10	150	5	0.0%
2 C 4	SF6 used in Al and Mg Foundries	SF6	47		4	228	2	0.0%
2 C 7	Metal Industry Other - Non-ferrous metals	SF6			13	14	0	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	40			349	205	0.3%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	19	0	1 582	2.0%
2 G	Other Product Manufacture and Use	N2O	49			224	134	0.2%
2 G 2	Other product manufacture and use - SF6 and PFCs fro	SF6		37		121	319	0.4%
3 A 1	Cattle	CH4	6	5	24	4 579	3 886	4.9%
3 B 1 1	Cattle	CH4	35	34		424	336	0.4%
3 B 1 1	Cattle	N2O	44	40		258	266	0.3%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	12	9		1 884	1 793	2.3%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	38	32		363	353	0.4%
5 A	Solid Waste Disposal	CH4	7	16	7	3 644	1 212	1.5%

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	Tier 1 Level Assessment 1990	Tier 1 Level Assesment 2016	Tier 1 Trend Assessment 1990-2016	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate Ex,t
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	9	4		3 294	3 997
1 A 1 a liquid	Public Electricity and Heat Production	CO2	19	34	15	1 228	346
1 A 1 a other	Public Electricity and Heat Production	CO2	44	14		352	1 464
1 A 1 a solid	Public Electricity and Heat Production	CO2	4	12	6	6 247	1 587
1 A 1 b gaseous	Petroleum Refining	CO2	39	27		437	535
1 A 1 b liquid	Petroleum Refining	CO2	14	8		1 958	2 250
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO2	35	41		506	271
1 A 2 a gaseous	Iron and Steel	CO2	27	20		650	981
1 A 2 a liquid	Iron and Steel	CO2			26	75	6
1 A 2 a solid	Iron and Steel	CO2	18	30	16	1 335	433
1 A 2 b gaseous	Non-Ferrous Metals	CO2		36		75	332
1 A 2 c gaseous	Chemicals	CO2	32	19		519	984
1 A 2 c other	Chemicals	CO2		44		174	230
1 A 2 d gaseous	Pulp, Paper and Print	CO2	23	15		943	1 283
1 A 2 d liquid	Pulp, Paper and Print	CO2	25		2	853	24
1 A 2 d solid	Pulp, Paper and Print	CO2	41	32		398	365
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	34	22		507	783
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	46	49		343	191
1 A 2 f gaseous	Non-Metallic Minerals	CO2	30	23		559	645
1 A 2 f liquid	Non-Metallic Minerals	CO2	33		25	508	165
1 A 2 f other	Non-Metallic Minerals	CO2		24		67	600
1 A 2 f solid	Non-Metallic Minerals	CO2	31	46		535	221
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	52	17		256	1 079
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	22	10		1 014	1 758
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	28	37		607	329
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			3	91	0
1 A 3 b diesel oil	Road Transportation	CO2	6	1	13	5 378	17 700
1 A 3 b gasoline	Road Transportation	CO2	1	3	11	7 924	4 779
1 A 3 e gaseous	Other Transportation	CO2	55	26		224	556
1 A 4 a gaseous	Commercial/Institutional	CO2	26	18		707	985
1 A 4 a liquid	Commercial/Institutional	CO2	17	29	17	1 423	483
1 A 4 a other	Commercial/Institutional	CO2			21	116	6
1 A 4 b biomass	Residential	CH4	53	47		228	219
1 A 4 b gaseous	Residential	CO2	16	7		1 847	2 797
1 A 4 b liquid	Residential	CO2	5	6	14	5 605	3 376
1 A 4 b solid	Residential	CO2	12		1	2 511	80
1 A 4 b solid	Residential	CH4			10	200	6
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	20	21		1 182	785
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2			23	51	2
1 B 1 a	Coal Mining and Handling	CH4	47			333	NA
1 B 2 b	Natural Gas	CH4	50	43		259	253
2 A 1	Cement Production	CO2	13	11		2 033	1 729
2 A 2	Lime Production	CO2	42	25		396	582
2 A 4 c	Non-metallurgical Magnesium	CO2	36	39		481	318
2 B 1	Ammonia Production	CO2	37	28		467	527
2 B 2	Nitric Acid Production	N2O	24		5	877	36
2 C 1	Iron and Steel Production	CO2	3	2	19	6 610	10 418
2 C 3	Aluminium Production	PFC	21			1 149	0
2 C 3	Aluminium Production	CO2			12	150	5
2 C 4	Magnesium Production	SF6	54		4	228	2
2 C 7	Metal Industry Other - Non-ferrous metals	SF6			24	14	0
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	45	48		349	205
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	22	0	1 582
2 G 2	Other product manufacture and use - SF6 and PFCs from	SF6		38		121	319
3 A 1	Cattle	CH4	7	5	27	4 579	3 886
3 B 1 1	Cattle	CH4	40	35		424	336
3 B 1 1	Cattle	N2O	51	42		258	266
3 D 1	Direct N2O Emissions from Managed Soils	N2O	15	9		1 884	1 793
3 D 2	Indirect N2O emissions from Managed Soils	N2O	43	33		363	353
4A1	Forest land remaining forest land	CO2	2	52	7	-7 849	-2 579
4A2	Land converted to forest land	CO2	11	51	20	-3 043	-1 741
4B2	Land converted to cropland	CO2		45		194	224
4C1	Grassland remaining grassland	CO2	49	40		294	296
4C2	Land converted to grassland	CO2	48		18	332	37
4E2	Land converted to Settlements	CO2	29	31		577	379
4F2	Land converted to Other land	CO2	38			444	166
4G	HWP	CO2	10	50	9	-3 122	-1 042
5 A	Solid Waste Disposal	CH4	8	16	8	3 644	1 212

Table A 9: Approach 2 - Level Assessment of the KCA excluding LULUCF for 1990.

IPCC Category Code	IPCC Category	Greenhouse Gas	Latest Year (1990) Estimate $E_{x,t}$	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 884	0.347	34.7%
3 A 1	Cattle	CH4	4 579	0.094	44.1%
5 A	Solid Waste Disposal	CH4	3 644	0.093	53.4%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	363	0.067	60.0%
2 C 3	Aluminium Production	PFC	1 149	0.053	65.3%
1 A 3 b gasoline	Road Transportation	CO2	7 924	0.031	68.4%
3 B 1 1	Cattle	N2O	258	0.024	70.8%
1 A 3 b diesel oil	Road Transportation	CO2	5 378	0.021	72.9%
3 B 2 5	Indirect N2O Emissions	N2O	107	0.020	74.9%
1 B 1 a	Coal Mining and Handling	CH4	333	0.015	76.4%
1 A 4 b biomass	Residential	CH4	228	0.011	77.5%
2 A 1	Cement Production	CO2	2 033	0.010	78.5%
1 A 4 b solid	Residential	CH4	200	0.009	79.4%
5 D	Waste Water Treatment and Discharge	N2O	96	0.009	80.3%
3 B 1 1	Cattle	CH4	424	0.009	81.2%
1 A 4 b gaseous	Residential	CO2	1 847	0.009	82.0%
3 G	Liming	CO2	90	0.008	82.9%
2 A 2	Lime Production	CO2	396	0.008	83.6%
1 A 1 a other	Public Electricity and Heat Production	CO2	352	0.007	84.3%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 294	0.006	85.0%
2 G 2	Other product manufacture and use - SF6 and PI	SF6	121	0.006	85.6%
1 A 3 b gasoline	Road Transportation	N2O	96	0.006	86.2%
5 D	Waste Water Treatment and Discharge	CH4	121	0.006	86.8%
1 A 4 b liquid	Residential	CO2	5 605	0.006	87.4%
3 B 1 3	Swine	N2O	59	0.005	87.9%
3 A 3	Swine	CH4	138	0.005	88.5%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 014	0.005	88.9%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	0.004	89.4%
2 B 2	Nitric Acid Production	N2O	877	0.004	89.8%
2 C 1	Iron and Steel Production	CO2	6 610	0.004	90.2%

Table A 10: Approach 2 - Level Assessment of the KCA excluding LULUCF for 2016.

IPCC Category Code	IPCC Category	Greenhouse Gas	Latest Year (2016) Estimate Ex,t	Level Assessment with Uncertainty $LU_{x,t}$	Cumulative Total of $L_{x,t}$
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 793	0.337	33.7%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 582	0.080	41.6%
3 A 1	Cattle	CH4	3 886	0.073	48.9%
1 A 3 b diesel oil	Road Transportation	CO2	17 700	0.070	56.0%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	353	0.066	62.6%
5 A	Solid Waste Disposal	CH4	1 212	0.032	65.8%
1 A 1 a other	Public Electricity and Heat Production	CO2	1 464	0.031	68.8%
3 B 1 1	Cattle	N2O	266	0.025	71.3%
3 B 2 5	Indirect N2O Emissions	N2O	114	0.021	73.5%
1 A 3 b gasoline	Road Transportation	CO2	4 779	0.019	75.4%
2 G 2	Other product manufacture and use - SF6 and PFCs fron	SF6	319	0.017	77.1%
5 D	Waste Water Treatment and Discharge	N2O	164	0.016	78.6%
1 A 4 b gaseous	Residential	CO2	2 797	0.013	79.9%
1 A 2 f other	Non-Metallic Minerals	CO2	600	0.013	81.2%
1 A 4 b biomass	Residential	CH4	219	0.010	82.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 758	0.008	83.1%
3 G	Liming	CO2	85	0.008	83.9%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 997	0.008	84.6%
2 C 1	Iron and Steel Production	CO2	10 418	0.007	85.3%
3 B 1 1	Cattle	CH4	336	0.006	86.0%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	1 283	0.006	86.6%
5 B	Biological Treatment of Solid Waste	N2O	98	0.005	87.1%
1 A 2 c other	Chemicals	CO2	230	0.005	87.5%
1 A 3 b diesel oil	Road Transportation	N2O	166	0.005	88.0%
1 A 4 a gaseous	Commercial/Institutional	CO2	985	0.005	88.5%
1 A 2 c gaseous	Chemicals	CO2	984	0.005	88.9%
1 A 2 a gaseous	Iron and Steel	CO2	981	0.005	89.4%
5 B	Biological Treatment of Solid Waste	CH4	83	0.004	89.8%
3 A 3	Swine	CH4	105	0.004	90.2%

Table A 11: Approach 2 - Trend Assessment of the KCA excluding LULUCF for the trend 1990–2016.

IPCC Category Code	IPCC Category	Greenhouse Gas	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate $E_{x,t}$	Trend Assessment with Uncertainty $TU_{x,t}$	% Contribution to Trend	Cumulative Total of $TU_{x,t}$
1 A 4 b solid	Residential	CH4	200	6	3.849	21.6%	21.6%
5 A	Solid Waste Disposal	CH4	3 644	1 212	2.578	14.4%	36.0%
2 C 4	Magnesium Production	SF6	228	2	2.039	11.4%	47.4%
2 B 2	Nitric Acid Production	N2O	877	36	1.411	7.9%	55.3%
1 A 4 b solid	Residential	CO2	2 511	80	1.085	6.1%	61.4%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 582	1.082	6.1%	67.5%
1 A 3 b gasoline	Road Transportation	N2O	96	11	0.662	3.7%	71.2%
1 A 4 a other	Commercial/Institutional	CO2	116	6	0.557	3.1%	74.3%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2	91	0	0.470	2.6%	76.9%
1 A 2 d liquid	Pulp, Paper and Print	CO2	853	24	0.427	2.4%	79.3%
5 D	Waste Water Treatment and Discharge	CH4	121	24	0.344	1.9%	81.2%
1 A 3 b gasoline	Road Transportation	CO2	7 924	4 779	0.281	1.6%	82.8%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 884	1 793	0.241	1.4%	84.2%
1 A 4 b solid	Residential	N2O	12	0	0.237	1.3%	85.5%
3 A 1	Cattle	CH4	4 579	3 886	0.208	1.2%	86.6%
1 A 3 b diesel oil	Road Transportation	CO2	5 378	17 700	0.202	1.1%	87.8%
1 A 1 a solid	Public Electricity and Heat Production	CO2	6 247	1 587	0.165	0.9%	88.7%
1 A 3 b gasoline	Road Transportation	CH4	64	9	0.159	0.9%	89.6%
2 C 3	Aluminium Production	CO2	150	5	0.116	0.7%	90.2%

Table A 12: Approach 2 - Level Assessment of the KCA including LULUCF for 1990.

IPCC Category Code	IPCC Category	Greenhouse Gas	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 $L_{x,t}$
4A1	Forest land remaining forest land	CO2	-7 849	7 849	0.343	34.3%
4F2	Land converted to Other land	CO2	444	444	0.146	48.9%
4A2	Land converted to forest land	CO2	-3 043	3 043	0.098	58.6%
4C2	Land converted to grassland	CO2	332	332	0.081	66.7%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 884	1 884	0.080	74.8%
5 A	Solid Waste Disposal	CH4	3 644	3 644	0.039	78.7%
4G	HWP	CO2	-3 122	3 122	0.033	82.0%
3 A 1	Cattle	CH4	4 579	4 579	0.031	85.1%
4B2	Land converted to cropland	CO2	194	194	0.019	87.0%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	363	363	0.015	88.5%
4E2	Land converted to Settlements	CO2	577	577	0.013	89.9%
2 C 3	Aluminium Production	PFC	1 149	1 149	0.012	91.1%

Table A 13: Approach 2 - Level Assessment of the KCA including LULUCF for 2016.

IPCC Category Code	IPCC Category	Greenhouse Gas	Latest Year (2016) Estimate Ex,t	Absolute Value of Year 2015 Estimate Ex,t	Level Assessment with Uncertainty LUx,t	Cumulative Total of $L_{x,t}$
4A1	Forest land remaining forest land	CO2	-2 579	2 579	0.408	40.8%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 793	1 793	0.090	49.8%
4F2	Land converted to Other land	CO2	166	166	0.079	57.7%
4A2	Land converted to forest land	CO2	-1 741	1 741	0.058	63.4%
4C2	Land converted to grassland	CO2	37	37	0.053	68.7%
4B1	Cropland remaining cropland	CO2	-184	184	0.040	72.7%
3 A 1	Cattle	CH4	3 886	3 886	0.031	75.8%
4B2	Land converted to cropland	CO2	224	224	0.026	78.3%
4E2	Land converted to Settlements	CO2	379	379	0.022	80.5%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 582	1 582	0.021	82.6%
1 A 3 b diesel oil	Road Transportation	CO2	17 700	17 700	0.019	84.5%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	353	353	0.018	86.3%
4D2	Land converted to Wetlands	CO2	77	77	0.016	87.9%
5 A	Solid Waste Disposal	CH4	1 212	1 212	0.015	89.4%
4G	HWP	CO2	-1 042	1 042	0.013	90.8%

Table A 14: Approach 2 - Trend Assessment of the KCA including LULUCF for the trend 1990–2016.

IPCC Category Code	IPCC Category	Greenhouse Gas	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate Ex,t	Trend Assessment with Uncertainty $TU_{x,t}$	% Contribution to Trend	Cumulative Total of $TU_{x,t}$
4C2	Land converted to grassland	CO2	332	37	156.865	51.9%	51.9%
4A1	Forest land remaining forest land	CO2	7 849	2 579	106.584	35.3%	87.2%
4F2	Land converted to Other land	CO2	444	166	14.876	4.9%	92.2%

Table A 15: Approach 2 - Key categories identified including their ranking in the level and trend assessment for the KCA excluding LULUCF.

IPCC Category Code	IPCC Category	Greenhouse Gas	Tier 1 Level Assessment 1990	Tier 1 Level Assesment 2016	Tier 1 Trend Assessment 1990-2016	Tier 2 Level Assessment 1990	Tier 2 Level Assesment 2016	Tier 2 Trend Assessment 1990-2016	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate Ex,t	Share Latest Year (2016)
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	8	4		7	4		3 294	3 997	5.0%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	16	33	14				1 228	346	0.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	39	14		18	10		352	1 464	1.8%
1 A 1 a solid	Public Electricity and Heat Production	CO2	3	12	6			17	6 247	1 587	2.0%
1 A 1 b gaseous	Petroleum refining	CO2	34	27					437	535	0.7%
1 A 1 b liquid	Petroleum refining	CO2	11	8					1 958	2 250	2.8%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	31	39					506	271	0.3%
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CO2			21				4	0	0.0%
1 A 2 a gaseous	Iron and Steel	CO2	24	20			15		650	981	1.2%
1 A 2 a liquid	Iron and Steel	CO2			23				75	6	0.0%
1 A 2 a solid	Iron and Steel	CO2	15	30	15				1 335	433	0.5%
1 A 2 b gaseous	Non-ferrous Metals	CO2		35					75	332	0.4%
1 A 2 c gaseous	Chemicals	CO2	28	19			14		519	984	1.2%
1 A 2 c other	Chemicals	CO2		42			21		174	230	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	20	15		13	11		943	1 283	1.6%
1 A 2 d liquid	Pulp, Paper and Print	CO2	22		3			10	853	24	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO2	36	31					398	365	0.5%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	30	22					507	783	1.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	41						343	191	0.2%
1 A 2 f gaseous	Other	CO2	26	23					559	645	0.8%
1 A 2 f liquid	Other	CO2	29		22				508	165	0.2%
1 A 2 f other	Other	CO2		24			16		67	600	0.8%
1 A 2 f solid	Other	CO2	27	43					535	221	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	45	17					256	1 079	1.4%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	19	10		12	8		1 014	1 758	2.2%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	25	36					607	329	0.4%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			2			9	91	0	0.0%
1 A 3 b diesel oil	Road Transportation	CO2	5	1	11	4	1	16	5 378	17 700	22.2%
1 A 3 b diesel oil	Road Transportation	N2O					23		13	166	0.2%
1 A 3 b gasoline	Road Transportation	CO2	1	3	9	1	3	12	7 924	4 779	6.0%
1 A 3 b gasoline	Road Transportation	N2O				28		7	96	11	0.0%
1 A 3 b gasoline	Road Transportation	CH4						18	64	9	0.0%
1 A 3 e gaseous	Other	CO2	48	26					224	556	0.7%
1 A 4 a gaseous	Commercial/Institutional	CO2	23	18			13		707	985	1.2%
1 A 4 a liquid	Commercial/Institutional	CO2	14	29	16				1 423	483	0.6%
1 A 4 a other	Commercial/Institutional	CO2			18			8	116	6	0.0%
1 A 4 b biomass	Residential	CH4	46	44		21	22		228	219	0.3%
1 A 4 b gaseous	Residential	CO2	13	7		10	6		1 847	2 797	3.5%
1 A 4 b liquid	Residential	CO2	4	6	12	3			5 605	3 376	4.2%
1 A 4 b solid	Residential	CO2	9		1			5	2 511	80	0.1%
1 A 4 b solid	Residential	N2O						14	12	0	0.0%
1 A 4 b solid	Residential	CH4	50		8	22		1	200	6	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO2	17	21					1 182	785	1.0%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2			20				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH4	42			19			333	NA	NA
1 B 2 b	Natural Gas	CH4	43	41					259	253	0.3%
2 A 1	Cement Production	CO2	10	11		8			2 033	1 729	2.2%
2 A 2	Lime Production	CO2	37	25		16			396	582	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO2	32	38					481	318	0.4%
2 B 1	Ammonia Production	CO2	33	28					467	527	0.7%
2 B 2	Nitric Acid Production	N2O	21		5	14		4	877	36	0.0%
2 C 1	Iron and Steel Production	CO2	2	2	17	2	2		6 610	10 418	13.1%
2 C 3	Aluminium Production	PFC	18			11			1 149	0	0.0%
2 C 3	Aluminium Production	CO2			10			19	150	5	0.0%
2 C 4	SF6 used in Al and Mg Foundries	SF6	47		4			3	228	2	0.0%
2 C 7	Metal Industry Other - Non-ferrous metals	SF6			13				14	0	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	40						349	205	0.3%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	19		9	6	0	1 582	2.0%
2 G	Other Product Manufacture and Use	N2O	49						224	134	0.2%
2 G 2	Other product manufacture and use - SF6 and PFCs fron	SF6		37		25	19		121	319	0.4%
3 A 1	Cattle	CH4	6	5	24	5	5	15	4 579	3 886	4.9%
3 A 3	Swine	CH4				23	26		138	105	0.1%
3 B 1 1	Cattle	CH4	35	34		15	18		424	336	0.4%
3 B 1 1	Cattle	N2O	44	40		20	20		258	266	0.3%
3 B 1 3	Swine	N2O				30			59	37	0.0%
3 B 2 5	Indirect N2O Emissions	N2O				26	25		107	114	0.1%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	12	9		9	7	13	1 884	1 793	2.3%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	38	32		17	17		363	353	0.4%
3 G	Liming	CO2				29	28		90	85	0.1%
5 A	Solid Waste Disposal	CH4	7	16	7	6	12	2	3 644	1 212	1.5%
5 B	Biological Treatment of Solid Waste	N2O					27		23	98	0.1%
5 B	Biological Treatment of Solid Waste	CH4					29		13	83	0.1%
5 D	Waste Water Treatment and Discharge	N2O				27	24		96	164	0.2%
5 D	Waste Water Treatment and Discharge	CH4				24		11	121	24	0.0%

Table A 16: Approach 2 - Key categories identified including their ranking in the level and trend assessment for the KCA including LULUCF.

IPCC Category Code	IPCC Category	Greenhouse Gas	Tier 1 Level Assessment 1990	Tier 1 Level Assesment 2015	Tier 1 Trend Assessment 1990-2016	Tier 2 Level Assessment 1990	Tier 2 Level Assesment 2016	Tier 2 Trend Assessment 1990-2016	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2016) Estimate Ex,t	Share Latest Year (2016)
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	9	4					3 294	3 997	4.6%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	19	34	15				1 228	346	0.4%
1 A 1 a other	Public Electricity and Heat Production	CO2	44	14					352	1 464	1.7%
1 A 1 a solid	Public Electricity and Heat Production	CO2	4	12	6				6 247	1 587	1.8%
1 A 1 b gaseous	Petroleum refining	CO2	39	27					437	535	0.6%
1 A 1 b liquid	Petroleum refining	CO2	14	8					1 958	2 250	2.6%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	35	41					506	271	0.3%
1 A 2 a gaseous	Iron and Steel	CO2	27	20					650	981	1.1%
1 A 2 a liquid	Iron and Steel	CO2			26				75	6	0.0%
1 A 2 a solid	Iron and Steel	CO2	18	30	16				1 335	433	0.5%
1 A 2 b gaseous	Non-ferrous Metals	CO2		36					75	332	0.4%
1 A 2 c gaseous	Chemicals	CO2	32	19					519	984	1.1%
1 A 2 c other	Chemicals	CO2		44					174	230	0.3%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	23	15					943	1 283	1.5%
1 A 2 d liquid	Pulp, Paper and Print	CO2	25		2				853	24	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO2	41	32					398	365	0.4%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	34	22					507	783	0.9%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	46	49					343	191	0.2%
1 A 2 f gaseous	Other	CO2	30	23					559	645	0.7%
1 A 2 f liquid	Other	CO2	33		25				508	165	0.2%
1 A 2 f other	Other	CO2		24					67	600	0.7%
1 A 2 f solid	Other	CO2	31	46					535	221	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	52	17					256	1 079	1.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	22	10					1 014	1 758	2.0%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			3				91	0	0.0%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	28	37					607	329	0.4%
1 A 3 b diesel oil	Road Transportation	CO2	6	1	13		1		5 378	17 700	20.4%
1 A 3 b gasoline	Road Transportation	CO2	1	3	11				7 924	4 779	5.5%
1 A 3 e gaseous	Other	CO2	55	26					224	556	0.6%
1 A 4 a gaseous	Commercial/Institutional	CO2	26	18					707	985	1.1%
1 A 4 a liquid	Commercial/Institutional	CO2	17	29	17				1 423	483	0.6%
1 A 4 a other	Commercial/Institutional	CO2			21				116	6	0.0%
1 A 4 b biomass	Residential	CH4	53	47					228	219	0.3%
1 A 4 b gaseous	Residential	CO2	16	7					1 847	2 797	3.2%
1 A 4 b liquid	Residential	CO2	5	6	14				5 605	3 376	3.9%
1 A 4 b solid	Residential	CO2	12		1				2 511	80	0.1%
1 A 4 b solid	Residential	CH4			10				200	6	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO2	20	21					1 182	785	0.9%
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2			23				51	2	0.0%
1 B 1 a	Coal Mining and Handling	CH4	47						333	NA	0.0%
1 B 2 b	Natural Gas	CH4	50	43					259	253	0.3%
2 A 1	Cement Production	CO2	13	11					2 033	1 729	2.0%
2 A 2	Lime Production	CO2	42	25					396	582	0.7%
2 A 4 c	Non-metallurgical Magnesium	CO2	36	39					481	318	0.4%
2 B 1	Ammonia Production	CO2	37	28					467	527	0.6%
2 B 2	Nitric Acid Production	N2O	24		5				877	36	0.0%
2 C 1	Iron and Steel Production	CO2	3	2	19				6 610	10 418	12.0%
2 C 3	Aluminium Production	PFC	21			7			1 149	0	0.0%
2 C 3	Aluminium Production	CO2			12				150	5	0.0%
2 C 4	SF6 used in Al and Mg Foundries	SF6	54		4				228	2	0.0%
2 C 7	Metal Industry Other - Non-ferrous metals	SF6			24				14	0	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	45	48					349	205	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	22		4		0	1 582	1.8%
2 G 2	Other product manufacture and use - SF6 and PFCs from	SF6		38					121	319	0.4%
3 A 1	Cattle	CH4	7	5	27	2	2		4 579	3 886	4.5%
3 B 1 1	Cattle	CH4	40	35					424	336	0.4%
3 B 1 1	Cattle	N2O	51	42					258	266	0.3%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	15	9		6	3		1 884	1 793	2.1%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	43	33		10	7		363	353	0.4%
4A1	Forest land remaining forest land	CO2	2	52	7	1	15	2	-7 849	-2 579	-3.0%
4A2	Land converted to forest land	CO2	11	51	20	5	14		-3 043	-1 741	-2.0%
4B1	Cropland remaining cropland	CO2					12		-18	-184	-0.2%
4B2	Land converted to cropland	CO2		45		12	8		194	224	0.3%
4C1	Grassland remaining grassland	CO2	49	40					294	296	0.3%
4C2	Land converted to grassland	CO2	48		18	11	11	1	332	37	0.0%
4D2	Land converted to Wetlands	CO2					10		42	77	0.1%
4E2	Land converted to Settlements	CO2	29	31		8	6		577	379	0.4%
4F2	Land converted to Other land	CO2	38			9	9	3	444	166	0.2%
4G	HWP	CO2	10	50	9	4	13		-3 122	-1 042	-1.2%
5 A	Solid Waste Disposal	CH4	8	16	8	3	5		3 644	1 212	1.4%

Table A 17: Source/sink categories and emissions/removals for key category analysis.

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	Gg	1 228	1 558	1 181	1 572	819	1 129	1 172	1 113	989	703	695	627	682	381	228	191	156	253	346
1 A 1 a solid	Public Electricity and Heat Production	CO_2	Gg	6 247	4 529	4 824	5 871	5 515	6 921	6 676	5 843	5 642	5 066	4 440	3 020	3 870	4 252	3 454	3 295	2 305	2 335	1 587
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2	Gg	3 294	3 439	3 463	3 523	3 829	4 564	4 373	5 405	4 547	4 072	4 616	4 764	5 238	4 730	4 164	3 374	2 799	3 621	3 997
1 A 1 a other	Public Electricity and Heat Production	CO_2	Gg	352	318	312	325	427	493	587	613	770	785	789	1 042	1 100	1 212	1 303	1 288	1 280	1 336	1 464
1 A 1 b liquid	Petroleum Refining	CO_2	Gg	1 958	2 169	1 837	1 906	2 283	2 401	2 373	2 311	2 349	2 415	2 300	2 579	2 226	2 270	2 293	2 171	2 111	2 269	2 250
1 A 1 b gaseous	Petroleum Refining	CO_2	Gg	437	421	362	313	283	286	471	516	481	453	506	231	499	498	543	656	602	535	535
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	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	284	260	224	171	248	394	262	264	237	264	238	324	271	250	247	274	271
1 A 2 a liquid	Iron and Steel	CO_2	Gg	75	82	73	43	28	21	32	58	53	20	92	22	31	26	23	10	3	3	6
1 A 2 a solid	Iron and Steel	CO_2	Gg	1 335	667	180	275	562	613	665	922	551	336	414	232	332	358	370	481	293	289	433
1 A 2 a gaseous	Iron and Steel	CO_2	Gg	650	757	1 009	1 144	1 164	1 140	1 252	1 090	1 062	1 036	1 018	911	1 101	1 239	1 279	1 373	1 348	1 112	981
1 A 2 b liquid	Non-Ferrous Metals	CO_2	Gg	35	41	46	52	44	42	37	34	33	31	22	16	19	22	22	22	16	19	9
1 A 2 b solid	Non-Ferrous Metals	CO_2	Gg	22	10	18	10	16	16	16	14	13	14	14	16	7	7	6	13	14	17	14
1 A 2 b gaseous	Non-Ferrous Metals	CO_2	Gg	75	205	128	144	148	156	167	172	177	207	216	199	209	218	218	226	280	310	332
1 A 2 b other	Non-Ferrous Metals	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
1 A 2 c liquid	Chemicals	CO_2	Gg	93	98	60	86	70	75	73	72	63	72	84	117	141	122	124	103	53	61	58
1 A 2 c solid	Chemicals	CO_2	Gg	106	150	250	252	251	250	236	149	105	79	71	70	76	68	71	84	123	103	105
1 A 2 c gaseous	Chemicals	CO_2	Gg	519	572	874	857	828	837	838	1 042	939	909	959	987	1 013	1 017	1 036	1 004	1 005	983	984
1 A 2 c other	Chemicals	CO_2	Gg	174	224	203	232	300	388	338	287	299	236	404	303	312	299	309	319	296	320	230
1 A 2 d liquid	Pulp, Paper and Print	CO_2	Gg	853	524	173	179	152	165	135	140	127	95	82	102	72	55	39	47	24	41	24
1 A 2 d solid	Pulp, Paper and Print	CO_2	Gg	398	381	446	381	459	420	440	438	466	361	330	345	326	353	348	369	361	384	365
1 A 2 d gaseous	Pulp, Paper and Print	CO_2	Gg	943	1 361	1 763	1 680	1 636	1 830	1 698	1 709	1 596	1 716	1 769	1 764	1 934	1 877	1 664	1 507	1 323	1 384	1 283
1 A 2 d other	Pulp, Paper and Print	CO_2	Gg	20	50	0	12	13	21	26	7	7	11	9	9	8	8	7	22	23	25	20
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO_2	Gg	343	345	167	239	178	224	256	243	244	210	188	204	205	200	188	182	164	176	191
1 A 2 e solid	Food Processing, Beverages and Tobacco	CO_2	Gg	18	6	22	12	16	16	13	13	11	11	12	14	15	16	17	16	19	23	16
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO_2	Gg	507	583	694	677	906	704	681	704	680	666	675	689	749	746	771	735	703	804	783
1 A 2 e other	Food Processing, Beverages	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	and Tobacco																					
1 A 2 f liquid	Non-Metallic Minerals	CO_2	Gg	508	348	198	165	301	308	414	296	219	227	209	168	195	205	169	169	157	159	165
1 A 2 f solid	Non-Metallic Minerals	CO_2	Gg	535	435	503	461	343	310	288	373	546	616	578	437	312	282	293	262	278	266	221
1 A 2 f gaseous	Non-Metallic Minerals	CO_2	Gg	559	615	641	663	753	776	819	659	639	661	642	536	602	617	585	629	636	625	645
1 A 2 f other	Non-Metallic Minerals	CO_2	Gg	67	122	197	218	263	293	309	327	367	391	417	413	419	442	483	492	542	555	600
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO_2	Gg	256	358	551	518	504	537	591	809	977	1 057	1 163	1 120	1 074	1 078	1 114	1 124	1 099	1 064	1 079
1 A 2 g 8 liquid	Other Manufacturing Industries	CO_2	Gg	607	789	603	682	514	650	664	710	729	588	501	494	504	524	531	450	309	331	329
1 A 2 g 8 solid	Other Manufacturing Industries	CO_2	Gg	91	18	30	7	14	13	14	35	41	43	32	15	15	15	0	1	0	4	0
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO_2	Gg	1 014	1 423	1 070	958	951	1 007	1 019	1 310	1 303	1 276	1 341	1 425	1 547	1 352	1 440	1 355	1 394	1 497	1 758
1 A 2 g 8 other	Other Manufacturing Industries	CO_2	Gg	5	70	45	84	60	75	116	44	35	31	44	42	45	37	44	30	21	28	29
1 A 3 a aviation gasoline	Domestic Aviation	CO_2	Gg	8	7	6	6	7	8	7	9	9	9	9	10	9	14	8	8	7	8	10
1 A 3 a jet kerosene	Domestic Aviation	CO_2	Gg	24	51	61	54	55	54	57	58	63	65	62	57	54	48	47	46	42	42	37
1 A 3 b gasoline	Road Transportation	CO_2	Gg	7 924	7 424	6 115	6 159	6 631	6 781	6 597	6 411	6 152	6 008	5 397	5 381	5 294	5 100	4 964	4 861	4 734	4 777	4 779
1 A 3 b diesel oil	Road Transportation	CO_2	Gg	5 378	7 784	11 933	13 229	14 850	16 445	17 155	17 673	16 522	16 843	16 060	15 429	16 294	15 753	15 778	16 880	16 475	16 777	17 700
1 A 3 b LPG	Road Transportation	CO_2	Gg	26	32	43	46	63	72	61	63	64	62	64	60	57	55	58	58	50	40	31
1 A 3 b gaseous	Road Transportation	CO_2	Gg	0	0	0	0	0	0	1	1	1	4	8	18	25	27	30	36	39	40	40
1 A 3 c liquid	Railways	CO_2	Gg	171	143	133	128	139	139	139	161	152	152	151	146	142	120	123	113	118	105	110
1 A 3 c solid	Railways	CO_2	Gg	7	6	2	2	2	2	1	0	1	1	0	1	0	0	0	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	CO_2	Gg	5	5	6	5	4	4	7	7	6	7	5	4	4	5	5	5	4	4	4
1 A 3 d gasoline	Domestic Navigation	CO_2	Gg	9	9	9	9	9	9	9	9	8	8	8	8	7	7	7	7	7	7	7
1 A 3 e gaseous	Other Transportation	CO_2	Gg	224	227	338	497	277	371	372	359	466	488	465	436	459	568	458	607	503	582	556
1 A 4 a liquid	Commercial/Institutional	CO_2	Gg	1 423	1 319	1 341	1 755	1 816	2 219	1 719	2 550	2 366	1 496	1 988	1 524	1 182	911	469	485	501	478	483
1 A 4 a solid	Commercial/Institutional	CO_2	Gg	91	60	105	118	81	112	79	75	52	41	25	17	20	14	14	13	11	10	10
1 A 4 a gaseous	Commercial/Institutional	CO_2	Gg	707	1 706	1 398	1 941	1 755	1 983	2 370	2 121	2 251	1 869	2 032	1 834	1 819	1 495	1 208	1 109	1 005	946	985
1 A 4 a other	Commercial/Institutional	CO_2	Gg	116	54	58	65	64	68	55	54	36	17	3	4	5	4	4	5	6	6	6
1 A 4 b liquid	Residential	CO_2	Gg	5 605	5 818	5 580	5 525	5 341	5 377	5 137	4 364	4 144	3 784	3 863	3 619	3 992	3 484	3 608	3 538	3 281	3 444	3 376
1 A 4 b solid	Residential	CO_2	Gg	2 511	1 651	851	807	648	545	517	337	328	274	284	215	235	139	151	112	91	87	80
1 A 4 b gaseous	Residential	CO_2	Gg	1 847	2 392	2 631	2 942	2 751	2 906	2 836	2 644	2 491	2 338	2 368	2 438	2 744	2 408	2 685	2 929	2 365	2 559	2 797

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1 A 4 b peat	Residential	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO_2	Gg	1 182	927	1 000	1 021	982	972	986	947	917	904	913	800	778	821	782	778	786	777	785
1 A 4 c solid	Agriculture/Forestry/Fishing	CO_2	Gg	51	37	17	15	11	9	8	10	8	11	11	3	4	3	3	1	2	2	2
1 A 4 c gaseous	Agriculture/Forestry/Fishing	CO_2	Gg	20	27	30	33	31	33	32	30	28	26	27	28	31	27	30	33	27	29	32
1 A 5 b liquid	Mobile combustion - Military	CO_2	Gg	35	33	41	41	42	42	43	44	44	45	45	46	46	47	47	48	49	49	50
1 B 2 a	Oil	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 B 2 b	Natural Gas	CO_2	Gg	102	127	165	183	167	184	165	160	180	185	162	205	184	180	184	191	169	162	131
2 A 1	Cement Production	CO_2	Gg	2 033	1 631	1 712	1 720	1 736	1 754	1 790	1 797	1 954	2 131	2 133	1 799	1 622	1 666	1 673	1 656	1 639	1 701	1 729
2 A 2	Lime Production	CO_2	Gg	396	395	498	507	543	572	595	579	570	596	621	507	575	605	569	588	589	579	582
2 A 3	Glass Production	CO_2	Gg	39	42	36	43	38	42	28	35	37	40	44	41	40	36	37	39	37	40	38
2 A 4 a	Ceramics	CO_2	Gg	116	149	116	124	120	116	134	128	130	130	110	94	81	99	93	80	94	91	91
2 A 4 b	Other uses of soda ash	CO_2	Gg	5	6	8	7	8	8	16	13	12	11	10	9	10	11	12	10	11	10	11
2 A 4 c	Non-metallurgical Magnesium	CO_2	Gg	481	410	339	334	374	311	329	310	312	329	332	244	314	345	305	330	334	301	318
2 A 4 d	Other	CO_2	Gg	21	25	25	25	25	25	25	27	38	28	26	21	19	17	15	16	17	17	19
2 B 1	Ammonia Production	CO_2	Gg	467	509	491	449	458	495	494	462	491	423	475	430	477	497	473	426	530	510	527
2 B 2	Nitric Acid Production	CO_2	Gg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 B 5	Carbide Production	CO_2	Gg	38	26	48	47	41	41	36	36	31	36	41	42	43	49	49	48	47	53	48
2 B-10	Other (please specify)	CO_2	Gg	138	134	135	133	138	138	138	145	144	142	136	115	157	148	142	128	143	135	147
2 C 1	Iron and Steel Production	CO_2	Gg	6 610	7 393	8 420	8 261	8 742	8 720	8 736	9 544	10 009	10 517	10 713	8 377	10 198	10 217	9 868	10 224	10 210	10 781	10 418
2 C 2	Ferroalloys Production	CO_2	Gg	21	21	19	18	17	17	17	19	19	20	17	17	20	20	20	20	20	20	20
2 C 3	Aluminium Production	CO_2	Gg	150	1	2	2	2	2	1	1	1	1	1	3	4	4	4	4	5	5	5
2 C 5	Lead Production	CO_2	Gg	5	4	4	4	4	4	5	5	6	6	5	4	5	5	5	5	5	5	5
2 D	Non-Energy Products from Fuels and Solvent Use	CO_2	Gg	349	234	228	227	212	215	209	210	209	213	212	207	207	210	216	202	202	201	205
2 G	Other Product Manufacture and Use	CO_2	Gg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3 G	Liming	CO_2	Gg	90	92	90	90	90	90	91	91	90	89	88	88	88	87	87	86	86	86	85
3 H	Urea application	CO_2	Gg	4	8	8	6	6	9	11	12	15	18	17	22	20	18	22	22	25	26	31
5 C	Incineration and Open Burning of Waste	CO_2	Gg	28	11	12	12	12	12	12	12	10	8	6	4	2	2	2	2	2	2	2
1 A 1 a liquid	Public Electricity and Heat Production	CH_4	Gg CO_2 e	1	1	1	1	1	1	1	1	1	1	1	1	1	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	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	0

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1 A 1 a gaseous	Public Electricity and Heat Production	CH_4	Gg CO_2 e	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2
1 A 1 a biomass	Public Electricity and Heat Production	CH_4	Gg CO_2 e	0	1	2	3	3	4	4	4	6	8	10	11	13	13	14	14	13	13	13
1 A 1 a other	Public Electricity and Heat Production	CH_4	Gg CO_2 e	1	2	2	2	2	2	3	3	4	4	4	5	5	6	6	6	7	7	7
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	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	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	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	0	0	0	0	0	0	0
1 A 1 b liquid	Petroleum Refining	CH_4	Gg CO_2 e	1	1	1	1	2	2	2	2	1	1	1	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	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	0	0	0	0	0	0	0
1 A 2 a gaseous	Iron and Steel	CH_4	Gg CO_2 e	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0
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	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	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	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	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	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	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	0	0	0	0	0	0	0
1 A 2 c solid	Chemicals	CH_4	Gg CO_2 e	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 c gaseous	Chemicals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 c biomass	Chemicals	CH_4	Gg CO_2 e	1	0	1	0	0	0	0	0	0	1	1	0	1	1	1	1	0	0	0
1 A 2 c other	Chemicals	CH_4	Gg CO_2 e	1	1	1	1	1	2	2	1	1	1	2	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	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	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	1	1	1	1	1	1
1 A 2 d biomass	Pulp, Paper and Print	CH_4	Gg CO_2 e	2	4	3	4	3	3	3	4	4	4	4	4	4	4	4	4	4	4	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	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	0	0	0	0	0	0	0
1 A 2 e solid	Food Processing, Beverages	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	and Tobacco																					
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	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	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	0	0	0	0	0	0	0
1 A 2 f liquid	Non-Metallic Minerals	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	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	1	1	1	1	1	1	1	1	1	2	2	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	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	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
1 A 2 f other	Non-Metallic Minerals	CH_4	Gg CO_2 e	0	1	1	1	1	1	2	1	2	2	2	2	2	2	2	2	2	2	2
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CH_4	Gg CO_2 e	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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	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	1	1	1	1	1	0	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	0	0	0	0	0	0	0
1 A 2 g 8 gaseous	Other Manufacturing Industries	CH_4	Gg CO_2 e	0	1	0	0	0	0	0	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	2	3	3	3	3	3	3	4	6	5	5	6	6	7	9	7	8	7
1 A 2 g 8 other	Other Manufacturing Industries	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1
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	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	0	0	0	0	0	0	0
1 A 3 b gasoline	Road Transportation	CH_4	Gg CO_2 e	64	41	25	24	24	23	21	20	18	16	14	13	12	11	11	10	9	9	9
1 A 3 b diesel oil	Road Transportation	CH_4	Gg CO_2 e	3	3	3	4	4	4	4	3	3	3	2	2	2	1	1	1	1	1	1
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	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	0	0	0	0	0	0	0
1 A 3 b biomass	Road Transportation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0
1 A 3 c liquid	Railways	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	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	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	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	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1 A 3 d gasoline	Domestic Navigation	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	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	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	0	0	0	0	0	0	0
1 A 4 a liquid	Commercial/Institutional	CH_4	Gg CO_2 e	4	3	2	3	4	4	3	3	4	2	2	2	2	1	1	1	1	0	0
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	0	0	0	0	0	0	0
1 A 4 a gaseous	Commercial/Institutional	CH_4	Gg CO_2 e	2	4	3	4	4	4	5	5	5	4	5	4	4	3	3	3	2	2	2
1 A 4 a biomass	Commercial/Institutional	CH_4	Gg CO_2 e	8	6	6	6	6	7	9	5	7	8	11	9	10	8	10	10	9	13	10
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	0	0	0	0	0	0	0
1 A 4 b liquid	Residential	CH_4	Gg CO_2 e	11	9	9	8	8	8	8	6	6	5	5	5	5	4	4	4	4	4	4
1 A 4 b solid	Residential	CH_4	Gg CO_2 e	200	132	68	64	52	43	41	27	26	22	23	17	19	11	12	9	7	7	6
1 A 4 b gaseous	Residential	CH_4	Gg CO_2 e	4	5	6	7	6	7	6	6	6	5	5	6	6	5	6	7	5	6	6
1 A 4 b biomass	Residential	CH_4	Gg CO_2 e	228	242	222	233	217	212	201	215	208	196	200	198	221	207	216	237	199	213	219
1 A 4 b peat	Residential	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	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	3	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
1 A 4 c solid	Agriculture/Forestry/Fishing	CH_4	Gg CO_2 e	4	3	1	1	1	1	1	1	1	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	0	0	0	0	0	0	0
1 A 4 c biomass	Agriculture/Forestry/Fishing	CH_4	Gg CO_2 e	30	34	37	42	40	42	45	37	36	36	38	41	42	46	50	52	46	47	49
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	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	0	0	0	0	0	0	0
1 B 1 a	Coal Mining and Handling	CH_4	Gg CO_2 e	333	37	27	26	31	25	5	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1 B 2 a	Oil	CH_4	Gg CO_2 e	7	8	8	8	8	8	8	8	8	8	8	8	7	8	8	8	8	8	8
1 B 2 b	Natural Gas	CH_4	Gg CO_2 e	259	292	297	297	293	298	288	269	277	279	262	267	277	274	283	273	261	254	253
2 B 1	Ammonia Production	CH_4	Gg CO_2 e	2	2	2	1	2	1	1	2	3	4	2	2	2	2	2	6	2	2	2
2 B 8	Petrochemical and Carbon Black Production	CH_4	Gg CO_2 e	26	26	26	26	26	26	26	26	38	38	38	38	38	38	38	38	38	38	38
2 B-10	Other (please specify)	CH_4	Gg CO_2 e	7	7	7	7	7	7	7	8	8	7	7	7	7	7	7	6	7	7	7
2 C 1	Iron and Steel Production	CH_4	Gg CO_2 e	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 A 1	Cattle	CH_4	Gg CO_2 e	4 579	4 372	4 135	4 074	3 995	3 949	3 953	3 899	3 890	3 891	3 895	3 942	3 927	3 878	3 850	3 861	3 881	3 874	3 886
3 A 2	Sheep	CH_4	Gg CO_2 e	62	73	68	64	61	65	65	65	62	70	67	69	72	72	73	71	70	71	76
3 A 3	Swine	CH_4	Gg CO_2 e	138	139	126	129	124	122	117	119	118	123	115	118	118	113	112	109	108	107	105

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
3 A 4	Other (please specify)	CH_4	Gg CO_2 e	41	54	58	59	60	61	62	64	65	67	69	71	73	74	76	76	78	80	80
3 B 1 1	Cattle	CH_4	Gg CO_2 e	424	399	371	364	356	349	348	344	342	342	342	346	344	340	336	336	337	336	336
3 B 1 2	Sheep	CH_4	Gg CO_2 e	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	2
3 B 1 3	Swine	CH_4	Gg CO_2 e	149	141	117	119	113	110	102	103	100	102	93	95	94	91	89	86	85	84	83
3 B 1 4	Other (please specify)	CH_4	Gg CO_2 e	12	13	12	13	13	13	13	13	14	14	14	14	15	15	15	16	16	16	16
3 F	Field Burning of Agricultural Residues	CH_4	Gg CO_2 e	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
5 A	Solid Waste Disposal	CH_4	Gg CO_2 e	3 644	3 355	2 667	2 558	2 549	2 545	2 587	2 438	2 314	2 184	2 074	1 929	1 803	1 686	1 583	1 477	1 382	1 294	1 212
5 B	Biological Treatment of Solid Waste	CH_4	Gg CO_2 e	13	26	31	36	40	46	56	62	68	72	73	74	76	76	79	75	79	81	83
5 C	Incineration and Open Burning of Waste	CH_4	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 D	Waste Water Treatment and Discharge	CH_4	Gg CO_2 e	121	105	67	61	55	49	45	41	37	35	32	30	28	26	25	24	23	23	24
1 A 1 a liquid	Public Electricity and Heat Production	N_2O	Gg CO_2 e	3	3	3	4	2	3	3	3	2	2	2	1	2	1	1	0	0	1	1
1 A 1 a solid	Public Electricity and Heat Production	N_2O	Gg CO_2 e	27	20	22	27	25	32	31	28	27	24	21	15	19	20	17	16	11	11	8
1 A 1 a gaseous	Public Electricity and Heat Production	N_2O	Gg CO_2 e	2	2	2	2	2	2	2	3	2	2	2	3	3	3	2	2	2	2	2
1 A 1 a biomass	Public Electricity and Heat Production	N_2O	Gg CO_2 e	2	5	9	13	15	16	19	20	30	39	47	51	63	63	66	64	59	62	59
1 A 1 a other	Public Electricity and Heat Production	N_2O	Gg CO_2 e	6	6	7	7	8	9	12	13	16	16	16	20	22	24	25	25	26	28	28
1 A 1 b liquid	Petroleum Refining	N_2O	Gg CO_2 e	2	2	2	3	3	4	4	3	3	3	3	4	3	3	4	4	4	4	4
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	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	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	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	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0
1 A 2 a gaseous	Iron and Steel	N_2O	Gg CO_2 e	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
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	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	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	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	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	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	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1 A 2 c liquid	Chemicals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	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	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0
1 A 2 c gaseous	Chemicals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1
1 A 2 c biomass	Chemicals	N_2O	Gg CO_2 e	3	2	4	2	2	2	2	2	2	3	3	2	3	3	3	3	2	2	2
1 A 2 c other	Chemicals	N_2O	Gg CO_2 e	2	3	3	3	5	7	9	5	5	3	7	5	5	5	5	5	5	5	3
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	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	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1 A 2 d gaseous	Pulp, Paper and Print	N_2O	Gg CO_2 e	1	1	1	1	1	1	1	1	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	23	19	25	19	20	21	27	25	26	25	26	25	25	25	26	25	24	28
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	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	1	0	1	1	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	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	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	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0
1 A 2 f liquid	Non-Metallic Minerals	N_2O	Gg CO_2 e	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1 A 2 f solid	Non-Metallic Minerals	N_2O	Gg CO_2 e	3	2	2	2	2	1	1	2	3	3	3	2	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	0	0	0	0	0	0	0
1 A 2 f biomass	Non-Metallic Minerals	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	2	2	2	4	4	3	4	4	2	1	1	1
1 A 2 f other	Non-Metallic Minerals	N_2O	Gg CO_2 e	2	2	4	5	5	5	6	6	7	7	6	6	6	6	7	7	8	9	9
1 A 2 g 7 liquid	Off-road vehicles and other machinery	N_2O	Gg CO_2 e	27	39	66	62	60	61	61	69	70	66	66	59	54	52	51	48	46	43	41
1 A 2 g 7 bio-mass	Off-road vehicles and other machinery	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	1	3	3	3	4	3	3	3	3	3	3	3
1 A 2 g 8 liquid	Other Manufacturing Indust-ries	N_2O	Gg CO_2 e	1	2	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1
1 A 2 g 8 solid	Other Manufacturing Indust-ries	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 A 2 g 8 gase-ous	Other Manufacturing Indust-ries	N_2O	Gg CO_2 e	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1 A 2 g 8 bio-mass	Other Manufacturing Indust-ries	N_2O	Gg CO_2 e	6	5	10	10	10	12	12	13	17	24	21	23	26	29	32	41	35	36	35
1 A 2 g 8 other	Other Manufacturing Indust-ries	N_2O	Gg CO_2 e	0	1	1	1	1	1	1	2	2	2	2	1	2	4	2	3	3	3	4

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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	0	0	0	0	0	0	0
1 A 3 a jet kero-sene	Domestic Aviation	N_2O	Gg CO_2 e	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1 A 3 b gasoline	Road Transportation	N_2O	Gg CO_2 e	96	111	75	71	70	65	57	50	45	37	29	24	21	18	15	14	12	11	11
1 A 3 b diesel oil	Road Transportation	N_2O	Gg CO_2 e	13	25	51	58	68	78	84	89	91	102	106	109	123	127	134	149	147	152	166
1 A 3 b LPG	Road Transportation	N_2O	Gg CO_2 e	0	1	1	1	1	1	1	1	1	0	0	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	0	0	0	0	0	0	0
1 A 3 b biomass	Road Transportation	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	1	5	7	9	13	13	14	14	16	21	24	17
1 A 3 c liquid	Railways	N_2O	Gg CO_2 e	18	15	14	14	15	15	15	17	16	15	14	13	13	10	10	9	8	7	7
1 A 3 c solid	Railways	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	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	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
1 A 3 d gas/diesel oil	Domestic Navigation	N_2O	Gg CO_2 e	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
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	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	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	0	0	0	0	0	0	0
1 A 4 a liquid	Commercial/Institutional	N_2O	Gg CO_2 e	3	3	3	4	4	5	4	6	5	3	4	3	2	2	1	1	1	1	1
1 A 4 a solid	Commercial/Institutional	N_2O	Gg CO_2 e	0	0	0	1	0	1	0	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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1 A 4 a biomass	Commercial/Institutional	N_2O	Gg CO_2 e	2	2	4	3	3	4	4	4	4	4	5	4	4	4	4	4	4	6	5
1 A 4 a other	Commercial/Institutional	N_2O	Gg CO_2 e	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1 A 4 b liquid	Residential	N_2O	Gg CO_2 e	20	21	20	20	20	20	19	17	16	14	14	13	14	12	12	11	10	11	10
1 A 4 b solid	Residential	N_2O	Gg CO_2 e	12	8	4	4	3	3	2	2	2	1	1	1	1	1	1	1	0	0	0
1 A 4 b gaseous	Residential	N_2O	Gg CO_2 e	1	1	1	2	1	2	2	1	1	1	1	1	1	1	1	2	1	1	2
1 A 4 b biomass	Residential	N_2O	Gg CO_2 e	69	75	71	76	71	70	68	75	73	67	69	70	77	75	80	86	73	77	79
1 A 4 b peat	Residential	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	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	77	77	87	90	89	84	84	85	80	77	74	63	58	60	54	51	48	45	43
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	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	0	0	0	0	0	0	0
1 A 4 c biomass	Agriculture/Forestry/Fishing	N_2O	Gg CO_2 e	5	5	6	7	6	7	7	7	9	9	9	10	10	11	12	12	11	11	11

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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	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	0	0	0	0	0	0	0
2 B 2	Nitric Acid Production	N_2O	Gg CO_2 e	877	824	915	756	776	849	270	264	269	260	313	159	61	46	51	48	48	47	36
2 G	Other Product Manufacture and Use	N_2O	Gg CO_2 e	224	224	224	212	201	190	178	167	158	154	150	140	144	141	135	137	135	133	134
3 B 1 1	Cattle	N_2O	Gg CO_2 e	258	266	266	264	261	261	264	261	263	264	266	270	269	266	264	264	266	265	266
3 B 1 2	Sheep	N_2O	Gg CO_2 e	5	6	5	5	5	5	5	5	5	5	5	5	5	6	6	5	5	5	6
3 B 1 3	Swine	N_2O	Gg CO_2 e	59	59	50	51	49	48	45	46	45	46	43	43	43	41	40	39	38	38	37
3 B 1 4	Other (please specify)	N_2O	Gg CO_2 e	9	11	11	12	12	12	12	12	13	13	13	14	14	15	15	15	16	16	16
3 B 2 5	Indirect N2O Emissions	N_2O	Gg CO_2 e	107	114	109	111	110	110	110	111	111	114	113	115	115	114	114	114	114	114	114
3 D 1	Direct N2O Emissions from Managed Soils	N_2O	Gg CO_2 e	1 884	1 917	1 739	1 747	1 744	1 659	1 646	1 636	1 623	1 632	1 744	1 694	1 577	1 684	1 651	1 632	1 723	1 716	1 793
3 D 2	Indirect N2O emissions from Managed Soils	N_2O	Gg CO_2 e	363	371	338	338	336	325	321	320	320	325	339	336	318	331	329	327	340	342	353
3 F	Field Burning of Agricultural Residues	N_2O	Gg CO_2 e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 B	Biological Treatment of Solid Waste	N_2O	Gg CO_2 e	23	43	51	58	65	71	85	89	90	91	90	91	92	93	95	91	94	94	98
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	0	0	0	0	0	0	0
5 D	Waste Water Treatment and Discharge	N_2O	Gg CO_2 e	96	111	134	140	142	144	145	148	153	154	155	157	158	159	159	159	160	162	164
2 C 3	Aluminium Production	PFC	Gg CO_2 e	1 149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 C 4	Magnesium Production	SF_6	Gg CO_2 e	228	409	35	27	7	3	0	5	11	0	0	0	0	0	4	9	15	2	2
2 C 7	Aluminium Production	SF_6	Gg CO_2 e	14	14	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2 E	Electronics Industry	HFC	Gg CO_2 e	2	11	5	6	5	5	5	5	6	9	9	2	2	2	2	2	2	2	2
2 E	Electronics Industry	PFC	Gg CO_2 e	34	83	87	116	102	126	158	158	171	229	207	36	78	74	51	49	53	50	50
2 E	Electronics Industry	SF_6	Gg CO_2 e	97	409	317	342	342	361	363	161	160	94	101	71	66	39	40	29	31	42	34
2 E	Electronics Industry	NF3	Gg CO_2 e	0	6	11	11	11	22	27	28	33	59	53	5	4	4	9	10	11	13	6
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	Gg CO_2 e	0	38	404	538	626	767	870	936	1 033	1 079	1 173	1 238	1 412	1 350	1 431	1 455	1 526	1 562	1 582
2 F 2	Foam Blowing Agents	HFC	Gg CO_2 e	0	301	278	283	300	265	244	155	49	49	29	34	34	18	17	17	17	17	17
2 F 3	Fire Protection	HFC	Gg CO_2 e	0	0	0	4	2	0	5	7	7	6	13	13	13	15	13	13	13	13	13
2 F 4	Aerosols	HFC	Gg CO_2 e	0	4	27	31	34	33	34	42	57	52	24	21	22	22	23	25	26	26	27
2 F 5	Solvents	HFC	Gg CO_2 e	0	0	0	1	2	2	1	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	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	Gas	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2 G 1	Other product manufacture and use - Electrical Equipment	SF_6	Gg CO_2 e	11	14	17	18	19	19	21	22	23	24	26	27	29	29	32	33	34	36	38
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	PFC	Gg CO_2 e	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF_6	Gg CO_2 e	121	254	205	242	246	166	100	305	258	248	246	243	241	238	236	234	232	229	319
2 G 4 b	ORC	PFC	Gg CO_2 e	0	0	1	0	0	0	0	5	0	0	0	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	0	0	0	0	0	0	0
4A1	Forest land remaining forest land	CO_2	Gg	-7 849	-9 218	-13 607	-15 625	-9 997	-73	-5 180	-6 658	-869	134	1 003	-2 494.37	-2 510	-2 526	-2 542	-2 561	-2 580	-2 579	-2 579
4A2	Land converted to forest land	CO_2	Gg	-3 043	-3 028	-2 391	-2 326	-2 260	-2 191	-2 165	-2 139	-2 114	-2 088	-2 063	-2 003.28	-1 955	-1 906	-1 857	-1 805	-1 753	-1 747	-1 741
4B1	Cropland remaining cropland	CO_2	Gg	-18	-161	-158	-228	-233	-256	-269	-271	-269	-397	-395	-405.28	-413	-420	-424	-409	-381	-194	-184
4B2	Land converted to cropland	CO_2	Gg	194	170	167	167	178	178	177	174	175	183	194	174.18	177	178	179	184	189	203	224
4C1	Grassland remaining grassland	CO_2	Gg	294	295	295	295	295	295	295	295	295	295	295	295.44	296	296	296	296	296	296	296
4C2	Land converted to grassland	CO_2	Gg	332	149	154	153	361	357	359	360	359	358	353	58.96	57	56	56	56	58	55	37
4D2	Land converted to Wetlands	CO_2	Gg	42	30	36	36	47	47	47	47	37	39	51	68.13	69	73	70	101	71	59	77
4E2	Land converted to Settlements	CO_2	Gg	577	527	506	504	585	585	584	581	578	554	589	496.14	468	449	459	417	421	391	379
4F2	Land converted to Other land	CO_2	Gg	444	375	366	367	335	336	328	320	312	304	296	211.27	204	196	188	181	173	170	166
4G	HWP	CO_2	Gg	-3 122	-2 569	-1 889	-2 701	-3 635	-4 223	-3 448	-3 461	-3 776	-5 046	-4 756	-1 102.15	-2 427	-2 659	-2 058	-1 141	-1 375	-1 257	-1 042
4	Total land use categories	CH_4	Gg CO_2 e	24	24	24	24	24	24	24	24	24	24	24	23.92	24	24	24	24	24	24	24
4	Total land use categories	N_2O	Gg CO_2 e	144	145	134	134	133	133	131	131	131	131	132	132.65	133	132	133	132	132	134	135

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. The same uncertainty information was applied for approach 1 and 2 uncertainty. As will be explained below, considerable difference between those approaches can be explained by covariance of uncertainties between (key) source categories, which occurs when data are statistically dependent. The approach 1 allows considering co-variance between years for one source category, but does not cover co-variances between source categories.

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 7(1)(p) MMR) – excluding LULUCF

IPCC category/Group	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
	0	Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
	0	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	CH4	271.72	304.30	5.0	50.0	50.25	0.0368	0.0004	0.0039	0.0185	0.0273	0.0011
1.A Stationary Combustion – Biomass	N2O	103.19	223.70	5.0	50.0	50.25	0.0199	0.0015	0.0028	0.0758	0.0201	0.0061
1.A Stationary Combustion – Gaseous Fuels	CH4	9.64	13.83	2.0	50.0	50.04	0.0001	0.0001	0.0002	0.0026	0.0005	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO2	11 076.18	15 382.09	2.0	0.5	2.06	0.1584	0.0529	0.1955	0.0264	0.5529	0.3064
1.A Stationary Combustion – Gaseous Fuels	N2O	5.96	8.27	2.0	50.0	50.04	0.0000	0.0000	0.0001	0.0014	0.0003	0.0000
1.A Stationary Combustion – Liquid Fuels	CH4	22.89	8.70	0.5	50.0	50.00	0.0000	-0.0002	0.0001	-0.0092	0.0001	0.0001
1.A Stationary Combustion – Liquid Fuels	CO2	14 168.58	9 100.77	0.5	0.5	0.71	0.0065	-0.0665	0.1157	-0.0333	0.0818	0.0078
1.A Stationary Combustion – Liquid Fuels	N2O	136.96	102.95	0.5	50.0	50.00	0.0042	-0.0005	0.0013	-0.0227	0.0009	0.0005
1.A Stationary Combustion – Other fuels	CH4	2.70	11.42	10.0	50.0	50.99	0.0001	0.0001	0.0001	0.0055	0.0021	0.0000
1.A Stationary Combustion – Other fuels	CO2	733.70	2 349.71	10.0	20.0	22.36	0.4349	0.0204	0.0299	0.4084	0.4223	0.3451
1.A Stationary Combustion – Other fuels	N2O	10.72	45.36	10.0	50.0	50.99	0.0008	0.0004	0.0006	0.0219	0.0082	0.0005
1.A Stationary Combustion – Solid Fuels	CH4	208.91	9.11	0.5	50.0	50.00	0.0000	-0.0026	0.0001	-0.1286	0.0001	0.0165
1.A Stationary Combustion – Solid Fuels	CO2	11 405.92	2 833.71	0.5	0.5	0.71	0.0006	-0.1106	0.0360	-0.0553	0.0255	0.0037
1.A Stationary Combustion – Solid Fuels	N2O	45.91	11.77	0.5	50.0	50.00	0.0001	-0.0004	0.0001	-0.0221	0.0001	0.0005
1.A.3.a Transport – Civil Aviation	CH4	0.06	0.02	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	CO2	32.00	47.49	3.0	3.0	4.24	0.0000	0.0002	0.0006	0.0006	0.0026	0.0000
1.A.3.a Transport – Civil Aviation	N2O	0.38	0.39	3.0	30.0	30.15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH4	2.72	0.96	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0007	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO2	5 377.78	17 700.32	3.0	3.0	4.24	0.8884	0.1556	0.2249	0.4669	0.9543	1.1287
1.A.3.b Transport – Road Transportation – Diesel	N2O	13.10	166.07	3.0	30.0	30.15	0.0039	0.0019	0.0021	0.0583	0.0090	0.0035
1.A.3.b Transport – Road Transportation – Gaseous	CO2	0.00	39.85	3.0	3.0	4.24	0.0000	0.0005	0.0005	0.0015	0.0021	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH4	0.00	0.06	3.0	50.0	50.09	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N2O	0.00	0.12	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	CH4	64.30	8.66	3.0	30.0	30.15	0.0000	-0.0007	0.0001	-0.0215	0.0005	0.0005
1.A.3.b Transport – Road Transportation – Gasoline	CO2	7 923.81	4 779.23	3.0	3.0	4.24	0.0648	-0.0412	0.0607	-0.1235	0.2577	0.0817
1.A.3.b Transport – Road Transportation – Gasoline	N2O	95.91	10.97	3.0	70.0	70.06	0.0001	-0.0011	0.0001	-0.0766	0.0006	0.0059
1.A.3.b Transport – Road Transportation – LPG	CO2	26.46	30.54	3.0	3.0	4.24	0.0000	0.0000	0.0004	0.0001	0.0016	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH4	0.19	0.03	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 – LPG	N2O	0.38	0.08	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	CH4	0.00	0.40	5.0	30.0	30.41	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N2O	0.00	17.32	5.0	3.0	5.83	0.0000	0.0002	0.0002	0.0007	0.0016	0.0000
1.A.3.c Transport – Railways	CH4	0.22	0.06	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO2	177.98	110.63	3.0	3.0	4.24	0.0000	-0.0009	0.0014	-0.0027	0.0060	0.0000
1.A.3.c Transport – Railways	N2O	17.95	7.83	3.0	30.0	30.15	0.0000	-0.0001	0.0001	-0.0039	0.0004	0.0000
1.A.3.d Transport – Navigation	CH4	0.18	0.08	3.0	30.0	30.15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.d Transport – Navigation	CO2	14.79	10.44	3.0	3.0	4.24	0.0000	-0.0001	0.0001	-0.0002	0.0006	0.0000
1.A.3.d Transport – Navigation	N2O	0.61	0.30	3.0	70.0	70.06	0.0000	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CH4	0.10	0.25	2.0	50.0	50.04	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO2	224.37	555.81	2.0	0.5	2.06	0.0002	0.0042	0.0071	0.0021	0.0200	0.0004
1.A.3.e Transport – Other Transportation	N2O	0.12	0.30	2.0	50.0	50.04	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000

IPCC category/Group	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
	0	Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
	0	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.5.b Mobile	CH4	0.03	0.04	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO2	35.00	49.65	1.0	0.5	1.12	0.0000	0.0002	0.0006	0.0001	0.0009	0.0000
1.A.5.b Mobile	N2O	0.84	0.97	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH4	333.22	0.00	5.0	50.0	50.25	0.0000	-0.0043	0.0000	-0.2144	0.0000	0.0460
1.B.2.a Fugitive Emission – Oil	CH4	7.37	7.68	0.5	50.0	50.00	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO2	0.00	0.00	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	CH4	259.05	252.90	5.0	10.0	11.18	0.0013	-0.0001	0.0032	-0.0012	0.0227	0.0005
1.B.2.b Fugitive Emission – Natural Gas	CO2	102.16	131.25	5.0	0.5	5.02	0.0001	0.0004	0.0017	0.0002	0.0118	0.0001
2.A.1 Mineral Industry – Cement Production	CO2	2 033.41	1 729.00	1.1	2.0	2.28	0.0025	-0.0042	0.0220	-0.0084	0.0342	0.0012
2.A.2 Mineral Industry – Lime Production	CO2	396.29	581.62	1.6	5.0	5.25	0.0015	0.0023	0.0074	0.0115	0.0167	0.0004
2.A.3 Mineral Industry – Glass Production	CO2	38.51	38.26	10.0	1.0	10.05	0.0000	0.0000	0.0005	0.0000	0.0069	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO2	116.48	91.19	2.0	5.0	5.39	0.0000	-0.0003	0.0012	-0.0017	0.0033	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO2	5.14	10.72	10.0	5.0	11.18	0.0000	0.0001	0.0001	0.0004	0.0019	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO2	481.23	318.22	2.0	5.0	5.39	0.0005	-0.0021	0.0040	-0.0107	0.0114	0.0002
2.A.4.d Other Process Uses of Carbonates – other	CO2	21.40	18.85	20.0	2.0	20.10	0.0000	0.0000	0.0002	-0.0001	0.0068	0.0000
2.B.1 Chemical Industry – Ammonia Production	CH4	1.56	1.72	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	CO2	467.42	527.18	2.0	5.0	5.39	0.0013	0.0007	0.0067	0.0034	0.0189	0.0004
2.B.2 Chemical Industry – Nitric Acid Production	CO2	0.41	0.41	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	N2O	876.72	35.76	2.0	5.0	5.39	0.0000	-0.0108	0.0005	-0.0541	0.0013	0.0029
2.B.5 Chemical Industry – Carbide Production	CO2	37.51	47.62	5.0	10.0	11.18	0.0000	0.0001	0.0006	0.0012	0.0043	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH4	26.25	37.50	10.0	10.0	14.14	0.0000	0.0001	0.0005	0.0014	0.0067	0.0000
2.B.10 Chemical Industry – Other	CH4	7.30	7.33	2.0	5.0	5.39	0.0000	0.0000	0.0001	0.0000	0.0003	0.0000
2.B.10 Chemical Industry – Other	CO2	138.15	147.16	2.0	5.0	5.39	0.0001	0.0001	0.0019	0.0005	0.0053	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO2	6 610.49	10 417.75	0.5	0.5	0.71	0.0085	0.0473	0.1324	0.0236	0.0936	0.0093
2.C.2 Metal Industry – Ferroalloys Production	CO2	20.81	19.72	5.0	25.0	25.50	0.0000	0.0000	0.0003	-0.0004	0.0018	0.0000
2.C.3 Metal Industry – Aluminium Production	CO2	150.25	4.92	2.0	0.5	2.06	0.0000	-0.0019	0.0001	-0.0009	0.0002	0.0000
2.C.3 Metal Industry – Aluminium Production	PFC	1 148.76	0.00	2.0	50.0	50.04	0.0000	-0.0148	0.0000	-0.7389	0.0000	0.5460
2.C.3 Metal Industry – Aluminium Production	SF6	13.68	0.07	5.0	5.0	7.07	0.0000	-0.0002	0.0000	-0.0009	0.0000	0.0000
2.C.4 Metal Industry – Magnesium Production	SF6	228.00	2.28	5.0	5.0	7.07	0.0000	-0.0029	0.0000	-0.0145	0.0002	0.0002
2.C.5 Metal Industry – Lead Production	CO2	4.70	4.88	10.0	50.0	50.99	0.0000	0.0000	0.0001	0.0001	0.0009	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO2	348.94	204.85	5.0	10.0	11.18	0.0008	-0.0019	0.0026	-0.0189	0.0184	0.0007
2.E Electronics Industry	HFC	2.44	2.13	5.0	10.0	11.18	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
2.E Electronics Industry	PFC	34.03	50.39	5.0	10.0	11.18	0.0001	0.0002	0.0006	0.0020	0.0045	0.0000
2.E Electronics Industry	SF6	97.40	33.57	5.0	10.0	11.18	0.0000	-0.0008	0.0004	-0.0083	0.0030	0.0001
2.E Electronics Industry	NF3	0.00	6.14	5.0	10.0	11.18	0.0000	0.0001	0.0001	0.0008	0.0006	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0.00	1 581.51	20.0	50.0	53.85	1.1427	0.0201	0.0201	1.0049	0.5685	1.3330
2.F.2 Foam Blowing	HFC	0.00	16.70	20.0	50.0	53.85	0.0001	0.0002	0.0002	0.0106	0.0060	0.0001
2.F.3 Fire Extinguishers	HFC	0.00	12.78	20.0	50.0	53.85	0.0001	0.0002	0.0002	0.0081	0.0046	0.0001
2.F.4 Aerosols	HFC	0.00	27.49	20.0	50.0	53.85	0.0003	0.0003	0.0003	0.0175	0.0099	0.0004
2.F.5 Solvents	HFC	0.00	0.00	20.0	50.0	53.85	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.6 Other Applications	HFC	0.00	0.00	25.0	50.0	55.90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	10.80	38.37	25.0	50.0	55.90	0.0007	0.0003	0.0005	0.0174	0.0172	0.0006
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	PFC	0.00	0.00	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 – SF6 and PFCs from other product use	SF6	120.73	318.55	25.0	50.0	55.90	0.0500	0.0025	0.0040	0.1247	0.1431	0.0360
2.G. Other Product Manufacture and Use	CO2	0.00	0.00	20.0	0.0	20.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G. Other Product Manufacture and Use	N2O	223.50	133.74	20.0	0.0	20.00	0.0011	-0.0012	0.0017	0.0000	0.0481	0.0023
3.A.1 Enteric Fermentation – Cattle	CH4	4 579.36	3 885.95	1.0	20.0	20.02	0.9539	-0.0095	0.0494	-0.1907	0.0698	0.0412
3.A.2 Enteric Fermentation – Sheep	CH4	61.98	75.68	10.0	40.0	41.23	0.0015	0.0002	0.0010	0.0066	0.0136	0.0002
3.A.3 Enteric Fermentation – Swine	CH4	138.30	104.73	4.0	40.0	40.20	0.0028	-0.0004	0.0013	-0.0179	0.0075	0.0004
3.A.4 Enteric Fermentation – Other	CH4	40.88	80.30	10.0	40.0	41.23	0.0017	0.0005	0.0010	0.0198	0.0144	0.0006

IPCC category/Group	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
	0	Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
	0	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
3.B.1.1 Manure Management – Cattle	CH4	424.44	336.23	1.0	20.0	20.02	0.0071	-0.0012	0.0043	-0.0238	0.0060	0.0006
3.B.1.1 Manure Management – Cattle	N2O	258.18	266.35	1.0	100.0	100.00	0.1118	0.0001	0.0034	0.0063	0.0048	0.0001
3.B.1.2 Manure Management – Sheep	CH4	1.47	1.80	10.0	30.0	31.62	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000
3.B.1.2 Manure Management – Sheep	N2O	4.75	5.80	10.0	100.0	100.50	0.0001	0.0000	0.0001	0.0013	0.0010	0.0000
3.B.1.3 Manure Management – Swine	CH4	148.97	82.86	4.0	20.0	20.40	0.0004	-0.0009	0.0011	-0.0173	0.0060	0.0003
3.B.1.3 Manure Management – Swine	N2O	59.42	37.34	4.0	100.0	100.08	0.0022	-0.0003	0.0005	-0.0290	0.0027	0.0008
3.B.1.4. Manure Management – Other	CH4	12.14	16.08	10.0	30.0	31.62	0.0000	0.0000	0.0002	0.0014	0.0029	0.0000
3.B.1.4. Manure Management – Other	N2O	8.98	15.96	10.0	100.0	100.50	0.0004	0.0001	0.0002	0.0087	0.0029	0.0001
3.B.2.5 Indirect N2O Emissions	N2O	106.94	113.85	5.0	200.0	200.06	0.0817	0.0001	0.0014	0.0142	0.0102	0.0003
3.D.1 Direct N2O Emissions from Managed Soils	N2O	1 883.63	1 793.25	5.0	200.0	200.06	20.2766	-0.0014	0.0228	-0.2894	0.1611	0.1097
3.D.2 Indirect N2O emissions from Managed Soils	N2O	363.11	353.38	5.0	200.0	200.06	0.7874	-0.0002	0.0045	-0.0363	0.0318	0.0023
3.F Field Burning of Agricultural Residues	CH4	1.34	0.57	100.0	40.0	107.70	0.0000	0.0000	0.0000	-0.0004	0.0010	0.0000
3.F Field Burning of Agricultural Residues	N2O	0.32	0.10	100.0	50.0	111.80	0.0000	0.0000	0.0000	-0.0001	0.0002	0.0000
3.G Liming and Urea application	CO2	89.97	84.90	100.0	10.0	100.50	0.0115	-0.0001	0.0011	-0.0008	0.1526	0.0233
3.H Urea application	CO2	4.45	31.30	100.0	10.0	100.50	0.0016	0.0003	0.0004	0.0034	0.0562	0.0032
5.A Solid Waste Disposal	CH4	3 643.89	1 211.68	12.0	25.0	27.73	0.1779	-0.0315	0.0154	-0.7868	0.2613	0.6874
5.B Biological Treatment of Solid Waste	CH4	13.01	82.56	20.0	50.0	53.85	0.0031	0.0009	0.0010	0.0441	0.0297	0.0028
5.B Biological Treatment of Solid Waste	N2O	22.73	97.79	20.0	50.0	53.85	0.0044	0.0010	0.0012	0.0475	0.0351	0.0035
5.C Incineration and Open Burning of Waste	CH4	0.02	0.00	7.0	0.0	7.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and Open Burning of Waste	CO2	27.92	2.05	7.0	20.0	21.19	0.0000	-0.0003	0.0000	-0.0067	0.0003	0.0000
5.C Incineration and Open Burning of Waste	N2O	0.13	0.01	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	CH4	121.25	23.60	20.0	50.0	53.85	0.0003	-0.0013	0.0003	-0.0630	0.0085	0.0040
5.D Waste Water Treatment and Discharge	N2O	96.07	163.78	20.0	100.0	101.98	0.0439	0.0008	0.0021	0.0845	0.0589	0.0106
Total		78 690.05	79 672.64				25.30					4.78
Total Uncertainties						Uncertainty in total inventory %:	5.03				Trend uncertainty %:	2.19

Table A 19: Approach 1 Uncertainty Analysis (Article 7(1)(p) MMR) – including LULUCF

IPCC category/Group	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
	0	Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
	0	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	CH4	271.72	304.30	5.0	50.0	50.25	0.0411	0.0000	0.0046	-0.0023	0.0323	0.0010
1.A Stationary Combustion – Biomass	N2O	103.19	223.70	5.0	50.0	50.25	0.0222	0.0016	0.0034	0.0802	0.0237	0.0070
1.A Stationary Combustion – Gaseous Fuels	CH4	9.64	13.83	2.0	50.0	50.04	0.0001	0.0000	0.0002	0.0022	0.0006	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO2	11 076.18	15 382.09	2.0	0.5	2.06	0.1766	0.0427	0.2306	0.0213	0.6522	0.4258
1.A Stationary Combustion – Gaseous Fuels	N2O	5.96	8.27	2.0	50.0	50.04	0.0000	0.0000	0.0001	0.0011	0.0004	0.0000
1.A Stationary Combustion – Liquid Fuels	CH4	22.89	8.70	0.5	50.0	50.00	0.0000	-0.0003	0.0001	-0.0129	0.0001	0.0002
1.A Stationary Combustion – Liquid Fuels	CO2	14 168.58	9 100.77	0.5	0.5	0.71	0.0073	-0.1036	0.1364	-0.0518	0.0965	0.0120
1.A Stationary Combustion – Liquid Fuels	N2O	136.96	102.95	0.5	50.0	50.00	0.0047	-0.0008	0.0015	-0.0390	0.0011	0.0015
1.A Stationary Combustion – Other fuels	CH4	2.70	11.42	10.0	50.0	50.99	0.0001	0.0001	0.0002	0.0063	0.0024	0.0000
1.A Stationary Combustion – Other fuels	CO2	733.70	2 349.71	10.0	20.0	22.36	0.4847	0.0228	0.0352	0.4556	0.4981	0.4557
1.A Stationary Combustion – Other fuels	N2O	10.72	45.36	10.0	50.0	50.99	0.0009	0.0005	0.0007	0.0249	0.0096	0.0007
1.A Stationary Combustion – Solid Fuels	CH4	208.91	9.11	0.5	50.0	50.00	0.0000	-0.0034	0.0001	-0.1703	0.0001	0.0290
1.A Stationary Combustion – Solid Fuels	CO2	11 405.92	2 833.71	0.5	0.5	0.71	0.0007	-0.1507	0.0425	-0.0753	0.0300	0.0066
1.A Stationary Combustion – Solid Fuels	N2O	45.91	11.77	0.5	50.0	50.00	0.0001	-0.0006	0.0002	-0.0301	0.0001	0.0009
1.A.3.a Transport – Civil Aviation	CH4	0.06	0.02	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	CO2	32.00	47.49	3.0	3.0	4.24	0.0000	0.0002	0.0007	0.0005	0.0030	0.0000
1.A.3.a Transport – Civil Aviation	N2O	0.38	0.39	3.0	30.0	30.15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH4	2.72	0.96	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0009	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO2	5 377.78	17 700.32	3.0	3.0	4.24	0.9903	0.1740	0.2653	0.5220	1.1257	1.5398
1.A.3.b Transport – Road Transportation – Diesel	N2O	13.10	166.07	3.0	30.0	30.15	0.0044	0.0023	0.0025	0.0680	0.0106	0.0047
1.A.3.b Transport – Road Transportation – Gaseous	CO2	0.00	39.85	3.0	3.0	4.24	0.0000	0.0006	0.0006	0.0018	0.0025	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH4	0.00	0.06	3.0	50.0	50.09	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N2O	0.00	0.12	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	CH4	64.30	8.66	3.0	30.0	30.15	0.0000	-0.0010	0.0001	-0.0288	0.0006	0.0008
1.A.3.b Transport – Road Transportation – Gasoline	CO2	7 923.81	4 779.23	3.0	3.0	4.24	0.0722	-0.0627	0.0716	-0.1880	0.3040	0.1277
1.A.3.b Transport – Road Transportation – Gasoline	N2O	95.91	10.97	3.0	70.0	70.06	0.0001	-0.0015	0.0002	-0.1023	0.0007	0.0105
1.A.3.b Transport – Road Transportation – LPG	CO2	26.46	30.54	3.0	3.0	4.24	0.0000	0.0000	0.0005	0.0000	0.0019	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH4	0.19	0.03	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 – LPG	N2O	0.38	0.08	3.0	50.0	50.09	0.0000	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH4	0.00	0.40	5.0	30.0	30.41	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N2O	0.00	17.32	5.0	3.0	5.83	0.0000	0.0003	0.0003	0.0008	0.0018	0.0000
1.A.3.c Transport – Railways	CH4	0.22	0.06	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO2	177.98	110.63	3.0	3.0	4.24	0.0000	-0.0014	0.0017	-0.0041	0.0070	0.0001
1.A.3.c Transport – Railways	N2O	17.95	7.83	3.0	30.0	30.15	0.0000	-0.0002	0.0001	-0.0056	0.0005	0.0000
1.A.3.d Transport – Navigation	CH4	0.18	0.08	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.d Transport – Navigation	CO2	14.79	10.44	3.0	3.0	4.24	0.0000	-0.0001	0.0002	-0.0003	0.0007	0.0000
1.A.3.d Transport – Navigation	N2O	0.61	0.30	3.0	70.0	70.06	0.0000	0.0000	0.0000	-0.0004	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CH4	0.10	0.25	2.0	50.0	50.04	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO2	224.37	555.81	2.0	0.5	2.06	0.0002	0.0045	0.0083	0.0023	0.0236	0.0006
1.A.3.e Transport – Other Transportation	N2O	0.12	0.30	2.0	50.0	50.04	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000

IPCC category/Group	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
	0	Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
	0	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.5.b Mobile	CH4	0.03	0.04	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO2	35.00	49.65	1.0	0.5	1.12	0.0000	0.0002	0.0007	0.0001	0.0011	0.0000
1.A.5.b Mobile	N2O	0.84	0.97	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH4	333.22	0.00	5.0	50.0	50.25	0.0000	-0.0057	0.0000	-0.2825	0.0000	0.0798
1.B.2.a Fugitive Emission – Oil	CH4	7.37	7.68	0.5	50.0	50.00	0.0000	0.0000	0.0001	-0.0005	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO2	0.00	0.00	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	CH4	259.05	252.90	5.0	10.0	11.18	0.0014	-0.0006	0.0038	-0.0060	0.0268	0.0008
1.B.2.b Fugitive Emission – Natural Gas	CO2	102.16	131.25	5.0	0.5	5.02	0.0001	0.0002	0.0020	0.0001	0.0139	0.0002
2.A.1 Mineral Industry – Cement Production	CO2	2 033.41	1 729.00	1.1	2.0	2.28	0.0027	-0.0086	0.0259	-0.0171	0.0403	0.0019
2.A.2 Mineral Industry – Lime Production	CO2	396.29	581.62	1.6	5.0	5.25	0.0016	0.0020	0.0087	0.0100	0.0197	0.0005
2.A.3 Mineral Industry – Glass Production	CO2	38.51	38.26	10.0	1.0	10.05	0.0000	-0.0001	0.0006	-0.0001	0.0081	0.0001
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO2	116.48	91.19	2.0	5.0	5.39	0.0000	-0.0006	0.0014	-0.0030	0.0039	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO2	5.14	10.72	10.0	5.0	11.18	0.0000	0.0001	0.0002	0.0004	0.0023	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO2	481.23	318.22	2.0	5.0	5.39	0.0005	-0.0034	0.0048	-0.0170	0.0135	0.0005
2.A.4.d Other Process Uses of Carbonates – other	CO2	21.40	18.85	20.0	2.0	20.10	0.0000	-0.0001	0.0003	-0.0002	0.0080	0.0001
2.B.1 Chemical Industry – Ammonia Production	CH4	1.56	1.72	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	CO2	467.42	527.18	2.0	5.0	5.39	0.0014	0.0000	0.0079	-0.0001	0.0224	0.0005
2.B.2 Chemical Industry – Nitric Acid Production	CO2	0.41	0.41	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	N2O	876.72	35.76	2.0	5.0	5.39	0.0000	-0.0143	0.0005	-0.0716	0.0015	0.0051
2.B.5 Chemical Industry – Carbide Production	CO2	37.51	47.62	5.0	10.0	11.18	0.0000	0.0001	0.0007	0.0008	0.0050	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH4	26.25	37.50	10.0	10.0	14.14	0.0000	0.0001	0.0006	0.0012	0.0080	0.0001
2.B.10 Chemical Industry – Other	CH4	7.30	7.33	2.0	5.0	5.39	0.0000	0.0000	0.0001	-0.0001	0.0003	0.0000
2.B.10 Chemical Industry – Other	CO2	138.15	147.16	2.0	5.0	5.39	0.0001	-0.0001	0.0022	-0.0007	0.0062	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO2	6 610.49	10 417.75	0.5	0.5	0.71	0.0095	0.0440	0.1562	0.0220	0.1104	0.0127
2.C.2 Metal Industry – Ferroalloys Production	CO2	20.81	19.72	5.0	25.0	25.50	0.0000	-0.0001	0.0003	-0.0014	0.0021	0.0000
2.C.3 Metal Industry – Aluminium Production	CO2	150.25	4.92	2.0	0.5	2.06	0.0000	-0.0025	0.0001	-0.0012	0.0002	0.0000
2.C.3 Metal Industry – Aluminium Production	PFC	1 148.76	0.00	2.0	50.0	50.04	0.0000	-0.0195	0.0000	-0.9739	0.0000	0.9484
2.C.3 Metal Industry – Aluminium Production	SF6	13.68	0.07	5.0	5.0	7.07	0.0000	-0.0002	0.0000	-0.0012	0.0000	0.0000
2.C.4 Metal Industry – Magnesium Production	SF6	228.00	2.28	5.0	5.0	7.07	0.0000	-0.0038	0.0000	-0.0192	0.0002	0.0004
2.C.5 Metal Industry – Lead Production	CO2	4.70	4.88	10.0	50.0	50.99	0.0000	0.0000	0.0001	-0.0003	0.0010	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO2	348.94	204.85	5.0	10.0	11.18	0.0009	-0.0028	0.0031	-0.0285	0.0217	0.0013
2.E Electronics Industry	HFC	2.44	2.13	5.0	10.0	11.18	0.0000	0.0000	0.0000	-0.0001	0.0002	0.0000
2.E Electronics Industry	PFC	34.03	50.39	5.0	10.0	11.18	0.0001	0.0002	0.0008	0.0018	0.0053	0.0000
2.E Electronics Industry	SF6	97.40	33.57	5.0	10.0	11.18	0.0000	-0.0011	0.0005	-0.0115	0.0036	0.0001
2.E Electronics Industry	NF3	0.00	6.14	5.0	10.0	11.18	0.0000	0.0001	0.0001	0.0009	0.0007	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0.00	1 581.51	20.0	50.0	53.85	1.2737	0.0237	0.0237	1.1854	0.6706	1.8548
2.F.2 Foam Blowing	HFC	0.00	16.70	20.0	50.0	53.85	0.0001	0.0003	0.0003	0.0125	0.0071	0.0002
2.F.3 Fire Extinguishers	HFC	0.00	12.78	20.0	50.0	53.85	0.0001	0.0002	0.0002	0.0096	0.0054	0.0001
2.F.4 Aerosols	HFC	0.00	27.49	20.0	50.0	53.85	0.0004	0.0004	0.0004	0.0206	0.0117	0.0006
2.F.5 Solvents	HFC	0.00	0.00	20.0	50.0	53.85	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.6 Other Applications	HFC	0.00	0.00	25.0	50.0	55.90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	10.80	38.37	25.0	50.0	55.90	0.0008	0.0004	0.0006	0.0196	0.0203	0.0008
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	PFC	0.00	0.00	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 – SF6 and PFCs from other product use	SF6	120.73	318.55	25.0	50.0	55.90	0.0557	0.0027	0.0048	0.1364	0.1688	0.0471
2.G. Other Product Manufacture and Use	CO2	0.00	0.00	20.0	0.0	20.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G. Other Product Manufacture and Use	N2O	223.50	133.74	20.0	0.0	20.00	0.0013	-0.0018	0.0020	0.0000	0.0567	0.0032
3.A.1 Enteric Fermentation – Cattle	CH4	4 579.36	3 885.95	1.0	20.0	20.02	1.0633	-0.0194	0.0583	-0.3878	0.0824	0.1572
3.A.2 Enteric Fermentation – Sheep	CH4	61.98	75.68	10.0	40.0	41.23	0.0017	0.0001	0.0011	0.0033	0.0160	0.0003
3.A.3 Enteric Fermentation – Swine	CH4	138.30	104.73	4.0	40.0	40.20	0.0031	-0.0008	0.0016	-0.0310	0.0089	0.0010
3.A.4 Enteric Fermentation – Other	CH4	40.88	80.30	10.0	40.0	41.23	0.0019	0.0005	0.0012	0.0204	0.0170	0.0007

IPCC category/Group	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
	0	Gg CO2 equivalent	Gg CO2 equivalent	%	%	%		%	%	%	%	%
	0	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
3.B.1.1 Manure Management – Cattle	CH4	424.44	336.23	1.0	20.0	20.02	0.0080	-0.0022	0.0050	-0.0431	0.0071	0.0019
3.B.1.1 Manure Management – Cattle	N2O	258.18	266.35	1.0	100.0	100.00	0.1246	-0.0004	0.0040	-0.0386	0.0056	0.0015
3.B.1.2 Manure Management – Sheep	CH4	1.47	1.80	10.0	30.0	31.62	0.0000	0.0000	0.0000	0.0001	0.0004	0.0000
3.B.1.2 Manure Management – Sheep	N2O	4.75	5.80	10.0	100.0	100.50	0.0001	0.0000	0.0001	0.0006	0.0012	0.0000
3.B.1.3 Manure Management – Swine	CH4	148.97	82.86	4.0	20.0	20.40	0.0005	-0.0013	0.0012	-0.0257	0.0070	0.0007
3.B.1.3 Manure Management – Swine	N2O	59.42	37.34	4.0	100.0	100.08	0.0025	-0.0004	0.0006	-0.0448	0.0032	0.0020
3.B.1.4. Manure Management – Other	CH4	12.14	16.08	10.0	30.0	31.62	0.0000	0.0000	0.0002	0.0011	0.0034	0.0000
3.B.1.4. Manure Management – Other	N2O	8.98	15.96	10.0	100.0	100.50	0.0005	0.0001	0.0002	0.0087	0.0034	0.0001
3.B.2.5 Indirect N2O Emissions	N2O	106.94	113.85	5.0	200.0	200.06	0.0911	-0.0001	0.0017	-0.0214	0.0121	0.0006
3.D.1 Direct N2O Emissions from Managed Soils	N2O	1 883.63	1 793.25	5.0	200.0	200.06	22.6012	-0.0051	0.0269	-1.0119	0.1901	1.0602
3.D.2 Indirect N2O emissions from Managed Soils	N2O	363.11	353.38	5.0	200.0	200.06	0.8777	-0.0009	0.0053	-0.1721	0.0375	0.0310
3.F Field Burning of Agricultural Residues	CH4	1.34	0.57	100.0	40.0	107.70	0.0000	0.0000	0.0000	-0.0006	0.0012	0.0000
3.F Field Burning of Agricultural Residues	N2O	0.32	0.10	100.0	50.0	111.80	0.0000	0.0000	0.0000	-0.0002	0.0002	0.0000
3.G Liming and Urea application	CO2	89.97	84.90	100.0	10.0	100.50	0.0128	-0.0003	0.0013	-0.0025	0.1800	0.0324
3.H Urea application	CO2	4.45	31.30	100.0	10.0	100.50	0.0017	0.0004	0.0005	0.0039	0.0664	0.0044
5.A Solid Waste Disposal	CH4	3 643.89	1 211.68	12.0	25.0	27.73	0.1983	-0.0436	0.0182	-1.0902	0.3083	1.2835
4 Total land use categories	CH4	24.25	23.83			0.0	0.0000	-0.0001	0.0004	0.0000	0.0000	0.0000
4 Total land use categories	N2O	143.80	135.26			0.0	0.0000	-0.0004	0.0020	0.0000	0.0000	0.0000
4.A.1 Forest land remaining forest land	CO2	-7 849.45	-2 578.62			629.6	462.8319	0.0946	0.0387	0.0000	0.0000	0.0000
4.A.2 Land converted to forest land	CO2	-3 043.01	-1 740.90			131.9	9.2608	0.0255	0.0261	0.0000	0.0000	0.0000
4.B.1 Cropland remaining cropland	CO2	-18.47	-184.49			860.9	4.4293	-0.0025	0.0028	0.0000	0.0000	0.0000
4.B.2 Land converted to cropland	CO2	193.54	223.60			456.8	1.8322	0.0001	0.0034	0.0000	0.0000	0.0000
4.C.1 Grassland remaining grassland	CO2	294.26	295.92			14.6	0.0033	-0.0006	0.0044	0.0000	0.0000	0.0000
4.C.2 Land converted to grassland	CO2	332.00	37.13			5652.3	7.7353	-0.0051	0.0006	0.0000	0.0000	0.0000
4.D.2 Land converted to Wetlands	CO2	42.08	77.00			850.2	0.7525	0.0004	0.0012	0.0000	0.0000	0.0000
4.E.2 Land converted to Settlements	CO2	577.10	378.71			226.9	1.2971	-0.0041	0.0057	0.0000	0.0000	0.0000
4.F.2 Land converted to Other land	CO2	444.28	165.97			1893.3	17.3389	-0.0050	0.0025	0.0000	0.0000	0.0000
4.G HWP	CO2	-3 122.28	-1 041.85			50.0	0.4765	0.0373	0.0156	0.0000	0.0000	0.0000
5.B Biological Treatment of Solid Waste	CH4	13.01	82.56	20.0	50.0	53.85	0.0035	0.0010	0.0012	0.0508	0.0350	0.0038
5.B Biological Treatment of Solid Waste	N2O	22.73	97.79	20.0	50.0	53.85	0.0049	0.0011	0.0015	0.0540	0.0415	0.0046
5.C Incineration and Open Burning of Waste	CH4	0.02	0.00	7.0	0.0	7.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and Open Burning of Waste	CO2	27.92	2.05	7.0	20.0	21.19	0.0000	-0.0004	0.0000	-0.0089	0.0003	0.0001
5.C Incineration and Open Burning of Waste	N2O	0.13	0.01	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	CH4	121.25	23.60	20.0	50.0	53.85	0.0003	-0.0017	0.0004	-0.0851	0.0100	0.0073
5.D Waste Water Treatment and Discharge	N2O	96.07	163.78	20.0	100.0	101.98	0.0490	0.0008	0.0025	0.0826	0.0694	0.0116
Total		66 708.16	75 464.20				534.16					8.19
Total Uncertainties						Uncertainty in total inventory %:	23.11				Trend uncertainty %:	2.86

ANNEX 3: DETAILED METHODOLOGICAL DESCRIPTIONS

Annex 3.1 – CRF 1.A Fuel Combustion

This annex includes detailed information about category 1.A (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 Sector 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 is described.

Trend information by sub category

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

Table A 20: Greenhouse gas emissions from Category 1.A.1.a

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	11 121	0.24	0.13	11 166
1991	11 814	0.26	0.15	11 864
1992	8 671	0.25	0.11	8 710
1993	8 467	0.26	0.10	8 504
1994	8 754	0.26	0.10	8 791
1995	9 843	0.27	0.12	9 887
1996	11 141	0.33	0.14	11 192
1997	11 160	0.34	0.15	11 213
1998	10 121	0.33	0.13	10 167
1999	10 112	0.31	0.13	10 157
2000	9 781	0.30	0.14	9 831
2001	11 292	0.36	0.17	11 353
2002	10 591	0.37	0.18	10 652
2003	13 107	0.43	0.21	13 180
2004	12 808	0.47	0.22	12 886
2005	12 974	0.50	0.22	13 053
2006	11 947	0.60	0.26	12 040
2007	10 626	0.65	0.28	10 725
2008	10 539	0.72	0.30	10 646
2009	9 453	0.78	0.30	9 562
2010	10 890	0.92	0.36	11 020
2011	10 574	0.92	0.37	10 707
2012	9 149	0.94	0.37	9 282
2013	8 148	0.90	0.36	8 278

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2014	6 539	0.86	0.33	6 659
2015	7 545	0.91	0.35	7 671
2016	7 393	0.90	0.33	7 513
Trend 1990-2016	*-33.5%*	*271.9%*	*147.9%*	*-32.7%*

Solid fossil fuels and natural gas are dominant compared to other fuel types. Since 2002 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 1% in 1990 to 20% in 2016.

Table A 21: Share of fuel types on total CO_2 emissions from Category 1.A.1.a

	Liquid	Solid	Gaseous	Other
1990	11%	56%	30%	3%
1991	13%	58%	27%	3%
1992	17%	46%	32%	5%
1993	24%	36%	35%	4%
1994	22%	37%	37%	4%
1995	16%	46%	35%	3%
1996	14%	42%	40%	4%
1997	17%	45%	34%	4%
1998	22%	35%	40%	3%
1999	17%	37%	42%	3%
2000	12%	49%	35%	3%
2001	14%	52%	31%	3%
2002	8%	52%	36%	4%
2003	9%	53%	35%	4%
2004	9%	52%	34%	5%
2005	9%	45%	42%	5%
2006	8%	47%	38%	6%
2007	7%	48%	38%	7%
2008	7%	42%	44%	7%
2009	7%	32%	50%	11%
2010	6%	36%	48%	10%
2011	4%	40%	45%	11%
2012	2%	38%	46%	14%
2013	2%	40%	41%	16%
2014	2%	35%	43%	20%
2015	3%	31%	48%	18%
2016	5%	21%	54%	20%

1.A.1.b Petroleum Refining

Table A 22: 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	2 152	0.06	0.01	2 156
2000	2 199	0.06	0.01	2 203
2001	2 219	0.06	0.01	2 223
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	0.07	0.01	2 832
2006	2 830	0.07	0.01	2 835
2007	2 868	0.07	0.01	2 872
2008	2 806	0.07	0.01	2 811
2009	2 809	0.08	0.01	2 816
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	0.01	2 833
2014	2 713	0.08	0.01	2 719
2015	2 804	0.08	0.01	2 810
2016	2 784	0.09	0.02	2 791
Trend 1990-2016	*16.3%*	*63.8%*	*99.9%*	*16.4%*

Table A 23 presents the share of CO_2 emissions on the different fuel types.

Table A 23: 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%

	Liquid	Gaseous
1999	83%	17%
2000	84%	16%
2001	86%	14%
2002	89%	11%
2003	89%	11%
2004	83%	17%
2005	82%	18%
2006	83%	17%
2007	84%	16%
2008	82%	18%
2009	92%	8%
2010	82%	18%
2011	82%	18%
2012	81%	19%
2013	77%	23%
2014	78%	22%
2015	81%	19%
2016	81%	19%

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

Table A 24: 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	286	0.04	0.0005	287
2000	284	0.04	0.0005	285
2001	260	0.04	0.0005	261
2002	224	0.04	0.0004	225
2003	171	0.03	0.0003	172
2004	248	0.04	0.0004	249
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	324	0.04	0.0006	326
2012	271	0.05	0.0005	273
2013	250	0.04	0.0005	251
2014	247	0.04	0.0004	249
2015	274	0.05	0.0005	276
2016	271	0.05	0.0005	273
Trend 1990-2016	*-46.8%*	*30.1%*	*-48.5%*	*-46.6%*

Almost all emissions of category 1.A.1.c originated from natural gas combustion.

Table A 25: 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%

	Liquid	Gaseous
1999	NO	100%
2000	NO	100%
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%

1.A.2.a Iron and Steel

Table A 26: Greenhouse gas emissions from Category 1.A.2.a.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	2 060	0.03	0.003	2 062
1991	1 686	0.02	0.003	1 687
1992	1 355	0.02	0.002	1 356
1993	1 531	0.02	0.003	1 532
1994	1 533	0.03	0.003	1 535
1995	1 507	0.03	0.003	1 508
1996	1 809	0.03	0.004	1 811
1997	1 886	0.03	0.003	1 888
1998	1 161	0.02	0.003	1 162
1999	1 318	0.02	0.003	1 320
2000	1 262	0.02	0.003	1 263
2001	1 462	0.03	0.003	1 463
2002	1 755	0.03	0.003	1 756
2003	1 774	0.03	0.003	1 775
2004	1 949	0.03	0.003	1 951
2005	2 070	0.03	0.004	2 072
2006	1 665	0.03	0.003	1 666
2007	1 393	0.03	0.003	1 394
2008	1 524	0.03	0.003	1 526
2009	1 164	0.02	0.002	1 165
2010	1 464	0.03	0.003	1 466
2011	1 623	0.03	0.003	1 625
2012	1 672	0.03	0.003	1 674

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2013	1 864	0.03	0.003	1 866
2014	1 645	0.03	0.003	1 646
2015	1 404	0.02	0.002	1 405
2016	1 420	0.02	0.002	1 421
Trend 1990-2016	-31.1%	-19.9%	-23.9%	-31.1%

CO_2 emissions from category *1.A.2.a (without blast furnaces)* mainly arise from gaseous fuels.

Table A 27: Share of fuel types in total CO_2 emissions from Category 1.A.2.a.

	Liquid	Solid	Gaseous
1990	3.7%	64.8%	31.5%
1991	4.4%	55.8%	39.8%
1992	4.2%	48.6%	47.1%
1993	4.9%	55.2%	39.9%
1994	4.8%	50.9%	44.2%
1995	5.5%	44.3%	50.3%
1996	6.6%	41.9%	51.5%
1997	3.7%	38.8%	57.5%
1998	5.7%	2.5%	91.8%
1999	2.5%	19.0%	78.4%
2000	5.8%	14.3%	79.9%
2001	3.0%	18.8%	78.3%
2002	1.6%	32.1%	66.3%
2003	1.2%	34.5%	64.3%
2004	1.6%	34.1%	64.2%
2005	2.8%	44.5%	52.7%
2006	3.2%	33.1%	63.8%
2007	1.5%	24.1%	74.4%
2008	6.0%	27.2%	66.8%
2009	1.9%	19.9%	78.2%
2010	2.1%	22.7%	75.2%
2011	1.6%	22.1%	76.4%
2012	1.4%	22.1%	76.5%
2013	0.5%	25.8%	73.6%
2014	0.2%	17.8%	82.0%
2015	0.2%	20.6%	79.2%
2016	0.4%	30.5%	69.1%

1.A.2.b Non-Ferrous Metals

Table A 28: 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	133
1991	118	0.004	0.001	118
1992	125	0.003	0.000	126
1993	157	0.005	0.001	157

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1994	261	0.006	0.001	261
1995	255	0.006	0.001	256
1996	178	0.005	0.001	178
1997	219	0.007	0.001	219
1998	205	0.006	0.001	205
1999	188	0.006	0.001	188
2000	192	0.006	0.001	193
2001	205	0.005	0.001	206
2002	208	0.006	0.001	209
2003	214	0.006	0.001	214
2004	220	0.006	0.001	221
2005	220	0.005	0.001	220
2006	223	0.005	0.001	223
2007	253	0.006	0.001	253
2008	252	0.006	0.001	253
2009	232	0.006	0.001	232
2010	235	0.005	0.001	236
2011	247	0.005	0.001	247
2012	247	0.005	0.001	247
2013	263	0.007	0.001	263
2014	311	0.007	0.001	311
2015	347	0.008	0.001	347
2016	356	0.008	0.001	357
Trend 1990-2016	*169.2%*	*87.6%*	*75.2%*	*169.0%*

CO_2 emissions from category *1.A.2.b* mainly arise from gaseous fuels.

Table A 29: Share of fuel types in total CO_2 emissions from Category 1.A.2.b

	Liquid	Solid	Gaseous
1990	27%	17%	57%
1991	28%	15%	57%
1992	24%	6%	70%
1993	20%	12%	68%
1994	15%	6%	79%
1995	16%	4%	80%
1996	28%	9%	63%
1997	31%	9%	60%
1998	30%	8%	62%
1999	25%	12%	64%
2000	24%	9%	67%
2001	25%	5%	70%
2002	21%	8%	71%
2003	20%	7%	73%
2004	17%	7%	76%
2005	16%	6%	78%

	Liquid	Solid	Gaseous
2006	15%	6%	79%
2007	12%	6%	82%
2008	9%	6%	85%
2009	7%	7%	86%
2010	8%	3%	89%
2011	9%	3%	88%
2012	9%	3%	88%
2013	8%	5%	86%
2014	5%	5%	90%
2015	6%	5%	89%
2016	3%	4%	93%

1.A.2.c Chemicals

Table A 30: Greenhouse gas emissions from Category 1.A.2.c.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	892	0.07	0.02	900
1991	915	0.08	0.02	924
1992	997	0.09	0.03	1 007
1993	1 043	0.08	0.02	1 051
1994	994	0.07	0.02	1 001
1995	1 044	0.07	0.02	1 051
1996	1 133	0.09	0.03	1 143
1997	1 212	0.10	0.03	1 222
1998	1 129	0.08	0.02	1 138
1999	1 360	0.11	0.03	1 372
2000	1 387	0.11	0.03	1 398
2001	1 427	0.09	0.02	1 436
2002	1 449	0.11	0.03	1 460
2003	1 551	0.13	0.04	1 565
2004	1 485	0.14	0.04	1 501
2005	1 551	0.10	0.03	1 561
2006	1 406	0.10	0.03	1 416
2007	1 296	0.08	0.02	1 305
2008	1 518	0.12	0.04	1 532
2009	1 477	0.10	0.03	1 488
2010	1 543	0.11	0.03	1 555
2011	1 506	0.10	0.03	1 517
2012	1 540	0.11	0.03	1 551
2013	1 510	0.11	0.03	1 522
2014	1 477	0.10	0.03	1 488
2015	1 468	0.10	0.03	1 479
2016	1 378	0.08	0.02	1 386
Trend 1990-2016	***54.5%***	***10.2%***	***-1.3%***	***54.1%***

In 2016 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 31: Share of fuel types in total CO_2 emissions from Category 1.A.2.c

	Liquid	Solid	Gaseous	Other
1990	10%	12%	58%	20%
1991	11%	15%	50%	24%
1992	7%	19%	49%	25%
1993	8%	18%	58%	16%
1994	10%	15%	56%	19%
1995	9%	14%	55%	21%
1996	9%	16%	51%	24%
1997	12%	21%	50%	18%
1998	11%	22%	51%	16%
1999	6%	23%	60%	12%
2000	4%	18%	63%	15%
2001	6%	18%	60%	16%
2002	5%	17%	57%	21%
2003	5%	16%	54%	25%
2004	5%	16%	56%	23%
2005	5%	10%	67%	19%
2006	4%	7%	67%	21%
2007	6%	6%	70%	18%
2008	6%	5%	63%	27%
2009	8%	5%	67%	21%
2010	9%	5%	66%	20%
2011	8%	4%	68%	20%
2012	8%	5%	67%	20%
2013	7%	6%	67%	21%
2014	4%	8%	68%	20%
2015	4%	7%	67%	22%
2016	4%	8%	71%	17%

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

Table A 32: Greenhouse gas emissions from Category 1.A.2.d.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv.[kt]
1990	2 214	0.19	0.07	2 239
1991	2 675	0.21	0.07	2 702
1992	2 167	0.20	0.07	2 193
1993	2 024	0.23	0.09	2 055
1994	2 555	0.24	0.09	2 588
1995	2 315	0.24	0.09	2 348
1996	2 417	0.21	0.08	2 445
1997	2 819	0.25	0.09	2 853
1998	2 633	0.21	0.08	2 661
1999	2 338	0.23	0.09	2 371
2000	2 382	0.20	0.08	2 410

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv.[kt]
2001	2 252	0.24	0.10	2 287
2002	2 260	0.20	0.08	2 288
2003	2 436	0.21	0.08	2 465
2004	2 298	0.21	0.08	2 327
2005	2 294	0.26	0.10	2 331
2006	2 195	0.24	0.10	2 230
2007	2 183	0.24	0.10	2 219
2008	2 190	0.23	0.09	2 224
2009	2 220	0.25	0.10	2 255
2010	2 340	0.24	0.09	2 374
2011	2 293	0.24	0.09	2 327
2012	2 057	0.22	0.09	2 090
2013	1 945	0.23	0.10	1 980
2014	1 731	0.22	0.09	1 765
2015	1 834	0.22	0.09	1 866
2016	1 692	0.25	0.10	1 729
Trend 1990-2016	***-23.6%***	***32.8%***	***55.3%***	***-22.8%***

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 33: 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	41%	20%	38%	1%
1992	31%	21%	47%	1%
1993	34%	21%	44%	1%
1994	26%	14%	59%	1%
1995	23%	16%	59%	2%
1996	17%	15%	65%	3%
1997	18%	16%	66%	0%
1998	17%	17%	66%	0%
1999	10%	15%	74%	1%
2000	7%	19%	74%	0%
2001	8%	17%	75%	1%
2002	7%	20%	72%	1%
2003	7%	17%	75%	1%
2004	6%	19%	74%	1%
2005	6%	19%	74%	0%
2006	6%	21%	73%	0%
2007	4%	17%	79%	1%
2008	4%	15%	81%	0%
2009	5%	16%	79%	0%
2010	3%	14%	83%	0%
2011	2%	15%	82%	0%

	Liquid	Solid	Gaseous	Other
2012	2%	17%	81%	0%
2013	2%	19%	77%	1%
2014	1%	21%	76%	1%
2015	2%	21%	75%	1%
2016	1%	22%	76%	1%

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

Table A 34: Greenhouse gas emissions from Category 1.A.2.e.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	868	0.03	0.004	870
1991	933	0.03	0.005	935
1992	853	0.03	0.004	855
1993	888	0.03	0.005	890
1994	915	0.03	0.004	917
1995	934	0.03	0.004	936
1996	888	0.02	0.003	890
1997	1 042	0.03	0.004	1 044
1998	944	0.02	0.003	945
1999	827	0.02	0.003	829
2000	883	0.02	0.004	885
2001	928	0.03	0.004	930
2002	1 100	0.03	0.004	1 102
2003	944	0.03	0.004	946
2004	949	0.03	0.004	951
2005	961	0.03	0.005	963
2006	934	0.03	0.005	936
2007	886	0.03	0.004	888
2008	876	0.02	0.004	877
2009	907	0.02	0.004	909
2010	969	0.02	0.003	971
2011	962	0.02	0.003	963
2012	976	0.02	0.003	978
2013	933	0.02	0.003	934
2014	885	0.02	0.003	887
2015	1 003	0.02	0.003	1 004
2016	990	0.02	0.003	992
Trend 1990-2016	***14.1%***	***-17.2%***	***-29.8%***	***14.0%***

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 decreased since 1990.

Table A 35: 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%	60%	0.00%
1995	37%	1%	62%	0.00%
1996	29%	1%	70%	0.07%
1997	30%	1%	69%	0.06%
1998	26%	1%	72%	0.07%
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	21%	1%	77%	0.00%
2009	22%	2%	76%	0.00%
2010	21%	2%	77%	0.04%
2011	21%	2%	78%	0.04%
2012	19%	2%	79%	0.03%
2013	19%	2%	79%	0.02%
2014	18%	2%	79%	0.00%
2015	18%	2%	80%	0.00%
2016	19%	2%	79%	0.00%

1.A.2.f Non-Metallic Minerals

Table A 36: 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	1 676
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	1 610
1999	1 467	0.09	0.02	1 475
2000	1 540	0.11	0.02	1 550
2001	1 508	0.12	0.03	1 519
2002	1 659	0.11	0.03	1 670

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2003	1 687	0.11	0.02	1 697
2004	1 831	0.12	0.03	1 843
2005	1 656	0.14	0.04	1 670
2006	1 772	0.16	0.04	1 788
2007	1 895	0.17	0.04	1 913
2008	1 845	0.17	0.05	1 863
2009	1 554	0.15	0.04	1 570
2010	1 528	0.14	0.04	1 543
2011	1 546	0.14	0.04	1 561
2012	1 530	0.15	0.04	1 546
2013	1 552	0.13	0.04	1 565
2014	1 613	0.14	0.04	1 628
2015	1 605	0.14	0.04	1 620
2016	1 630	0.14	0.04	1 646
Trend 1990-2016	*-2.3%*	*38.1%*	*114.0%*	*-1.9%*

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 37: 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%
1995	23%	29%	40%	8%
1996	17%	34%	43%	7%
1997	16%	32%	43%	8%
1998	18%	33%	45%	5%
1999	22%	24%	41%	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%

	Liquid	Solid	Gaseous	Other
2014	10%	17%	39%	34%
2015	10%	17%	39%	35%
2016	10%	14%	40%	37%

1.A.2.g.7 Manufacturing Industries and Construction – Mobile sources

Table A 38: 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	283
1991	289	0.02	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	809	0.02	0.23	880
2006	977	0.03	0.24	1 050
2007	1 057	0.03	0.23	1 127
2008	1 163	0.03	0.23	1 233
2009	1 120	0.03	0.21	1 183
2010	1 074	0.02	0.19	1 132
2011	1 078	0.02	0.19	1 134
2012	1 114	0.02	0.18	1 169
2013	1 124	0.02	0.17	1 176
2014	1 099	0.02	0.16	1 148
2015	1 064	0.02	0.15	1 111
2016	1 079	0.02	0.15	1 124
Trend 1990-2016	***321.7%***	***64.5%***	***65.1%***	***297.0%***

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 39: Greenhouse gas emissions from Category 1.A.2.g.8.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	1 716	0.11	0.03	1 726
1991	1 872	0.12	0.03	1 884
1992	1 901	0.11	0.03	1 913
1993	2 007	0.12	0.03	2 019
1994	2 047	0.12	0.03	2 058
1995	2 300	0.12	0.03	2 311
1996	2 434	0.13	0.03	2 447
1997	2 549	0.10	0.02	2 558
1998	2 286	0.11	0.03	2 297
1999	1 710	0.19	0.05	1 728
2000	1 748	0.15	0.04	1 764
2001	1 731	0.16	0.04	1 748
2002	1 539	0.15	0.04	1 555
2003	1 744	0.18	0.05	1 763
2004	1 812	0.19	0.05	1 832
2005	2 098	0.21	0.06	2 121
2006	2 109	0.24	0.07	2 137
2007	1 938	0.31	0.10	1 974
2008	1 918	0.27	0.08	1 949
2009	1 976	0.26	0.09	2 008
2010	2 111	0.30	0.10	2 149
2011	1 927	0.34	0.12	1 971
2012	2 014	0.35	0.12	2 059
2013	1 835	0.42	0.15	1 891
2014	1 723	0.36	0.13	1 772
2015	1 859	0.37	0.13	1 909
2016	2 116	0.38	0.14	2 167
Trend 1990-2016	***23.3%***	***262.2%***	***428.3%***	***25.5%***

Natural gas and liquid fossil fuel combustion is the main source of CO_2 emissions from category *1.A.2.g.8*. In 2016, the use of liquid fuels increased while gaseous fuels decreased.

Table A 40: Share of fuel types on total CO_2 emissions from Category 1.A.2.g.8

	Liquid	Solid	Gaseous	Other
1990	35%	5%	57%	3%
1991	27%	2%	67%	4%
1992	40%	3%	54%	3%
1993	31%	2%	63%	3%
1994	34%	1%	62%	3%
1995	40%	1%	56%	3%
1996	55%	2%	37%	6%
1997	51%	2%	41%	7%

	Liquid	Solid	Gaseous	Other
1998	36%	7%	51%	5%
1999	34%	2%	61%	3%
2000	39%	0%	55%	5%
2001	33%	1%	62%	4%
2002	37%	1%	58%	4%
2003	37%	1%	56%	6%
2004	34%	2%	62%	2%
2005	35%	2%	62%	2%
2006	30%	2%	66%	2%
2007	26%	2%	70%	2%
2008	25%	1%	72%	2%
2009	24%	1%	73%	2%
2010	27%	1%	70%	2%
2011	26%	0%	71%	2%
2012	25%	0%	74%	2%
2013	18%	0%	81%	1%
2014	18%	0%	81%	1%
2015	16%	0%	83%	1%
2016	35%	5%	57%	3%

1.A.3.e Other Transportation – Pipeline Compressors

Table A 41: Greenhouse gas emissions from Category 1.A.3.e.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	224	0.004	0.0004	225
1991	225	0.004	0.0004	225
1992	220	0.004	0.0004	220
1993	214	0.004	0.0004	214
1994	209	0.004	0.0004	210
1995	227	0.004	0.0004	227
1996	234	0.004	0.0004	234
1997	233	0.004	0.0004	233
1998	351	0.006	0.0006	352
1999	434	0.008	0.0008	435
2000	338	0.006	0.0006	338
2001	497	0.009	0.0009	497
2002	277	0.005	0.0005	277
2003	371	0.007	0.0007	372
2004	372	0.007	0.0007	372
2005	359	0.006	0.0006	359
2006	466	0.008	0.0008	466
2007	488	0.009	0.0009	488
2008	465	0.008	0.0008	465
2009	436	0.008	0.0008	436
2010	459	0.008	0.0008	459

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2011	568	0.010	0.0010	568
2012	458	0.008	0.0008	458
2013	607	0.011	0.0011	607
2014	503	0.009	0.0009	503
2015	582	0.011	0.0011	583
2016	556	0.010	0.0010	556
Trend 1990-2016	***147.7%***	***147.7%***	***147.7%***	***147.7%***

All emissions from pipeline compressors arise from gaseous fuels.

1.A.4 Other sectors

Table A 42: Greenhouse gas emissions from Category 1.A.4.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1990	13 552	19.76	0.64	14 238
1991	14 707	20.70	0.68	15 427
1992	14 174	18.87	0.66	14 841
1993	14 103	17.69	0.66	14 741
1994	12 831	16.10	0.63	13 422
1995	13 992	17.60	0.65	14 625
1996	15 026	17.48	0.70	15 671
1997	13 575	15.43	0.69	14 166
1998	13 626	14.62	0.68	14 193
1999	14 184	14.74	0.70	14 761
2000	13 011	14.29	0.67	13 567
2001	14 224	14.87	0.70	14 804
2002	13 480	13.60	0.67	14 020
2003	14 225	13.28	0.66	14 753
2004	13 740	12.85	0.64	14 253
2005	13 132	12.28	0.67	13 637
2006	12 623	12.01	0.64	13 115
2007	10 760	11.27	0.60	11 221
2008	11 514	11.67	0.60	11 985
2009	10 484	11.30	0.57	10 934
2010	10 809	12.42	0.57	11 290
2011	9 308	11.51	0.56	9 763
2012	8 955	12.15	0.55	9 424
2013	9 003	12.96	0.56	9 495
2014	8 074	10.96	0.50	8 498
2015	8 339	11.77	0.52	8 787
2016	8 556	11.93	0.51	9 007
Trend 1990-2016	***-36.9%***	***-39.6%***	***-20.2%***	***-36.7%***

As can be seen from Table A 43 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 43: Share of fuel types on total CO_2 emissions from Category 1.A.4.

	Liquid	Solid	Gaseous	Other
1990	61%	20%	19%	1%
1991	58%	20%	21%	1%
1992	57%	18%	25%	1%
1993	57%	15%	28%	0%
1994	58%	14%	27%	0%
1995	58%	12%	29%	0%
1996	61%	11%	27%	0%
1997	61%	10%	29%	0%
1998	61%	8%	30%	0%
1999	62%	8%	30%	0%
2000	61%	7%	31%	0%
2001	58%	7%	35%	0%
2002	60%	5%	34%	0%
2003	60%	5%	35%	0%
2004	57%	4%	38%	0%
2005	60%	3%	37%	0%
2006	59%	3%	38%	0%
2007	57%	3%	39%	0%
2008	59%	3%	38%	0%
2009	57%	2%	41%	0%
2010	55%	2%	43%	0%
2011	56%	2%	42%	0%
2012	54%	2%	44%	0%
2013	53%	1%	45%	0%
2014	57%	1%	42%	0%
2015	56%	1%	42%	0%
2016	54%	1%	45%	0%

1.A.4 Other sectors – stationary sources

Table A 44: 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	12 637	19.62	0.37	13 237
1991	13 795	20.57	0.40	14 351
1992	13 254	18.73	0.37	13 763
1993	13 178	17.56	0.37	13 662
1994	11 901	15.97	0.34	12 343
1995	13 094	17.47	0.37	13 575
1996	14 100	17.36	0.40	14 589
1997	12 612	15.31	0.37	13 048
1998	12 678	14.50	0.36	13 095

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
1999	13 229	14.62	0.38	13 654
2000	12 080	14.18	0.35	12 488
2001	13 269	14.76	0.37	13 694
2002	13 269	14.76	0.37	13 694
2003	13 306	13.17	0.35	13 692
2004	12 799	12.74	0.34	13 172
2005	12 152	12.17	0.35	12 517
2006	11 666	11.91	0.34	12 022
2007	9 798	11.18	0.31	10 130
2008	10 548	11.58	0.32	10 892
2009	9 601	11.22	0.32	9 937
2010	9 946	12.34	0.35	10 312
2011	8 382	11.44	0.33	8 726
2012	8 066	12.08	0.35	8 427
2013	8 115	12.90	0.37	8 500
2014	7 177	10.90	0.32	7 505
2015	7 454	11.71	0.34	7 806
2016	7 656	11.87	0.35	8 013
Trend 1990-2016	***-39.4%***	***-39.5%***	***-4.6%***	***-39.5%***

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 45: Share of fuel types in total CO_2 emissions from Category 1.A.4 stationary sources.

	Liquid	Solid	Gaseous	Other
1990	58%	21%	20%	0.9%
1991	56%	21%	22%	0.7%
1992	54%	19%	27%	0.5%
1993	54%	16%	30%	0.3%
1994	55%	16%	29%	0.4%
1995	55%	13%	32%	0.4%
1996	59%	12%	29%	0.4%
1997	58%	10%	31%	0.5%
1998	59%	9%	32%	0.5%
1999	59%	8%	32%	0.5%
2000	58%	8%	34%	0.5%
2001	55%	7%	37%	0.5%
2002	54%	6%	34%	0.5%
2003	57%	5%	37%	0.5%
2004	54%	5%	41%	0.4%
2005	57%	3%	39%	0.4%
2006	55%	3%	41%	0.3%

	Liquid	Solid	Gaseous	Other
2007	53%	3%	43%	0.2%
2008	55%	3%	42%	0.0%
2009	53%	2%	45%	0.0%
2010	51%	3%	46%	0.0%
2011	51%	2%	47%	0.0%
2012	49%	2%	49%	0.1%
2013	48%	2%	50%	0.1%
2014	51%	1%	47%	0.1%
2015	51%	1%	47%	0.1%
2016	49%	1%	50%	0.1%

1.A.4.a.1 Commercial/Institutional – stationary sources

Table A 46: 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	2 336	0.57	0.03	2 358
1991	2 430	0.52	0.03	2 451
1992	2 859	0.53	0.02	2 879
1993	3 028	0.53	0.02	3 047
1994	2 524	0.46	0.02	2 541
1995	3 139	0.55	0.02	3 159
1996	3 286	0.51	0.03	3 306
1997	3 375	0.45	0.03	3 395
1998	3 176	0.41	0.03	3 194
1999	3 674	0.54	0.04	3 698
2000	2 903	0.50	0.03	2 925
2001	3 879	0.58	0.03	3 903
2002	3 716	0.57	0.03	3 739
2003	4 383	0.65	0.04	4 410
2004	4 222	0.68	0.03	4 249
2005	4 800	0.55	0.04	4 825
2006	4 705	0.65	0.04	4 733
2007	3 423	0.59	0.03	3 447
2008	4 048	0.72	0.04	4 077
2009	3 380	0.60	0.03	3 404
2010	3 026	0.66	0.03	3 050
2011	2 425	0.51	0.02	2 444
2012	1 695	0.55	0.02	1 714
2013	1 612	0.54	0.02	1 631
2014	1 522	0.46	0.02	1 539
2015	1 440	0.64	0.03	1 464

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 equiv. [kt]
2016	1 484	0.52	0.02	1 505
Trend 1990-2016	***-36.5%***	***-7.9%***	***-5.4%***	***-36.2%***

1.A.4.b.1 Residential – stationary sources

Table A 47: 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	9 819	17.64	0.32	10 355
1991	10 922	18.46	0.35	11 489
1992	9 996	16.70	0.33	10 512
1993	9 863	15.55	0.33	10 350
1994	9 156	14.17	0.31	9 601
1995	9 715	15.43	0.33	10 198
1996	10 553	15.22	0.35	11 039
1997	8 972	13.29	0.32	9 400
1998	9 229	12.62	0.31	9 638
1999	9 262	12.45	0.32	9 669
2000	8 920	12.12	0.30	9 312
2001	9 132	12.43	0.31	9 537
2002	8 598	11.25	0.29	8 967
2003	8 687	10.77	0.29	9 043
2004	8 350	10.20	0.28	8 689
2005	7 207	10.10	0.29	7 547
2006	6 829	9.79	0.28	7 158
2007	6 264	9.09	0.26	6 569
2008	6 387	9.31	0.27	6 700
2009	6 147	8.98	0.27	6 452
2010	6 848	9.99	0.30	7 186
2011	5 909	9.07	0.29	6 221
2012	6 322	9.53	0.30	6 650
2013	6 456	10.26	0.32	6 809
2014	5 614	8.59	0.27	5 911
2015	5 968	9.17	0.29	6 284
2016	6 129	9.38	0.30	6 452
Trend 1990-2016	*-37.6%*	*-46.8%*	*-6.8%*	*-37.7%*

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 48: 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	483	1.42	0.02	524
1991	442	1.58	0.02	488
1992	400	1.50	0.02	443
1993	287	1.49	0.02	330
1994	221	1.34	0.02	260
1995	240	1.49	0.02	283
1996	261	1.62	0.02	308
1997	265	1.57	0.02	311
1998	274	1.47	0.02	317
1999	293	1.63	0.02	341
2000	257	1.57	0.02	303
2001	257	1.76	0.02	308
2002	215	1.67	0.02	263
2003	236	1.75	0.02	288
2004	226	1.86	0.03	281
2005	145	1.52	0.02	190
2006	132	1.47	0.02	175
2007	111	1.50	0.02	154
2008	113	1.54	0.02	158
2009	74	1.64	0.02	122
2010	72	1.69	0.02	121
2011	49	1.86	0.02	103
2012	49	2.01	0.03	107
2013	47	2.10	0.03	107
2014	41	1.85	0.02	94
2015	46	1.91	0.03	101
2016	42	1.97	0.03	99
Trend 1990-2016	*-91.2%*	*38.6%*	*30.9%*	*-81.0%*

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 49: Activity data recalculations by sub categories with respect to previous submission [PJ absolut values].

	Fuel Consumption [PJ]								
	1990			2014			2015		
IPCC Category / Fuel Group	Subm, 2018	Subm, 2017	Diffe-rence	Subm, 2018	Subm, 2017	Diffe-rence	Subm, 2018	Subm, 2017	Diffe-rence
1 A FUEL COMBUSTION ACTIVITIES	792.81	792.81	-	954.80	950.57	4.22	992.96	992.36	0.60
1 A liquid	368.21	368.21	-	403.82	403.69	0.13	413.14	413.14	0.00
1 A solid	115.87	115.87	-	37.60	37.60	0.00	37.63	38.56	-0.93

1 A gaseous	203.98	203.98	-	257.67	257.67	0.00	276.18	276.18	-
1 A other	8.99	8.99	-	36.02	34.35	1.67	37.60	36.14	1.46
1 A peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A biomass	95.75	95.75	-	219.68	217.26	2.42	228.40	228.34	0.06
1 A 1 Energy Industries	187.34	185.10	2.25	202.82	200.83	1.99	223.35	224.62	-1.27
1 A 1 liquid	43.15	43.15	-	30.46	30.45	0.01	33.38	33.44	-0.05
1 A 1 solid	61.40	61.40	-	24.74	24.74	-	24.98	24.98	-
1 A 1 gaseous	76.48	76.48	-	65.86	66.37	-0.51	79.96	83.04	-3.07
1 A 1 other	4.66	2.41	2.25	22.21	22.21	-	23.10	23.11	-0.01
1 A 1 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 biomass	1.66	1.66	-	59.55	57.06	2.49	61.93	60.07	1.87
1 A 1 a Public Electricity and Heat Production	142.77	140.52	2.25	158.98	156.99	1.99	178.52	177.24	1.28
1 A 1 a liquid	15.62	15.62	-	1.99	1.99	0.01	3.20	3.25	-0.05
1 A 1 a solid	61.40	61.40	-	24.74	24.74	-	24.98	24.98	-
1 A 1 a gaseous	59.46	59.46	-	50.52	51.03	-0.51	65.36	65.88	-0.52
1 A 1 a other	4.66	2.41	2.25	22.21	22.21	-	23.10	23.11	-0.01
1 A 1 a peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 a biomass	1.63	1.63	-	59.51	57.02	2.49	61.89	60.02	1.87
1 A 1 b Petroleum refining	35.35	35.35	-	39.34	39.34	-	39.84	39.84	-
1 A 1 b liquid	27.47	27.47	-	28.47	28.47	-	30.18	30.18	-
1 A 1 b solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 b gaseous	7.88	7.88	-	10.87	10.87	-	9.65	9.65	-
1 A 1 b other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 b peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 b biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	9.23	9.23	-	4.50	4.50	-	5.00	7.55	-2.55
1 A 1 c liquid	0.06	0.06	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c gaseous	9.13	9.13	-	4.47	4.47	-	4.95	7.50	-2.55
1 A 1 c other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c biomass	0.03	0.03	-	0.04	0.04	-	0.04	0.04	0.00
1 A 1 c 1 Manufacture of Solid Fuels	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 1 liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 1 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 1 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 1 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 1 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 1 biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 2 Oil and gas extraction	6.73	6.73	-	1.24	1.24	-	1.55	4.10	-2.55
1 A 1 c 2 liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 2 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 2 gaseous	6.73	6.73	-	1.24	1.24	-	1.55	4.10	-2.55
1 A 1 c 2 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 2 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 2 biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-

1 A 1 c 3 Other Energy Industries	2.50	2.50	-	3.26	3.26	-	3.44	3.44	0.00
1 A 1 c 3 liquid	0.06	0.06	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 3 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 3 gaseous	2.41	2.41	-	3.22	3.22	-	3.40	3.40	-
1 A 1 c 3 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 3 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 1 c 3 biomass	0.03	0.03	-	0.04	0.04	-	0.04	0.04	0.00
1 A 2 Manufacturing Industries and Construction	172.08	172.08	-	241.69	234.39	7.31	241.61	234.11	7.50
1 A 2 liquid	35.95	35.95	-	24.09	25.31	-1.22	24.47	24.99	-0.53
1 A 2 solid	26.28	26.28	-	11.75	11.76	0.00	11.59	12.35	-0.76
1 A 2 gaseous	76.99	76.99	-	120.72	116.31	4.41	121.19	115.80	5.39
1 A 2 other	3.22	3.22	-	13.72	12.05	1.67	14.41	12.95	1.47
1 A 2 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 biomass	29.63	29.63	-	71.40	68.95	2.45	69.95	68.02	1.93
1 A 2 a Iron and Steel	26.84	26.84	-	27.46	27.53	-0.07	23.15	23.65	-0.50
1 A 2 a liquid	1.00	1.00	-	0.04	0.08	-0.04	0.04	0.09	-0.04
1 A 2 a solid	14.11	14.11	-	3.09	3.09	0.00	3.04	3.47	-0.43
1 A 2 a gaseous	11.73	11.73	-	24.33	24.35	-0.03	20.06	20.09	-0.02
1 A 2 a other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 a peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 a biomass	0.00	0.00	-	0.00	0.00	0.00	0.00	0.01	0.00
1 A 2 b Non-Ferrous Metals	2.08	2.08	-	5.44	4.59	0.85	6.05	5.00	1.04
1 A 2 b liquid	0.52	0.52	-	0.21	0.25	-0.04	0.25	0.17	0.08
1 A 2 b solid	0.21	0.21	-	0.14	0.14	0.00	0.16	0.32	-0.16
1 A 2 b gaseous	1.35	1.35	-	5.05	4.15	0.89	5.59	4.47	1.12
1 A 2 b other	0.00	0.00	-	0.01	0.01	-	0.01	0.01	-
1 A 2 b peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 b biomass	0.00	0.00	-	0.03	0.03	0.00	0.03	0.03	0.00
1 A 2 c Chemicals	16.23	16.23	-	26.60	26.40	0.21	26.40	27.44	-1.03
1 A 2 c liquid	1.21	1.21	-	0.70	0.95	-0.25	0.80	0.99	-0.19
1 A 2 c solid	1.09	1.09	-	1.29	1.29	-	1.08	1.08	-
1 A 2 c gaseous	9.36	9.36	-	18.15	18.59	-0.44	17.75	19.33	-1.58
1 A 2 c other	1.67	1.67	-	4.12	2.36	1.76	4.54	2.98	1.56
1 A 2 c peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 c biomass	2.90	2.90	-	2.35	3.21	-0.86	2.23	3.05	-0.82
1 A 2 d Pulp, Paper and Print	54.16	54.16	-	65.92	66.83	-0.91	65.31	66.19	-0.88
1 A 2 d liquid	10.94	10.94	-	0.31	0.35	-0.04	0.52	0.52	0.00
1 A 2 d solid	4.13	4.13	-	4.19	4.19	-	4.29	4.29	-
1 A 2 d gaseous	17.01	17.01	-	23.88	24.19	-0.31	24.98	25.32	-0.34
1 A 2 d other	0.19	0.19	-	0.18	0.18	-	0.18	0.18	-
1 A 2 d peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 d biomass	21.88	21.88	-	37.37	37.93	-0.56	35.34	35.87	-0.54
1 A 2 e Food Processing, Beverages and Tobacco	13.88	13.88	-	15.32	15.90	-0.59	17.36	17.78	-0.43
1 A 2 e liquid	4.42	4.42	-	2.15	2.08	0.07	2.32	2.08	0.23
1 A 2 e solid	0.18	0.18	-	0.17	0.17	-	0.22	0.22	-
1 A 2 e gaseous	9.15	9.15	-	12.69	13.31	-0.62	14.51	15.13	-0.62

1 A 2 e other	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 e peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 e biomass	0.13	0.13	-	0.30	0.34	-0.04	0.31	0.35	-0.04
1 A 2 f Non-Metallic Minerals	23.34	23.34	-	23.76	23.76	-	23.83	23.75	0.08
1 A 2 f liquid	6.26	6.26	-	1.69	1.69	-	1.72	1.64	0.08
1 A 2 f solid	5.69	5.69	-	2.88	2.88	-	2.77	2.77	-
1 A 2 f gaseous	10.09	10.09	-	11.48	11.48	-	11.28	11.28	-
1 A 2 f other	1.31	1.31	-	6.51	6.51	-	7.23	7.23	-
1 A 2 f peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 f biomass	0.00	0.00	-	1.21	1.21	-	0.83	0.83	-
1 A 2 g Other (please specify)	35.55	35.55	-	77.19	69.38	7.82	79.52	70.30	9.22
1 A 2 g liquid	11.60	11.60	-	18.99	19.92	-0.92	18.81	19.50	-0.70
1 A 2 g solid	0.88	0.88	-	0.00	0.01	0.00	0.04	0.20	-0.16
1 A 2 g gaseous	18.30	18.30	-	25.16	20.24	4.92	27.02	20.18	6.84
1 A 2 g other	0.05	0.05	-	2.91	3.00	-0.09	2.45	2.54	-0.09
1 A 2 g peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 g biomass	4.73	4.73	-	30.13	26.22	3.91	31.20	27.87	3.33
1 A 2 g 7 Off-road vehicles and other machinery	3.45	3.45	-	15.67	15.84	-0.17	15.27	15.44	-0.18
1 A 2 g 7 liquid	3.45	3.45	-	14.77	14.77	0.00	14.31	14.31	0.00
1 A 2 g 7 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 g 7 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 g 7 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 g 7 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 g 7 biomass	0.00	0.00	-	0.90	1.07	-0.17	0.96	1.14	-0.18
1 A 2 g 8 Other Manufacturing Industries	32.10	32.10	-	61.52	53.54	7.98	64.25	54.85	9.40
1 A 2 g 8 liquid	8.15	8.15	-	4.22	5.14	-0.92	4.50	5.19	-0.69
1 A 2 g 8 solid	0.88	0.88	-	0.00	0.01	0.00	0.04	0.20	-0.16
1 A 2 g 8 gaseous	18.30	18.30	-	25.16	20.24	4.92	27.02	20.18	6.84
1 A 2 g 8 other	0.05	0.05	-	2.91	3.00	-0.09	2.45	2.54	-0.09
1 A 2 g 8 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 2 g 8 biomass	4.73	4.73	-	29.23	25.16	4.08	30.24	26.74	3.50
1 A 3 Transport	183.89	183.89	-	313.73	316.73	-3.01	321.16	324.48	-3.32
1 A 3 liquid	179.77	179.77	-	287.32	287.26	0.05	291.62	291.54	0.08
1 A 3 solid	0.07	0.07	-	0.00	0.00	-	0.00	0.00	-
1 A 3 gaseous	4.05	4.05	-	9.78	9.78	-	11.24	11.24	-
1 A 3 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 biomass	0.00	0.00	-	16.62	19.69	-3.06	18.30	21.70	-3.40
1 A 3 a Domestic Aviation	0.44	0.44	-	0.68	0.68	-	0.68	0.68	-
1 A 3 a aviation gasoline	0.10	0.10	-	0.10	0.10	-	0.11	0.11	-
1 A 3 a jet kerosene	0.33	0.33	-	0.58	0.58	-	0.57	0.57	-
1 A 3 a biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b Road Transportation	176.83	176.83	-	302.11	305.10	-2.99	308.29	311.43	-3.13
1 A 3 b gasoline	103.90	103.90	-	62.56	62.56	0.00	63.14	63.14	0.00
1 A 3 b diesel oil	72.51	72.51	-	221.55	221.49	0.05	225.62	225.38	0.23
1 A 3 b LPG	0.41	0.41	-	0.79	0.79	-	0.62	0.62	-
1 A 3 b other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b gaseous	0.00	0.00	-	0.70	0.70	-	0.72	0.72	-

1 A 3 b other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b biomass	0.00	0.00	-	16.52	19.56	-3.05	18.20	21.57	-3.37
1 A 3 b 1 Cars	113.09	114.53	-1.44	180.33	163.93	16.40	188.69	166.26	22.43
1 A 3 b 1 gasoline	94.76	95.51	-0.75	59.26	59.66	-0.40	59.51	59.91	-0.40
1 A 3 b 1 diesel oil	17.95	18.64	-0.69	110.25	92.98	17.27	117.34	94.38	22.96
1 A 3 b 1 LPG	0.38	0.38	0.00	0.78	0.78	0.00	0.61	0.61	0.00
1 A 3 b 1 other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 1 gaseous	0.00	0.00	-	0.69	0.69	0.00	0.71	0.71	0.00
1 A 3 b 1 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 1 biomass	0.00	0.00	-	9.35	9.82	-0.48	10.53	10.66	-0.12
1 A 3 b 2 Light duty trucks	12.65	12.41	0.24	19.67	19.76	-0.09	20.11	20.21	-0.10
1 A 3 b 2 gasoline	5.77	5.52	0.24	0.77	0.73	0.04	1.06	1.01	0.05
1 A 3 b 2 diesel oil	6.86	6.87	-0.01	17.76	17.70	0.06	17.77	17.71	0.06
1 A 3 b 2 LPG	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.00
1 A 3 b 2 other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 2 gaseous	0.00	0.00	-	0.01	0.01	0.00	0.02	0.01	0.00
1 A 3 b 2 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 2 biomass	0.00	0.00	-	1.12	1.32	-0.20	1.24	1.46	-0.22
1 A 3 b 3 Heavy duty trucks and buses	49.81	49.11	0.70	99.49	119.16	-19.68	96.81	122.64	-25.83
1 A 3 b 3 gasoline	2.10	2.10	0.00	0.03	0.03	0.00	0.02	0.02	0.00
1 A 3 b 3 diesel oil	47.70	47.01	0.70	93.54	110.82	-17.28	90.50	113.29	-22.79
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	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 3 gaseous	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 3 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 3 biomass	0.00	0.00	-	5.92	8.31	-2.39	6.29	9.33	-3.05
1 A 3 b 4 Motorcycles	1.28	0.77	0.51	2.63	2.25	0.38	2.69	2.32	0.37
1 A 3 b 4 gasoline	1.28	0.77	0.51	2.50	2.14	0.36	2.55	2.20	0.35
1 A 3 b 4 diesel oil	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 4 LPG	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 4 other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 4 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 4 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 4 biomass	0.00	0.00	-	0.14	0.11	0.02	0.14	0.12	0.02
1 A 3 b 5 Other (please specify)	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 gasoline	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 diesel oil	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 LPG	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 b 5 biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 c Railways	2.38	2.38	-	1.69	1.71	-0.02	1.52	1.71	-0.19
1 A 3 c liquid	2.31	2.31	-	1.59	1.59	-	1.42	1.58	-0.16
1 A 3 c solid	0.07	0.07	-	0.00	0.00	-	0.00	0.00	-
1 A 3 c gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 c other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 c biomass	0.00	0.00	-	0.10	0.12	-0.02	0.10	0.13	-0.03
1 A 3 d Domestic Navigation	0.20	0.20	-	0.16	0.16	0.00	0.16	0.15	0.00

1 A 3 d residual oil	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 d gas/diesel oil	0.07	0.07	-	0.06	0.06	-	0.05	0.05	-
1 A 3 d gasoline	0.12	0.12	-	0.09	0.09	-	0.09	0.09	-
1 A 3 d other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 d gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 d other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 d biomass	0.00	0.00	-	0.01	0.01	0.00	0.01	0.01	0.00
1 A 3 e Other Transportation	4.05	4.05	-	9.08	9.08	-	10.51	10.51	-
1 A 3 e liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e gaseous	4.05	4.05	-	9.08	9.08	-	10.51	10.51	-
1 A 3 e other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 1 Pipeline Transport	4.05	4.05	-	9.08	9.08	-	10.51	10.51	-
1 A 3 e 1 liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 1 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 1 gaseous	4.05	4.05	-	9.08	9.08	-	10.51	10.51	-
1 A 3 e 1 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 1 biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 Other (please specify)	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 Other Sectors	249.02	251.26	-2.25	195.89	197.95	-2.06	206.16	208.48	-2.32
1 A 4 liquid	108.86	108.86	-	61.29	60.00	1.29	63.00	62.50	0.51
1 A 4 solid	28.12	28.12	-	1.10	1.09	0.01	1.06	1.23	-0.17
1 A 4 gaseous	46.46	46.46	-	61.31	65.21	-3.90	63.79	66.11	-2.32
1 A 4 other	1.11	3.36	-2.25	0.08	0.08	-	0.08	0.08	-
1 A 4 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 biomass	64.46	64.46	-	72.10	71.56	0.54	78.22	78.56	-0.34
1 A 4 a Commercial/Institutional	35.59	37.84	-2.25	28.93	37.03	-8.10	29.78	33.16	-3.38
1 A 4 a liquid	18.70	18.70	-	6.69	10.81	-4.12	6.38	9.80	-3.41
1 A 4 a solid	0.96	0.96	-	0.12	0.11	0.00	0.11	0.13	-0.02
1 A 4 a gaseous	12.75	12.75	-	18.14	22.84	-4.70	17.07	19.62	-2.55
1 A 4 a other	1.11	3.36	-2.25	0.08	0.08	-	0.08	0.08	-
1 A 4 a peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 a biomass	2.06	2.06	-	3.91	3.19	0.72	6.13	3.53	2.59
1 A 4 a 1 Stationary combustion	35.59	37.84	-2.25	28.93	37.03	-8.10	29.78	33.16	-3.38
1 A 4 a 1 liquid	18.70	18.70	-	6.69	10.81	-4.12	6.38	9.80	-3.41
1 A 4 a 1 solid	0.96	0.96	-	0.12	0.11	0.00	0.11	0.13	-0.02
1 A 4 a 1 gaseous	12.75	12.75	-	18.14	22.84	-4.70	17.07	19.62	-2.55
1 A 4 a 1 other	1.11	3.36	-2.25	0.08	0.08	-	0.08	0.08	-
1 A 4 a 1 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 a 1 biomass	2.06	2.06	-	3.91	3.19	0.72	6.13	3.53	2.59
1 A 4 b Residential	192.77	192.77	-	149.10	141.85	7.25	158.37	155.56	2.81
1 A 4 b liquid	74.42	74.42	-	44.02	38.66	5.36	46.15	42.28	3.87
1 A 4 b solid	26.62	26.62	-	0.97	0.96	0.01	0.93	1.08	-0.15
1 A 4 b gaseous	33.34	33.34	-	42.68	41.90	0.79	46.19	45.97	0.22

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	-	0.00	0.00	-	0.00	0.00	-
1 A 4 b biomass	58.40	58.40	-	61.43	60.33	1.09	65.09	66.23	-1.14
1 A 4 b 1 Stationary combustion	190.86	190.86	-	147.38	140.11	7.27	156.64	153.81	2.83
1 A 4 b 1 liquid	72.50	72.50	-	42.38	37.02	5.36	44.51	40.63	3.87
1 A 4 b 1 solid	26.62	26.62	-	0.97	0.96	0.01	0.93	1.08	-0.15
1 A 4 b 1 gaseous	33.34	33.34	-	42.68	41.90	0.79	46.19	45.97	0.22
1 A 4 b 1 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 b 1 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 b 1 biomass	58.40	58.40	-	61.34	60.23	1.11	65.00	66.12	-1.12
1 A 4 b 2 Mobile combustion	1.92	1.92	-	1.73	1.74	-0.02	1.73	1.75	-0.02
1 A 4 b 2 liquid	1.92	1.92	-	1.64	1.64	-	1.64	1.64	0.00
1 A 4 b 2 biomass	0.00	0.00	-	0.09	0.10	-0.02	0.09	0.11	-0.02
1 A 4 c Agriculture/Forestry/Fishing	20.66	20.66	-	17.86	19.07	-1.21	18.01	19.76	-1.75
1 A 4 c liquid	15.74	15.74	-	10.58	10.54	0.05	10.47	10.42	0.04
1 A 4 c solid	0.55	0.55	-	0.02	0.02	0.00	0.02	0.02	0.00
1 A 4 c gaseous	0.37	0.37	-	0.48	0.47	0.01	0.52	0.52	0.00
1 A 4 c other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c biomass	4.01	4.01	-	6.77	8.04	-1.27	7.00	8.79	-1.79
1 A 4 c 1 Stationary combustion	10.28	10.28	-	6.83	7.92	-1.10	7.09	8.71	-1.62
1 A 4 c 1 liquid	5.36	5.36	-	0.18	0.14	0.05	0.23	0.18	0.05
1 A 4 c 1 solid	0.55	0.55	-	0.02	0.02	0.00	0.02	0.02	0.00
1 A 4 c 1 gaseous	0.37	0.37	-	0.48	0.47	0.01	0.52	0.52	0.00
1 A 4 c 1 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c 1 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c 1 biomass	4.01	4.01	-	6.14	7.29	-1.15	6.32	7.99	-1.66
1 A 4 c 2 Mobile combustion	10.38	10.38	-	11.03	11.15	-0.12	10.92	11.05	-0.13
1 A 4 c 2 gasoline	0.43	0.43	-	0.39	0.39	-	0.39	0.39	0.00
1 A 4 c 2 diesel oil	9.95	9.95	-	10.01	10.01	0.00	9.84	9.85	0.00
1 A 4 c 2 LPG	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c 2 other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c 2 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c 2 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 4 c 2 biomass	0.00	0.00	-	0.63	0.74	-0.12	0.68	0.81	-0.12
1 A 5 Other	0.48	0.48	-	0.67	0.67	0.00	0.68	0.68	0.00
1 A 5 liquid	0.48	0.48	-	0.67	0.67	-	0.67	0.67	-
1 A 5 solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 biomass	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 5 a Stationary combustion	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 a liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 a solid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 a gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 a other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 a peat	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
1 A 5 a biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-

1 A 5 b Mobile combustion - Military	0.48	0.48	-	0.67	0.67	0.00	0.68	0.68	0.00
1 A 5 b liquid	0.48	0.48	-	0.67	0.67	-	0.67	0.67	-
1 A 5 b biomass	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00
Memo - International Aviation	12.19	12.19	-	27.18	27.18	-	29.25	29.25	-
aviation gasoline	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
jet kerosene	12.19	12.19	-	27.18	27.18	-	29.25	29.25	-
biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Memo - International Navigation	0.67	0.67	-	0.86	0.86	-	0.71	0.71	-
residual oil	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
gas/diesel oil	0.67	0.67	-	0.86	0.86	-	0.71	0.71	-
gasoline	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
other liquid	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
gaseous	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
other	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
biomass	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-

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 50 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 50: Categories of the national energy balance (JQ 2015) 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			

IEA-Category and ISIC Codes[2]	Comments	SNAP	IPCC-Category
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
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	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
Road			
Rail			
Inland Waterways			
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

IEA-Category and ISIC Codes[2]	Comments	SNAP	IPCC-Category
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 51: 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]		

Auto Producers (Electricity + CHP + Heat), of which:			
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 52.

Table A 52: 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	28.20	Solid (coal)
104 A	Hard Coal Briquettes	Patent Fuel	31.00	Solid (coal)
105 A	Brown Coal	Lignite/Brown Coal	20.48	Solid (coal)
106 A	Brown Coal Briquettes	BKB/PB	19.80	Solid (coal)
107 A	Coke	Coke Oven Coke	28.88	Solid (coal)
113 A	Peat	Peat	n.r	Solid
304 A	Coke Oven Gas	Coke Oven Gas	17.24	Solid
305 A	Blast Furnace Gas	Blast Furnace Gas	3.67	Solid
110 A	Petrol Coke	Petrol Coke	30.80	Liquid
203 B	Light Fuel Oil Sulphur Content < 0,2 %	Residual Fuel Oil	41.37	Liquid (residual oil)
203 C	Medium Fuel Oil Sulphur Content < 0,4%			
203 D	Heavy Fuel Oil Sulphur Content >= 1%			
204 A	Gasoil	Heating and other Gasoil	42.80	Liquid (gas/diesel oil)
205 0	Diesel	Transport Diesel	42.39	Liquid (diesel oil; gas/diesel oil)
206 A	Petroleum	Other Kerosene	43.30	Liquid
206 B	Kerosene	Kerosene Type Jet Fuel	43.30	Liquid (jet kerosene)
207 A	Aviation Gasoline	Gasoline Type Jet Fuel	42.60	Liquid (aviation gasoline)
208 0	Motor Gasoline	Motor Gasoline	41.15	Liquid (gasoline)
224 A	Other Petroleum Products	Other Products	41.80	Liquid
303 A	Liquified Petroleum Gas (LPG)	LPG	46.12	Liquid
308 A	Refinery Gas	Refinery Gas	29.87	Liquid
301 A	Natural Gas	Natural Gas	36.29	Gaseous (natural gas)
114 B	Municipal Waste	Municipal Solid Waste Renewable	[4]10.40	Other Fuels
		Municipal Solid Waste Non Renewable	[4]10.39	Other Fuels
115 A	Industrial Waste	Industrial Wastes	12.42	Other Fuels
111 A	Fuel Wood	*Wood/Wood wastes/Other Solid Wastes, of which:* Wood	14.31	Biomass
112 A	Char Coal	Char coal	30.00	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)	8.03	Biomass

Inventory Fuel Category		**IEA Fuel Category**		**IPCC Fuel Category** [(3)]
Code [(1)]	**Category**	**Category**	**Average Net Calorific Value**[(2)]	
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)]8.61	Biomass
309 A	Biogas	Biogas	[(4)]13.57	Biomass
309 B	Sewage Sludge Gas	Sewage Sludge Gas	[(4)]17.38	Biomass
310 A	Landfill Gas	Landfill Gas	[(4)]14.09	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 2015 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 2016. 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 53: 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 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total	1 A 1 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total
	Total Solid	**16.91**	**12.63**	**0.00**	**0.98**	**30.52**	**1.59**	**1.16**	**0.00**	**0.09**	**2.83**
102A	Hard Coal	16.91	6.12	0.00	0.12	23.16	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	0.17
106A	Brown Coal Briquettes				0.25	0.25				0.02	0.02
107A	Coke		0.37		0.45	0.83		0.04		0.04	0.08
113A	Peat										
304A	Coke Oven Gas		4.48			4.48		0.42			0.42
	Total Liquid	**33.48**	**24.56**	**303.83**	**62.20**	**424.07**	**2.60**	**1.86**	**22.73**	**4.64**	**31.83**
110A	Petrol Coke	2.19	1.57			3.75	0.22	0.15			0.37
203B	Light Fuel Oil	0.16	4.99			5.15	0.01	0.39			0.40
203C	Medium Fuel Oil	0.47				0.47	0.04				0.04
203D	Heavy Fuel Oil	3.71	1.29			5.00	0.30	0.10			0.40
204A	Gasoil	0.02	0.32		48.67	49.01	0.00	0.02		3.65	3.68
2050	Diesel	0.00	14.39	239.53	10.82	264.75	0.00	1.07	17.82	0.81	19.69
206A	Other Kerosene										
206B	Jet Kerosene			1.17		1.17			0.09		0.09
207A	Aviation Gasoline			0.13		0.13			0.01		0.01
2080	Motor Gasoline		0.11	62.52	1.25	63.87		0.01	4.79	0.10	4.89
224A	Other Petroleum Products	21.83	0.14			21.97	1.70	0.01			1.71
303A	Liquified Petroleum Gas (LPG)	1.15	1.75	0.48	1.46	4.84	0.07	0.11	0.03	0.09	0.31
308A	Refinery Gas	3.94				3.94	0.25				0.25
301A	**Total Gaseous (Natural Gas)**	**86.69**	**122.12**	**10.75**	**68.84**	**288.41**	**4.80**	**6.77**	**0.60**	**3.81**	**15.98**
	Total Other Fuel	**23.88**	**14.08**		**0.09**	**38.06**	**1.46**	**0.88**		**0.01**	**2.35**
114B	Municipal Waste	18.53				18.53	0.91				0.91
115A	Industrial Waste	5.35	14.08		0.09	19.53	0.56	0.88		0.01	1.44
	Total Biomass[(1)]	**59.33**	**73.10**	**17.33**	**79.42**	**229.17**	**(7.54)**	**(1.23)**	**(1.23)**	**(0.00)**	**(23.65)**
111A	Fuel Wood	0.05	0.06		56.86	56.97	0.01	0.01		6.37	6.38
112A	Char Coal	0.05			0.46	0.51				0.05	0.05
116A	Wood Wastes	46.71	40.43		20.56	107.70	5.23	4.53		2.30	12.06
118A	Sewage Sludge	2.46	0.49			2.95	0.28	0.05			0.33
215A	Black Liquor		29.16			29.16		2.78			2.78
250A	Liquid Biofuels		0.88	17.31	0.71	18.90		0.06	1.23	0.05	1.34
309A	Biogas	9.85	1.95	0.01	0.60	12.41	0.54	0.11	0.00	0.03	0.68
309B	Sewage Sludge Gas	0.19	0.13		0.10	0.42	0.01	0.01		0.01	0.02
310A	Landfill Gas	0.04			0.11	0.16	0.00			0.01	0.01
	Total[(1)]	**220.30**	**246.49**	**331.91**	**211.53**	**1 010.22**	**10.45**	**10.66**	**23.32**	**8.56**	**52.99**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 54: 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 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total	1 A 1 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total
	Total Solid	**24.98**	**11.59**	**0.00**	**1.06**	**37.64**	**2.34**	**1.09**	**0.00**	**0.10**	**3.52**
102A	Hard Coal	24.98	6.25	0.00	0.20	31.43	2.34	0.57	0.00	0.02	2.92
104A	Hard Coal Briquettes				0.12	0.12				0.01	0.01
105A	Brown Coal		1.89		0.04	1.93		0.18		0.00	0.19
106A	Brown Coal Briquettes				0.25	0.25				0.02	0.02
107A	Coke		0.50		0.44	0.95		0.05		0.04	0.09
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		2.95			2.95		0.28			0.28
	Total Liquid	**33.38**	**24.47**	**292.29**	**63.00**	**413.14**	**2.52**	**1.85**	**21.81**	**4.70**	**30.89**
110A	Petrol Coke	1.85	1.48			3.33	0.19	0.14			0.33
203B	Light Fuel Oil	0.12	5.00		0.04	5.16	0.01	0.39		0.00	0.40
203C	Medium Fuel Oil	0.47				0.47	0.04				0.04
203D	Heavy Fuel Oil	2.47	1.45			3.93	0.20	0.11			0.31
204A	Gasoil	0.13	0.30		49.21	49.64	0.01	0.02		3.69	3.72
2050	Diesel	0.00	14.20	227.11	10.62	251.94	0.00	1.06	16.89	0.79	18.73
206A	Other Kerosene				0.04	0.04				0.00	0.00
206B	Jet Kerosene			1.22		1.22			0.09		0.09
207A	Aviation Gasoline			0.11		0.11			0.01		0.01
2080	Motor Gasoline		0.11	63.23	1.26	64.60		0.01	4.78	0.10	4.89
224A	Other Petroleum Products	19.24	0.13			19.37	1.50	0.01			1.51
303A	Liquified Petroleum Gas (LPG)	0.74	1.80	0.62	1.83	4.98	0.05	0.12	0.04	0.12	0.32
308A	Refinery Gas	8.36				8.36	0.53				0.53
301A	**Total Gaseous (Natural Gas)**	**79.96**	**121.19**	**11.24**	**63.79**	**276.18**	**4.43**	**6.71**	**0.62**	**3.53**	**15.30**
	Total Other Fuel	**23.10**	**14.41**		**0.08**	**37.60**	**1.34**	**0.93**		**0.01**	**2.27**
114B	Municipal Waste	19.35				19.35	0.95				0.95
115A	Industrial Waste	3.75	14.41		0.08	18.25	0.39	0.93		0.01	1.33
	Total Biomass[(1)]	**61.93**	**69.95**	**18.30**	**78.22**	**228.40**	**(7.21)**	**(1.30)**	**(1.30)**	**(0.00)**	**(23.54)**
111A	Fuel Wood	0.05	0.05		55.51	55.61	0.01	0.01		6.22	6.23
112A	Char Coal	0.04			0.46	0.50				0.05	0.05
116A	Wood Wastes	49.26	38.02		20.74	108.02	5.52	4.26		2.32	12.10
118A	Sewage Sludge	2.43	0.53			2.96	0.27	0.06			0.33
215A	Black Liquor		28.40			28.40		2.71			2.71
250A	Liquid Biofuels		0.96	18.29	0.77	20.02		0.07	1.30	0.05	1.42
309A	Biogas	9.94	1.40	0.01	0.56	11.92	0.54	0.08	0.00	0.03	0.65
309B	Sewage Sludge Gas	0.11	0.58		0.09	0.78	0.01	0.03		0.00	0.04
310A	Landfill Gas	0.09			0.09	0.19	0.01			0.01	0.01
	Total[(1)]	**223.35**	**241.61**	**321.84**	**206.16**	**992.96**	**10.62**	**10.58**	**22.43**	**8.34**	**51.98**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 55: 2014 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 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total	1 A 1 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total
	Total Solid	**24.74**	**11.75**	**0.00**	**1.11**	**37.60**	**2.30**	**1.09**	**0.00**	**0.10**	**3.50**
102A	Hard Coal	24.74	6.37	0.00	0.09	31.21	2.30	0.57	0.00	0.01	2.88
104A	Hard Coal Briquettes				0.19	0.19				0.02	0.02
105A	Brown Coal		1.98		0.04	2.02		0.19		0.00	0.20
106A	Brown Coal Briquettes				0.29	0.29				0.03	0.03
107A	Coke		0.40		0.49	0.89		0.04		0.05	0.09
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		3.00			3.00		0.28			0.28
	Total Liquid	**30.46**	**24.09**	**287.98**	**61.29**	**403.82**	**2.27**	**1.82**	**21.49**	**4.57**	**30.15**
110A	Petrol Coke	1.69	1.52			3.22	0.17	0.14			0.31
203B	Light Fuel Oil	0.11	4.42		0.33	4.86	0.01	0.34		0.03	0.38
203C	Medium Fuel Oil	0.54				0.54	0.04				0.04
203D	Heavy Fuel Oil	1.12	1.12			2.24	0.09	0.09			0.18
204A	Gasoil	0.21	0.34		46.72	47.28	0.02	0.03		3.50	3.55
2050	Diesel	0.00	14.66	223.22	10.79	248.68	0.00	1.09	16.60	0.80	18.49
206A	Other Kerosene				0.04	0.04				0.00	0.00
206B	Jet Kerosene			1.22		1.22			0.09		0.09
207A	Aviation Gasoline			0.10		0.10			0.01		0.01
2080	Motor Gasoline		0.11	62.65	1.25	64.01		0.01	4.74	0.09	4.84
224A	Other Petroleum Products	16.33	0.15			16.48	1.27	0.01			1.28
303A	Liquified Petroleum Gas (LPG)	0.19	1.75	0.79	2.15	4.89	0.01	0.11	0.05	0.14	0.31
308A	Refinery Gas	10.26				10.26	0.65				0.65
301A	**Total Gaseous (Natural Gas)**	**65.86**	**120.72**	**9.78**	**61.31**	**257.67**	**3.65**	**6.69**	**0.54**	**3.40**	**14.27**
	Total Other Fuel	**22.21**	**13.72**		**0.08**	**36.02**	**1.28**	**0.88**		**0.01**	**2.17**
114B	Municipal Waste	18.70				18.70	0.91				0.91
115A	Industrial Waste	3.51	13.72		0.08	17.31	0.37	0.88		0.01	1.25
	Total Biomass[(1)]	**59.55**	**71.40**	**16.63**	**72.10**	**219.68**	**(7.34)**	**(1.18)**	**(1.18)**	**(0.00)**	**(22.62)**
111A	Fuel Wood	0.04	0.05		52.00	52.09	0.00	0.01		5.82	5.83
112A	Char Coal	0.04			0.36	0.40				0.04	0.04
116A	Wood Wastes	47.46	37.53		18.30	103.29	5.32	4.20		2.05	11.57
118A	Sewage Sludge	2.15	0.61			2.77	0.24	0.07			0.31
215A	Black Liquor		30.33			30.33		2.89			2.89
250A	Liquid Biofuels		0.90	16.61	0.71	18.22		0.06	1.18	0.05	1.29
309A	Biogas	9.63	1.44	0.02	0.54	11.62	0.53	0.08	0.00	0.03	0.63
309B	Sewage Sludge Gas	0.14	0.54		0.09	0.76	0.01	0.03		0.00	0.04
310A	Landfill Gas	0.10			0.10	0.20	0.01			0.01	0.01
	Total[(1)]	**202.82**	**241.69**	**314.39**	**195.89**	**954.80**	**9.50**	**10.48**	**22.03**	**8.07**	**50.09**

[(1)] *CO_2 emissions of Biomass are not included in Total.*

Table A 56: 2013 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 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total	1 A 1 Energy Ind.	1 A 2 Industry	1 A 3 + 1 A 5 Transport	1 A 4 Other Sectors	1 A Total
	Total Solid	**35.78**	**13.18**	**0.00**	**1.34**	**50.30**	**3.29**	**1.23**	**0.00**	**0.13**	**4.65**
102A	Hard Coal	35.78	6.12	0.00	0.09	41.99	3.29	0.55	0.00	0.01	3.85
104A	Hard Coal Briquettes				0.28	0.28				0.03	0.03
105A	Brown Coal		1.70		0.05	1.75		0.17		0.01	0.17
106A	Brown Coal Briquettes		0.00		0.33	0.33		0.00		0.03	0.03
107A	Coke		0.37		0.59	0.96		0.04		0.05	0.09
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		4.99			4.99		0.47			0.47
	Total Liquid	**31.52**	**27.88**	**295.41**	**64.37**	**419.18**	**2.36**	**2.11**	**22.03**	**4.80**	**31.30**
110A	Petrol Coke	2.25	1.59			3.84	0.23	0.15			0.38
203B	Light Fuel Oil	0.12	4.59		0.37	5.08	0.01	0.36		0.03	0.40
203C	Medium Fuel Oil	0.54				0.54	0.04				0.04
203D	Heavy Fuel Oil	1.64	1.90			3.54	0.13	0.15			0.28
204A	Gasoil	0.13	2.61		50.02	52.76	0.01	0.20		3.75	3.96
2050	Diesel	0.00	15.05	229.23	10.71	254.99	0.00	1.12	17.00	0.79	18.91
206A	Other Kerosene				0.17	0.17				0.01	0.01
206B	Jet Kerosene			1.27		1.27			0.09		0.09
207A	Aviation Gasoline			0.11		0.11			0.01		0.01
2080	Motor Gasoline		0.11	63.90	1.24	65.25		0.01	4.87	0.09	4.97
224A	Other Petroleum Products	16.60	0.23			16.84	1.29	0.02			1.31
303A	Liquified Petroleum Gas (LPG)	0.28	1.80	0.90	1.86	4.84	0.02	0.12	0.06	0.12	0.31
308A	Refinery Gas	9.96				9.96	0.63				0.63
301A	**Total Gaseous (Natural Gas)**	**77.26**	**123.25**	**11.60**	**73.48**	**285.59**	**4.28**	**6.83**	**0.64**	**4.07**	**15.82**
	Total Other Fuel	**20.71**	**12.66**		**0.07**	**33.44**	**1.29**	**0.86**		**0.00**	**2.16**
114B	Municipal Waste	15.72				15.72	0.77				0.77
115A	Industrial Waste	4.99	12.66		0.07	17.72	0.52	0.86		0.00	1.39
	Total Biomass(1)	**59.96**	**78.10**	**15.77**	**83.72**	**237.55**	**(8.11)**	**(1.12)**	**(1.12)**	**(0.00)**	**(24.91)**
111A	Fuel Wood	0.05	0.55		62.06	62.67	0.01	0.06		6.95	7.02
112A	Char Coal	0.04			0.38	0.42				0.04	0.04
116A	Wood Wastes	51.70	44.07		20.20	115.97	5.79	4.94		2.26	12.99
118A	Sewage Sludge	2.10	0.73			2.83	0.24	0.08			0.32
215A	Black Liquor		30.09			30.09		2.87			2.87
250A	Liquid Biofuels		0.84	15.77	0.65	17.26		0.06	1.12	0.05	1.22
309A	Biogas	5.79	1.33	0.00	0.19	7.31	0.32	0.07	0.00	0.01	0.40
309B	Sewage Sludge Gas	0.19	0.49		0.19	0.87	0.01	0.03		0.01	0.05
310A	Landfill Gas	0.09			0.05	0.14	0.01			0.00	0.01
	Total(1)	**225.22**	**255.06**	**322.79**	**222.98**	**1 026.05**	**11.22**	**11.03**	**22.67**	**9.00**	**53.92**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 57: 2012 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	**37.18**	**11.86**	**0.00**	**1.81**	**50.84**	**3.45**	**1.10**	**0.00**	**0.17**	**4.73**
102A	Hard Coal	37.18	5.95	0.00	0.23	43.35	3.45	0.54	0.00	0.02	4.01
104A	Hard Coal Briquettes				0.22	0.22				0.02	0.02
105A	Brown Coal		1.73		0.04	1.77		0.17		0.00	0.17
106A	Brown Coal Briquettes				0.40	0.40				0.04	0.04
107A	Coke		0.37		0.91	1.28		0.04		0.08	0.12
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		3.81			3.81		0.36			0.36
	Total Liquid	**33.56**	**29.34**	**281.96**	**65.20**	**410.05**	**2.52**	**2.21**	**21.04**	**4.86**	**30.63**
110A	Petrol Coke	2.30	1.64			3.94	0.23	0.15			0.38
203B	Light Fuel Oil	0.11	4.82		0.83	5.76	0.01	0.38		0.06	0.45
203C	Medium Fuel Oil	0.57				0.57	0.04				0.04
203D	Heavy Fuel Oil	2.09	2.08			4.18	0.16	0.16			0.33
204A	Gasoil	0.17	2.95		49.79	52.92	0.01	0.22		3.73	3.97
2050	Diesel	0.00	14.91	214.50	10.72	240.13	0.00	1.11	15.91	0.79	17.81
206A	Other Kerosene				0.26	0.26				0.02	0.02
206B	Jet Kerosene			1.27		1.27			0.09		0.09
207A	Aviation Gasoline			0.11		0.11			0.01		0.01
2080	Motor Gasoline		0.11	65.18	1.24	66.53		0.01	4.97	0.09	5.07
224A	Other Petroleum Products	18.24	0.50			18.74	1.42	0.04			1.46
303A	Liquified Petroleum Gas (LPG)	0.19	2.31	0.90	2.37	5.77	0.01	0.15	0.06	0.15	0.37
308A	Refinery Gas	9.88				9.88	0.62				0.62
301A	**Total Gaseous (Natural Gas)**	**89.87**	**126.22**	**8.80**	**70.80**	**295.70**	**4.98**	**6.99**	**0.49**	**3.92**	**16.38**
	Total Other Fuel	**20.76**	**11.88**		**0.04**	**32.68**	**1.30**	**0.84**		**0.00**	**2.15**
114B	Municipal Waste	15.55				15.55	0.76				0.76
115A	Industrial Waste	5.21	11.88		0.04	17.13	0.54	0.84		0.00	1.39
	Total Biomass[(1)]	**62.02**	**70.68**	**16.11**	**77.87**	**226.67**	**(7.28)**	**(1.14)**	**(1.14)**	**(0.00)**	**(23.66)**
111A	Fuel Wood	0.05	0.59		57.39	58.04	0.01	0.07		6.43	6.50
112A	Char Coal	0.04			0.40	0.44				0.04	0.04
116A	Wood Wastes	53.17	36.86		19.01	109.04	5.95	4.13		2.13	12.21
118A	Sewage Sludge	2.15	0.61			2.75	0.24	0.07			0.31
215A	Black Liquor		30.12			30.12		2.87			2.87
250A	Liquid Biofuels		0.88	16.11	0.69	17.68		0.06	1.14	0.05	1.25
309A	Biogas	6.28	1.09	0.00	0.14	7.51	0.34	0.06	0.00	0.01	0.41
309B	Sewage Sludge Gas	0.23	0.53		0.17	0.93	0.01	0.03		0.01	0.05
310A	Landfill Gas	0.10			0.06	0.16	0.01			0.00	0.01
	Total[(1)]	**243.38**	**249.98**	**306.87**	**215.72**	**1 015.95**	**12.26**	**11.15**	**21.52**	**8.95**	**53.89**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 58: 2011 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	**45.64**	**11.73**	**0.00**	**1.67**	**59.05**	**4.25**	**1.10**	**0.00**	**0.16**	**5.51**
102A	Hard Coal	45.64	5.84	0.00	0.34	51.82	4.25	0.53	0.00	0.03	4.81
104A	Hard Coal Briquettes										
105A	Brown Coal		1.83		0.04	1.87		0.18		0.00	0.18
106A	Brown Coal Briquettes				0.39	0.39				0.04	0.04
107A	Coke		0.38		0.90	1.28		0.04		0.08	0.12
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		3.69			3.69		0.35			0.35
	Total Liquid	**36.01**	**29.54**	**283.39**	**70.13**	**419.07**	**2.65**	**2.23**	**21.15**	**5.22**	**31.25**
110A	Petrol Coke	2.05	1.98			4.03	0.21	0.18			0.38
203B	Light Fuel Oil	0.09	5.22		1.63	6.94	0.01	0.41		0.13	0.54
203C	Medium Fuel Oil	1.25				1.25	0.10				0.10
203D	Heavy Fuel Oil	3.36	2.48			5.84	0.27	0.19			0.46
204A	Gasoil	0.13	2.89		52.50	55.52	0.01	0.22		3.94	4.16
2050	Diesel	0.00	14.43	214.11	11.19	239.73	0.00	1.07	15.88	0.83	17.78
206A	Other Kerosene				0.04	0.04				0.00	0.00
206B	Jet Kerosene			1.28		1.28			0.09		0.09
207A	Aviation Gasoline			0.18		0.18			0.01		0.01
2080	Motor Gasoline		0.11	66.96	1.26	68.33		0.01	5.11	0.10	5.21
224A	Other Petroleum Products	14.49	0.50			14.99	1.13	0.03			1.16
303A	Liquified Petroleum Gas (LPG)	1.20	1.93	0.85	3.51	7.50	0.08	0.12	0.05	0.22	0.48
308A	Refinery Gas	13.44				13.44	0.86				0.86
301A	**Total Gaseous (Natural Gas)**	**100.22**	**127.55**	**10.74**	**70.95**	**309.46**	**5.55**	**7.07**	**0.59**	**3.93**	**17.14**
	Total Other Fuel	**19.84**	**12.92**		**0.04**	**32.79**	**1.21**	**0.79**		**0.00**	**2.00**
114B	Municipal Waste	15.47				15.47	0.76				0.76
115A	Industrial Waste	4.37	12.92		0.04	17.33	0.46	0.79		0.00	1.25
	Total Biomass[(1)]	**58.11**	**66.75**	**15.47**	**73.93**	**214.25**	**(6.90)**	**(1.10)**	**(1.10)**	**(0.00)**	**(22.41)**
111A	Fuel Wood	0.04	1.05		55.16	56.25	0.00	0.12		6.18	6.30
112A	Char Coal	0.04			0.34	0.38				0.04	0.04
116A	Wood Wastes	50.54	34.26		17.32	102.12	5.66	3.84		1.94	11.44
118A	Sewage Sludge	2.00	0.64			2.64	0.22	0.07			0.30
215A	Black Liquor		28.91			28.91		2.76			2.76
250A	Liquid Biofuels		0.82	15.47	0.69	16.98		0.06	1.10	0.05	1.20
309A	Biogas	5.06	0.57	0.00	0.13	5.76	0.28	0.03	0.00	0.01	0.31
309B	Sewage Sludge Gas	0.33	0.50		0.21	1.04	0.02	0.03		0.01	0.06
310A	Landfill Gas	0.10			0.07	0.18	0.01			0.00	0.01
	Total[(1)]	**259.82**	**248.49**	**309.60**	**216.71**	**1 034.62**	**13.67**	**11.18**	**21.74**	**9.31**	**55.90**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 59: 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	Transport	Other Sectors	Total	Energy Ind.	Industry	Transport	Other Sectors	Total
	Total Solid	**41.47**	**11.55**	**0.00**	**2.75**	**55.77**	**3.87**	**1.08**	**0.00**	**0.26**	**5.21**
102A	Hard Coal	41.47	6.07	0.00	0.23	47.77	3.87	0.56	0.00	0.02	4.45
104A	Hard Coal Briquettes				0.40	0.40				0.04	0.04
105A	Brown Coal		1.73		0.15	1.88		0.17		0.02	0.18
106A	Brown Coal Briquettes				0.56	0.56				0.05	0.05
107A	Coke		0.35		1.40	1.74		0.04		0.13	0.16
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		3.41			3.41		0.32			0.32
	Total Liquid	**39.31**	**29.65**	**293.59**	**79.97**	**442.52**	**2.91**	**2.24**	**21.91**	**5.95**	**33.01**
110A	Petrol Coke	2.00	1.44			3.44	0.20	0.14			0.34
203B	Light Fuel Oil	0.15	4.96		4.16	9.27	0.01	0.39		0.32	0.72
203C	Medium Fuel Oil	1.79				1.79	0.14				0.14
203D	Heavy Fuel Oil	6.57	3.06			9.63	0.52	0.24			0.76
204A	Gasoil	0.09	3.17		59.59	62.85	0.01	0.24		4.47	4.71
2050	Diesel	0.00	14.37	221.71	10.35	246.42	0.00	1.07	16.44	0.77	18.28
206A	Other Kerosene				0.17	0.17				0.01	0.01
206B	Jet Kerosene			1.36		1.36			0.10		0.10
207A	Aviation Gasoline			0.12		0.12			0.01		0.01
2080	Motor Gasoline		0.11	69.52	1.26	70.88		0.01	5.30	0.10	5.41
224A	Other Petroleum Products	13.96	0.52			14.47	1.09	0.04			1.12
303A	Liquified Petroleum Gas (LPG)	1.34	2.02	0.89	4.44	8.69	0.09	0.13	0.06	0.28	0.56
308A	Refinery Gas	13.41				13.41	0.85				0.85
301A	**Total Gaseous (Natural Gas)**	**107.85**	**129.16**	**8.73**	**82.93**	**328.68**	**5.97**	**7.16**	**0.48**	**4.59**	**18.21**
	Total Other Fuel	**18.19**	**11.17**		**0.05**	**29.41**	**1.10**	**0.78**		**0.00**	**1.89**
114B	Municipal Waste	14.38				14.38	0.70				0.70
115A	Industrial Waste	3.81	11.17		0.05	15.03	0.40	0.78		0.00	1.19
	Total Biomass[1]	**58.01**	**64.56**	**15.80**	**75.34**	**213.71**	**(6.67)**	**(1.12)**	**(1.12)**	**(0.00)**	**(22.37)**
111A	Fuel Wood	0.05	1.20		59.56	60.82	0.01	0.13		6.67	6.81
112A	Char Coal	0.04			0.37	0.41				0.04	0.04
116A	Wood Wastes	52.00	32.40		14.32	98.72	5.82	3.63		1.60	11.06
118A	Sewage Sludge	0.71	0.69			1.40	0.08	0.08			0.16
215A	Black Liquor		28.53			28.53		2.72			2.72
250A	Liquid Biofuels		0.80	15.80	0.63	17.24		0.06	1.12	0.04	1.22
309A	Biogas	4.78	0.42	0.00	0.11	5.30	0.26	0.02	0.00	0.01	0.29
309B	Sewage Sludge Gas	0.32	0.51		0.27	1.10	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]	**264.83**	**246.09**	**318.13**	**241.04**	**1 070.09**	**13.85**	**11.26**	**22.39**	**10.81**	**58.32**

(1) *CO_2 emissions of Biomass are not included in Total.*

Table A 60: 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	Transport	Other Sectors	Total	Energy Ind.	Industry	Transport	Other Sectors	Total
	Total Solid	**61.63**	**20.83**	**0.01**	**4.48**	**86.94**	**5.84**	**1.94**	**0.00**	**0.42**	**8.21**
102A	Hard Coal	51.50	7.73	0.01	1.32	60.56	4.80	0.72	0.00	0.12	5.65
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal	10.12	2.54		0.21	12.87	1.04	0.22		0.02	1.28
106A	Brown Coal Briquettes		0.00		1.00	1.00		0.00		0.10	0.10
107A	Coke		1.15		1.91	3.07		0.12		0.18	0.30
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		9.40			9.40		0.89			0.89
	Total Liquid	**46.37**	**30.91**	**327.22**	**105.45**	**509.94**	**3.42**	**2.36**	**24.43**	**7.86**	**38.08**
110A	Petrol Coke	2.12	2.05			4.17	0.21	0.19			0.41
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	0.21	4.97		77.55	82.73	0.02	0.37		5.82	6.20
2050	Diesel	0.00	10.80	240.59	11.74	263.13	0.00	0.80	17.84	0.87	19.51
206A	Other Kerosene				0.17	0.17				0.01	0.01
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	84.17	1.44	85.72		0.01	6.42	0.11	6.54
224A	Other Petroleum Products	12.26	0.13			12.39	0.96	0.01			0.96
303A	Liquified Petroleum Gas (LPG)	2.27	1.56	0.98	5.31	10.12	0.15	0.10	0.06	0.34	0.65
308A	Refinery Gas	15.66				15.66	1.00				1.00
301A	**Total Gaseous (Natural Gas)**	**113.99**	**120.69**	**6.49**	**86.56**	**327.73**	**6.32**	**6.69**	**0.36**	**4.80**	**18.16**
	Total Other Fuel	**10.60**	**10.33**		**0.52**	**21.45**	**0.61**	**0.67**		**0.05**	**1.33**
114B	Municipal Waste	8.88				8.88	0.43				0.43
115A	Industrial Waste	1.72	10.33		0.52	12.57	0.18	0.67		0.05	0.90
	Total Biomass(1)	**20.27**	**52.10**	**2.20**	**71.67**	**146.23**	**(5.31)**	**(0.16)**	**(0.16)**	**(0.00)**	**(15.54)**
111A	Fuel Wood	0.05	1.14		58.04	59.22	0.01	0.13		6.50	6.63
112A	Char Coal	0.03			0.36	0.39				0.04	0.04
116A	Wood Wastes	16.04	22.91		12.77	51.73	1.80	2.57		1.43	5.79
118A	Sewage Sludge	0.75	0.04			0.79	0.08	0.00			0.09
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	2.66	0.68		0.14	3.48	0.15	0.04		0.01	0.19
309B	Sewage Sludge Gas	0.69	0.59		0.06	1.34	0.04	0.03		0.00	0.07
310A	Landfill Gas	0.04			0.19	0.23	0.00			0.01	0.01
	Total(1)	**252.85**	**234.86**	**335.91**	**268.67**	**1 092.29**	**16.19**	**11.66**	**24.79**	**13.13**	**65.78**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 61: 2000 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO2 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	**41.48**	**24.66**	**245.21**	**105.75**	**417.10**	**3.02**	**1.87**	**18.35**	**7.92**	**31.16**
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	0.00	1.58		71.99	73.57	0.00	0.12		5.40	5.52
2050	Diesel		7.32	162.80	11.06	181.18		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	80.29	1.45	81.85		0.01	6.12	0.11	6.24
224A	Other Petroleum Pro-ducts	9.74	0.15			9.89	0.76	0.01			0.77
303A	Liquified Petroleum Gas (LPG)	0.92	2.58	0.67	3.70	7.87	0.06	0.16	0.04	0.24	0.50
308A	Refinery Gas	14.33				14.33	0.85				0.85
301A	**Total Gaseous (Natu-ral Gas)**	**74.17**	**111.55**	**6.10**	**73.27**	**265.10**	**4.11**	**6.18**	**0.34**	**4.06**	**14.69**
	Total Other Fuel	**5.46**	**6.25**		**0.56**	**12.27**	**0.31**	**0.45**		**0.06**	**0.82**
114B	Municipal Waste	4.64				4.64	0.23				0.23
115A	Industrial Waste	0.82	6.25		0.56	7.63	0.09	0.45		0.06	0.59
	Total Biomass(1)	**8.08**	**40.83**		**69.27**	**118.18**	**(4.13)**				**(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	6.98	15.15		9.24	31.37	0.78	1.70		1.03	3.51
118A	Sewage Sludge	0.96				0.96	0.11				0.11
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)	**178.35**	**198.51**	**251.34**	**259.19**	**887.38**	**12.26**	**9.95**	**18.69**	**13.01**	**53.91**

(1) *CO_2 emissions of Biomass are not included in Total.*

Table A 62: 1995 energy consumption and CO_2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO2 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**	**17.52**	**0.06**	**18.59**	**81.66**	**4.53**	**1.67**	**0.01**	**1.75**	**7.95**
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		6.73			6.73		0.64			0.64
	Total Liquid	**46.31**	**33.81**	**206.14**	**107.63**	**393.89**	**3.73**	**2.58**	**15.49**	**8.06**	**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	0.17		70.54	70.80	0.01	0.01		5.29	5.31
2050	Diesel	0.30	4.82	106.98	10.61	122.70	0.02	0.36	7.93	0.79	9.10
206A	Other Kerosene				0.26	0.26				0.02	0.02
206B	Jet Kerosene			1.11		1.11			0.08		0.08
207A	Aviation Gasoline			0.09		0.09			0.01		0.01
2080	Motor Gasoline		0.07	97.46	1.47	99.00		0.01	7.43	0.11	7.55
224A	Other Petroleum Pro-ducts	8.88	0.15		0.01	9.04	0.69	0.01		0.00	0.70
303A	Liquified Petroleum Gas (LPG)	1.02	2.92	0.49	4.18	8.61	0.07	0.19	0.03	0.27	0.55
308A	Refinery Gas	14.95				14.95	1.23				1.23
301A	**Total Gaseous (Natu-ral Gas)**	**80.70**	**99.58**	**4.09**	**74.46**	**258.83**	**4.47**	**5.52**	**0.23**	**4.13**	**14.34**
	Total Other Fuel	**5.13**	**5.27**		**0.52**	**10.92**	**0.32**	**0.47**		**0.05**	**0.84**
114B	Municipal Waste	3.91				3.91	0.19				0.19
115A	Industrial Waste	1.22	5.27		0.52	7.01	0.13	0.47		0.05	0.65
	Total Biomass(1)	**4.05**	**35.89**		**69.85**	**109.79**	**(3.65)**				**(11.88)**
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	3.25	13.04		2.63	18.92	0.36	1.46		0.29	2.12
118A	Sewage Sludge	0.73				0.73	0.08				0.08
215A	Black Liquor		21.63			21.63		2.06			2.06
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)	**181.67**	**192.08**	**210.29**	**271.06**	**855.09**	**13.04**	**10.23**	**15.72**	**13.99**	**52.99**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 63: 1990 energy consumption and CO2 emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO2 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**	**26.28**	**0.07**	**28.13**	**115.88**	**6.25**	**2.51**	**0.01**	**2.65**	**11.41**
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		14.03			14.03		1.33			1.33
	Total Liquid	**43.15**	**35.95**	**180.25**	**108.86**	**368.21**	**3.19**	**2.77**	**13.58**	**8.21**	**27.75**
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				52.99	52.99				3.97	3.97
2050	Diesel		3.40	74.93	10.80	89.13		0.25	5.56	0.80	6.61
206A	Other Kerosene				0.74	0.74				0.06	0.06
206B	Jet Kerosene			0.78		0.78			0.06		0.06
207A	Aviation Gasoline			0.10		0.10			0.01		0.01
2080	Motor Gasoline		0.05	104.02	1.49	105.56		0.00	7.93	0.11	8.05
224A	Other Petroleum Pro-ducts	6.93	0.18		0.87	7.97	0.54	0.01		0.06	0.61
303A	Liquified Petroleum Gas (LPG)	0.42	2.96	0.41	2.32	6.11	0.03	0.19	0.03	0.15	0.39
308A	Refinery Gas	18.28				18.28	1.20				1.20
301A	**Total Gaseous (Natu-ral 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**	**0.35**	**0.27**		**0.12**	**0.73**
114B	Municipal Waste	2.41				2.41	0.12				0.12
115A	Industrial Waste	2.25	3.22		1.11	6.58	0.23	0.27		0.12	0.62
	Total Biomass(1)	**1.66**	**29.63**		**64.46**	**95.75**	**(3.02)**				**(10.42)**
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	0.97	10.99		1.79	13.75	0.11	1.23		0.20	1.54
118A	Sewage Sludge	0.66				0.66	0.07				0.07
215A	Black Liquor		17.98			17.98		1.71			1.71
250A	Liquid Biofuels										
309A	Biogas										
309B	Sewage Sludge Gas										
310A	Landfill Gas										
	Total(1)	**187.34**	**172.08**	**184.37**	**249.02**	**792.81**	**14.03**	**9.81**	**13.81**	**13.55**	**51.20**

(1) *CO_2 emissions of Biomass are not included in Total.*

Annex 3.2 – CRF 3 Agriculture

In this Annex additional information on the sector agriculture is included as recommended by the ERT in the ARR 2013. The first section presents tables on the fractions of livestock manure handled in different animal waste management systems (AWMS) for all animal subcategories and all reporting years (ARR 2013, para 49). The second section includes a schematic diagram of the Austrian N flow and additional description of the country specific method used in the Austrian inventory (ARR 2013, para 51 and para 52).

AWMS for all animal subcategories and all reporting years

Dairy cattle

Table A 64: Manure Management System distribution in Austria for dairy cattle 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Dairy cattle	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	32.7	49.4	10.7	3.1	0.0	4.1
1991	32.6	49.4	10.2	3.4	0.0	4.3
1992	32.6	49.4	9.8	3.6	0.0	4.6
1993	32.6	49.4	9.4	3.8	0.0	4.8
1994	32.6	49.4	8.9	4.1	0.1	5.0
1995	32.6	49.3	8.5	4.3	0.1	5.2
1996	32.6	49.3	8.1	4.5	0.1	5.4
1997	32.5	49.3	7.6	4.8	0.1	5.6
1998	32.5	49.3	7.2	5.0	0.1	5.8
1999	32.5	49.3	6.8	5.2	0.2	6.1
2000	32.4	49.2	6.4	5.5	0.2	6.3
2001	32.4	49.2	5.9	5.7	0.3	6.5
2002	32.4	49.2	5.5	5.9	0.3	6.7
2003	32.3	49.2	5.1	6.2	0.3	6.9
2004	32.3	49.2	4.6	6.4	0.4	7.1
2005	32.3	49.1	4.2	6.6	0.4	7.3
2006	32.3	49.1	3.8	6.9	0.4	7.5
2007	32.2	49.1	3.3	7.1	0.5	7.8
2008	32.2	49.1	2.9	7.4	0.5	8.0
2009	32.2	49.1	2.9	7.4	0.5	8.0
2010	32.2	49.1	2.9	7.4	0.5	8.0
2011	32.2	49.0	2.9	7.4	0.5	8.0
2012	32.2	49.0	2.9	7.4	0.5	8.0
2013	32.2	49.0	2.9	7.4	0.6	8.0
2014	32.2	49.0	2.9	7.4	0.6	8.0
2015	32.2	49.0	2.9	7.4	0.6	8.0
2016	32.2	49.0	2.9	7.4	0.6	8.0

Table A 65: Other systems in detail for dairy cattle 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Dairy cattle	**[%]**	**[%]**	**[%]**
1990	0.9	1.3	2.0
1991	1.0	1.3	2.1
1992	1.0	1.3	2.3
1993	1.1	1.3	2.4
1994	1.1	1.3	2.6
1995	1.2	1.3	2.7
1996	1.3	1.3	2.9
1997	1.3	1.3	3.0
1998	1.4	1.3	3.2
1999	1.4	1.3	3.3
2000	1.5	1.3	3.5
2001	1.6	1.3	3.6
2002	1.6	1.3	3.8
2003	1.7	1.3	3.9
2004	1.7	1.3	4.0
2005	1.8	1.3	4.2
2006	1.9	1.3	4.3
2007	1.9	1.3	4.5
2008	2.0	1.4	4.6
2009	2.0	1.4	4.6
2010	2.0	1.4	4.6
2011	2.0	1.4	4.6
2012	2.0	1.4	4.6
2013	2.0	1.4	4.6
2014	2.0	1.4	4.6
2015	2.0	1.4	4.6
2016	2.0	1.4	4.6

Non-dairy cattle

Table A 66: Manure Management System distribution in Austria for non-dairy cattle 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Non-dairy cattle	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	27.5	44.5	10.4	2.6	0.0	15.0
1991	27.5	44.4	10.1	2.8	0.0	15.2
1992	27.4	44.4	9.8	3.0	0.0	15.4
1993	28.3	43.9	9.8	3.1	0.0	14.9
1994	27.9	43.9	9.5	3.3	0.1	15.3

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Non-dairy cattle	[%]	[%]	[%]	[%]	[%]	[%]
1995	26.5	43.9	9.6	3.5	0.1	16.4
1996	26.2	43.9	9.4	3.7	0.1	16.7
1997	26.4	43.8	9.2	3.9	0.1	16.5
1998	26.3	43.8	8.9	4.1	0.1	16.7
1999	25.9	43.8	8.7	4.3	0.2	17.1
2000	24.8	43.7	8.7	4.6	0.2	18.0
2001	24.5	43.7	8.4	4.8	0.3	18.3
2002	24.6	43.6	8.1	4.9	0.3	18.4
2003	24.6	43.6	7.8	5.1	0.3	18.5
2004	24.3	43.5	7.6	5.3	0.4	18.9
2005	24.1	43.3	7.4	5.5	0.4	19.2
2006	24.1	43.2	7.1	5.7	0.4	19.4
2007	24.2	43.1	6.8	5.9	0.5	19.6
2008	24.2	43.0	6.5	6.1	0.5	19.8
2009	24.5	43.0	6.4	6.0	0.5	19.7
2010	24.6	42.9	6.3	6.0	0.5	19.6
2011	24.5	42.9	6.4	6.0	0.5	19.7
2012	24.4	43.0	6.3	6.0	0.5	19.7
2013	24.7	43.0	6.2	6.0	0.6	19.6
2014	24.7	43.0	6.1	6.0	0.6	19.6
2015	24.9	43.0	6.1	6.0	0.6	19.5
2016	24.8	43.1	6.0	6.0	0.6	19.5

Table A 67: Other systems in detail for non-dairy cattle 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Non-dairy cattle	[%]	[%]	[%]
1990	0.8	12.6	1.6
1991	0.9	12.6	1.7
1992	0.9	12.7	1.8
1993	1.0	12.0	1.9
1994	1.0	12.3	2.0
1995	1.1	13.2	2.1
1996	1.2	13.3	2.2
1997	1.2	13.0	2.3
1998	1.3	13.0	2.4
1999	1.4	13.2	2.5
2000	1.5	14.0	2.5
2001	1.5	14.2	2.6

Livestock category	Yard	Deep Litter	Aerobic Treatment
Non-dairy cattle	[%]	[%]	[%]
2002	1.6	14.1	2.7
2003	1.6	14.0	2.9
2004	1.7	14.2	3.0
2005	1.8	14.4	3.0
2006	1.8	14.5	3.1
2007	1.9	14.5	3.2
2008	1.9	14.5	3.3
2009	1.9	14.4	3.4
2010	1.9	14.3	3.4
2011	1.9	14.4	3.4
2012	1.9	14.4	3.4
2013	1.9	14.3	3.4
2014	1.9	14.3	3.4
2015	1.9	14.1	3.4
2016	1.9	14.2	3.4

Suckling cows

Table A 68: Manure Management System distribution in Austria for suckling cows 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Suckling cows	[%]	[%]	[%]	[%]	[%]	[%]
1990	17.2	46.0	10.7	2.9	0.0	23.3
1991	17.1	45.7	10.9	3.0	0.0	23.4
1992	17.0	45.3	11.1	3.2	0.0	23.4
1993	16.8	45.0	11.3	3.4	0.0	23.5
1994	16.7	44.7	11.5	3.5	0.1	23.6
1995	16.6	44.4	11.7	3.7	0.1	23.6
1996	16.4	44.0	11.9	3.9	0.1	23.7
1997	16.3	43.7	12.1	4.1	0.1	23.8
1998	16.1	43.4	12.3	4.2	0.1	23.8
1999	16.0	43.0	12.5	4.4	0.2	23.9
2000	15.8	42.7	12.7	4.6	0.2	24.0
2001	15.7	42.4	12.9	4.8	0.3	24.0
2002	15.5	42.1	13.1	4.9	0.3	24.1
2003	15.4	41.7	13.3	5.1	0.3	24.2
2004	15.2	41.4	13.5	5.3	0.4	24.2
2005	15.1	41.1	13.7	5.4	0.4	24.3
2006	14.9	40.7	13.9	5.6	0.4	24.4

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Suckling cows	[%]	[%]	[%]	[%]	[%]	[%]
2007	14.8	40.4	14.1	5.8	0.5	24.4
2008	14.7	40.1	14.3	6.0	0.5	24.5
2009	14.7	40.1	14.3	6.0	0.5	24.5
2010	14.7	40.0	14.3	6.0	0.5	24.5
2011	14.7	40.0	14.3	6.0	0.5	24.5
2012	14.6	40.0	14.3	6.0	0.5	24.5
2013	14.6	40.0	14.3	6.0	0.6	24.5
2014	14.6	40.0	14.3	6.0	0.6	24.5
2015	14.6	40.0	14.3	6.0	0.6	24.5
2016	14.6	40.0	14.3	6.0	0.6	24.5

Table A 69: Other systems in detail for suckling cows 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Suckling cows	[%]	[%]	[%]
1990	1.1	21.2	1.1
1991	1.1	21.1	1.1
1992	1.2	21.1	1.2
1993	1.3	21.0	1.2
1994	1.3	20.9	1.3
1995	1.4	20.9	1.4
1996	1.5	20.8	1.4
1997	1.5	20.7	1.5
1998	1.6	20.7	1.6
1999	1.7	20.6	1.6
2000	1.8	20.5	1.7
2001	1.8	20.5	1.8
2002	1.9	20.4	1.8
2003	2.0	20.3	1.9
2004	2.0	20.3	1.9
2005	2.1	20.2	2.0
2006	2.2	20.1	2.1
2007	2.2	20.1	2.1
2008	2.3	20.0	2.2
2009	2.3	20.0	2.2
2010	2.3	20.0	2.2
2011	2.3	20.0	2.2
2012	2.3	20.0	2.2
2013	2.3	20.0	2.2

Livestock category	Yard	Deep Litter	Aerobic Treatment
Suckling cows	**[%]**	**[%]**	**[%]**
2014	2.3	20.0	2.2
2015	2.3	20.0	2.2
2016	2.3	20.0	2.2

Young cattle <1year

Table A 70: Manure Management System distribution in Austria for young cattle <1 year 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Young cattle <1 year	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	16.9	51.0	4.8	3.2	0.0	24.1
1991	16.8	50.9	4.6	3.4	0.0	24.2
1992	16.8	50.7	4.5	3.6	0.0	24.4
1993	16.7	50.6	4.3	3.9	0.0	24.6
1994	16.6	50.4	4.2	4.1	0.1	24.7
1995	16.5	50.2	4.0	4.3	0.1	24.9
1996	16.4	50.1	3.8	4.5	0.1	25.0
1997	16.4	49.9	3.7	4.7	0.1	25.2
1998	16.3	49.7	3.5	5.0	0.1	25.4
1999	16.2	49.6	3.4	5.2	0.2	25.5
2000	16.1	49.4	3.2	5.4	0.2	25.7
2001	16.0	49.2	3.0	5.6	0.3	25.9
2002	15.9	49.1	2.9	5.8	0.3	26.0
2003	15.8	48.9	2.7	6.1	0.3	26.2
2004	15.7	48.8	2.6	6.3	0.4	26.3
2005	15.6	48.6	2.4	6.5	0.4	26.5
2006	15.5	48.4	2.2	6.7	0.4	26.7
2007	15.4	48.3	2.1	6.9	0.5	26.8
2008	15.4	48.1	1.9	7.2	0.5	27.0
2009	15.4	48.1	1.9	7.2	0.5	27.0
2010	15.4	48.1	1.9	7.2	0.5	27.0
2011	15.4	48.0	1.9	7.2	0.5	27.0
2012	15.3	48.0	1.9	7.2	0.5	27.0
2013	15.3	48.0	1.9	7.2	0.6	27.0
2014	15.3	48.0	1.9	7.2	0.6	27.0
2015	15.3	48.0	1.9	7.2	0.6	27.0
2016	15.3	48.0	1.9	7.2	0.6	27.0

Table A 71: Other systems in detail for young cattle <1 year 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Young cattle <1 year	**[%]**	**[%]**	**[%]**
1990	0.8	22.0	1.2
1991	0.9	22.1	1.3
1992	0.9	22.1	1.4
1993	1.0	22.1	1.5
1994	1.0	22.1	1.6
1995	1.1	22.2	1.6
1996	1.1	22.2	1.7
1997	1.2	22.2	1.8
1998	1.2	22.2	1.9
1999	1.3	22.3	2.0
2000	1.3	22.3	2.<1
2001	1.4	22.3	2.2
2002	1.4	22.3	2.2
2003	1.5	22.4	2.3
2004	1.5	22.4	2.4
2005	1.6	22.4	2.5
2006	1.7	22.4	2.6
2007	1.7	22.5	2.7
2008	1.8	22.5	2.7
2009	1.8	22.5	2.7
2010	1.8	22.5	2.7
2011	1.8	22.5	2.7
2012	1.8	22.5	2.7
2013	1.8	22.5	2.7
2014	1.8	22.5	2.7
2015	1.8	22.5	2.7
2016	1.8	22.5	2.7

Breeding heifers 1-2 years

Table A 72: Manure Management System distribution in Austria for breeding heifers 1-2 years 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Breeding heifers 1-2 years	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	25.7	37.9	26.2	2.4	0.0	7.8
1991	26.0	38.3	25.1	2.6	0.0	8.1
1992	26.3	38.7	23.9	2.8	0.0	8.3
1993	26.5	39.0	22.8	3.1	0.0	8.5

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Breeding heifers 1-2 years	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1994	26.8	39.4	21.7	3.3	0.1	8.8
1995	27.1	39.7	20.5	3.5	0.1	9.0
1996	27.4	40.1	19.4	3.8	0.1	9.3
1997	27.6	40.5	18.3	4.0	0.1	9.5
1998	27.9	40.8	17.1	4.2	0.1	9.8
1999	28.1	41.2	16.0	4.4	0.2	10.0
2000	28.4	41.6	14.9	4.7	0.2	10.3
2001	28.7	41.9	13.7	4.9	0.3	10.5
2002	28.9	42.3	12.6	5.1	0.3	10.8
2003	29.2	42.7	11.5	5.4	0.3	11.0
2004	29.4	43.0	10.3	5.6	0.4	11.2
2005	29.7	43.4	9.2	5.8	0.4	11.5
2006	30.0	43.8	8.1	6.0	0.4	11.7
2007	30.2	44.1	6.9	6.3	0.5	12.0
2008	30.5	44.5	5.8	6.5	0.5	12.2
2009	30.5	44.5	5.8	6.5	0.5	12.2
2010	30.5	44.4	5.8	6.5	0.5	12.2
2011	30.5	44.4	5.8	6.5	0.5	12.2
2012	30.5	44.4	5.8	6.5	0.5	12.2
2013	30.5	44.4	5.8	6.5	0.6	12.2
2014	30.5	44.4	5.8	6.5	0.6	12.2
2015	30.5	44.4	5.8	6.5	0.6	12.2
2016	30.5	44.4	5.8	6.5	0.6	12.2

Table A 73: Other systems in detail for breeding heifers 1-2 years 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Breeding heifers 1-2 years	**[%]**	**[%]**	**[%]**
1990	0.8	5.9	1.1
1991	0.8	6.0	1.2
1992	0.9	6.1	1.3
1993	0.9	6.2	1.4
1994	1.0	6.3	1.5
1995	1.0	6.4	1.6
1996	1.1	6.5	1.8
1997	1.1	6.6	1.9
1998	1.2	6.7	2.0
1999	1.2	6.7	2.1
2000	1.3	6.8	2.2

Livestock category	Yard	Deep Litter	Aerobic Treatment
Breeding heifers 1-2 years	**[%]**	**[%]**	**[%]**
2001	1.3	6.9	2.3
2002	1.4	7.0	2.4
2003	1.4	7.1	2.5
2004	1.5	7.2	2.6
2005	1.5	7.3	2.7
2006	1.6	7.4	2.8
2007	1.6	7.4	2.9
2008	1.7	7.5	3.0
2009	1.7	7.5	3.0
2010	1.7	7.5	3.0
2011	1.7	7.5	3.0
2012	1.7	7.5	3.0
2013	1.7	7.5	3.0
2014	1.7	7.5	3.0
2015	1.7	7.5	3.0
2016	1.7	7.5	3.0

Fattening heifers, bulls, oxen 1-2 year

Table A 74: Manure Management System distribution in Austria for fattening heifers, bulls, oxen 1-2 years 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Fattening heifers, bulls, oxen 1-2 years	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	46.5	41.4	0.6	1.9	0.0	9.5
1991	46.4	41.3	0.6	2.0	0.0	9.7
1992	46.2	41.1	0.6	2.2	0.0	9.9
1993	46.1	41.0	0.5	2.3	0.0	10.1
1994	45.9	40.8	0.5	2.4	0.1	10.2
1995	45.8	40.7	0.5	2.5	0.1	10.4
1996	45.6	40.6	0.5	2.7	0.1	10.6
1997	45.4	40.4	0.5	2.8	0.1	10.8
1998	45.3	40.3	0.4	2.9	0.1	11.0
1999	45.1	40.1	0.4	3.0	0.2	11.1
2000	44.9	40.0	0.4	3.2	0.2	11.3
2001	44.7	39.8	0.4	3.3	0.3	11.5
2002	44.5	39.7	0.4	3.4	0.3	11.7
2003	44.4	39.6	0.3	3.5	0.3	11.9
2004	44.2	39.4	0.3	3.7	0.4	12.0

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Fattening heifers, bulls, oxen 1-2 years	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
2005	44.0	39.3	0.3	3.8	0.4	12.2
2006	43.9	39.1	0.3	3.9	0.4	12.4
2007	43.7	39.0	0.3	4.0	0.5	12.6
2008	43.5	38.8	0.2	4.2	0.5	12.7
2009	43.5	38.8	0.2	4.2	0.5	12.7
2010	43.5	38.8	0.2	4.2	0.5	12.7
2011	43.5	38.8	0.2	4.2	0.5	12.7
2012	43.5	38.8	0.2	4.2	0.5	12.7
2013	43.5	38.8	0.2	4.2	0.6	12.7
2014	43.5	38.8	0.2	4.2	0.6	12.7
2015	43.5	38.8	0.2	4.2	0.6	12.7
2016	43.5	38.8	0.2	4.2	0.6	12.7

Table A 75: Other systems in detail for fattening heifers, bulls, oxen 1-2 years 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Fattening heifers, bulls, oxen 1-2 years	**[%]**	**[%]**	**[%]**
1990	0.8	6.8	2.0
1991	0.8	6.8	2.1
1992	0.9	6.8	2.2
1993	0.9	6.8	2.4
1994	1.0	6.8	2.5
1995	1.0	6.8	2.6
1996	1.1	6.8	2.8
1997	1.1	6.8	2.9
1998	1.2	6.8	3.0
1999	1.2	6.8	3.2
2000	1.3	6.8	3.3
2001	1.3	6.8	3.4
2002	1.4	6.8	3.5
2003	1.4	6.8	3.7
2004	1.5	6.8	3.8
2005	1.5	6.8	3.9
2006	1.6	6.8	4.1
2007	1.6	6.8	4.2
2008	1.7	6.8	4.3
2009	1.7	6.8	4.3
2010	1.7	6.8	4.3

Livestock category	Yard	Deep Litter	Aerobic Treatment
Fattening heifers, bulls, oxen 1-2 years	**[%]**	**[%]**	**[%]**
2011	1.7	6.8	4.3
2012	1.7	6.8	4.3
2013	1.7	6.8	4.3
2014	1.7	6.8	4.3
2015	1.7	6.8	4.3
2016	1.7	6.8	4.3

Other cattle >2 year

Table A 76: Manure Management System distribution in Austria for other cattle >2 years 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Other cattle >2 years	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	27.4	42.6	17.8	2.6	0.0	9.6
1991	27.4	42.7	17.2	2.8	0.0	9.9
1992	27.4	42.8	16.6	3.0	0.0	10.2
1993	27.4	42.9	16.0	3.2	0.0	10.5
1994	27.3	43.0	15.4	3.4	0.1	10.8
1995	27.3	43.0	14.8	3.6	0.1	11.1
1996	27.3	43.1	14.2	3.8	0.1	11.4
1997	27.3	43.2	13.6	4.0	0.1	11.7
1998	27.3	43.3	13.1	4.2	0.1	12.0
1999	27.2	43.4	12.5	4.4	0.2	12.3
2000	27.2	43.5	11.9	4.6	0.2	12.6
2001	27.2	43.6	11.3	4.8	0.3	12.9
2002	27.1	43.6	10.7	5.0	0.3	13.2
2003	27.1	43.7	10.1	5.2	0.3	13.5
2004	27.1	43.8	9.5	5.4	0.4	13.8
2005	27.1	43.9	8.9	5.7	0.4	14.1
2006	27.0	44.0	8.3	5.9	0.4	14.4
2007	27.0	44.1	7.7	6.1	0.5	14.7
2008	27.0	44.1	7.1	6.3	0.5	15.0
2009	27.0	44.1	7.1	6.3	0.5	15.0
2010	27.0	44.1	7.1	6.3	0.5	15.0
2011	27.0	44.1	7.1	6.3	0.5	15.0
2012	27.0	44.1	7.1	6.3	0.5	15.0
2013	27.0	44.1	7.1	6.3	0.6	15.0
2014	27.0	44.1	7.1	6.3	0.6	15.0
2015	27.0	44.1	7.1	6.3	0.6	15.0

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Other cattle >2 years	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
2016	27.0	44.1	7.1	6.3	0.6	15.0

Table A 77: Other systems in detail for other cattle >2 years 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Other cattle >2 years	**[%]**	**[%]**	**[%]**
1990	1.0	6.2	2.4
1991	1.0	6.3	2.6
1992	1.1	6.3	2.8
1993	1.1	6.4	3.0
1994	1.2	6.4	3.2
1995	1.3	6.5	3.4
1996	1.3	6.5	3.6
1997	1.4	6.5	3.8
1998	1.5	6.6	4.0
1999	1.5	6.6	4.2
2000	1.6	6.7	4.4
2001	1.6	6.7	4.6
2002	1.7	6.7	4.8
2003	1.8	6.8	4.9
2004	1.8	6.8	5.1
2005	1.9	6.9	5.3
2006	2.0	6.9	5.5
2007	2.0	6.9	5.7
2008	2.1	7.0	5.9
2009	2.1	7.0	5.9
2010	2.1	7.0	5.9
2011	2.1	7.0	5.9
2012	2.1	7.0	5.9
2013	2.1	7.0	5.9
2014	2.1	7.0	5.9
2015	2.1	7.0	5.9
2016	2.1	7.0	5.9

Swine (total)

Table A 78: Manure Management System distribution in Austria for swine (total) 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Swine (total)	[%]	[%]	[%]	[%]	[%]	[%]
1990	69.1	11.1	0.0	0.6	0.1	19.1
1991	69.5	10.9	0.0	0.7	0.1	18.8
1992	70.0	10.7	0.0	0.7	0.1	18.5
1993	70.4	10.6	0.0	0.7	0.2	18.1
1994	70.5	10.5	0.0	0.8	0.5	17.8
1995	70.8	10.4	0.0	0.8	0.6	17.4
1996	71.2	10.2	0.0	0.9	0.7	17.1
1997	71.5	10.0	0.0	0.9	0.9	16.8
1998	72.1	9.6	0.0	0.9	1.0	16.4
1999	72.1	9.4	0.0	0.9	1.5	16.1
2000	72.3	9.2	0.0	1.0	1.8	15.7
2001	72.5	9.1	0.0	1.0	2.0	15.4
2002	72.7	8.9	0.0	1.0	2.3	15.1
2003	73.0	8.7	0.0	1.1	2.5	14.7
2004	73.2	8.5	0.0	1.1	2.8	14.4
2005	73.8	8.2	0.0	1.1	2.9	14.0
2006	73.9	8.2	0.0	1.2	3.1	13.7
2007	74.7	7.7	0.0	1.2	3.3	13.2
2008	74.8	7.6	0.0	1.2	3.5	12.8
2009	75.1	7.4	0.0	1.2	3.5	12.8
2010	75.3	7.3	0.0	1.1	3.6	12.7
2011	75.0	7.4	0.0	1.1	3.8	12.7
2012	75.0	7.2	0.0	1.1	4.1	12.6
2013	74.7	7.1	0.0	1.1	4.5	12.6
2014	74.5	7.1	0.0	1.1	4.7	12.6
2015	74.1	7.1	0.0	1.1	5.0	12.6
2016	74.3	7.0	0.0	1.1	5.0	12.6

Table A 79: Other systems in detail for swine (total) 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Swine (total)	[%]	[%]	[%]
1990	0.7	16.9	1.5
1991	0.8	16.4	1.6
1992	0.8	15.9	1.7
1993	0.9	15.4	1.8
1994	0.9	14.9	1.9
1995	1.0	14.4	2.0

Livestock category	Yard	Deep Litter	Aerobic Treatment
Swine (total)	**[%]**	**[%]**	**[%]**
1996	1.0	13.9	2.2
1997	1.1	13.4	2.3
1998	1.1	12.9	2.4
1999	1.2	12.4	2.5
2000	1.2	11.9	2.6
2001	1.3	11.4	2.7
2002	1.3	10.9	2.9
2003	1.4	10.4	3.0
2004	1.4	9.9	3.1
2005	1.5	9.3	3.2
2006	1.5	8.8	3.3
2007	1.5	8.2	3.4
2008	1.6	7.7	3.6
2009	1.6	7.6	3.6
2010	1.6	7.6	3.6
2011	1.6	7.6	3.6
2012	1.6	7.5	3.6
2013	1.6	7.5	3.6
2014	1.6	7.4	3.6
2015	1.6	7.5	3.6
2016	1.6	7.4	3.6

Young & fattening pigs >20kg

Table A 80: Manure Management System distribution in Austria for young & fattening pigs >20kg 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Young & fattening pigs >20kg	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	69.9	7.9	0.0	0.3	0.1	21.7
1991	70.9	7.6	0.0	0.3	0.1	21.1
1992	71.8	7.2	0.0	0.3	0.1	20.4
1993	72.8	6.9	0.0	0.3	0.2	19.8
1994	73.5	6.6	0.0	0.3	0.5	19.1
1995	74.4	6.2	0.0	0.3	0.6	18.5
1996	75.3	5.9	0.0	0.3	0.7	17.8
1997	76.2	5.5	0.0	0.3	0.9	17.2
1998	77.0	5.2	0.0	0.3	1.0	16.5
1999	77.5	4.8	0.0	0.3	1.5	15.8
2000	78.3	4.5	0.0	0.3	1.8	15.2

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Young & fattening pigs >20kg	[%]	[%]	[%]	[%]	[%]	[%]
2001	79.1	4.1	0.0	0.3	2.0	14.5
2002	79.8	3.8	0.0	0.3	2.3	13.9
2003	80.6	3.4	0.0	0.3	2.5	13.2
2004	81.3	3.1	0.0	0.3	2.8	12.6
2005	82.2	2.7	0.0	0.3	2.9	11.9
2006	83.0	2.4	0.0	0.3	3.1	11.2
2007	83.9	2.0	0.0	0.3	3.3	10.6
2008	84.6	1.7	0.0	0.2	3.5	9.9
2009	84.6	1.7	0.0	0.2	3.5	9.9
2010	84.5	1.7	0.0	0.2	3.6	9.9
2011	84.3	1.8	0.0	0.2	3.8	9.9
2012	84.0	1.8	0.0	0.2	4.1	9.9
2013	83.6	1.7	0.0	0.2	4.5	9.9
2014	83.3	1.7	0.0	0.2	4.7	9.9
2015	83.1	1.7	0.0	0.2	5.0	9.9
2016	83.1	1.7	0.0	0.2	5.0	9.9

Table A 81: Other systems in detail for young & fattening pigs >20kg 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Young & fattening pigs >20kg	[%]	[%]	[%]
1990	0.6	19.9	1.3
1991	0.6	19.1	1.4
1992	0.6	18.2	1.6
1993	0.7	17.4	1.7
1994	0.7	16.6	1.8
1995	0.7	15.8	2.0
1996	0.8	14.9	2.1
1997	0.8	14.1	2.2
1998	0.8	13.3	2.4
1999	0.9	12.5	2.5
2000	0.9	11.7	2.6
2001	1.0	10.8	2.7
2002	1.0	10.0	2.9
2003	1.0	9.2	3.0
2004	1.1	8.4	3.1
2005	1.1	7.5	3.3
2006	1.1	6.7	3.4

Livestock category	Yard	Deep Litter	Aerobic Treatment
Young & fattening pigs >20kg	[%]	[%]	[%]
2007	1.2	5.9	3.5
2008	1.2	5.1	3.7
2009	1.2	5.1	3.7
2010	1.2	5.1	3.7
2011	1.2	5.1	3.7
2012	1.2	5.1	3.7
2013	1.2	5.1	3.7
2014	1.2	5.1	3.7
2015	1.2	5.1	3.7
2016	1.2	5.1	3.7

Breeding sows >50kg

Table A 82: Manure Management System distribution in Austria for breeding sows >50kg 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Breeding sows >50kg	[%]	[%]	[%]	[%]	[%]	[%]
1990	67.3	17.9	0.0	1.2	0.1	13.5
1991	66.6	18.1	0.0	1.3	0.1	13.8
1992	65.9	18.3	0.0	1.5	0.1	14.2
1993	65.2	18.5	0.0	1.6	0.2	14.5
1994	64.1	18.7	0.0	1.7	0.5	14.9
1995	63.4	19.0	0.0	1.8	0.6	15.2
1996	62.6	19.2	0.0	2.0	0.7	15.6
1997	61.7	19.4	0.0	2.1	0.9	15.9
1998	60.9	19.6	0.0	2.2	1.0	16.3
1999	59.7	19.8	0.0	2.3	1.5	16.7
2000	58.7	20.0	0.0	2.5	1.8	17.0
2001	57.9	20.2	0.0	2.6	2.0	17.4
2002	56.9	20.4	0.0	2.7	2.3	17.7
2003	56.0	20.6	0.0	2.8	2.5	18.1
2004	55.0	20.8	0.0	3.0	2.8	18.4
2005	54.2	21.1	0.0	3.1	2.9	18.8
2006	53.3	21.3	0.0	3.2	3.1	19.1
2007	52.4	21.5	0.0	3.3	3.3	19.5
2008	51.5	21.7	0.0	3.5	3.5	19.8
2009	51.5	21.7	0.0	3.5	3.5	19.8
2010	51.4	21.8	0.0	3.5	3.6	19.8
2011	51.2	21.8	0.0	3.5	3.8	19.8
2012	50.9	21.8	0.0	3.5	4.1	19.8

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Breeding sows >50kg	[%]	[%]	[%]	[%]	[%]	[%]
2013	50.5	21.8	0.0	3.5	4.5	19.8
2014	50.2	21.7	0.0	3.5	4.7	19.8
2015	50.0	21.7	0.0	3.5	5.0	19.8
2016	49.9	21.7	0.0	3.5	5.0	19.8

Table A 83: Other systems in detail for breeding sows >50kg 1990–2016.

Livestock category	Yard	Deep Litter	Aerobic Treatment
Breeding sows >50kg	[%]	[%]	[%]
1990	1.2	10.6	1.8
1991	1.2	10.7	1.9
1992	1.3	10.9	1.9
1993	1.4	11.1	2.0
1994	1.5	11.3	2.1
1995	1.5	11.5	2.2
1996	1.6	11.7	2.3
1997	1.7	11.9	2.4
1998	1.8	12.1	2.5
1999	1.8	12.3	2.5
2000	1.9	12.5	2.6
2001	2.0	12.7	2.7
2002	2.1	12.8	2.8
2003	2.1	13.0	2.9
2004	2.2	13.2	3.0
2005	2.3	13.4	3.1
2006	2.4	13.6	3.1
2007	2.5	13.8	3.2
2008	2.5	14.0	3.3
2009	2.5	14.0	3.3
2010	2.5	14.0	3.3
2011	2.5	14.0	3.3
2012	2.5	14.0	3.3
2013	2.5	14.0	3.3
2014	2.5	14.0	3.3
2015	2.5	14.0	3.3
2016	2.5	14.0	3.3

Layers

Table A 84: Manure Management System distribution in Austria for chicken 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Chicken	**[%]**	**[%]**	**[%]**
1990	0.0	99.8	0.2
1991	0.0	99.7	0.3
1992	0.0	99.7	0.3
1993	0.0	99.6	0.4
1994	0.0	98.9	1.1
1995	0.0	98.7	1.3
1996	0.0	98.5	1.5
1997	0.0	98.3	1.7
1998	0.0	97.9	2.1
1999	0.0	97.1	2.9
2000	0.0	95.9	4.1
2001	0.0	95.6	4.4
2002	0.0	95.2	4.8
2003	0.0	94.9	5.1
2004	0.0	94.7	5.3
2005	0.0	94.5	5.5
2006	0.0	94.3	5.7
2007	0.0	93.8	6.2
2008	0.0	93.5	6.5
2009	0.0	93.2	6.8
2010	0.0	93.0	7.0
2011	0.0	92.8	7.2
2012	0.0	92.9	7.1
2013	0.0	93.1	6.9
2014	0.0	93.2	6.8
2015	0.0	92.5	7.5
2016	0.0	92.6	7.4

Broilers

Table A 85: Manure Management System distribution in Austria for chicken 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Chicken	**[%]**	**[%]**	**[%]**
1990	0.0	99.8	0.2
1991	0.0	99.7	0.3
1992	0.0	99.7	0.3
1993	0.0	99.6	0.4
1994	0.0	98.9	1.1

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Chicken	**[%]**	**[%]**	**[%]**
1995	0.0	98.7	1.3
1996	0.0	98.5	1.5
1997	0.0	98.3	1.7
1998	0.0	97.9	2.1
1999	0.0	97.1	2.9
2000	0.0	95.9	4.1
2001	0.0	95.6	4.4
2002	0.0	95.2	4.8
2003	0.0	94.9	5.1
2004	0.0	94.7	5.3
2005	0.0	94.5	5.5
2006	0.0	94.3	5.7
2007	0.0	93.8	6.2
2008	0.0	93.5	6.5
2009	0.0	93.2	6.8
2010	0.0	93.0	7.0
2011	0.0	92.8	7.2
2012	0.0	92.9	7.1
2013	0.0	93.1	6.9
2014	0.0	93.2	6.8
2015	0.0	92.5	7.5
2016	0.0	92.6	7.4

Other poultry (total)

Table A 86: Manure Management System distribution in Austria for other poultry 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Other poultry	**[%]**	**[%]**	**[%]**
1990	0.0	100.0	0.0
1991	0.0	100.0	0.0
1992	0.0	100.0	0.0
1993	0.0	100.0	0.0
1994	0.0	100.0	0.0
1995	0.0	100.0	0.0
1996	0.0	100.0	0.0
1997	0.0	100.0	0.0
1998	0.0	100.0	0.0
1999	0.0	100.0	0.0
2000	0.0	100.0	0.0
2001	0.0	100.0	0.0

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Other poultry	**[%]**	**[%]**	**[%]**
2002	0.0	100.0	0.0
2003	0.0	100.0	0.0
2004	0.0	100.0	0.0
2005	0.0	100.0	0.0
2006	0.0	100.0	0.0
2007	0.0	100.0	0.0
2008	0.0	100.0	0.0
2009	0.0	100.0	0.0
2010	0.0	100.0	0.0
2011	0.0	100.0	0.0
2012	0.0	100.0	0.0
2013	0.0	100.0	0.0
2014	0.0	100.0	0.0
2015	0.0	100.0	0.0
2016	0.0	100.0	0.0

Turkeys

Table A 87: Manure Management System distribution in Austria for other poultry 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Other poultry	**[%]**	**[%]**	**[%]**
1990	0.0	100.0	0.0
1991	0.0	100.0	0.0
1992	0.0	100.0	0.0
1993	0.0	100.0	0.0
1994	0.0	100.0	0.0
1995	0.0	100.0	0.0
1996	0.0	100.0	0.0
1997	0.0	100.0	0.0
1998	0.0	100.0	0.0
1999	0.0	100.0	0.0
2000	0.0	100.0	0.0
2001	0.0	100.0	0.0
2002	0.0	100.0	0.0

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Other poultry	[%]	[%]	[%]
2003	0.0	100.0	0.0
2004	0.0	100.0	0.0
2005	0.0	100.0	0.0
2006	0.0	100.0	0.0
2007	0.0	100.0	0.0
2008	0.0	100.0	0.0
2009	0.0	100.0	0.0
2010	0.0	100.0	0.0
2011	0.0	100.0	0.0
2012	0.0	100.0	0.0
2013	0.0	100.0	0.0
2014	0.0	100.0	0.0
2015	0.0	100.0	0.0
2016	0.0	100.0	0.0

Other poultry (geese, ducks, etc.)

Table A 88: Manure Management System distribution in Austria for other poultry 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Other poultry	[%]	[%]	[%]
1990	0.0	100.0	0.0
1991	0.0	100.0	0.0
1992	0.0	100.0	0.0
1993	0.0	100.0	0.0
1994	0.0	100.0	0.0
1995	0.0	100.0	0.0
1996	0.0	100.0	0.0
1997	0.0	100.0	0.0
1998	0.0	100.0	0.0
1999	0.0	100.0	0.0
2000	0.0	100.0	0.0
2001	0.0	100.0	0.0
2002	0.0	100.0	0.0
2003	0.0	100.0	0.0
2004	0.0	100.0	0.0
2005	0.0	100.0	0.0
2006	0.0	100.0	0.0
2007	0.0	100.0	0.0
2008	0.0	100.0	0.0
2009	0.0	100.0	0.0

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion
Other poultry	**[%]**	**[%]**	**[%]**
2010	0.0	100.0	0.0
2011	0.0	100.0	0.0
2012	0.0	100.0	0.0
2013	0.0	100.0	0.0
2014	0.0	100.0	0.0
2015	0.0	100.0	0.0
2016	0.0	100.0	0.0

Sheep

Table A 89: Manure Management System distribution in Austria for sheep 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Sheep	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	0.0	50.0	50.0	0.0	0.0	0.0
1991	0.0	50.0	50.0	0.0	0.0	0.0
1992	0.0	50.0	50.0	0.0	0.0	0.0
1993	0.0	50.0	50.0	0.0	0.0	0.0
1994	0.0	50.0	50.0	0.0	0.0	0.0
1995	0.0	50.0	50.0	0.0	0.0	0.0
1996	0.0	50.0	50.0	0.0	0.0	0.0
1997	0.0	50.0	50.0	0.0	0.0	0.0
1998	0.0	50.0	50.0	0.0	0.0	0.0
1999	0.0	50.0	50.0	0.0	0.0	0.0
2000	0.0	50.0	50.0	0.0	0.0	0.0
2001	0.0	50.0	50.0	0.0	0.0	0.0
2002	0.0	50.0	50.0	0.0	0.0	0.0
2003	0.0	50.0	50.0	0.0	0.0	0.0
2004	0.0	50.0	50.0	0.0	0.0	0.0
2005	0.0	50.0	50.0	0.0	0.0	0.0
2006	0.0	50.0	50.0	0.0	0.0	0.0
2007	0.0	50.0	50.0	0.0	0.0	0.0
2008	0.0	50.0	50.0	0.0	0.0	0.0
2009	0.0	50.0	50.0	0.0	0.0	0.0
2010	0.0	50.0	50.0	0.0	0.0	0.0
2011	0.0	50.0	50.0	0.0	0.0	0.0
2012	0.0	50.0	50.0	0.0	0.0	0.0
2013	0.0	50.0	50.0	0.0	0.0	0.0
2014	0.0	50.0	50.0	0.0	0.0	0.0
2015	0.0	50.0	50.0	0.0	0.0	0.0

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Sheep	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
2016	0.0	50.0	50.0	0.0	0.0	0.0

Goats

Table A 90: Manure Management System distribution in Austria for goats 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Goats	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1990	0.0	50.0	50.0	0.0	0.0	0.0
1991	0.0	50.0	50.0	0.0	0.0	0.0
1992	0.0	50.0	50.0	0.0	0.0	0.0
1993	0.0	50.0	50.0	0.0	0.0	0.0
1994	0.0	50.0	50.0	0.0	0.0	0.0
1995	0.0	50.0	50.0	0.0	0.0	0.0
1996	0.0	50.0	50.0	0.0	0.0	0.0
1997	0.0	50.0	50.0	0.0	0.0	0.0
1998	0.0	50.0	50.0	0.0	0.0	0.0
1999	0.0	50.0	50.0	0.0	0.0	0.0
2000	0.0	50.0	50.0	0.0	0.0	0.0
2001	0.0	50.0	50.0	0.0	0.0	0.0
2002	0.0	50.0	50.0	0.0	0.0	0.0
2003	0.0	50.0	50.0	0.0	0.0	0.0
2004	0.0	50.0	50.0	0.0	0.0	0.0
2005	0.0	50.0	50.0	0.0	0.0	0.0
2006	0.0	50.0	50.0	0.0	0.0	0.0
2007	0.0	50.0	50.0	0.0	0.0	0.0
2008	0.0	50.0	50.0	0.0	0.0	0.0
2009	0.0	50.0	50.0	0.0	0.0	0.0
2010	0.0	50.0	50.0	0.0	0.0	0.0
2011	0.0	50.0	50.0	0.0	0.0	0.0
2012	0.0	50.0	50.0	0.0	0.0	0.0
2013	0.0	50.0	50.0	0.0	0.0	0.0
2014	0.0	50.0	50.0	0.0	0.0	0.0
2015	0.0	50.0	50.0	0.0	0.0	0.0
2016	0.0	50.0	50.0	0.0	0.0	0.0

Horses

Table A 91: Manure Management System distribution in Austria for horses 1990–2016.

Horses	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
	[%]	[%]	[%]	[%]	[%]	[%]
1990	0.0	79.8	20.0	0.0	0.2	0.0
1991	0.0	79.7	20.0	0.0	0.3	0.0
1992	0.0	79.7	20.0	0.0	0.3	0.0
1993	0.0	79.6	20.0	0.0	0.4	0.0
1994	0.0	79.0	20.0	0.0	1.0	0.0
1995	0.0	79.0	20.0	0.0	1.0	0.0
1996	0.0	78.9	20.0	0.0	1.1	0.0
1997	0.0	78.6	20.0	0.0	1.4	0.0
1998	0.0	78.4	20.0	0.0	1.6	0.0
1999	0.0	77.9	20.0	0.0	2.1	0.0
2000	0.0	77.6	20.0	0.0	2.4	0.0
2001	0.0	77.3	20.0	0.0	2.7	0.0
2002	0.0	77.1	20.0	0.0	2.9	0.0
2003	0.0	76.9	20.0	0.0	3.1	0.0
2004	0.0	76.8	20.0	0.0	3.2	0.0
2005	0.0	76.7	20.0	0.0	3.3	0.0
2006	0.0	76.6	20.0	0.0	3.4	0.0
2007	0.0	76.4	20.0	0.0	3.6	0.0
2008	0.0	77.3	20.0	0.0	2.7	0.0
2009	0.0	78.2	20.0	0.0	1.8	0.0
2010	0.0	79.1	20.0	0.0	0.9	0.0
2011	0.0	80.0	20.0	0.0	0.0	0.0
2012	0.0	80.0	20.0	0.0	0.0	0.0
2013	0.0	80.0	20.0	0.0	0.0	0.0
2014	0.0	80.0	20.0	0.0	0.0	0.0
2015	0.0	80.0	20.0	0.0	0.0	0.0
2016	0.0	80.0	20.0	0.0	0.0	0.0

Deer

Table A 92: Manure Management System distribution in Austria for other animals (deer) 1990–2016.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Deer	[%]	[%]	[%]	[%]	[%]	[%]
1990	0.0	20.0	80.0	0.0	0.0	0.0
1991	0.0	20.0	80.0	0.0	0.0	0.0
1992	0.0	20.0	80.0	0.0	0.0	0.0

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock	Composting	Anaerobic Digestion	Other Systems
Deer	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1993	0.0	20.0	80.0	0.0	0.0	0.0
1994	0.0	20.0	80.0	0.0	0.0	0.0
1995	0.0	20.0	80.0	0.0	0.0	0.0
1996	0.0	20.0	80.0	0.0	0.0	0.0
1997	0.0	20.0	80.0	0.0	0.0	0.0
1998	0.0	20.0	80.0	0.0	0.0	0.0
1999	0.0	20.0	80.0	0.0	0.0	0.0
2000	0.0	20.0	80.0	0.0	0.0	0.0
2001	0.0	20.0	80.0	0.0	0.0	0.0
2002	0.0	20.0	80.0	0.0	0.0	0.0
2003	0.0	20.0	80.0	0.0	0.0	0.0
2004	0.0	20.0	80.0	0.0	0.0	0.0
2005	0.0	20.0	80.0	0.0	0.0	0.0
2006	0.0	20.0	80.0	0.0	0.0	0.0
2007	0.0	20.0	80.0	0.0	0.0	0.0
2008	0.0	20.0	80.0	0.0	0.0	0.0
2009	0.0	20.0	80.0	0.0	0.0	0.0
2010	0.0	20.0	80.0	0.0	0.0	0.0
2011	0.0	20.0	80.0	0.0	0.0	0.0
2012	0.0	20.0	80.0	0.0	0.0	0.0
2013	0.0	20.0	80.0	0.0	0.0	0.0
2014	0.0	20.0	80.0	0.0	0.0	0.0
2015	0.0	20.0	80.0	0.0	0.0	0.0
2016	0.0	20.0	80.0	0.0	0.0	0.0

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 2016 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 and N_2O 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 2018, chapter 6 (UMWELTBUNDESAMT 2018).

The N-flow model used by Austria was developed by the University of Natural Resources and Applied Life Sciences Vienna on behalf of the Umweltbundesamt in 2001 and further improved in 2008 and 2009 (AMON et al. 2002, 2008 & 2010). In 2014 the national emission model of sector agriculture was updated according to the 2006 IPCC Guidelines (AMON & HÖRTENHUBER 2014).

The following figure illustrates the pathways of N in the calculation of N-species emissions from the N excreted by livestock.

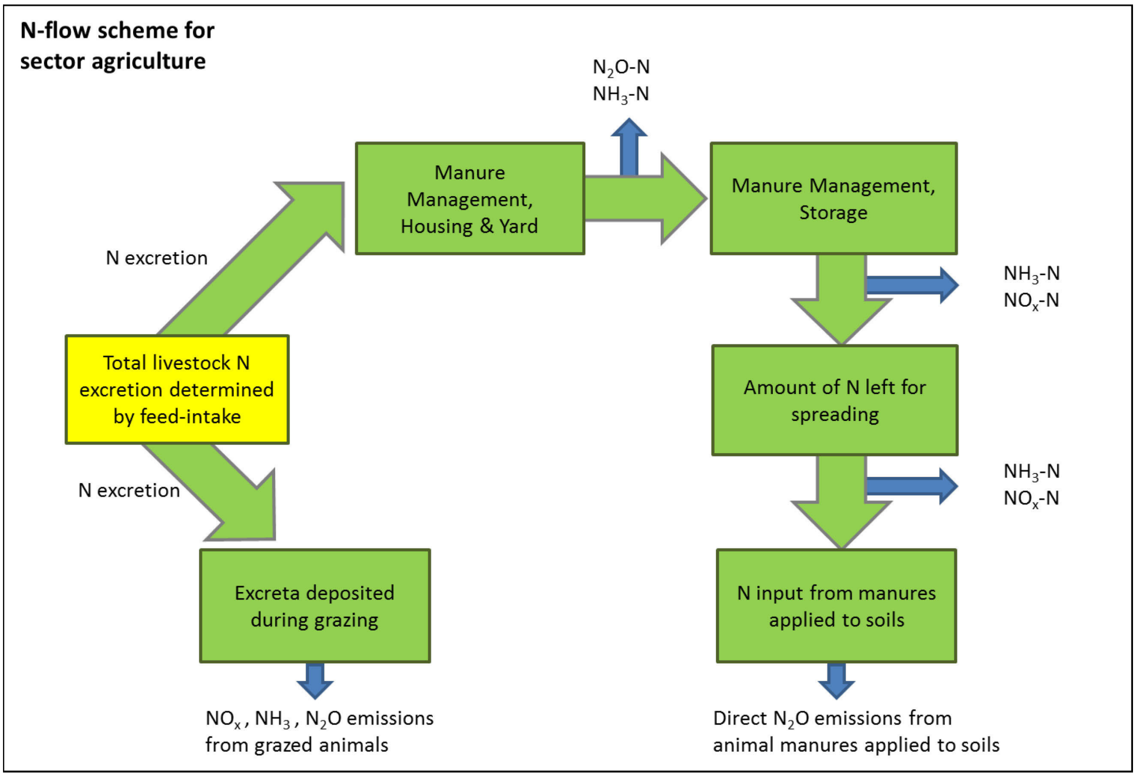

Figure 1 Schematic diagram of the Austrian N flow (animal manure)

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 2016).

N losses from manure management resulting from emissions of N_2O and NO_x 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 AWMS 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 $Frac_{LEACH}$.

New 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.

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EAGER: European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

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Annex 3.3 – CO_2 Reference Approach

In this annex the results, methodology and detailed data for the CO_2 reference approach are presented.

Methodology

The default methodology was used.

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.The selected values are presented in Table A 46.

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 46.

Activity data

Production, Imports, Exports, Stock Change

Activity data are taken from the national energy balance (IEA JQ 2017) (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 have been 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).

Lubricants are considered to be 100% stored.

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 2017). Changes of activity data are based on energy balance recalculations as described in Annex 2.

Results of the Reference Approach

Table A 94 to Table A 99 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 94 presents the calculation results for each fuel type of the Reference Approach for selected years.

Table A 93: Actual CO_2 emissions (kt CO_2) for selected years.

Fuel Type	1990	2000	2005	2008	2010	2012	2013	2014	2015
Crude Oil	24 783.73	25 693.58	27 257.98	27 141.55	24 151.05	26 021.05	26 697.37	26 289.08	27 679.12
Orimulsion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Liquids	109.89	286.93	294.93	317.83	359.16	332.36	217.11	469.06	142.06

Fuel Type	**1990**	**2000**	**2005**	**2008**	**2010**	**2012**	**2013**	**2014**	**2015**
Gasoline	-218.42	495.39	833.99	451.73	941.07	420.73	238.45	-435.86	-311.34
Jet Kerosene	-851.9	-1 587.6	-1 735.6	-1 359.2	-1 379.7	-1 820.0	-1 935.2	-1 713.8	-1 917.8
Other Kerosene	-43.87	15.56	9.34	6.22	3.12	18.69	12.46	3.12	3.12
Shale Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas / Diesel Oil	1 748.00	7 081.90	13 297.91	10 990.23	12 303.71	10 003.05	10 919.54	10 259.46	10 586.03
Residuel Fuel Oil	650.93	399.62	-424.88	-574.34	-423.89	-864.54	-1 244.30	-1 446.70	-1 500.72
LPG	248.20	397.44	327.82	214.68	295.91	168.70	113.44	116.35	-90.17
Ethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphtha	-1 070.26	-1 443.25	-1 401.99	-2 142.18	-2 259.35	-2 650.49	-2 654.61	-2 417.79	-2 326.19
Bitumen	-907.03	-1 206.82	-1 629.26	-1 605.92	-984.59	-1 234.10	-1 058.77	-1 058.77	-977.84
Lubricants	154.84	-173.19	-217.64	-282.02	-194.65	118.02	68.97	59.77	58.24
Petroleum Coke	96.84	82.09	210.46	137.78	152.67	175.44	161.49	155.28	149.07
Refinery Feedstocks	3 018.60	1 619.92	1 097.41	1 228.82	704.15	257.32	73.30	252.38	-350.19
OtherOil	432.21	-26.39	-56.42	-78.09	-297.34	12.26	-70.50	-26.06	-26.06
Liquid Fossil Totals	**28 151.81**	**31 635.17**	**37 864.07**	**34 447.06**	**33 371.33**	**30 958.46**	**31 538.74**	**30 505.51**	**31 117.28**
Anthracite	40.45	6.74	12.13	6.74	4.04	26.96	2.70	0.00	0.00
Coking Coal	7 004.27	5 626.33	5 671.96	4 802.19	4 747.01	4 622.09	4 613.12	4 548.03	4 608.92
Other Bit. Coal	4 712.74	4 809.32	5 614.53	5 187.40	4 553.66	4 059.10	3 896.16	2 859.15	2 863.12
Sub- Bit. Coal	0.00	79.42	137.00	165.45	141.89	153.45	152.24	177.43	170.47
Lignite	2 729.15	1 318.72	1 210.83	16.10	59.08	28.61	21.67	23.80	21.95
Oil Shale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB & Patent Fuel	548.08	197.83	92.32	160.21	76.11	49.55	46.44	37.30	36.28
Coke Oven / Gas Coke	-3 268.72	-3 383.49	-3 408.46	-3 770.12	-3 935.66	-3 838.71	-3 789.42	-3 723.94	-3 617.88
Coal Tar	0.00	-143.12	-2.92	0.00	0.00	0.00	58.42	64.38	-140.12
Solid Fuel Totals	**11 765.95**	**8 511.75**	**9 327.40**	**6 567.97**	**5 646.13**	**5 101.06**	**5 001.33**	**3 986.14**	**3 942.74**
Gaseous Fossil	11 416.95	14 782.05	18 292.60	17 024.62	18 364.33	16 523.01	15 953.96	14 423.01	15 396.85
Waste (non-biomass fraction)	758.20	935.55	1 457.30	2 192.75	2 408.48	2 345.40	2 205.43	2 279.94	2 444.27
Peat	0.47	0.47	0.47	0.44	0.47	0.47	0.47	0.47	0.47
TOTAL	**52 093.37**	**55 864.98**	**66 941.83**	**60 232.84**	**59 790.73**	**54 928.39**	**54 699.93**	**51 195.07**	**52 901.60**
Biomass Total	**9 416.02**	**11 831.39**	**15 025.96**	**19 005.23**	**21 442.66**	**21 932.44**	**23 121.83**	**21 891.96**	**22 993.80**
Solid Biomass	9 196.61	11 253.98	13 314.64	16 098.59	18 507.34	18 658.43	19 835.45	17 617.24	18 473.58
Liquid Biomass	18.54	50.96	246.05	934.75	970.07	1 008.89	966.02	1 308.85	1 472.12
Gas Biomass	0.00	139.79	520.89	783.68	703.66	947.24	925.58	1 361.44	1 377.31
Other non-fossil fuels (biogenic waste)	200.88	386.65	944.38	1 188.20	1 261.59	1 317.89	1 394.78	1 604.42	1 670.80

Table A 95 presents the apparent fuel consumption for each fuel type of the Reference Approach.

Table A 94: Apparent Consumption (TJ) for selected years.

Fuel Type	1990	2000	2005	2010	2012	2013	2014	2015	2016
Crude Oil	337 960	350 367	371 700	329 333	354 833	364 055	358 488	377 443	347 863
Orimulsion	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	1 743	4 550	4 677	5 695	5 270	3 443	7 438	2 253	255
Gasoline	-3 152	7 149	12 035	14 337	6 574	3 681	-6 746	-4 830	-4 280
Jet Kerosene	-11 914	-22 204	-24 274	-19 297	-25 455	-27 055	-23 969	-26 823	-27 028
Other Kerosene	-610	217	130	43	260	173	43	43	0
Shale Oil	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	23 600	95 615	181 233	177 606	144 616	157 791	149 131	154 707	175 818
Residuel Fuel Oil	13 251	14 778	4 221	2 913	-6 491	-10 917	-14 002	-18 480	-18 263
LPG	3 936	6 302	5 198	4 692	2 721	1 799	1 845	-1 430	-784
Ethane	0	0	0	0	0	0	0	0	0
Naphtha	90	0	-450	-4 816	-8 327	-8 282	-90	180	180
Bitumen	11 328	10 643	8 018	6 688	3 386	4 138	5 267	5 977	5 601
Lubricants	5 506	-84	-1 296	-1 296	3 302	1 965	1 630	1 588	1 714
Petroleum Coke	2 881	2 069	3 339	3 350	2 593	2 556	2 680	1 663	2 218
Refinery Feedstocks	41 163	22 090	14 965	9 602	3 509	1 000	3 442	-4 775	12 851
OtherOil	6 646	393	-347	-3 051	1 672	1 170	1 714	2 466	2 842
Liquid Fossil Totals	**432 428**	**491 883**	**579 149**	**525 800**	**488 463**	**495 517**	**486 869**	**489 982**	**498 986**
Anthracite	448	84	140	56	280	28	0	0	1 988
Coking Coal	67 937	54 564	55 204	53 622	52 297	52 162	51 421	51 366	52 048
Other Bit. Coal	50 568	51 604	60 229	53 379	47 645	48 452	38 163	54 729	43 962
Sub- Bit. Coal	0	844	1 455	1 507	1 630	1 617	1 885	1 811	1 544
Lignite	27 294	13 188	11 915	297	120	107	118	107	99
Oil Shale	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	5 912	2 134	1 017	811	535	493	403	326	317
Coke Oven / Gas Coke	19 304	30 110	36 810	33 635	34 037	35 459	34 640	29 334	26 735
Coal Tar	0	-1 810	-37	74	406	1 551	1 665	-1 735	-1 444
Solid Fuel Totals	**171 462**	**150 718**	**166 733**	**143 381**	**136 950**	**139 870**	**128 295**	**135 936**	**125 249**
Gaseous Fossil	**219 239**	**275 681**	**338 530**	**340 091**	**306 750**	**295 610**	**269 832**	**287 931**	**300 691**
Waste (non-biomass fraction)	**8 073**	**10 509**	**18 374**	**25 974**	**28 796**	**28 867**	**30 694**	**31 833**	**34 304**
Peat	4	4	4	4	4	4	4	4	0
TOTAL	831 205	928 797	1 102 790	1 035 251	960 963	959 868	915 694	945 687	959 230
Biomass Total	**96 503**	**120 409**	**147 182**	**213 773**	**226 323**	**239 895**	**226 617**	**236 233**	**235 644**
Solid Biomass	95 324	116 649	136 056	187 964	197 627	211 651	188 568	195 256	200 634
Liquid Biomass	262	720	3 299	13 631	14 250	13 643	18 484	20 789	14 585
Gas Biomass	0	1 275	4 751	6 418	8 431	8 235	12 234	12 561	13 109
Other non-fossil fuels (biogenic waste)	917	1 765	3 076	5 759	6 016	6 367	7 332	7 627	7 316

Table A 96 presents the carbon stored for each fuel type of the Reference Approach.

Table A 95: Carbon Stored (kt C) for selected years

Fuel Type	1990	2000	2005	2010	2012	2013	2014	2015	2016
Crude Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orimulsion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Liquids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jet Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shale Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas / Diesel Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residuel Fuel Oil	102.08	202.84	204.95	177.08	98.83	109.00	100.50	20.12	0.00
LPG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphtha	293.69	393.61	373.36	519.87	556.32	558.35	657.60	638.02	651.52
Bitumen	496.58	563.27	620.75	415.66	411.06	379.79	404.62	398.19	429.45
Lubricants	67.90	45.56	33.44	27.17	33.86	20.48	16.30	15.88	17.14
Petroleum Coke	52.82	34.51	34.44	50.50	23.47	26.26	31.34	5.08	16.94
Refinery Feedstocks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OtherOil	15.05	15.05	8.45	20.06	30.10	42.64	41.38	37.62	46.40
Liquid Fossil Totals	**1 028.12**	**1 254.84**	**1 275.39**	**1 210.34**	**1 153.64**	**1 136.51**	**1 251.74**	**1 114.91**	**1 161.45**
Anthracite	0.75	0.38	0.38	0.38	0.00	0.00	0.00	0.00	0.00
Coking Coal	37.10	29.59	58.62	54.35	59.18	60.93	54.37	39.78	35.54
Other Bit. Coal	0.00	0.00	0.00	116.01	98.51	152.91	185.58	597.08	609.65
Sub- Bit. Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lignite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil Shale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB & Patent Fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Oven / Gas Coke	1 474.97	1 823.38	2 066.73	2 092.32	2 077.40	2 101.39	2 069.77	1 903.61	1 819.28
Coal Tar	0.00	0.00	0.00	1.63	8.94	17.88	18.73	0.81	0.81
Solid Fuel Totals	**1 512.83**	**1 853.35**	**2 125.73**	**2 263.04**	**2 235.08**	**2 315.24**	**2 309.72**	**2 540.47**	**2 464.48**
Gaseous Fossil	**198.79**	**133.83**	**125.99**	**130.00**	**128.47**	**115.40**	**143.51**	**137.56**	**127.48**
Waste (non-biomass fraction)	**0.00**	**0.00**	**0.00**	**51.06**	**47.97**	**32.20**	**31.39**	**30.81**	**30.46**
Peat	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
TOTAL	**2 739.73**	**3 242.02**	**3 527.10**	**3 603.38**	**3 517.20**	**3 567.15**	**3 704.97**	**3 792.94**	**3 753.41**
Biomass Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Solid Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquid Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other non-fossil fuels (biogenic waste)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 97 presents international bunker fuels for the relevant fuel types of the Reference Approach.

Table A 96: International Bunkers [kt fuel].

Fuel Type	1990	2000	2005	2010	2012	2013	2014	2015	2016
Jet Kerosene	281	538	622	650	657	627	627	675	738
Diesel	16	23	25	22	20	22	20	17	18

Table A 98 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 97: Conversion factor, carbon emission factor and fraction of carbon oxidised.

Fuel Type	Conversion Factor [TJ/kt]		Carbon emission factor [t C/TJ]		Fraction of carbon oxidised [t C/t C]
	Default value	Country specific value 2016	Default value	Country specific value 2016	
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	40.97	18.90	17.90	1.00
Jet Kerosene	44.59	43.35	19.50	-	1.00
Other Kerosene	44.75	43.35	19.60	-	1.00
Shale Oil	-	-	-	-	1.00
Gas / Diesel Oil	43.33	40.18	20.20	18.92	1.00
Residuel Fuel Oil	40.19	40.35	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	30.80	27.50	-	1.00
Refinery Feedstocks	42.50	42.26	20.00	-	1.00
OtherOil	40.19	41.80	20.00	-	1.00
Anthracite	28.00	28.00	26.80	-	0.98
Coking Coal	28.00	28.97	25.80	25.88	0.98
Other Bit. Coal	28.00	28.40	25.80	25.58	0.98
Sub- Bit. Coal	22.20	22.08	26.20	-	0.98
Lignite	10.90	20.55	27.60	27.07	0.98
Oil Shale	-	-	-	-	-
BKB & Patent Fuel	19.30	19.30	25.80	-	0.98
Coke Oven / Gas Coke	28.20	28.60	29.50	30.36	0.98
Coal Tar		36.91	22.01	-	0.98
Natural Gas	-	-	15.30	15.11	1.00
Waste (non-biomass fraction)	-	-		23.48	1.00
Peat	8.80	8.80	28.90	-	0.98
Solid Biomass	-	-	29.90	-	0.88
Liquid Biomass	-	35.67	-	19.31	1.00
Gas Biomass	-	-	29.90	-	1.00

Table A 99 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 98: Country specific conversion factors for selected fuels [TJ/kt]

Fuel Type	1990	2000	2005	2010	2012	2013	2014	2015	2016
Other Bit. Coal	28.00	27.99	28.14	28.15	28.28	28.59	28.52	28.87	28.20
Lignite	10.90	9.82	9.84	8.50	7.97	9.70	9.86	9.70	9.90
Coke	28.50	28.67	29.00	28.75	28.72	28.57	29.01	28.84	28.88

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 December 2017.

Please note that for reasons of confidentiality energy consumption of autoproducers by sub sectors as quoted in ANNEX 2 are not published here.

Annex 4.1 – Coal

Table A 99: National Energy Balance 1990-2016 Coking Coal [1000 tons].

101A Coking Coal	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	2 376	1 738	2 063	1 806	1 859	1 931	1 661	1 907	1 748	1 791	1 758	1 824	1 730	1 797
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)	-39	139	-164	86	41	-68	32	-69	37	8	28	-57	43	19
Gross Inland Deliveries (Obs.)	2 337	1 877	1 899	1 892	1 900	1 863	1 693	1 838	1 785	1 799	1 786	1 767	1 773	1 816
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	2 337	1 877	1 899	1 892	1 900	1 863	1 693	1 838	1 785	1 799	1 786	1 767	1 773	1 816
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	1 877	1 899	1 892	1 900	1 863	1 693	1 838	1 785	1 799	1 786	1 767	1 773	1 816
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
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 100: National Energy Balance 1990-2016 Bituminous Coal & Anthracite [1000 tons].

102A Bitominous Coal & Anthracite (hard coal)	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	1 233	1 671	2 273	2 315	2 567	2 132	1 451	1 727	1 640	1 851	1 424	1 333	1 297	1 534
Total Exports (Balance)	0	0	3	0	1	2	0	1	1	2	1	0	10	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	589	176	-125	26	-191	52	79	172	398	-154	273	5	609	96
Gross Inland Deliveries (Obs.)	1 822	1 847	2 145	2 341	2 375	2 182	1 530	1 898	2 037	1 695	1 696	1 338	1 896	1 630
Statistical Difference	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total Transformation Sector	1 421	1 422	1 885	2 001	1 977	1 735	1 200	1 576	1 708	1 399	1 334	946	966	673
Public Electricity	964	1 203	1 694	1 799	1 801	1 540	1 020	1 396	1 524	1 225	1 144	729	718	438
Public Combined Heat and Power	409	161	148	145	140	157	140	144	148	140	153	174	208	195
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	10	7	7	7	7	0	0	0	0	1	0	0	0
Auto Producers for CHP	48	48	36	50	29	31	40	36	36	34	36	43	40	40
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	33	1	1	89	192	115	143	158	121	187	230	764	805
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	1	1	89	192	115	143	158	121	187	230	764	805
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	33	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	399	391	258	338	308	254	214	178	171	175	174	162	166	152
Total Transport	3	1	0	0	0	0	0	0	0	0	0	0	0	0
Rail	3	1	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	208	313	211	296	282	247	209	170	159	166	171	159	159	148
Iron and Steel	0	0	3	5	6	1	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	7	57	35	29	22	19	18	20	19	18	24	33	28	29
Non ferrous Metals	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Non metallic Mineral Products	199	170	86	140	156	141	97	56	39	42	35	30	29	22
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	1	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	1	1	1	0	0	0	0	0	0	0
Pulp, Paper and Printing	2	86	87	121	97	85	92	94	101	106	112	96	102	97
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	77	47	42	26	7	5	8	12	9	3	3	7	4
Commerce - Public Services	11	8	12	7	5	2	0	0	0	0	0	0	0	0
Residential	176	69	35	35	21	5	5	8	12	8	3	3	7	4
Agriculture	1	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	2	1	1	1	1	1	1	1	0	0	0	0	0	0

Table A 101: National Energy Balance 1990-2016 Patent Fuel [1000 tons].

104A Patent Fuel (hard coal briquettes)	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	0	4	1	1	9	75	18	13	0	7	13	9	4	4
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	-25	0	0	0	0	-4	-3	0	0
Gross Inland Deliveries (Obs.)	0	4	1	1	9	50	18	13	0	7	9	6	4	4
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	4	1	1	9	50	18	13	0	7	9	6	4	4
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	24	3	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	24	3	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	4	1	1	9	26	15	13	0	7	9	6	4	4
Commerce - Public Services	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	3	1	1	9	26	15	13	0	7	9	6	4	4
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 102: National Energy Balance 1990-2016 Lignite and Brown Coal [1000 tons].

105A Lignite and brown coal	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	2 448	1 249	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	36	54	113	140	120	132	111	116	110	89	85	98	93	80
Total Exports (Balance)	3	0	0	0	0	5	3	8	6	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	78	1 162	617	-25	-39	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	2 503	1 381	1 275	757	95	88	108	108	104	89	85	98	93	80
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	2 133	1 230	1 136	657	0	0	0	0	0	0	0	0	0	0
Public Electricity	1 182	1 168	1 068	624	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	881	26	48	32	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	16	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	54	35	20	1	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	2	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)	6	2	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	364	149	139	100	95	88	108	108	104	89	85	98	93	80
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	105	126	88	92	85	100	99	102	87	83	96	91	79
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	39	70	84	87	85	100	99	102	87	83	96	91	79
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	66	56	4	4	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	43	13	12	3	3	8	9	2	2	2	2	2	2
Commerce - Public Services	9	3	1	1	0	0	0	0	0	0	0	0	0	0
Residential	208	41	13	11	3	2	7	8	2	2	2	2	2	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	0	0

Table A 103: National Energy Balance 1990-2015 Brown Coal Briquettes [1000 tons].

106A BKB-PB	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	295	95	54	58	40	40	33	37	20	22	17	15	13	12
Total Exports (Balance)	0	0	2	1	1	0	2	0	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)	12	11	0	-12	3	3	-5	-7	1	0	0	0	0	0
Gross Inland Deliveries (Obs.)	306	107	52	45	43	43	26	29	20	21	17	15	13	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
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	107	52	45	43	43	26	29	20	21	17	15	13	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	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	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	63	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	230	107	52	45	43	43	26	29	20	21	17	15	13	12
Commerce - Public Services	8	34	17	13	12	11	7	8	5	5	4	4	3	3
Residential	214	70	31	29	27	28	19	21	14	15	12	11	9	9
Agriculture	8	3	3	3	4	4	0	0	1	1	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 104: National Energy Balance 1990-2016 Coke Oven Coke [1000 tons].

107A Coke Oven Coke	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	1 725	1 385	1 404	1 416	1 430	1 402	1 235	1 381	1 340	1 329	1 375	1 330	1 329	1 352
Total Imports (Balance)	815	981	1 402	1 268	1 266	1 421	813	1 252	1 132	1 191	1 263	1 186	959	842
Total Exports (Balance)	1	1	4	3	5	0	0	3	0	0	1	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	71	-129	76	16	-121	60	-79	90	-6	-22	8	58	83
Gross Inland Deliveries (Obs.)	2 402	2 435	2 673	2 758	2 707	2 701	2 108	2 551	2 562	2 514	2 616	2 525	2 346	2 278
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	623	909	1 162	1 179	1 233	1 246	909	1 200	1 253	1 195	1 288	1 250	1 214	1 177
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	909	1 162	1 179	1 233	1 246	909	1 200	1 253	1 195	1 288	1 250	1 214	1 177
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	1 167	1 239	1 162	1 131	921	1 067	1 034	1 049	1 057	1 011	856	828
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	1 167	1 239	1 162	1 131	921	1 067	1 034	1 049	1 057	1 011	856	828
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	853	436	328	321	294	302	257	264	252	248	247	242	245	239
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	247	262	260	239	248	214	215	220	216	226	225	230	223
Iron and Steel	235	207	229	236	217	228	203	206	210	206	216	214	216	213
Chemical (incl.Petro-Chemical)	14	15	9	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	7	6	4	4	5	5	5	4	4	4	4	5	4	4
Non metallic Mineral Products	23	10	14	16	13	12	2	0	1	0	0	0	1	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	5	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	5	7	6	4	4	3	5	5	5	6	5	6	7	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	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	190	66	62	54	54	43	49	31	32	21	17	15	16
Commerce - Public Services	13	6	4	3	2	1	1	2	1	1	1	1	1	1
Residential	537	180	61	57	51	52	41	46	29	30	19	15	14	14
Agriculture	12	4	1	1	1	1	1	1	1	1	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	14	16	18	17	22	20	20	23	22	24	21	31	34

Table A 105: National Energy Balance 1990-2016 Peat [1000 tons].

113A Peat	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	1	1	1	1	1	1	1	1	1	1	1	1	1	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	1	1	1	1	1	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
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	1	1	1	1	1	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	1	1	1	1	1	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	1	1	1	1	1	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 106: National Energy Balance 1990-2016 Coke Oven Gas [TJ].

304A Coke Oven Gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	13 117	10 466	10 854	10 821	10 832	10 858	10 010	10 716	10 595	10 696	10 323	10 087	10 337	9 954
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	10 466	10 854	10 821	10 832	10 858	10 010	10 716	10 595	10 696	10 323	10 087	10 337	9 954
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	3 385	3 592	2 099	1 907	1 855	2 007	2 733	2 584	2 497	2 592	2 017	2 703	4 331	3 369
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	3 256	1 914	1 783	1 702	1 809	2 503	2 346	2 240	2 316	1 833	2 519	4 039	3 098
Auto Producers for CHP	3 385	286	185	124	153	198	230	238	257	276	184	184	292	271
Auto Producer Heat Plants	0	50	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	4 136	3 300	5 176	5 057	5 624	5 425	4 550	4 799	4 898	5 226	5 381	4 803	3 512	3 139
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)	1 072	856	335	328	365	352	295	311	318	339	349	313	227	204
Blast Furnaces (Energy)	3 064	2 444	4 841	4 729	5 259	5 073	4 255	4 488	4 580	4 887	5 032	4 490	3 285	2 935
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	65	57	57	61	58	67	63	3	4	3	18	7
Final Consumption	5 596	3 574	3 514	3 800	3 296	3 365	2 669	3 266	3 137	2 875	2 921	2 578	2 476	3 439
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	3 574	3 514	3 800	3 296	3 365	2 669	3 266	3 137	2 875	2 921	2 578	2 476	3 439
Iron and Steel	5 596	3 574	3 514	3 800	3 296	3 365	2 669	3 266	3 137	2 875	2 921	2 578	2 476	3 439
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 107: National Energy Balance 1990-2016 Blast Furnace Gas [TJ].

305A Blast Furnace Gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2017
Indigenous Production	17 094	25 385	31 674	31 946	33 499	34 235	25 092	33 119	34 547	32 951	35 333	34 818	33 626	32 631
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	25 385	31 674	31 946	33 499	34 235	25 092	33 119	34 547	32 951	35 333	34 818	33 626	32 631
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	4 822	6 014	12 094	12 431	13 751	11 941	10 294	14 468	14 979	14 233	16 294	16 187	15 536	14 568
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	5 011	11 292	11 846	13 151	10 887	9 330	13 502	13 724	12 898	15 171	15 391	14 582	13 648
Auto Producers for CHP	4 822	1 003	802	585	600	1 054	964	966	1 255	1 335	1 123	796	954	920
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	9 682	15 254	16 177	15 905	16 034	17 506	12 326	16 002	16 929	16 508	16 727	16 706	15 971	16 033
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	3 675	2 276	2 302	2 086	2 089	1 185	1 778	2 049	2 052	1 947	1 988	1 683	1 783
Blast Furnaces (Energy)	7 291	11 579	13 901	13 603	13 948	15 417	11 141	14 224	14 880	14 456	14 780	14 718	14 288	14 250
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	2 567	2 621	2 639	3 374	1 175	1 387	1 409	1 018	944	780	974	941
Final Consumption	2 590	4 117	836	989	1 075	1 414	1 297	1 262	1 230	1 192	1 368	1 145	1 145	1 089
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	4 117	836	989	1 075	1 414	1 297	1 262	1 230	1 192	1 368	1 145	1 145	1 089
Iron and Steel	2 590	4 117	836	989	1 075	1 414	1 297	1 262	1 230	1 192	1 368	1 145	1 145	1 089
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 108: National Energy Balance 1990-2016. Crude Oil [1000 tons].

201A Crude Oil	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	1 149	971	855	856	853	862	909	877	838	839	843	953	854	786
Refinery Losses	254	157	8	31	94	11	47	135	181	112	82	73	113	97
Refinery Intake (Calculated)	7 952	8 240	8 743	8 472	8 548	8 666	8 306	7 749	8 298	8 349	8 566	8 435	8 881	8 185
Refinery Intake (Observed)	7 952	8 240	8 743	8 472	8 548	8 666	8 306	7 749	8 298	8 349	8 566	8 435	8 881	8 185
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	6 797	7 314	7 833	7 699	7 591	7 864	7 424	6 795	7 293	7 473	7 778	7 510	8 079	7 332
Total Exports (Balance)	0	61	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	6	16	55	-83	104	-60	-27	77	167	37	-55	-28	-52	67
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 109: National Energy Balance 1990-2016. Natural Gas Liquids [1000 tons].

302A Natural Gas Liquids	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	41	101	110	127	129	118	131	134	120	80	30	23	21	6
Refinery Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Intake (Calculated)	41	107	78	88	141	78	93	89	194	124	81	175	53	6
Refinery Intake (Observed)	41	107	78	88	141	78	93	89	194	124	81	175	53	6
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	0	6	0	0	50	0	0	0	113	44	51	153	31	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	0	0	0	-1	1	0
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 110: National Energy Balance 1990-2016. Refinery Feedstocks [1000 tons].

217A Refinery Feedstocks	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Intake (Calculated)	1 069	540	410	459	346	432	461	317	505	395	352	367	327	471
Refinery Intake (Observed)	1 069	540	410	459	346	432	461	317	505	395	352	367	327	471
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	1 009	627	265	501	305	347	481	359	458	143	5	77	18	144
Total Exports (Balance)	0	76	29	15	19	23	2	42	11	0	0	0	0	0
Stock Change (National Territory)	-26	-32	117	-43	-32	66	-31	-91	19	-59	19	6	-131	156

Table A 111: National Energy Balance 1990-2016 Residual Fuel Oil [1000 tons].

203X; Residual Fuel Oil	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	1 913	979	1 045	915	844	738	989	815	822	953	1 011	981	1 154	898
Refinery Fuel	81	37	24	4	5	4	38	6	3	107	78	91	55	33
Total Imports (Balance)	602	262	182	199	183	184	109	174	86	59	58	41	11	16
Total Exports (Balance)	185	152	72	58	37	148	296	244	266	220	325	428	524	576
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-93	246	-8	40	-23	8	-11	140	29	4	3	50	67	118
Gross Inland Deliveries (Obs.)	2 156	1 298	1 068	1 092	872	779	583	707	477	370	346	297	248	270
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	608	380	350	313	219	215	200	218	119	69	58	43	78	109
Public Electricity	28	109	84	95	75	68	42	32	19	2	1	1	35	27
Public Combined Heat and Power	253	162	174	156	96	93	104	143	70	29	20	7	10	50
Public Heat Plants	99	87	81	52	42	49	46	34	27	35	33	33	29	29
Auto Producers of Electricity	0	5	3	3	0	1	0	2	0	1	1	0	4	3
Auto Producers for CHP	227	15	9	7	5	4	8	5	3	2	3	2	0	0
Auto Producer Heat Plants	1	1	0	0	0	0	0	2	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	116	231	234	227	274	224	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)	116	231	234	227	274	224	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	1 432	687	484	552	379	340	284	286	226	184	163	140	153	149
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	518	277	263	259	222	215	199	186	186	164	154	132	152	149
Iron and Steel	19	21	15	16	6	28	7	8	8	6	3	1	1	1
Chemical (incl.Petro-Chemical)	23	11	13	11	13	14	26	30	26	25	26	12	15	15
Non ferrous Metals	4	9	6	6	5	5	4	5	6	6	5	4	5	2
Non metallic Mineral Products	115	51	45	46	49	49	47	39	32	28	25	12	16	16
Transportation Equipment	13	4	5	4	4	3	2	2	2	2	1	1	1	1
Machinery	29	30	32	31	24	22	23	23	29	27	23	17	19	19
Mining and Quarrying	6	12	12	11	7	3	4	4	5	4	4	5	6	6
Food, Beverages and Tobacco	78	38	42	42	37	34	33	31	32	30	30	44	46	50
Pulp, Paper and Printing	126	41	39	36	31	24	24	18	14	9	11	6	9	5
Wood and Wood Products	15	9	13	12	9	3	4	6	6	5	5	5	5	5
Construction	32	16	16	21	16	14	10	4	10	8	8	15	18	17
Textiles and Leather	27	12	11	9	7	6	6	7	6	5	4	4	5	5
Non Specified (Industry)	30	23	15	15	12	10	9	9	10	9	9	6	6	7
Total Other Sectors	914	410	221	293	157	125	85	100	40	20	9	8	1	0
Commerce - Public Services	316	117	81	165	68	34	35	62	24	13	8	8	1	0
Residential	471	232	111	101	71	72	40	30	13	6	1	0	0	0
Agriculture	127	60	29	26	18	19	10	8	3	1	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	116	231	234	227	274	224	0	0	0	0	0	0	0	0

Table A 112: National Energy Balance 1990-2016. Heating and Oher Gas Oil [1000 tons].

204A Heating and Other Gas Oil	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	1 239	1 062	997	1 004	612	991	835	795	738	688	820	683	658	635
Refinery Fuel	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Total Imports (Balance)	0	533	926	850	743	813	706	708	614	634	642	588	636	639
Total Exports (Balance)	0	1	20	36	10	34	33	14	34	51	86	102	31	12
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	5	125	30	-88	122	-102	-21	10	-23	65	-19	6	7	-48
Gross Inland Deliveries (Obs.)	1 244	1 719	1 933	1 730	1 467	1 668	1 487	1 465	1 295	1 235	1 233	1 101	1 156	1 145
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	5	5	5	5	5	3	5	4	3	6	4	1
Public Electricity	0	0	1	1	1	1	1	0	1	1	1	1	1	0
Public Combined Heat and Power	0	0	3	1	2	2	1	1	1	1	1	1	1	0
Public Heat Plants	0	0	1	2	1	1	2	1	1	1	1	3	1	0
Auto Producers of Electricity	0	0	0	1	1	1	1	1	1	1	0	1	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	1	0	0	0	1	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	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	1 244	1 719	1 928	1 725	1 462	1 663	1 482	1 462	1 290	1 231	1 230	1 095	1 152	1 144
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	37	116	107	86	70	70	74	68	69	61	8	7	8
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	2	2	1	1	1	1	1	1	2	1	1	1	0
Non ferrous Metals	0	2	1	1	1	0	0	0	0	0	1	0	0	0
Non metallic Mineral Products	0	2	6	6	6	7	6	6	5	5	5	1	1	1
Transportation Equipment	0	0	1	1	1	1	1	1	1	1	1	0	0	0
Machinery	0	5	13	13	10	7	8	9	8	8	7	3	2	3
Mining and Quarrying	0	1	4	4	3	2	1	1	1	1	1	1	1	1
Food, Beverages and Tobacco	0	10	29	27	24	22	24	26	24	23	21	1	1	2
Pulp, Paper and Printing	0	1	2	2	1	1	1	1	1	1	1	0	0	0
Wood and Wood Products	0	1	7	7	5	1	1	1	1	2	1	0	0	0
Construction	0	10	41	34	26	23	22	23	21	21	17	1	1	1
Textiles and Leather	0	1	4	4	3	2	2	2	2	2	2	0	0	0
Non Specified (Industry)	0	2	6	7	5	3	3	3	3	3	3	0	0	0
Total Other Sectors	1 244	1 682	1 812	1 618	1 376	1 593	1 412	1 388	1 222	1 162	1 169	1 087	1 145	1 136
Commerce - Public Services	27	265	641	502	344	541	390	244	208	120	136	142	144	146
Residential	1 216	1 416	1 170	1 115	1 031	1 051	1 021	1 143	1 013	1 041	1 032	944	1 000	989
Agriculture	1	1	1	1	1	1	1	1	1	1	1	1	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 113: National Energy Balance 1990-2016. Diesel [1000 tons].

2050 Diesel	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	1 531	2 662	2 905	2 682	2 850	2 954	3 032	2 545	3 186	3 071	3 031	3 073	3 209	2 958
Refinery Fuel	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Total Imports (Balance)	576	2 075	4 129	4 055	4 273	4 099	3 652	4 281	3 647	3 814	3 997	3 902	3 949	4 477
Total Exports (Balance)	3	415	889	583	945	1 039	805	859	865	960	876	910	861	829
International Marine Bunkers	16	23	25	22	24	22	19	22	20	20	22	20	17	18
Stock Change (National Territory)	-8	-60	87	-149	-10	-79	-59	44	-98	-85	72	47	-42	-67
Gross Inland Deliveries (Obs.)	2 080	4 239	6 234	6 082	6 271	6 066	5 933	6 185	6 031	6 067	6 420	6 317	6 482	6 729
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	2 080	4 239	6 234	6 082	6 271	6 066	5 933	6 185	6 031	6 067	6 420	6 317	6 482	6 729
Total Transport	1 750	3 807	5 632	5 483	5 667	5 449	5 326	5 602	5 439	5 473	5 833	5 728	5 885	6 129
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	1 694	3 763	5 579	5 427	5 610	5 392	5 270	5 549	5 393	5 426	5 789	5 683	5 841	6 087
Rail	54	42	51	54	55	55	55	52	44	45	42	44	43	41
Inland Waterways	2	2	2	2	2	2	1	1	2	2	2	1	1	1
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	80	172	338	336	341	356	339	314	325	327	319	323	331	332
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	1	1	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	1	1	1	1	1	1	1	1	1	1	1	1	1
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	2	3	4	4	4	4	4	4	4	4	4	4	5	4
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	1	1	1	2	1	1	1	1	1	1	1	1	1
Construction	77	165	331	329	334	350	333	308	319	321	313	317	324	326
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	250	260	264	263	263	261	268	269	267	267	268	266	266	268
Commerce - Public Services	9	19	27	27	27	26	33	35	34	34	36	35	35	38
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	241	241	237	236	236	235	235	234	233	233	232	231	231	230
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 114: National Energy Balance 1990-2016. Other Kerosene [1000 tons].

206A Other Kerosene	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	31	1	1	13	1	8	3	3	0	16	18	18	27	21
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	14	5	3	2	2	2	2	1	1	6	4	1	1	0
Total Exports (Balance)	21	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)	-7	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	17	6	4	3	3	3	5	4	1	6	4	1	1	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
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	4	3	3	3	5	4	1	6	4	1	1	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

206A Other Kerosene	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	17	6	4	3	3	3	5	4	1	6	4	1	1	0
Commerce - Public Services	17	6	4	3	3	3	5	4	1	6	4	1	1	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 115: National Energy Balance 1990-2016. Kerosene Type Jet Fuel [1000 tons].

206B Kerosene Type Jet Fuel	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	291	544	592	526	604	472	313	476	615	618	654	581	648	651
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	13	35	85	190	159	252	228	193	113	92	95	82	109	137
Total Exports (Balance)	5	5	2	1	1	2	0	0	7	24	21	31	37	24
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	-5	-22	-32	-38	3	92	12	-4	2	-72	23	-16	1
Gross Inland Deliveries (Obs.)	299	569	653	683	724	725	633	681	717	688	656	655	704	765
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	299	569	653	683	724	725	633	681	717	688	656	655	704	765
Total Transport	299	569	653	683	724	725	633	681	717	688	656	655	704	765
International Civil Aviation	281	537	621	650	690	692	601	650	688	659	627	627	676	737
Domestic Air Transport	18	32	32	33	34	33	32	31	29	29	29	28	28	28
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 116: National Energy Balance 1990-2016. Gasoline Type Jet Fuel [1000 tons].

207A Gasoline Type Jet Fuel	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	3	3	6	7	5	7	4	4	6	2	4	3	4	3
Total Exports (Balance)	0	1	3	3	3	4	2	2	1	0	2	1	1	1
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	1	-1	0	1	1	0	-1	1	0	0	0	0
Gross Inland Deliveries (Obs.)	3	2	4	3	2	4	3	2	4	3	2	2	3	3
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	4	3	2	4	3	2	4	3	2	2	3	3
Total Transport	3	2	4	3	2	4	3	2	4	3	2	2	3	3
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	3	2	4	3	2	4	3	2	4	3	2	2	3	3
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 117: National Energy Balance 1990-2016. Motor Gasoline [1000 tons].

2080 Motor Gasoline	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Refinery Gross Output	2 631	1 815	1 798	1 615	1 704	1 684	1 652	1 436	1 531	1 553	1 549	1 773	1 721	1 671
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	259	670	1 090	959	883	712	719	834	779	884	814	771	826	804
Total Exports (Balance)	281	472	767	562	646	653	575	598	569	776	829	871	974	874
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-55	-32	-44	-4	28	95	-37	108	-63	48	102	-64	29	-36
Gross Inland Deliveries (Obs.)	2 545	1 981	2 077	2 009	1 968	1 838	1 846	1 825	1 761	1 734	1 670	1 626	1 644	1 642
Statistical Difference	9	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	2 545	1 981	2 077	2 009	1 968	1 838	1 846	1 825	1 761	1 734	1 670	1 626	1 644	1 642
Total Transport	2 545	1 981	2 077	2 009	1 968	1 838	1 846	1 825	1 761	1 734	1 670	1 626	1 644	1 642
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	2 542	1 978	2 074	2 006	1 966	1 835	1 843	1 822	1 758	1 731	1 667	1 624	1 642	1 640
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	3	3	3	3	3	3	3	3	3	3	3	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	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 118: National Energy Balance 1990-2016. Lubricants [1000 tons].

219A Lubricants	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	31	111	111	120	122	128	97	96	72	2	2	0	0	0
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	177	57	53	53	52	60	52	45	47	113	108	81	73	110
Total Exports (Balance)	32	58	85	91	102	117	91	71	50	46	59	42	37	69
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-12	-1	1	-3	3	1	2	-5	1	12	-2	0	2	0
Gross Inland Deliveries (Obs.)	164	109	80	79	75	72	60	65	70	81	49	39	38	41
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	12	9	9	7	7	7	7	7	7	6	5	5	5
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	5	4	3	3	2	2	2	2	2	2	2	2	2	2
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	1	1	1	1	1	1	1	1	1	1	1
Non Specified (Energy)	9	6	5	5	4	4	4	4	4	4	3	2	2	2
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	146	97	71	70	68	65	53	58	63	74	43	34	33	36
Total Transport	67	44	33	32	31	30	24	26	29	44	26	23	22	25
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	43	33	32	31	30	24	26	29	44	26	23	22	25
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	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	76	51	37	37	36	34	28	31	32	29	16	10	10	10
Iron and Steel	15	9	7	7	7	6	4	6	6	5	3	2	2	2
Chemical (incl.Petro-Chemical)	6	4	3	3	3	3	2	3	3	2	1	1	1	1
Non ferrous Metals	2	2	1	1	1	1	1	1	1	1	0	0	0	0
Non metallic Mineral Products	10	7	5	5	5	4	4	4	4	4	3	1	1	1
Transportation Equipment	2	1	1	1	1	1	1	1	1	1	0	0	0	0
Machinery	3	2	3	3	3	3	2	2	3	2	2	1	1	1
Mining and Quarrying	3	2	1	1	1	1	1	1	1	1	0	0	0	0
Food, Beverages and Tobacco	10	7	5	5	5	5	4	4	4	4	2	1	1	1
Pulp, Paper and Printing	8	5	4	4	4	4	3	3	3	3	2	1	1	1
Wood and Wood Products	3	2	1	1	1	1	1	1	1	1	1	1	1	1
Construction	2	1	1	1	1	1	1	1	1	1	0	0	0	0
Textiles and Leather	4	3	2	2	2	2	2	2	2	2	1	1	1	1
Non Specified (Industry)	8	6	3	3	2	2	2	2	2	2	1	1	1	1
Total Other Sectors	3	2	1	1	1	1	1	1	2	1	1	1	1	1
Commerce - Public Services	3	2	1	1	1	1	1	1	1	1	1	1	1	1
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	1	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	109	80	79	75	72	60	65	70	81	49	39	38	41

Table A 119: National Energy Balance 1990-2016. White Spirit [1000 tons].

220A White Spirit	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	0	0	0	0	0	0	64	70	65	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	7	11	13	12	12	13	12	14	15	16	19	19	19
Total Exports (Balance)	0	0	0	0	0	0	70	65	69	0	1	1	1	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	4	-5	3	0	0	0	0	0
Gross Inland Deliveries (Obs.)	11	7	11	13	12	12	11	12	13	15	15	18	18	19
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	7	11	13	12	12	11	12	13	15	15	18	18	19
Total Transport	0	1	5	5	4	3	3	4	6	7	8	10	10	11
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	3	3	4	6	7	8	10	10	11
Rail	0	1	5	5	4	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	6	6	8	8	9	8	8	7	8	7	8	8	8
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	11	4	4	5	3	4	3	3	3	3	3	3	3	3
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	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	1	2	3	5	5	5	5	4	5	4	5	5	5
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	11	5	4	5	3	4	3	3	3	3	3	3	3	3

Table A 120: National Energy Balance 1990-2016. Bitumen [1000 tons].

222A Bitumen	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	269	343	466	392	411	444	420	292	376	366	314	314	290	333
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	284	292	335	415	268	272	281	346	291	270	258	274	271	278
Total Exports (Balance)	1	45	147	122	151	215	198	182	209	205	159	145	131	144
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-12	-3	-3	1	-1	5	-1	-4	1	16	0	-3	3	0
Gross Inland Deliveries (Obs.)	540	587	651	686	527	506	502	452	459	447	413	440	433	467
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	587	651	686	527	506	502	452	459	447	413	440	433	467
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	587	651	686	527	506	502	452	459	447	413	440	433	467
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	540	587	651	686	527	506	502	452	459	447	413	440	433	467
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0

222A Bitumen	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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	587	651	686	527	506	502	452	459	447	413	440	433	467

Table A 121: National Energy Balance 1990-2016. Other Oil Products [1000 tons].

224A Other Oil Products	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	7	15	36	125	138	194	10	59	23	32	57	43	19	25
Refinery Fuel	70	0	4	30	103	139	5	4	0	0	0	0	0	0
Total Imports (Balance)	182	149	97	48	34	29	35	33	36	5	19	27	45	50
Total Exports (Balance)	3	139	111	34	16	25	33	35	33	9	8	3	3	3
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-31	-8	-5	-11	-8	6	13	-13	11	29	2	-1	-1	2
Gross Inland Deliveries (Obs.)	35	18	13	94	45	65	20	40	26	57	70	66	60	74
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	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	0	0	4	5	5	8	8	11	11	12	5	3	3	3
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	4	5	5	8	8	11	11	12	5	3	3	3
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	4	5	5	8	8	11	11	12	5	3	3	3
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	18	9	89	40	57	12	29	15	45	65	63	57	71

Table A 122: National Energy Balance 1990-2016. LPG [1000 tons].

303A LPG	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	47	34	107	50	70	98	92	87	101	67	66	65	139	122
Refinery Fuel	8	20	49	3	22	21	40	29	26	4	6	4	16	25
Total Imports (Balance)	97	159	133	155	129	112	99	114	91	81	62	64	54	53
Total Exports (Balance)	14	17	20	21	21	37	8	11	29	22	24	21	83	68
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	2	-5	0	-2	3	-1	0	-1	0	0	1	-3	-2	-2
Gross Inland Deliveries (Obs.)	124	151	171	179	159	151	143	160	137	121	99	102	92	80
Statistical Difference	0	0	0	0	0	0	0	0	0	1	0	-1	0	0
Total Transformation Sector	1	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	1	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	123	151	171	179	159	151	143	160	137	121	99	102	92	80
Total Transport	9	15	20	21	20	22	20	19	19	20	20	16	12	10
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	9	15	20	21	20	22	20	19	19	20	20	16	12	10
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	64	56	34	43	37	37	41	44	42	50	39	38	39	38
Iron and Steel	4	1	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Non ferrous Metals	8	4	4	4	4	2	1	1	1	1	1	1	1	1
Non metallic Mineral Products	12	15	3	5	6	8	9	9	8	9	9	2	2	2
Transportation Equipment	1	1	2	2	3	2	1	1	1	1	1	1	1	1
Machinery	11	14	10	12	10	9	10	12	10	12	10	10	11	11
Mining and Quarrying	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Food, Beverages and Tobacco	3	4	5	6	4	3	6	7	7	6	6	6	8	8
Pulp, Paper and Printing	1	2	1	1	0	0	0	1	1	0	0	0	0	0
Wood and Wood Products	0	1	1	1	1	1	2	2	2	8	2	11	11	9
Construction	23	13	6	9	7	10	10	9	10	10	8	5	3	4
Textiles and Leather	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	1	1	1	2	1	1	1	1
Total Other Sectors	50	80	117	115	102	92	82	97	76	51	40	48	41	32
Commerce - Public Services	32	24	76	75	56	44	49	62	53	6	3	5	3	4
Residential	16	51	38	37	42	44	30	32	21	42	34	40	34	26
Agriculture	2	5	3	3	4	4	3	3	2	3	3	3	4	2
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 123: National Energy Balance 1990-2016. Refinery Gas [1000 tons].

308A Refinery Gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Refinery Gross Output	373	312	309	390	417	383	369	392	381	311	311	342	282	218
Refinery Fuel	373	310	339	427	453	421	405	433	418	308	308	341	282	218
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	2	2	2	2	2	2	4	2	3	3	1	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
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	0	2	2	2	2	2	2	4	2	3	3	1	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	2	2	2	2	2	2	4	2	3	3	1	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	2	2	2	2	2	2	4	2	3	3	1	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 124: National Energy Balance 1990-2016. Natural Gas [PJ NCV].

301A Natural Gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	46.4	64.8	55.7	61.7	62.7	51.7	56.3	58.5	57.6	61.9	49.8	45.4	43.4	40.8
Total Imports (Balance)	187.9	222.8	336.4	368.7	341.6	349.8	367.1	426.6	459.9	487.0	357.0	348.1	409.0	496.5
Total Exports (Balance)	0.0	0.6	37.0	89.2	94.8	70.4	99.0	170.6	125.0	219.2	136.1	82.9	200.1	238.5
Stock Change (National Territory)	-15.1	-11.3	-16.6	-24.3	-10.9	-15.2	-15.8	25.6	-71.5	-23.0	24.9	-40.8	35.6	2.0
Gross Inland Deliveries (Obs.)	219.2	275.7	338.5	316.9	298.7	315.9	308.6	340.1	321.0	306.7	295.6	269.8	287.9	300.7
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	83.3	115.2	97.3	91.7	100.8	103.3	113.8	102.6	89.2	72.3	61.0	76.3	82.0
Public Electricity	28.1	25.4	46.7	32.2	24.1	33.3	36.6	35.2	30.1	14.1	3.2	1.4	14.6	17.8
Public Combined Heat and Power	23.8	27.7	39.2	37.9	38.8	36.9	39.3	48.9	43.7	48.2	42.7	36.2	38.9	42.8
Public Heat Plants	7.6	9.2	9.1	8.7	8.9	11.4	9.9	10.1	10.8	12.0	14.1	12.2	11.2	11.2
Auto Producers of Electricity	9.6	12.0	9.0	6.2	7.2	6.7	6.4	7.5	5.6	5.0	2.2	3.0	3.0	2.7
Auto Producers for CHP	5.7	8.6	10.7	11.9	12.1	11.6	10.4	11.9	12.3	9.7	9.7	7.8	8.2	7.0
Auto Producer Heat Plants	0.0	0.4	0.6	0.3	0.5	0.9	0.8	0.1	0.1	0.2	0.3	0.5	0.4	0.5
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
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	11.6	17.0	14.7	12.1	13.1	6.7	12.1	16.3	17.5	19.4	18.3	13.0	12.2
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	4.3	6.8	4.3	4.2	3.9	4.4	3.8	4.4	4.4	3.3	3.3	3.5	3.4
Inputs to Oil Refineries	6.8	6.5	5.5	5.7	5.2	6.3	1.1	5.8	5.9	6.7	8.6	8.2	7.1	7.1
Coke Ovens (Energy)	0.0	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Blast furnace (Energy)	0.0	0.5	2.0	1.4	1.1	1.1	1.0	2.1	5.3	5.6	6.6	6.0	1.6	1.3
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	0.2	2.6	3.2	1.6	1.7	0.2	0.3	0.7	0.8	0.8	0.7	0.6	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	0.1	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	167.5	193.0	191.4	182.6	188.3	184.2	198.4	188.1	186.7	191.3	176.5	185.1	192.3
Total Transport	4.1	6.1	6.5	8.4	8.9	8.5	8.2	8.7	10.7	8.8	11.6	9.8	11.2	10.8
Road	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.5	0.5	0.5	0.6	0.7	0.7	0.7
Pipeline Transport	4.1	6.1	6.5	8.4	8.8	8.4	7.9	8.3	10.3	8.3	11.0	9.1	10.5	10.0
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	69.0	88.4	100.0	96.9	97.4	100.3	99.0	106.7	106.5	107.2	106.3	105.5	110.2	112.8
Iron and Steel	10.5	13.6	14.1	13.9	14.3	13.8	13.4	14.6	15.1	16.3	17.3	17.0	17.6	15.4
Chemical (incl.Petro-Chemical)	7.7	14.4	16.4	14.6	14.5	15.6	16.4	16.5	16.6	16.9	16.5	16.5	16.2	16.0
Non ferrous Metals	1.4	2.3	3.1	3.2	3.7	3.9	3.6	3.8	3.9	3.9	4.1	5.0	5.6	6.0
Non metallic Mineral Products	10.1	11.6	15.6	13.5	13.8	13.6	12.7	13.5	14.0	13.2	12.9	14.7	15.1	17.4
Transportation Equipment	1.5	1.3	2.2	2.2	2.1	1.7	1.5	1.9	1.9	2.0	1.9	1.4	1.3	1.4
Machinery	4.3	4.8	6.5	6.9	6.8	7.0	7.7	8.8	8.8	9.2	8.8	9.1	10.2	11.6
Mining and Quarrying	2.6	2.3	1.6	2.8	2.9	3.0	1.6	2.0	2.2	2.1	2.2	2.5	2.5	2.8
Food, Beverages and Tobacco	8.9	11.4	11.5	11.2	10.9	11.3	11.3	12.4	12.3	12.8	11.3	10.3	11.8	13.1
Pulp, Paper and Printing	12.9	19.5	20.3	19.9	20.0	21.6	22.2	24.7	23.6	22.4	22.6	20.4	21.0	19.2
Wood and Wood Products	1.7	1.7	3.3	2.8	2.9	3.4	3.0	2.9	2.6	2.8	3.0	3.0	3.2	3.4
Construction	0.7	1.4	1.6	2.0	1.6	1.6	1.8	1.8	1.8	1.9	1.9	2.5	2.7	3.3
Textiles and Leather	3.5	2.9	2.1	2.0	2.1	2.0	1.8	1.8	1.7	1.7	1.7	1.2	1.2	1.4
Non Specified (Industry)	3.1	1.2	1.6	1.7	1.8	1.8	1.8	2.0	2.0	1.9	2.0	1.8	1.8	1.8
Total Other Sectors	40.4	73.0	86.6	86.1	76.3	79.4	77.0	82.9	70.9	70.7	73.4	61.2	63.7	68.7
Commerce - Public Services	6.7	25.0	38.3	40.6	33.7	36.2	32.5	32.8	26.9	21.7	19.9	18.1	17.0	17.7
Residential	33.3	47.5	47.7	45.0	42.2	42.7	44.0	49.5	43.5	48.5	52.9	42.7	46.2	50.5
Agriculture	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.6	0.5	0.5	0.6
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	13.3	13.2	13.4	12.0	13.5	14.2	15.8	13.9	13.2	12.4	14.0	13.4	14.1

Annex 4.4 – Renewable Fuels

Table A 125: National Energy Balance 1990-2016. Fuel Wood [PJ].

111A Fuel Wood	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	61.40	58.63	56.65	54.00	51.56	52.73	48.44	54.01	46.54	49.47	52.17	41.98	47.34	50.41
Total Imports (Balance)	2.30	1.80	3.50	4.19	3.36	3.44	7.26	7.87	10.62	9.41	11.29	10.99	8.55	6.83
Total Exports (Balance)	0.04	0.18	0.84	0.69	0.57	0.50	0.99	0.98	0.83	0.74	0.69	0.78	0.17	0.15
Stock Change (National Territory)	-0.55	0.00	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	60.25	59.31	57.51	54.35	55.67	54.72	60.91	56.33	58.14	62.77	52.19	55.72	57.09
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	0.08	0.14	0.12	0.11	0.13	0.15	0.14	0.13	0.16	0.15	0.14	0.16	0.17
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	0.05	0.02	0.02	0.03	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05
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
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	60.17	59.17	57.39	54.24	55.54	54.56	60.76	56.20	57.98	62.61	52.05	55.57	56.92
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	0.95	1.14	1.04	1.72	1.75	1.30	1.20	1.05	0.59	0.55	0.05	0.05	0.06
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	0.00	0.00	0.01	0.01	0.07	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	0.00	0.02	0.02	0.01	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	0.03	0.06	0.06	0.04	0.02	0.08	0.10	0.07	0.08	0.04	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	0.02	0.05	0.04	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.00	0.00	0.00
Pulp, Paper and Printing	0.01	0.00	0.00	0.00	0.00	0.00	0.67	0.55	0.50	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.23	0.71	0.36	0.32	1.16	1.35	0.21	0.37	0.32	0.35	0.35	0.00	0.00	0.00
Construction	0.00	0.11	0.27	0.29	0.28	0.27	0.18	0.09	0.08	0.08	0.08	0.05	0.05	0.05
Textiles and Leather	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Non Specified (Industry)	0.19	0.08	0.36	0.31	0.18	0.06	0.05	0.02	0.02	0.02	0.02	0.00	0.00	0.00
Total Other Sectors	62.46	59.22	58.04	56.35	52.52	53.79	53.26	59.56	55.16	57.39	62.06	52.00	55.51	56.86
Commerce - Public Services	1.33	0.34	0.59	0.65	0.70	0.76	0.75	0.85	0.73	0.43	0.43	0.54	0.59	0.61
Residential	57.50	55.38	54.04	52.40	48.75	49.89	49.40	55.23	51.20	53.58	57.98	48.41	51.66	52.92
Agriculture	3.63	3.49	3.41	3.30	3.07	3.14	3.11	3.48	3.23	3.38	3.65	3.05	3.26	3.34
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 126: National Energy Balance 1990-2016. Wood Waste [PJ].

116A Wood waste and other bio-mass	**1990**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Indigenous Production	14.34	35.70	58.84	56.22	73.84	81.89	86.00	99.89	104.19	111.76	118.94	106.94	112.53	113.51
Total Imports (Balance)	2.14	3.14	7.36	17.51	14.98	11.79	11.87	12.83	13.55	10.82	8.95	7.87	8.47	8.31
Total Exports (Balance)	2.08	6.51	13.84	12.41	13.17	13.32	9.72	12.95	12.31	11.46	8.70	8.76	10.29	11.15
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	-0.72	0.67	-0.40	0.00	0.28	0.09
Gross Inland Deliveries (Obs.)	14.41	32.34	52.36	61.32	75.65	80.36	88.14	100.06	104.72	111.79	118.80	106.05	110.99	110.76
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	12.50	20.70	29.13	39.62	46.48	49.12	59.70	61.22	66.14	64.29	59.15	61.18	57.63
Public Electricity	0.00	0.01	2.86	5.67	7.69	7.74	10.17	9.16	10.11	11.41	7.82	8.02	8.60	6.56
Public Combined Heat and Power	0.00	0.35	4.10	8.47	12.56	17.44	16.65	21.60	22.15	20.44	19.15	16.49	17.60	15.25
Public Heat Plants	1.63	7.59	9.80	10.52	12.43	14.21	15.86	21.94	20.28	23.47	26.83	25.10	25.49	27.35
Auto Producers of Electricity	0.00	1.51	1.32	1.10	2.77	2.95	2.86	3.01	4.78	5.30	4.77	3.93	3.69	1.40
Auto Producers for CHP	1.56	2.96	2.60	3.36	4.17	4.15	3.59	3.91	3.83	5.49	5.64	5.54	5.74	6.97
Auto Producer Heat Plants	0.00	0.08	0.02	0.00	0.00	0.00	0.00	0.08	0.07	0.04	0.08	0.07	0.06	0.09
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	11.22	19.84	31.66	32.19	36.02	33.87	39.02	40.37	43.50	45.65	54.51	46.91	49.81	53.13
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	11.62	19.01	19.79	24.47	22.38	25.18	26.43	26.45	27.09	34.52	28.62	29.08	32.58
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Chemical (incl.Petro-Chemical)	2.90	2.52	1.45	1.37	1.92	1.74	1.32	1.88	1.75	1.72	2.38	1.44	1.32	1.25
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.03	0.03
Non metallic Mineral Products	0.00	0.00	2.19	2.81	3.30	4.07	3.74	3.50	3.61	3.89	3.98	4.26	4.00	3.78
Transportation Equipment	0.00	0.00	0.00	0.02	0.02	0.03	0.01	0.02	0.06	0.05	0.05	0.05	0.05	0.05
Machinery	0.00	0.05	0.21	0.22	0.33	0.50	0.85	1.19	1.16	1.13	1.28	0.21	0.23	0.29
Mining and Quarrying	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.03	0.03	0.03	0.04	0.00	0.00	0.00
Food, Beverages and Tobacco	0.01	0.21	0.36	0.40	0.43	0.42	0.31	0.40	0.42	0.41	0.45	3.98	4.46	6.29
Pulp, Paper and Printing	3.66	1.95	6.83	5.47	6.04	4.58	5.37	4.07	3.38	2.81	4.59	4.56	4.42	5.57
Wood and Wood Products	2.76	6.00	7.02	8.10	10.73	9.13	11.06	12.44	13.41	14.40	18.80	13.13	13.48	13.90
Construction	0.04	0.36	0.47	0.45	0.68	0.76	0.95	1.18	1.09	1.15	1.23	0.68	0.74	0.99
Textiles and Leather	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.03	0.03	0.03	0.03	0.01	0.02	0.02
Non Specified (Industry)	0.07	0.52	0.46	0.92	1.00	1.15	1.51	1.69	1.50	1.48	1.64	0.26	0.31	0.40
Total Other Sectors	1.79	8.22	12.65	12.40	11.55	11.49	13.85	13.94	17.05	18.56	19.98	18.28	20.73	20.56
Commerce - Public Services	0.64	2.27	2.76	2.70	2.38	2.02	2.18	2.49	2.38	2.35	2.47	2.47	4.60	3.85
Residential	0.77	4.50	8.38	8.22	7.41	7.62	9.37	9.35	11.73	12.94	14.20	12.72	13.07	13.51
Agriculture	0.38	1.46	1.51	1.47	1.76	1.85	2.30	2.11	2.94	3.27	3.32	3.09	3.07	3.20
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 127: National Energy Balance 1990-2016. Black Liquor [PJ].

215A Black Liquor	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	17.80	24.06	24.38	24.68	25.07	25.78	24.93	26.99	27.32	27.69	30.09	30.33	28.54	32.79
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.)	17.80	24.06	24.38	24.68	25.07	25.78	24.93	26.99	27.32	27.69	30.09	30.33	28.54	32.79
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	5.26	7.62	8.78	7.30	6.32	7.24	7.41	7.26	8.04	9.81	9.18	9.00	9.02	8.23
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	2.62	2.00	2.42	0.79	0.35	0.66	0.40	0.42	0.42	1.91	1.73	1.93	2.65	0.00
Auto Producers for CHP	2.64	5.62	6.36	6.51	5.96	6.58	7.01	6.85	7.62	7.90	7.45	7.07	6.37	8.23
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	12.54	16.44	15.61	17.38	18.75	18.54	17.52	19.73	19.28	17.88	20.91	21.33	19.52	24.55
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	12.54	16.44	15.61	17.38	18.75	18.54	17.52	19.73	19.28	17.88	20.91	21.33	19.52	24.55
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	12.54	16.44	15.61	17.38	18.75	18.54	17.52	19.73	19.28	17.88	20.91	21.33	19.52	24.55
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 128: National Energy Balance 1990-2016. Biogas [PJ].

309A Biogas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0.00	0.36	3.48	5.85	5.34	6.03	5.43	5.30	5.76	7.51	7.31	11.60	11.90	12.40
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	0.36	3.48	5.85	5.34	6.03	5.43	5.30	5.76	7.51	7.31	11.60	11.90	12.40
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	0.22	2.98	5.54	4.96	5.60	5.01	4.97	5.30	6.49	6.01	9.97	10.25	10.20
Public Electricity	0.00	0.00	2.46	4.69	4.25	4.83	4.44	4.36	4.65	5.91	5.44	9.39	9.77	9.50
Public Combined Heat and Power	0.00	0.00	0.20	0.28	0.31	0.29	0.28	0.33	0.33	0.28	0.26	0.17	0.10	0.27
Public Heat Plants	0.00	0.00	0.00	0.10	0.14	0.25	0.07	0.08	0.07	0.09	0.09	0.08	0.07	0.08
Auto Producers of Electricity	0.00	0.12	0.14	0.36	0.12	0.11	0.09	0.06	0.07	0.05	0.04	0.16	0.15	0.17
Auto Producers for CHP	0.00	0.10	0.18	0.10	0.14	0.13	0.13	0.13	0.18	0.16	0.18	0.19	0.15	0.18
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	0.15	0.50	0.31	0.38	0.43	0.41	0.33	0.46	1.02	1.30	1.63	1.65	2.20
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.04
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	0.01	0.03	0.03	0.04
Total Industry	0.00	0.15	0.50	0.31	0.38	0.42	0.39	0.30	0.41	0.94	1.16	1.23	1.23	1.74
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03
Chemical (incl.Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.11	0.10	0.04	0.41
Non ferrous Metals	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	0.02
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.04
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	0.01	0.02	0.03	0.04	0.05
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	0.10	0.13	0.17	0.21	0.22	0.08	0.14	0.57	0.31	0.30	0.31	0.28
Pulp, Paper and Printing	0.00	0.12	0.25	0.10	0.08	0.08	0.15	0.20	0.19	0.29	0.64	0.71	0.73	0.87
Wood and Wood Products	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Construction	0.00	0.00	0.15	0.09	0.13	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
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	0.01
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.01	0.02	0.01	0.01	0.01
Total Other Sectors	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.05	0.07	0.13	0.36	0.39	0.43
Commerce - Public Services	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.09	0.31	0.31	0.32
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.02	0.04	0.05	0.08	0.10
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 129: National Energy Balance 1990-2016. Sewage Sludge Gas [PJ].

309B Sewage sludge gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0.00	0.47	1.04	0.63	0.90	0.92	0.78	0.93	0.86	0.76	0.78	0.43	0.47	0.55
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	0.47	1.04	0.63	0.90	0.92	0.78	0.93	0.86	0.76	0.78	0.43	0.47	0.55
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	0.11	0.75	0.36	0.58	0.68	0.52	0.59	0.54	0.40	0.38	0.22	0.20	0.28
Public Electricity	0.00	0.08	0.65	0.25	0.47	0.56	0.42	0.28	0.28	0.17	0.13	0.07	0.06	0.12
Public Combined Heat and Power	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.06	0.05	0.06	0.05	0.06
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	0.03	0.01	0.03	0.02	0.01	0.01	0.22	0.15	0.13	0.15	0.07	0.07	0.08
Auto Producers for CHP	0.00	0.00	0.05	0.05	0.05	0.06	0.06	0.05	0.06	0.05	0.05	0.02	0.02	0.02
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	0.36	0.29	0.27	0.33	0.24	0.26	0.34	0.32	0.36	0.40	0.21	0.27	0.27
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	0.36	0.29	0.27	0.33	0.24	0.26	0.34	0.32	0.36	0.40	0.20	0.27	0.27
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	0.36	0.29	0.27	0.33	0.24	0.26	0.34	0.32	0.36	0.40	0.20	0.27	0.27
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 130: National Energy Balance 1990-2016. Landfill Gas [PJ].

310A Landfill Gas	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	0.00	0.44	0.23	0.20	0.20	0.20	0.21	0.19	0.18	0.16	0.14	0.20	0.19	0.16
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	0.44	0.23	0.20	0.20	0.20	0.21	0.19	0.18	0.16	0.14	0.20	0.19	0.16
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	0.44	0.23	0.20	0.20	0.20	0.21	0.19	0.18	0.16	0.14	0.20	0.19	0.16
Public Electricity	0.00	0.01	0.04	0.04	0.05	0.05	0.08	0.12	0.10	0.10	0.09	0.10	0.09	0.04
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	0.00	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	0.43	0.19	0.17	0.15	0.15	0.12	0.07	0.07	0.06	0.05	0.10	0.09	0.11
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	0.00	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 131: National Energy Balance 1990-2016. Municipal Solid Waste [PJ].

114B Municipal Solid Waste	**1990**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Indigenous Production	2.41	4.64	8.88	11.44	10.92	11.25	13.54	14.38	15.47	15.55	15.72	18.70	19.35	18.53
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.)	2.41	4.64	8.88	11.44	10.92	11.25	13.54	14.38	15.47	15.55	15.72	18.70	19.35	18.53
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	4.64	8.88	11.44	10.92	11.25	13.54	14.38	15.47	15.55	15.72	18.70	19.35	18.53
Public Electricity	0.00	0.72	2.19	2.39	2.60	2.24	2.95	2.82	3.77	4.25	3.71	4.80	5.12	5.01
Public Combined Heat and Power	1.72	2.23	3.14	3.15	2.94	3.52	4.72	3.01	3.17	2.44	1.88	2.38	3.22	3.48
Public Heat Plants	0.69	1.69	1.97	1.88	1.95	2.05	1.86	1.87	2.04	2.25	2.17	2.19	2.06	2.09
Auto Producers of Electricity	0.00	0.00	1.46	3.90	3.33	3.33	3.91	4.22	3.38	3.45	4.92	6.07	5.59	4.40
Auto Producers for CHP	0.00	0.00	0.10	0.11	0.10	0.10	0.11	2.46	3.11	3.16	3.04	3.26	3.35	3.55
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 132: National Energy Balance 1990-2016. Industrial Waste [PJ].

115A Industrial Waste	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Indigenous Production	6.58	7.63	12.57	14.95	15.11	17.21	15.75	17.35	20.14	19.26	19.51	19.32	20.11	23.09
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	7.63	12.57	14.95	15.11	17.21	15.75	17.35	20.14	19.26	19.51	19.32	20.11	23.09
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	1.46	2.88	3.34	3.70	4.04	5.16	5.92	6.44	7.29	7.11	5.47	5.90	8.67
Public Electricity	0.00	0.00	0.62	0.69	0.51	0.42	0.51	0.51	1.21	1.33	0.59	0.70	0.74	1.28
Public Combined Heat and Power	0.00	0.00	0.72	0.79	0.92	0.82	0.74	0.92	0.78	1.60	2.94	2.64	2.84	3.90
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.44	0.25	0.30	0.70	0.75	1.85	1.83	1.86	1.85	1.10	0.82	0.68	1.89
Auto Producers for CHP	2.54	1.02	0.91	1.02	1.00	1.43	1.45	2.14	1.91	1.82	1.85	1.14	1.47	1.43
Auto Producer Heat Plants	0.00	0.00	0.38	0.55	0.57	0.62	0.60	0.51	0.60	0.66	0.64	0.17	0.17	0.16
Total Energy Sector	0.00	0.00	0.00	1.00	1.53	2.26	1.65	2.32	2.81	2.14	1.79	2.01	1.87	1.82
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	6.18	9.69	10.62	9.88	10.91	8.95	9.11	10.89	9.83	10.60	11.84	12.35	12.60
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	5.61	9.17	10.27	9.71	10.89	8.90	9.06	10.85	9.79	10.56	11.81	12.31	12.56
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	1.64	4.74	5.19	3.30	4.93	3.20	3.00	3.05	3.22	3.24	3.01	3.27	3.21
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	0.16	0.17	0.18
Non metallic Mineral Products	1.31	3.56	3.81	4.40	5.43	5.23	5.10	5.29	6.86	5.68	6.23	6.73	7.07	7.49
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	0.04	0.03	0.04	0.03	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	0.06	0.08	0.11	0.07	0.08	0.09	0.09	0.06	0.16	0.18	0.23	0.09
Wood and Wood Products	0.04	0.37	0.44	0.47	0.54	0.51	0.48	0.66	0.81	0.75	0.71	1.67	1.50	1.50
Construction	0.00	0.02	0.04	0.05	0.05	0.05	0.04	0.03	0.03	0.04	0.04	0.02	0.02	0.02
Textiles and Leather	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
Non Specified (Industry)	0.01	0.02	0.05	0.05	0.23	0.08	0.01	0.00	0.01	0.02	0.02	0.03	0.04	0.06
Total Other Sectors	1.11	0.56	0.52	0.35	0.17	0.03	0.04	0.05	0.04	0.04	0.04	0.03	0.04	0.04
Commerce - Public Services	1.11	0.56	0.52	0.35	0.17	0.03	0.04	0.05	0.04	0.04	0.04	0.03	0.04	0.04
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 133: Net calorific values for 1990-2016 in [MJ/kg], [MJ/m³] taken from (IEA JQ 2016).

Fuel Code	Fuel Name		1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
101A	Coking Coal	T	29.07	29.07	29.07	29.07	29.07	29.07	29.07	29.17	28.99	29.07	29.21	29.10	28.97	28.66
102A	Hard Coal	FC	28.00	27.99	28.14	28.07	27.92	28.46	28.59	27.54	27.60	27.57	28.03	27.81	27.51	27.64
		T	28.00	26.74	27.92	27.78	27.79	27.97	28.71	28.14	28.22	28.29	28.58	28.52	28.73	28.29
104A	Hard Coal Briquettes	A	0.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00
105A	Brown Coal	FC	10.90	14.71	15.99	20.64	21.93	20.76	18.08	17.47	17.90	19.52	20.24	20.43	20.62	20.48
		T	10.90	9.86	9.09	9.48	21.93	20.76	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	19.30	19.30	19.30	19.30	19.80	19.80	19.80	19.80
107A	Coke Oven Coke	T	28.50	29.00	29.00	29.00	29.00	29.00	28.74	28.75	28.71	28.72	28.57	29.01	28.84	28.88
113A	Peat	FC	8.80	8.80	8.80	8.80	8.30	8.30	8.80	8.80	8.80	8.80	8.80	8.80	8.80	0.00
304A	Coke Oven Gas	P	17.61	17.61	17.56	17.49	17.38	17.56	17.75	17.69	18.06	18.06	17.58	17.31	17.69	17.24
305A	Blast Furnace Gas	P	3.68	3.70	3.80	3.65	3.77	3.78	3.59	3.74	3.75	3.67	3.69	3.71	3.67	3.67
110A	Petrol Coke	A	34.30	33.92	32.11	32.58	33.03	34.16	31.69	32.22	33.06	32.83	30.80	30.80	30.80	30.80
201A	Crude Oil	A	42.50	42.52	42.51	42.74	42.52	42.71	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
203X	Residual Fuel Oil	A	41.00	41.49	41.72	41.17	41.63	41.56	40.36	41.62	40.77	41.34	41.35	41.55	41.44	41.32
204A	Gasoil	A	42.60	42.80	42.80	42.80	42.70	42.80	42.85	42.90	42.89	42.81	42.79	42.94	42.94	42.80
2050	Diesel	A	42.60	42.80	42.75	42.52	42.48	42.48	42.80	42.80	42.49	42.52	42.52	42.40	42.40	42.39
206A	Petroleum	A	43.60	43.30	43.30	43.30	43.30	43.30	43.30	43.36	43.36	43.34	43.32	43.35	43.35	43.30
206B	Kerosene	A	43.60	43.30	43.30	43.30	43.30	43.30	43.30	43.36	43.36	43.34	43.32	43.35	43.35	43.30
207A	Aviation Gasoline	A	42.50	42.50	42.49	43.21	43.18	43.16	42.60	42.60	42.60	42.60	42.60	42.60	42.60	42.60
2080	Motor Gasoline	A	42.50	42.50	42.49	43.21	43.18	43.16	41.29	41.44	41.41	41.34	41.36	41.64	41.64	41.15
217A	Refinery Feedstocks	A	41.87	42.56	42.39	42.51	42.39	42.97	42.63	42.49	42.55	41.77	41.65	41.46	42.26	42.84
219A	Lubricants	A	41.40	41.80	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	42.49	43.21	43.18	43.16	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
222A	Bitumen	A	41.80	43.62	43.34	43.78	44.15	44.84	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
224A	Other Petroleum Products	FC	34.30	33.92	32.11	32.58	33.03	34.16	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
		NE	41.80	43.62	43.34	43.78	44.15	44.84	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
302A	NGL	A	42.50	42.52	42.51	42.74	42.52	42.71	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
303A	LPG	A	46.30	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.12	46.12	46.12	46.12	46.12
308A	Refinery Gas	A	49.00	37.18	30.68	30.68	30.68	30.68	30.68	30.68	32.00	32.00	32.00	29.87	29.87	29.87
301A	Natural Gas	A	36.00	35.85	36.00	36.00	36.00	36.00	36.09	36.26	36.26	36.26	36.29	36.29	36.29	36.29

Legend: A…Average; T…Transformation; FC…Final Consumption; P…Production; NE…Non Energy use; NGL…Natural Gas Liquids; LPG…Liquified Petroleum Gas

Table A 135 presents the net calorific values from STATISTIK AUSTRIA, which are used for default unit conversion.

Table A 134: 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
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 136 presents the IPCC default values of net calorific values of gaseous biofuels which are used for default unit conversion.

Table A 135: 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 and the Kyoto Protocol the relevant COP (Conference of the Parties) or CMP (Meeting of the Parties to the Kyoto Protocol) 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 22/C.7 (15.CMP.1): Guidance for the preparation of the information required under Article 7 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;
- Austria's annual obligations under the European Council Regulation No 749/2014 ('Monitoring Mechanism Regulation'; repealing Decision No 280/2004/EC concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

In addition to the obligation under the UNFCCC and the Kyoto Protocol 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[1] concerning the reporting of national emission data on SO_2, NO_x, NMVOC, CO, heavy metals (Pb, Cd, Hg), benzene and particulate matter.

[1] AUSTRIAN AMBIENT AIR QUALITY LAW (1997): Immissionsschutzgesetz-Luft. Federal Law Gazette I 115/1997.

- 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 is 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
- In 2015: second re-accreditation according to EN ISO/IEC 17020
- Periodic external audit by “Accreditation Austria “ in 2017

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.

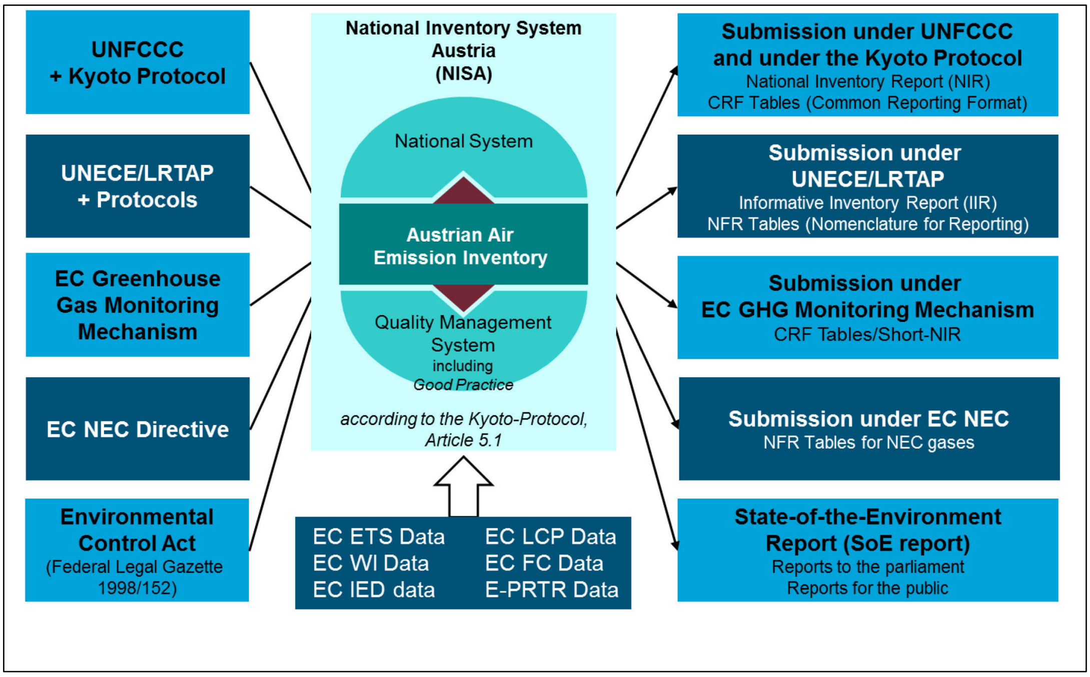

Figure 2: Structure of the National Inventory System in Austria (NISA).

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 takean 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 subchapter 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 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 2011 and 2015.
- 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 pertains to 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 Federal Ministry of Agriculture, Forestry, Environment and Water Management, 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 and 2015.

Table A 136: presents the timetable for the implementation of the quality management system.

Table A 136: 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	January 2011
2nd Re-Accreditation Audit	December 2015

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[2]. 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.

[2] The International Standard ISO/IEC 17020 superseded the European Standard EN 45004.

The EN ISO/IEC 17020 also takes into account requirements and recommendations of European and international documents such as the ISO 9000 (EN/ISO 9000) series of standards, and goes beyond: additionally to the requirements of the 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.

Accreditation Act

According to the 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 Digital, Business and Enterprise (BMDW) 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 every twelve to fifteen months a one day audit takes place and a full three day audit after five years).

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 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 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)

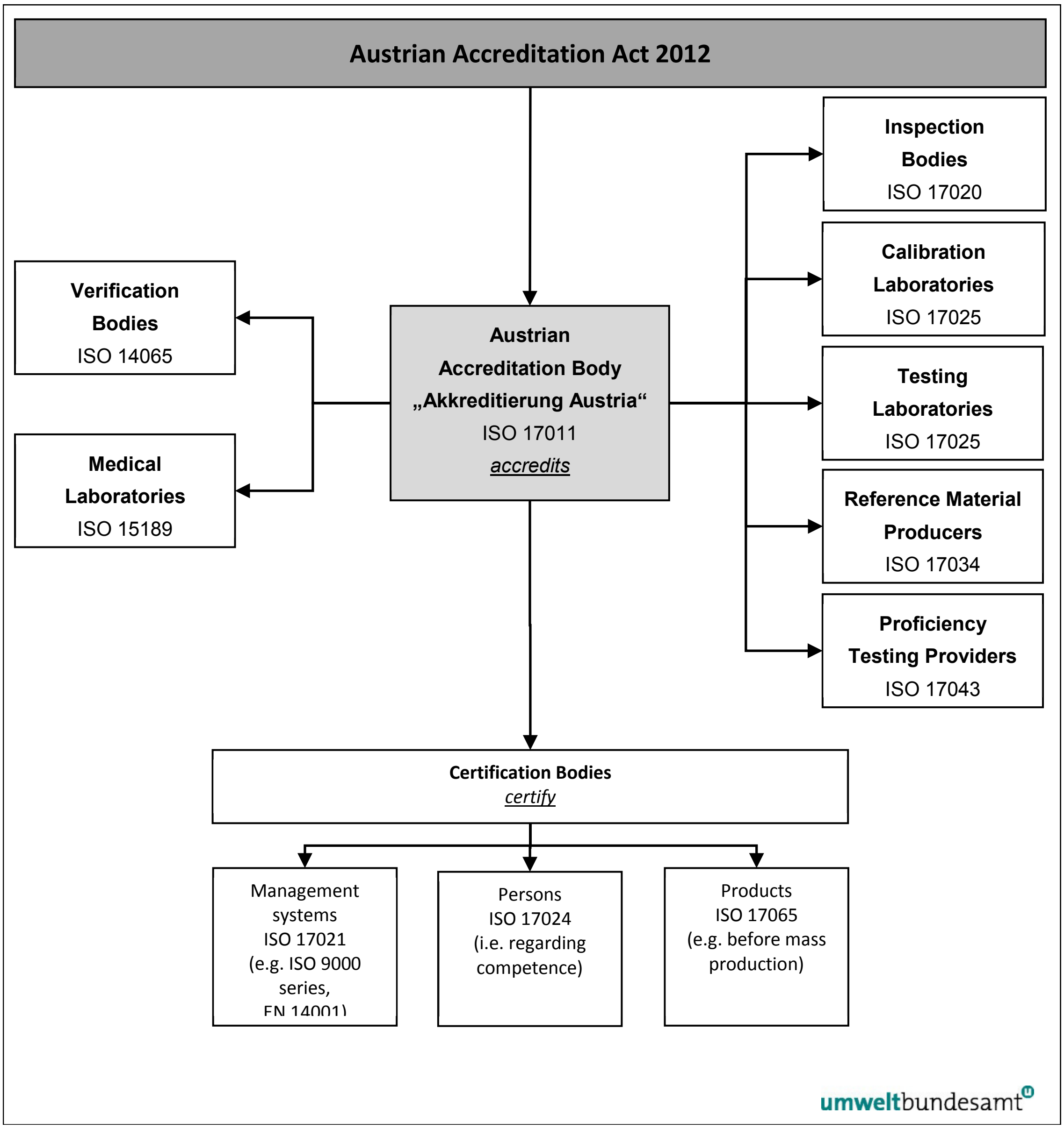

Figure 3: Overview of accreditation of conformity assessment bodies by “Akkreditierung Austria” and certification by certification bodies in Austria

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 director 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.

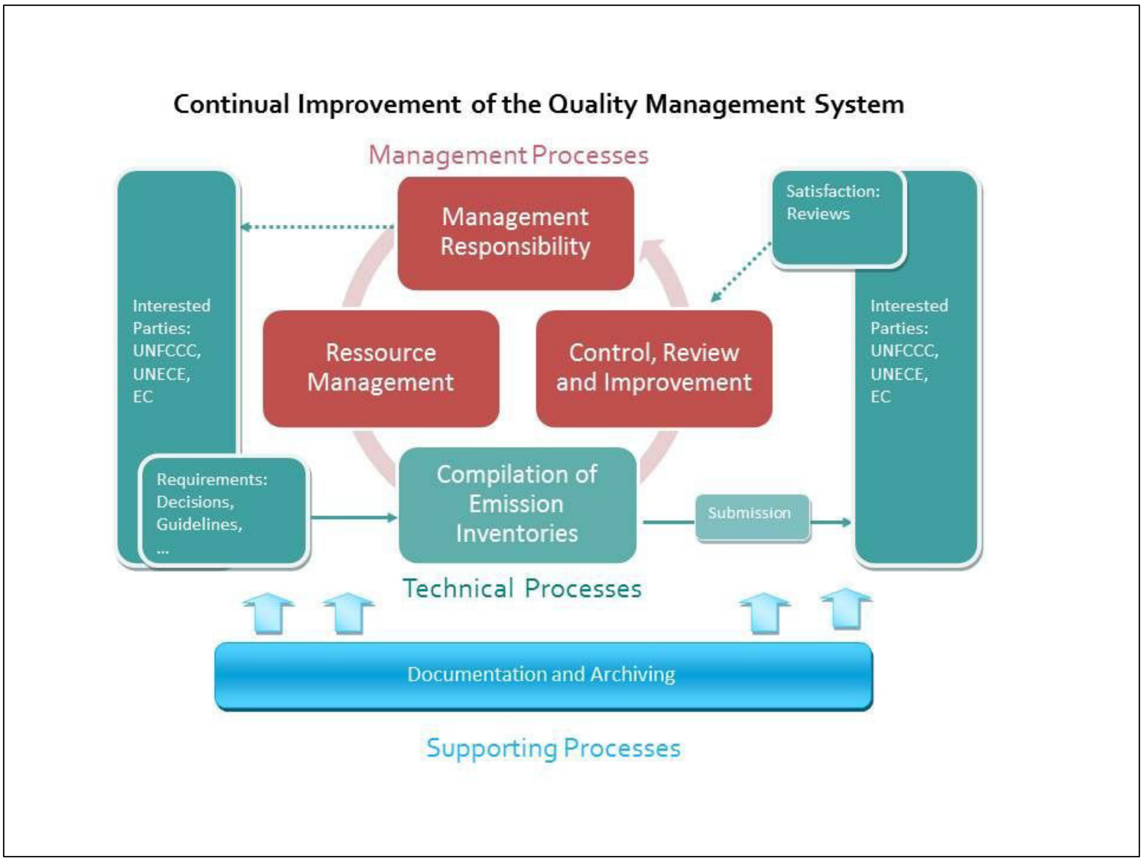

Figure 4: Process-based QMS of the IBE

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 director who is 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.