AUSTRIA'S NATIONAL INVENTORY REPORT 2015

Submission under the United Nations Framework Convention on Climate Change

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Since 23 December 2005, the Umweltbundesamt is 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/Federal Ministry of Economics, Family and Youth (No. BMWA-92.715/0036-I/12/2005, issued on 19 January 2006) for the field as published on www.bmwfj.gv.at/akkreditierung.

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This report is submitted to the European Commission in fulfilment of Art. 7 Monitoring Mechanism and is the official submission for the year 2015 under the UNFCCC. The present report is not an official submission under the Kyoto Protocol. Supplementary information required under Article 7 of the Kyoto Protocol is not submitted given the persistent problems with the CRF Reporter with the generation of KP-LULUCF Tables. CRF reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it is therefore not yet functioning to allow submission of all the information required under the Kyoto Protocol.

This report replaces the one designated as DRAFT submitted to the European Commission according to the Monitoring Mechanism on October 30th 2015

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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 itsreporting 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 for the first year of 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 gives an overview of actions planned to further improve the inventory and of changes previously made (recalculations), and it also describes improvements made in response to the previous UNFCCC review.

This is the 14th version of the National Inventory Report (NIR) submitted by Austria. It builds on the NIR submitted in 2014[4], but reflects also the changed requirements on sectoral inventories according to the IPCC 2006 Guidelines and UNFCCC Reporting Guidelines. 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 more widely than usual as some changes in allocations and methodological changes and refinements have been made to comply with the IPCC 2006 Guidelines. In addition, further improvements to enhance accuracy and transparency have been implemented, among others due to update of activity data (for further information see Chapter 9 Recalculations and Improvements).

The inventory as presented in the NIR 2015 and submitted to the EC and the UNFCCC replaces all previous versions of data submissions.

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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 2014 – Submission under the United Nations Framework Convention of Climate Change and the Kyoto Protocol. Report REP-0475; Umweltbundesamt, Vienna.

According to Decision 13/CP.20 of the Conference of the Parties to the UNFCCC, CRF Reporter version 5.0.0 was not functioning in order to enable Annex I Parties to submit their CRF tables for the year 2015. In the same Decision, the Conference of the Parties reiterated that Annex I Parties in 2015 may submit their CRF tables after 15/April, but no longer than the corresponding delay in the CRF Reporter availability. "Functioning" software means that the data on the greenhouse emissions/removals are reported accurately both in terms of reporting format tables and XML format.

CRF reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it is therefore not yet functioning to allow submission of all the information required under Kyoto Protocol.

Recalling the Conference of Parties invitation to submit as soon as practically possible, and considering that CRF reporter 5.10 allows sufficiently accurate reporting under the UNFCCC (even if minor inconsistencies may still exist in the reporting tables, as per the Release Note accompanying CRF Reporter 5.10), the present report is the official submission for the year 2015 under the UNFCCC. The present report is not an official submission under the Kyoto Protocol, even though some of the information included may relate to the requirements under the Kyoto Protocol.

Elisabeth Rigler in her function as head of the Department *Air Pollution Control & Climate Change Mitigation* 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.

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 air pollutant inventory is Stephan Poupa.

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- Chapter 3.3 .... Marion Pinterits, Katja Pazdernik
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- Chapter 4.5–4.8 .... Maria Purzner, Manuela Wieser
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- Chapter 8.4 .... Stephan Poupa
- Chapter 9 .... all sector experts

CONTENTS

EXECUTIVE SUMMARY 13

ES.1 Background information on greenhouse gas (GHG) inventories and climate change 13

ES.1.1 Background information on climate change 13

ES.1.2 Background information on greenhouse gas inventories 13

ES.2 Summary of national emission and removal-Rrelated trends 13

ES.3 Overview of source and sink category emission estimates and trends 14

ES.4 Other information 15

Overview of Emission Estimates and Trends of Indirect GHGs and SO_2 15

1 INTRODUCTION 17

1.1 Background Information on greenhouse gas inventories and climate change 17

1.1.1 Background information on climate change 17

1.1.2 Background information on greenhouse gas inventories 19

1.2 Institutional Arrangements for Inventory Preparation, including the legal and procedural arrangements for inventory planning, preparation and management 19

1.2.1 Overview of institutional, legal and procedural arrangements of compiling GHG inventory and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol 19

1.2.2 Overview of inventory planning 23

1.2.3 Overview of inventory preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol 23

1.3 Inventory Preparation 24

1.3.1 GHG Inventory and KP-LULUCF inventory 24

1.3.2 Data collection, processing and storage, including for KP-LULUCF inventory 25

1.3.3 Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory and KP-LULUCF inventory 25

1.4 Methodologies and Data Sources Used 25

1.4.1 GHG inventory 25

1.5 Brief description of key categories, including for KP-LULUCF 29

1.6 Information on the QA/QC plan 35

1.6.1 Roles and responsibilites 37

1.6.2 QA/QC Plan 37

1.6.3 QC Activities 38

1.6.4 QA Activities 39

1.6.5 Error correction and continuous improvement 40

1.6.6 Archiving and documentation 40

1.6.7 Focus of QA/QC activities in the year 2014 41

1.6.8 Treatment of confidentiality issues 42

1.7 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals 42

1.8 General assessment of the completeness 44

2 TREND IN TOTAL EMISSIONS 46

2.1 Emission Trends for Aggregated GHG Emissions 46

2.2 Emission Trends by Gas 48

2.3 Emission Trends by Source 49

2.3.1 Energy 51
2.3.2 Industrial Processes and Other Product Use 52
2.3.3 Agriculture 53
2.3.4 LULUCF 53
2.3.5 Waste 54

2.4 Emission Trends for Indirect Greenhouse Gases and SO_2 54

3 ENERGY (CRF SECTOR 1) 57

3.1 Sector Overview 57

3.2 Fuel Combustion Activities (CRF Category 1.A) 60

3.2.1 Comparison of the Sectoral Approach with the Reference Approach 60
3.2.2 International bunker fuels 64
3.2.3 Feedstocks and non-energy use of fuels 68
3.2.4 CO_2 capture from flue gases and subsequent CO_2 storage, if applicable 69
3.2.5 Country-specific issues 69
3.2.6 Source Category Description 70
3.2.7 Key Categories 71
3.2.8 Completeness 71
3.2.9 Methodological Issues 75
3.2.10 1.A.1 Energy Industries 83
3.2.11 1.A.2 Manufacturing Industries and Construction 90
3.2.12 1.A.3 Transport 107
3.2.13 1.A.4 Other sectors 134
3.2.14 1.A.5 Other 143
3.2.15 Quality Assurance/Quality Control and Verification 146
3.2.16 Uncertainties and time series consistency 147
3.2.17 Recalculations of Category 1.A 148
3.2.18 Planned Improvements 152

3.3 Fugitive Emissions (CRF Category 1.B) 152

3.3.1 Emission Trends 152
3.3.2 Completeness 153
3.3.3 Methodology 155
3.3.4 QA/QC 163
3.3.5 Uncertainty 164
3.3.6 Recalculations 165

3.4 CO_2 transport and storage (CRF Category 1.C) 165

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF SECTOR 2) 166

4.1 Sector Overview 166

4.1.1 Emission Trends 166

4.1.2 Key Categories 173
4.1.3 Methodology 174
4.1.4 Uncertainty Assessment 175
4.1.5 Quality Assurance and Quality Control (QA/QC) 175
4.1.6 Recalculations 176
4.1.7 Completeness 177
4.2 Mineral Products (2.A) 180
4.2.1 Cement Production (2.A.1) 180
4.2.2 Lime Production (2.A.2) 183
4.2.3 Glass Production 187
4.2.4 Other Process Uses of Carbonates (2.A.4) 188
4.3 Chemical Industry (2.B) 195
4.3.1 Ammonia Production (2.B.1) 195
4.3.2 Nitric Acid Production (2.B.2) 199
4.3.3 Calcium Carbide Production (2.B.5.b) 202
4.3.4 Chemical Industry –Ethylene (2.B.8.b) 203
4.3.5 Chemical Industry – Other: Production of bulk chemicals (2.B.10.i) 204
4.3.6 Chemical Industry – Other: Production of Fertilizers and Urea (2.B.10.ii) 205
4.4 Metal Production (2.C) 206
4.4.1 Iron and Steel (2.C.1) 206
4.4.2 Ferroalloys Production (2.C.2) 210
4.4.3 Aluminium Production (2.C.3) 211
4.4.4 SF_6 Used in Aluminium and Magnesium Foundries (2.C.4) 213
4.5 Non-Energy Products from Fuels and Solvent Use (2.D) 215
4.5.1 Source Category Description 215
4.5.2 Methodological Issues 216
4.5.3 Source specific QA/QC 220
4.5.4 Uncertainty Assessment 220
4.5.5 Planned Improvements 220
4.6 Electronics Industry (2.E) – 2.E.1 Integrated Circuit or Semiconductor 221
4.6.1 Source Category Description 221
4.6.2 Methodological Issues 221
4.6.3 Source specific QA/QC 223
4.6.4 Uncertainty Assessment 223
4.7 Product Uses as Substitutes for Ozone Depleting Substances (2.F) 223
4.7.1 Source Category Description 223
4.7.2 Methodological Issues 226
4.7.3 Source specific QA/QC 240
4.7.4 Uncertainty Assessment 240
4.7.5 Recalculations 241
4.8 Other Product Manufacture and Use (2.G) 242
4.8.1 Source Category Description 242
4.8.2 Methodological Issues 243
4.8.3 Source specific QA/QC 246
4.8.4 Uncertainty Assessment 246

4.8.5 Recalculations 247

5 AGRICULTURE (CRF SECTOR 3) 248

5.1 Sector Overview 248
5.1.1 Emission Trends 249
5.1.2 Key Categories 252
5.1.3 Methodology 252
5.1.4 Quality Assurance and Quality Control (QA/QC) 253
5.1.5 Uncertainty Assessment 254
5.1.6 Recalculations 256
5.1.7 Completeness 258
5.1.8 Planned Improvements 260

5.2 Enteric fermentation (CRF category 3.A) 261
5.2.1 Source Category Description 261
5.2.2 Methodological Issues 262
5.2.3 Source specific QA/QC 272
5.2.4 Uncertainties 273
5.2.5 Recalculations 273

5.3 Manure management (CRF category 3.B) 273
5.3.1 Source Category Description 273
5.3.2 Methodological Issues 276
5.3.3 Source specific QA/QC 293
5.3.4 Uncertainties 294
5.3.5 Recalculations 294

5.4 Agricultural soils (CRF category 3.D) 294
5.4.1 Source Category Description 294
5.4.2 Methodological Issues 296
5.4.3 Source specific QA/QC 316
5.4.4 Uncertainties 316
5.4.5 Recalculations 317

5.5 Field burning of agricultural residues (CRF Category 3.F) 318
5.5.1 Source Category Description 318
5.5.2 Methodological issues 319
5.5.3 Source specific QA/QC 320
5.5.4 Recalculations 320

5.6 Liming (CRF Category 3.G) 321
5.6.1 Source Category Description 321
5.6.2 Methodological issues 321
5.6.3 Source specific QA/QC 324

5.7 Urea Application (CRF Category 3.H) 324
5.7.1 Source category description 324
5.7.2 Methodological issues 325
5.7.3 Source specific QA/QC 326
5.7.4 Recalculations 326

6 LULUCF (CRF SECTOR 4) 327

6.1 Sector Overview 327
6.1.1 Emission Trends 328
6.1.2 Key Categories........ 328
6.1.3 Methodology........ 329
6.1.4 Quality Assurance and Quality Control (QA/QC)........ 333
6.1.5 Uncertainty Assessment (for LULUCF without HWPs)........ 334
6.1.6 Recalculations........ 335
6.1.7 Completeness 336
6.1.8 Planned improvements 339
6.2 Forest land 4.A 340
6.2.1 Category description 340
6.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation 343
6.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories 348
6.2.4 Methodological Issues 348
6.2.5 Uncertainty Assessment 362
6.2.6 QA/QC and Verification........ 364
6.2.7 Recalculations........ 364
6.2.8 Planned improvements 365
6.3 Cropland 4.B........ 365
6.3.1 Category description 365
6.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation 367
6.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories 370
6.3.4 Methodological Issues 370
6.3.5 Uncertainty assessment........ 384
6.3.6 QA/QC and Verification........ 385
6.3.7 Recalculations........ 385
6.3.8 Planned improvements 386
6.4 Grassland 4.C 386
6.4.1 Category description 386
6.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation 388
6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories 391
6.4.4 Methodological Issues 391
6.4.5 Uncertainty assessment........ 395
6.4.6 QA/QC and Verification........ 396
6.4.7 Recalculations........ 396
6.4.8 Planned improvements 397
6.5 Wetlands 4.D........ 397
6.5.1 Category description 397
6.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation 399
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) ... 399
6.5.4 Methodological Issues ... 400
6.5.5 Uncertainty assessment ... 401
6.5.6 QA/QC and Verification ... 401
6.5.7 Recalculations ... 402
6.5.8 Planned improvements ... 402

6.6 Settlements 4.E ... 402
6.6.1 Category description ... 402
6.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation ... 404
6.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories ... 405
6.6.4 Methodological Issues ... 406
6.6.5 Uncertainty assessment ... 409
6.6.6 QA/QC and Verification ... 409
6.6.7 Recalculations ... 409
6.6.8 Planned improvements ... 409

6.7 Other Land 4.F ... 410
6.7.1 Category description ... 410
6.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation ... 411
6.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories ... 412
6.7.4 Methodological Issues ... 412
6.7.5 Uncertainty assessment ... 413
6.7.6 QA/QC and Verification ... 413
6.7.7 Recalculations ... 413
6.7.8 Planned improvements ... 414

6.8 Harvested Wood Products 4.G ... 414
6.8.1 Category description ... 414
6.8.2 Methodological issues ... 415
6.8.3 Uncertainty assessment ... 417
6.8.4 Recalculations ... 417
6.8.5 Planned Improvements ... 417

7 WASTE (CRF SECTOR 5) ... 418

7.1 Sector overview ... 418
7.1.1 Emission Trend ... 418
7.1.2 Key Categories ... 421
7.1.3 Completeness ... 421
7.1.4 Methodological issues ... 422
7.1.5 Quality Assurance and Quality Control (QA/QC) ... 422

7.2 Solid Waste Disposal (CRF 5.A) ... 422
7.2.1 Source Category Description ... 422
7.2.2 Methodological Issues ... 427
7.2.3 Uncertainties and time series consistency ... 434

7.2.4 Category-specific QA/QC and verification ... 435
7.2.5 Category-specific recalculations ... 436
7.2.6 Category-specific planned improvements ... 436
7.3 Biological Treatment of Solid Waste (CRF 5.B) ... 436
7.3.1 Source category description ... 436
7.3.2 Methodological issues ... 436
7.3.3 Uncertainties and time-series consistency ... 439
7.3.4 Category-specific recalculations ... 440
7.3.5 Category-specific QA/QC and verification ... 440
7.3.6 Category-specific planned improvements ... 440
7.4 Incineration and Open Burning of Waste (CRF 5.C) ... 441
7.4.1 Source Category Description ... 441
7.4.2 Methodological Issues ... 442
7.5 Wastewater Treatment and Discharge (CRF 5.D) ... 445
7.5.1 Source category description ... 445
7.5.2 Methodological issues ... 446
7.5.3 Uncertainties and time-series consistency ... 453
7.5.4 Category-specific QA/QC and verification ... 453
7.5.5 Category-specific Recalculations ... 454
7.5.6 Category-specific planned improvements ... 455
8 RECALCULATIONS AND IMPROVEMENTS ... 456
8.1 Explanations and Justifications for Recalculations, including in response to the review process ... 456
8.2 Implication for Emission Levels ... 466
8.3 Implications for Emission Trends, including time series consistency ... 467
8.4 Planned improvements, including in response to the review process, and planned improvements to the inventory ... 468
ABBREVIATIONS ... 473
REFERENCES ... 477
DATA SOURCES BY SECTOR ... 496

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 dangerous 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. The so called Doha Agreement extents the Kyoto Protocol until 2020, however it has not yet been set into force.

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-Rrelated trends

In 2013 Austria's total greenhouse gas (GHG) emissions (without LULUCF) amounted to 79.6 Mt CO_2 equivalents (CO_2e). Compared to 1990 GHG emissions have increased by 1.2%, compared to 2012 GHG emissions have slightly decreased (–0.2%).

The most important GHG in Austria is carbon dioxide (CO_2) with a share of 85.1% in 2013. 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 4.1% in 2013. 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
1990	[kt CO_2 equivalent]	78 683.26	62 216.94	10 613.92	4 196.58	2.44	1 182.79	470.61	0.00
1991		82 395.48	65 803.11	10 416.36	4 365.37	3.89	1 192.62	614.14	0.00
1992		75 621.95	60 311.47	10 070.59	4 067.51	5.64	510.47	656.27	0.00
1993		75 703.86	60 699.97	9 971.86	3 989.24	235.26	63.52	744.00	0.00
1994		76 131.09	61 099.47	9 586.15	4 186.47	261.11	70.96	926.17	0.76
1995		79 456.34	64 147.44	9 470.88	4 290.19	357.93	83.35	1 100.11	6.44

GHG	Total	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
1996	82 646.81	67 590.96	9 192.48	4 177.50	420.79	80.25	1 176.90	7.93
1997	82 123.83	67 396.05	8 817.38	4 190.19	500.83	117.47	1 086.40	15.53
1998	81 415.54	66 976.00	8 648.72	4 245.64	610.34	55.53	869.88	9.43
1999	79 746.47	65 580.31	8 464.97	4 235.58	701.82	79.18	676.37	8.24
2000	80 123.87	66 229.10	8 296.30	4 212.50	713.63	87.32	574.53	10.51
2001	84 107.21	70 266.40	8 135.75	4 085.78	863.10	116.34	629.33	10.51
2002	85 921.27	72 122.22	8 019.09	4 085.40	968.78	101.97	613.30	10.51
2003	91 899.08	78 037.22	8 007.41	4 084.88	1 072.19	126.38	549.44	21.56
2004	91 523.36	78 417.79	7 792.37	3 486.73	1 158.34	157.57	484.01	26.54
2005	92 495.55	79 596.32	7 573.98	3 499.91	1 145.76	157.79	493.63	28.16
2006	89 713.22	76 968.46	7 438.29	3 495.43	1 152.47	172.39	453.46	32.73
2007	86 933.08	74 270.64	7 306.17	3 503.65	1 195.89	230.33	367.01	59.39
2008	86 756.64	74 039.95	7 162.10	3 670.97	1 248.53	208.19	373.43	53.47
2009	80 032.27	67 849.61	7 046.97	3 446.60	1 306.85	36.02	341.68	4.54
2010	84 788.00	72 690.78	6 946.86	3 250.66	1 481.67	78.05	335.87	4.12
2011	82 582.58	70 581.60	6 744.74	3 315.17	1 556.11	73.51	307.35	4.10
2012	79 792.99	67 843.27	6 634.36	3 288.92	1 655.28	50.72	311.88	8.56
2013	79 599.18	67 767.98	6 530.26	3 263.51	1 674.27	49.23	304.19	9.75

NOTE: Emissions without LULUCF

Over the period 1990–2013 CO_2 emissions increased by 8.9%, mainly due to increased emissions from transport. Methane emissions decreased during the same period by 38.5% mainly due to lower emissions from solid waste disposal; N_2O emissions decreased by 22.2% over the same period due to lower emissions from agricultural soils and from chemical industry. HFC emissions increased remarkably between 1990 and 2013 (from 2.4 to 1.674 kt CO_2e), whereas PFC and SF_6 emissions decreased by 95.8% and 35.4% respectively.

ES.3 Overview of source and sink category emission estimates and trends

The dominant sector regarding GHG emissions in Austria is *Energy*, causing 69.2% of total national GHG emissions in 2013 (67.2% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (20.1% in 2013) and *Agriculture* (8.6% in 2013).

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	52 906	13 593	7 959	-13 042	4 226	0
1991	56 592	13 606	7 987	-17 684	4 210	0
1992	52 016	11 944	7 571	-12 721	4 091	0
1993	52 309	11 924	7 432	-13 071	4 039	0
1994	51 957	12 660	7 677	-12 986	3 836	0
1995	54 439	13 566	7 815	-14 119	3 636	0
1996	58 636	12 995	7 569	-11 562	3 446	0
1997	57 153	14 174	7 516	-19 927	3 281	0

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO_2 equivalents (kt)					
1998	56 965	13 807	7 483	-18 047	3 161	0
1999	55 755	13 579	7 379	-20 167	3 034	0
2000	55 304	14 606	7 292	-16 888	2 922	0
2001	59 542	14 501	7 231	-19 610	2 833	0
2002	60 777	15 172	7 119	-14 760	2 854	0
2003	66 696	15 314	6 980	-5 331	2 909	0
2004	66 970	14 844	6 943	-9 674	2 766	0
2005	67 374	15 611	6 878	-11 142	2 632	0
2006	64 029	16 301	6 855	-5 806	2 528	0
2007	60 720	16 931	6 889	-5 942	2 394	0
2008	60 235	17 265	6 980	-4 747	2 276	0
2009	57 082	13 834	7 002	-4 688	2 115	0
2010	60 072	15 870	6 852	-6 167	1 993	0
2011	57 742	16 066	6 889	-6 439	1 884	0
2012	55 471	15 710	6 826	-6 016	1 785	0
2013	55 095	16 013	6 807	-4 978	1 684	0

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 2013: NO_x by 25.2%, CO by 54.9%, NMVOC by 55.2%, and SO_2 by 77.0%. 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 1990–2013.

Year		NO_x	CO	NMVOC	SO_2
1990	[kt]	214.62	1 286.43	280.90	74.39
1991		222.40	1 285.24	265.89	71.48
1992		209.73	1 215.46	232.64	55.10
1993		200.80	1 149.46	226.16	53.47
1994		193.62	1 084.00	205.16	47.82
1995		192.98	986.11	204.31	47.41
1996		211.15	991.79	196.10	44.72
1997		199.59	922.32	183.13	40.18
1998		211.67	884.71	169.01	35.54
1999		203.44	782.55	157.04	33.66
2000		208.77	783.58	163.49	31.58
2001		218.55	758.19	165.03	32.66
2002		224.16	724.85	167.46	31.79
2003		233.69	728.54	166.67	31.96
2004		231.16	707.60	149.52	27.32

2005	233.19	697.38	158.88	26.59
2006	219.03	670.71	169.03	27.62
2007	210.26	636.28	156.16	24.57
2008	193.55	617.60	147.36	22.23
2009	177.43	579.72	119.02	16.91
2010	177.99	593.56	130.42	18.60
2011	168.15	572.55	125.14	17.83
2012	162.88	579.58	132.17	17.29
2013	160.56	580.11	125.94	17.14

1 INTRODUCTION

1.1 Background Information on greenhouse gas 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 0.6–0.9°C in the 20th century and, according to the fifth assessment report of the IPCC, will rise by another 1.8–4.0°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 hydrologic 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 +1.8° C in the past 150 years. That is significantly higher than the global average (which is about 0.7 °C).

Even more important than the average temperature for agriculture, energy production, tourism etc. is precipitation. So far experts think that north of the Alps rainfall will increase, possibly leading to a higher frequency of extreme floods, whereas south of the Alps there could be a higher risk for droughts. An exact regionalization 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 FloodRisk as well as ProVision, three research programmes, in 2003 and 2005 respectively.

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 diox-

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

ide (CO_2), methane (CH_4), nitrous oxide (N_2O) as well as hydrogenated fluorocarbons (HFCs), perfluorated 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 – known as Annex 1 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 1 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 will be made in the true up process after finalization of the last review reports in 2015.

The so called Doha Agreement extents the Kyoto Protocol until 2020, establishing a second commitment period. However it has not yet been set into force as by the end of 2014 only 23 Parties have deposited their instruments of acceptance (144 are needed).

Independently of the setting into force of the Doha Agreement, 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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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 2013. 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 accreditated according to ISO/IEC 17020. In 2011 the re-accreditation was passed successfully.

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) since 2003. To date, Austria's Greenhouse Gas Inventory was reviewed by an in-country review[7] and a centralized review in 2001 (during the trial period of the review process), during the centralized reviews in 2003, 2004, 2005, 2008, 2009, 2010, 2011, 2012 and 2014 as well as by an In-Country Review in 2013. The reports on these reviews can be found on the UNFCCC website[8].

In 2012 GHG inventories were subject to a technical review performed according to the ESD Review Guidelines, with the aim of supporting the determination of Member States' annual emission allocations under Decision No 406/2009/EC (Effort-Sharing Decision).

1.2 Institutional Arrangements for Inventory Preparation, including the legal and procedural arrangements for inventory planning, preparation and management

1.2.1 Overview of institutional, legal and procedural arrangements of compiling GHG inventory and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Austria's reporting obligations to the UNFCCC, UNECE and EC are administered by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). With the En-

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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/resource/webdocs/iri(2)/2001/aut.pdf,
http://unfccc.int/resource/webdocs/iri(3)/2001/aut.pdf,
http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/autrep03.pdf,
http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_centralized_review_austria.pdf,
http://unfccc.int/resource/docs/2006/arr/aut.pdf
http://unfccc.int/resource/docs/2007/irr/aut.pdf and http://unfccc.int/resource/docs/2007/arr/aut.pdf

vironmental 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 addresses the Umweltbundesamt as a private limited company. 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 as described above. . Since 23 December 2005, the IBE is accredited as a Type A inspection body (Id.No. 241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG)[9], by decree of Accreditation Austria/Federal Ministry of Economics, Family and Youth (No. BMWA-92.715/0036-I/12/2005, issued on 19 January 2006.

For more information on the accreditation please refer to Annex 6 in NIR 2014 (UMWELTBUNDESAMT 2014a).

The personnel of the IBE is 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).

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, IP, 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 1.6.

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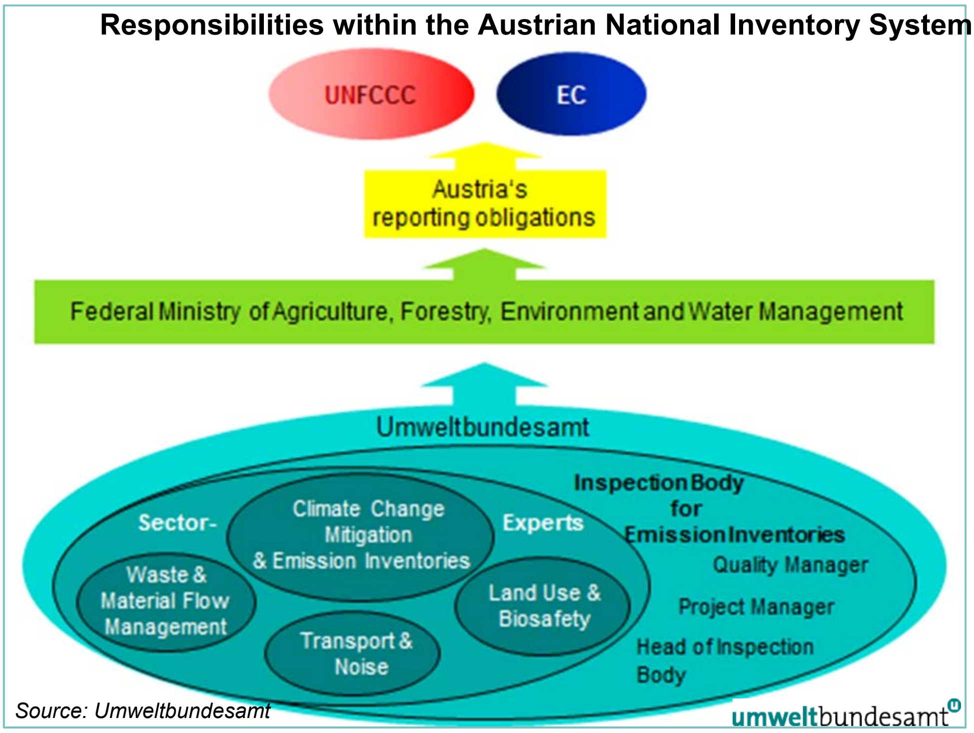
9 Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012)



Source: Umweltbundesamt

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

In addition, the Austrian emissions trading registry is managed by the Umweltbundesamt on behalf of the Federal Ministry of Agriculture, Forestry, Environment and Water Management. 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:

- Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions[10]
- This ordinance pertains to the Austrian Emissions Certificate Trading Act[11] that regulates monitoring and reporting in the context of the EU Emissions Trading scheme (ETS) in Austria.
- Paragraph 15 of this ordinance is designed to ensure consistency of emission trading data with the national inventory. It states that the Umweltbundesamt has to incorporate, as far as necessary, the emission reports of the emissions trading scheme into the national greenhouse gas inventory in order to comply with requirements of the EU Monitoring Mechanism Decision (280/2004/EC) 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, where the ordinance ensures data availability for most key categories (see Chapter 4 for details). First data from

[10] *„Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Überwachung und Berichterstattung betreffend Emissionen von Treibhausgasen"*; Federal Law Gazette II No. 458/2004

[11] *„Emissionszertifikate-Gesetz"*; Federal Law Gazette I No. 46/2004

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 Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) and with the Federal Ministry of Economy, Family and Youth (BMWFJ) 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[12]), 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*, *Solvents and Other 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"[12] (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 para 17 (1) of the (EG-K)[13] each licencee of an operating boiler with a thermal capacity of 2 megawatts (MW) or more is obligated 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 Landfill Ordinance (Deponieverordnung)[14] the operators of landfill sites have to report type and amount of waste deposited annually. This reports (collected in a central database) provide the main basis for calculating emissions from the sector *Waste*.
- Until 2008 the Umweltbundesamt has run a landfill database for solid waste disposals (Deponiedatenbank), where the data (reports) provided by the landfill operators were incorporated.
- However, since 2009 – starting with the deposited waste of the year 2008 – landfill operators are obliged to register their data electronically at the portal of **http://edm.gv.at** (Electronic Data Management).[15] Responsible for data collection and analysis is the BMLFUW. The necessary data is requested by the Umweltbundes for the purpose of inventory preparation.
- Since 2004 there is a reporting obligation to the BMLFUW under the Austrian Fluorinated Compounds (FC) Ordinance[16] 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 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 6).

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[12] *„Bundesstatistikgesetz"*; Federal Law Gazette I No. 163/1999

[13] *„Emissionsschutzgesetz für Kesselanlagen"*; Federal Law Gazette I No. 150/2004

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

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

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

1.2.2 Overview of inventory planning

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 finished improvments.

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 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 discussed.

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

1.2.3 Overview of inventory preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

The following table 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 anda plan for QMS and inventory improvement, i.a. 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 European Commission (Decision 280/2004/EC)	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	March 15

Task	Description	Deadline
UNFCCC Submission NIR	Submission ot the National Inventory Report to the UNFCCC	April 15

The following table gives an overview on 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

1.3 Inventory Preparation

1.3.1 GHG Inventory and KP-LULUCF inventory

The present Austrian greenhouse gas inventory for the period 1990 to 2013 was compiled according to the recommendations for inventories as specified in the UNFCCC reporting guidelines according to Decision 14/CP.11, 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 contracting out studies, if needed. As part of the quality management system the head of the „Inspection Body 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 reconstruction 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 the Umweltbundesamt.

1.3.2 Data collection, processing and storage, including for KP-LULUCF inventory

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

For the inventory management a reliable data management to fulfil the data collecting and reporting requirements is needed. As mentioned above, data are collected by the different sector experts and the reporting requirements grow rapidly and may change over time. Data management is carried out by using MS Excel™ spreadsheets in combination with Visual Basic™ macros, which is a very flexible system that can easily be adjusted to new requirements. The data are stored in a central network server which is backed up daily for the needs of data security. 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 (see Chapter 1.6).

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

1.3.3 Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory and KP-LULUCF inventory

QA/QC procedures are performed as defined in the QA/QC plan (see Chapter 1.6).

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 of them who prepare a partly independent emission inventory for their federal province compare their results with the disaggregated national inventory),
- data supplier, which are considered as industrial stakeholders (e.g. industrial facilities or association of industries)

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

1.4 Methodologies and Data Sources Used

1.4.1 GHG inventory

The following table presents the main data sources used for activity data as well as information on who did the actual calculations (for unpublished studies a detailed description of the methodologies is given in the NIR):

Table 6: Main data sources for activity data and emission values.

Sector	Data Sources for Activity Data	Emission Calculation
Energy	Energy Balance from Statistik Austria; EU-ETS; Steam boiler database; direct information from industry or associations of industry	Umweltbundesamt, plant operators
Transport	Energy Balance from Statistik Austria	Umweltbundesamt (Aviation), Technical University Graz (Road and Off-road transport)
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	Umweltbundesamt, plant operators F-gases: Umweltbundesamt, based on studies by the Institut für industrielle Ökologie and Forschungsinstitut für Energie und Umweltplanung, Wirtschaft und Marktanalysen GmbH[17]
Agriculture	National studies, national agricultural statistics obtained from Statistik Austria;	Umweltbundesamt, based on studies by: University of Natural Resources and Applied Life Sciences, Research Center Seibersdorf
LULUCF	National forest inventory obtained from the Austrian Federal Office and Research Centre for Forests National agricultural statistics and land use statistics obtained from Statistik Austria	Umweltbundesamt
Waste	Federal Waste Management Plan (Data sources: Database on landfills (1998-2007), EDM - Electronic Data Management (from 2008 onwards)) EMREG-OW (Electronic Emission Register of Surface Water Bodies)	Umweltbundesamt

* *Research Institute for Energy and Environmental Planning, Economy and Market Analysis Ltd./Institute for Industrial Ecology*

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.

[17] Research Institute for Energy and Environmental Planning, Economy and Market Analysis Ltd./Institute for Industrial Ecology

The main sources for emission factors are:

- National studies for country specific emission factors as well as information on emissions from large point sources (plant specific data)
- IPCC 2006 Guidelines for National Greenhouse Gas Inventories[18]
- EMEP/EEA air pollutant emission inventory guidebook – 2013. Technical report No. 12/2013.[19]

Table *Summary 3* of the CRF (Summary Report for Methods and Emission Factors Used) in Annex 8 presents the methods applied and the origin of emission factors used for the greenhouse gas source and sink categories in the IPCC format for the present Austrian inventory.

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).

1.4.1.1 Main Data Suppliers

The main data suppliers are also presented in Table 6.

- 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[20].
- 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 (BMLFUW) 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.

1.4.1.2 Data from the EU Emission trading Scheme

The European Emissions Trading Scheme (EU-ETS) has been established by Directive

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

[19] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

[20] „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.

2003/87/EC of the European Parliament and of the Council[1]. 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) and N_2O (since 2010) and PFC (since 2013).[2] About 200 installations are currently included.

Plant operators have to report their activity data and CO_2 emissions annually; 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.

General rules for reporting and verification of emissions in the EU ETS are defined in EU Directive 2003/87/EG and specific rules can be found in Commission Regulation (EU) No 601/2012[21]. In Austria, Member State specific regulations are defined in the Austrian Emissions Allowance Trading Act[22] and the Austrian Monitoring, Reporting and Verification Ordinance[23]. 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 CO_2 and N_2O emissions reported under the EU-ETS is that these emissions have to pass independent verification. The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management 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 Umweltbundesamt on behalf of the Ministry.

1.4.1.3 Data from EPER/E-PRTR

The European Pollutant Emission Register (EPER) was the first Europe-wide register for emissions from industrial facilities both into air and water. The legal basis of EPER is Article 15 of the IPPC Directive (EPER Decision 2000/479/EG), which stipulates that information on environmental pollution has to be provided to the public[24]. The reporting years under EPER were 2001 or 2002 and 2004. EPER was replaced by the European Pollutant Release and Transfer Register (E-PRTR) in 2007, which was established by the E-PRTR Regulation (EC) No 166/2006.

[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

[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.

21 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.

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

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

24 Data can be downloaded from: http://www.umweltbundesamt.at/umweltdaten/datenbanken10/eper/

E-PRTR 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.

The 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 electronically via the internet. 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 the Umweltbundesamt. The Umweltbundesamt also checks the data for consistency with the national inventory.

Data from EPER/E-PRTR has so far not been used as a data source for the national inventory, as the EPER/E-PRTR reports contain only very little information other than emission data. Concerning methodology the only information included is whether emissions are estimated, measured or calculated. For activity data facilities report one value that is often not useful in the context of emissions and may be different between producers of the same product.

In addition, EPER/E-PRTR data is not complete for IPCC sectors and it is difficult to include this point source information because no background information (such as fuel consumption data) is available. Furthermore the reporting thresholds are relatively high, so that many of the for Austria relevant installations do not have to report.

Thus 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 point source data for the national inventory, but for verification purposes only where possible.

1.5 Brief description of key categories, including for KP-LULUCF

The present NIR does not contain a national key category analysis as usually performed by the Inspection Body, but refers to the results of the key category analysis created by the CRF Reporter (Table 7 Summary Overview for Key Categories). A detailed key category analysis following Tier 1 and Tier 2 will again be submitted in 2016.

Table 7: Key Categories according to CRF Table 7 (Inventory 2013).

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CO2	X	X	X	X

1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Peat	CO2				
1.A.1 Fuel combustion - Energy Industries - Peat	CH4				
1.A.1 Fuel combustion - Energy Industries - Peat	N2O				
1.A.1 Fuel combustion - Energy Industries - Biomass	CH4				
1.A.1 Fuel combustion - Energy Industries - Biomass	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	*X*	*X*	*X*	*X*
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	*X*	*X*	*X*	*X*
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	*X*	*X*	*X*	*X*
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	*X*	*X*	*X*	*X*
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	CO2				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Biomass	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Biomass	N2O				
1.A.3.a Domestic Aviation	CO2				
1.A.3.a Domestic Aviation	CH4				
1.A.3.a Domestic Aviation	N2O				
1.A.3.b Road Transportation	CO2	*X*	*X*	*X*	*X*
1.A.3.b Road Transportation	CH4				
1.A.3.b Road Transportation	N2O				
1.A.3.c Railways	CO2				
1.A.3.c Railways	CH4				
1.A.3.c Railways	N2O				
1.A.3.d Domestic Navigation - Liquid Fuels	CO2				
1.A.3.d Domestic Navigation - Liquid Fuels	CH4				
1.A.3.d Domestic Navigation - Liquid Fuels	N2O				
1.A.3.d Domestic Navigation - Gaseous Fuels	CO2				
1.A.3.d Domestic Navigation - Gaseous Fuels	CH4				
1.A.3.d Domestic Navigation - Gaseous Fuels	N2O				
1.A.3.d Domestic Navigation - Other Fossil Fuels	CO2				
1.A.3.d Domestic Navigation - Other Fossil Fuels	CH4				
1.A.3.d Domestic Navigation - Other Fossil Fuels	N2O				

1.A.3.d Domestic Navigation - Biomass Fuels	CH4				
1.A.3.d Domestic Navigation - Biomass Fuels	N2O				
1.A.3.e Other Transportation	CO2	*X*	*X*	*X*	*X*
1.A.3.e Other Transportation	CH4				
1.A.3.e Other Transportation	N2O				
1.A.4 Other Sectors - Liquid Fuels	CO2	*X*	*X*	*X*	*X*
1.A.4 Other Sectors - Liquid Fuels	CH4				
1.A.4 Other Sectors - Liquid Fuels	N2O				
1.A.4 Other Sectors - Solid Fuels	CO2		*X*	*X*	*X*
1.A.4 Other Sectors - Solid Fuels	CH4				
1.A.4 Other Sectors - Solid Fuels	N2O				
1.A.4 Other Sectors - Gaseous Fuels	CO2	*X*	*X*	*X*	*X*
1.A.4 Other Sectors - Gaseous Fuels	CH4				
1.A.4 Other Sectors - Gaseous Fuels	N2O				
1.A.4 Other Sectors - Other Fossil Fuels	CO2		*X*	*X*	*X*
1.A.4 Other Sectors - Other Fossil Fuels	CH4				
1.A.4 Other Sectors - Other Fossil Fuels	N2O				
1.A.4 Other Sectors - Peat	CO2				
1.A.4 Other Sectors - Peat	CH4				
1.A.4 Other Sectors - Peat	N2O				
1.A.4 Other Sectors - Biomass	CH4		*X*	*X*	*X*
1.A.4 Other Sectors - Biomass	N2O				
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Solid Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Other Fossil Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Other Fossil Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Other Fossil Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Peat	CO2				
1.A.5 Other (Not specified elsewhere) - Peat	CH4				
1.A.5 Other (Not specified elsewhere) - Peat	N2O				
1.A.5 Other (Not specified elsewhere) - Biomass	CH4				
1.A.5 Other (Not specified elsewhere) - Biomass	N2O				
1.B.1 Fugitive emissions from Solid Fuels	CO2				
1.B.1 Fugitive emissions from Solid Fuels	CH4				
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO2				
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH4				
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO2				
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH4	*X*			*X*
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO2				
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4				
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N2O				
1.B.2.d Fugitive Emissions from Fuels - Other	CO2				
1.B.2.d Fugitive Emissions from Fuels - Other	CH4				
1.B.2.d Fugitive Emissions from Fuels - Other	N2O				

1.C CO2 Transport and Storage	CO2				
2.A.1 Cement Production	CO2	X	X	X	X
2.A.2 Lime Production	CO2	X	X	X	X
2.A.3 Glass Production	CO2				
2.A.4 Other Process Uses of Carbonates	CO2	X	X	X	X
2.B.1 Ammonia Production	CO2	X		X	X
2.B.1 Ammonia Production	CH4				
2.B.1 Ammonia Production	N2O				
2.B.2 Nitric Acid Production	N2O		X	X	X
2.B.3 Adipic Acid Production	CO2				
2.B.3 Adipic Acid Production	N2O				
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	CO2				
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O				
2.B.5 Carbide Production	CO2				
2.B.5 Carbide Production	CH4				
2.B.6 Titanium Dioxide Production	CO2				
2.B.7 Soda Ash Production	CO2				
2.B.8 Petrochemical and Carbon Black Production	CO2				
2.B.8 Petrochemical and Carbon Black Production	CH4				
2.B.9 Fluorochemical Production	Aggregate F-gases				
2.B.10 Other	CO2				
2.B.10 Other	CH4				
2.B.10 Other	N2O				
2.B.10 Other	Aggregate F-gases				
2.C.1 Iron and Steel Production	CO2	X	X	X	X
2.C.1 Iron and Steel Production	CH4				
2.C.2 Ferroalloys Production	CO2				
2.C.2 Ferroalloys Production	CH4				
2.C.3 Aluminium Production	CO2		X	X	
2.C.3 Aluminium Production	PFCs				
2.C.3 Aluminium Production	SF6				
2.C.4 Magnesium Production	CO2				
2.C.4 Magnesium Production	HFCs				
2.C.4 Magnesium Production	PFCs				
2.C.4 Magnesium Production	SF6				
2.C.4 Magnesium Production	Unspeci-fied mix of HFCs and PFCs				
2.C.5 Lead Production	CO2				
2.C.6 Zinc Production	CO2				
2.C.7 Other	CO2				
2.C.7 Other	CH4				
2.C.7 Other	N2O				
2.C.7 Other	Aggregate F-gases		X	X	X
2.D Non-energy Products from Fuels and Solvent Use	CO2				
2.D Non-energy Products from Fuels and Solvent Use	CH4				
2.D Non-energy Products from Fuels and Solvent Use	N2O				
2.E Electronics Industry	Aggregate F-gases				
2.F.1 Refrigeration and Air conditioning	Aggregate F-gases	X	X	X	X
2.F.2 Foam Blowing Agents	Aggregate				

	F-gases				
2.F.3 Fire Protection	Aggregate F-gases				
2.F.4 Aerosols	Aggregate F-gases				
2.F.5 Solvents	Aggregate F-gases				
2.F.6 Other Applications	Aggregate F-gases				
2.G Other Product Manufacture and Use	CO2				
2.G Other Product Manufacture and Use	CH4				
2.G Other Product Manufacture and Use	N2O				
2.G Other Product Manufacture and Use	Aggregate F-gases				
2.H Other	CO2				
2.H Other	CH4				
2.H Other	N2O				
2.H Other	Aggregate F-gases				
3.A Enteric Fermentation	CH4	*X*	*X*	*X*	*X*
3.B Manure Management	CH4	*X*	*X*	*X*	*X*
3.B Manure Management	N2O	*X*		*X*	*X*
3.C Rice Cultivation	CH4				
3.D Agricultural Soils	CH4				
3.D.1 Direct N2O Emissions From Managed Soils	N2O	*X*	*X*	*X*	*X*
3.D.2 Indirect N2O Emissions From Managed Soils	N2O	*X*			*X*
3.E Prescribed burning of savannas	CH4				
3.E Prescribed burning of savannas	N2O				
3.F Field burning of agricultural residues	CH4				
3.F Field burning of agricultural residues	N2O				
3.G Liming	CO2				
3.H Urea Application	CO2				
3.I. Other carbon-containing fertlizers	CO2				
3.J. Other	CO2				
3.J. Other	CH4				
3.J. Other	N2O				
4.A.1 Forest Land Remaining Forest Land	CO2	*X*	*X*		*X*
4.A.2 Land Converted to Forest Land	CO2	*X*	*X*		*X*
4.B.1 Cropland Remaining Cropland	CO2				
4.B.2 Land Converted to Cropland	CO2				
4.C.1 Grassland Remaining Grassland	CO2				
4.C.2 Land Converted to Grassland	CO2		*X*		*X*
4.D.1.1 Peat Extraction Remaining Peat Extraction	CO2				
4.D.1.2 Flooded Land Remaining Flooded Land	CO2				
4.D.1.3 Other Wetlands Remaining Other Wetlands	CO2				
4.D.2 Land Converted to Wetlands	CO2				
4.E.1 Settlements Remaining Settlements	CO2				
4.E.2 Land Converted to Settlements	CO2		*X*		*X*
4.F.1 Other Land Remaining Other Land	CO2		*X*		*X*
4.F.2 Land Converted to Other Land	CO2		*X*		*X*
4.G Harvested Wood Products	CO2	*X*	*X*		*X*
4(I). Direct N2O emissions from N inputs to managed soils	N2O				
4(II). Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO2				
4(II). Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH4				

4(II). Emissions and removals from drainage and rewetting and other management of organic and mineral soils	N2O				
4(III).Direct N2O emissions from N mineralization/immobilization	N2O				
4(IV) Indirect N2O Emissions from Managed Soils	N2O				
4(V) Biomass Burning	CO2				
4(V) Biomass Burning	CH4				
4(V) Biomass Burning	N2O				
4.H Other	CO2				
4.H Other	CH4				
4.H Other	N2O				
5.A Solid Waste Disposal	CH4	*X*	*X*	*X*	*X*
5.A Solid Waste Disposal	CO2				
5.B Biological Treatment of Soild Waste					
5.B Biological Treatment of Soild Waste					
5.C Incineration and Open Burning of Waste	CO2				
5.C Incineration and Open Burning of Waste	CH4				
5.C Incineration and Open Burning of Waste	N2O				
5.D Wastewater Treatment and Discharge	CH4				
5.D Wastewater Treatment and Discharge	N2O				
5.E Other	CO2				
5.E Other	CH4				
5.E Other	N2O				
6. Other	CO2				
6. Other	CH4				
6. Other	N2O				
6. Other	Aggregate F-gases				

1.6 Information on the QA/QC plan

For fulfillment of the reporting obligations as described in Chapter 1.2.1 a basic QA/QC system is mandatory.

However, the (former)[25] *Department of Air Emissions* of the Umweltbundesamt has decided to implement a QMS based on the International Standard ISO/IEC 17020 *General Criteria for the operation of various types of bodies performing inspections* which goes beyond these requirements: in addition to the elements of a QMS as described in the ISO 9000 series it also focusses on the competence of the personnel, and ensures strict independence, impartiality and integrity of the accredited bodies. The implementation is audited by the Austrian Accreditation Body regularly every 15 months, and has to be renewed every five years. The accreditation as *Inspection Body for Emission Inventories* (IBE) according to ISO/IEC 17020 has been awarded for the first time in 2005 and has been renewed in 2011.

As stated in the Quality Manual, 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 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 timly manner, particularly to enhance the transparency to allow full reproduction, and the correctness via quality checks and validation activities. One of the key managerial functions is raising the personnel's quality awareness.

The aim of the IBE is to provide a very good 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 to fulfil all relevant requirements in terms of content and format:

"TACCC": transparency, accuracy, completeness, comparability, consistency (as defined in the 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.

In 2011, the quality manual has been completely revised, the new manual being more user-friendly and providing an improved presentation of requirements relating to reporting obligations in the context of emission inventories. In the course of this work the revision of ISO/IEC 17020 was taken into account.

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[25] Now: Climate Change Mitigation & Emission Inventories

The Austrian Quality Management System (QMS) and the requirements of the 2006 IPCC GL (and the EMEP/EEA Guidebook 2013)

The 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.

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

Table 8: Overview of QAQC aspects in different technical and quality standards

IPCC 2006 GL	EMEP/EEA GB 2013[26]	ISO 9001[27]	ISO/IEC 17020[28]
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[29]	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

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

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

[28] contains additional requirements compared to ISO 9001

[29] According to the EMEP/EEA Guidebook 2013, it also is good practice to summarize lessons learned from previous inventory preparation cycles in an inventory management report.

1.6.1 Roles and responsibilites

The 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 coordinator, 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, IP, Product Use, Agriculture, LULUCF and Waste). Two experts form a sector team, whereas one team member 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.

1.6.2 QA/QC Plan

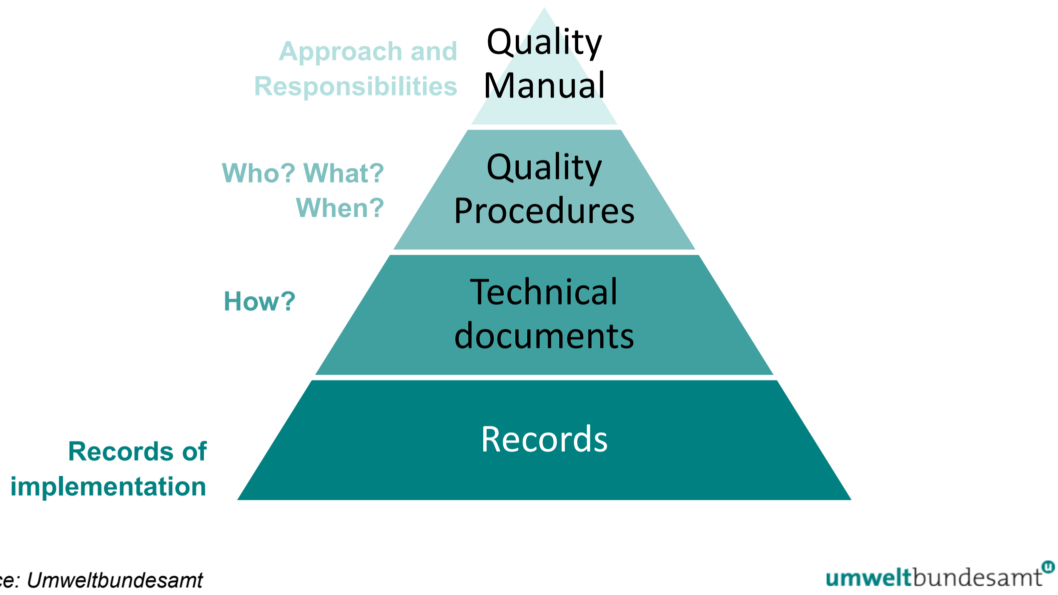
Activities to be conducted by the personnel of the inspection body are written down in quality and technical procedures that complement the Quality Manual. Such activities are:

- 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, whereas the activities listed above – quality and technical procedures – form Level 2:

- Level 1: General (the actual 'Quality Manual': general information, description of QMS, general responsibilities, etc.): http://www.umweltbundesamt.at/umweltsituation/luft/emissionsinventur/emi_ueberwachung/
- Level 2: Detailed description of activities to be conducted and checklists and forms to be filled out ('quality procedures' and 'technical documents').
- Level 3: Documentation of QC activities (filled out checklists, ...)



Source: Umweltbundesamt

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

1.6.3 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[30].

QC activities are conducted following QC checklists, covering issues like:

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

30

Additionally, in the course of preparation of the NIR, 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

1.6.4 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 (new) 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 (works 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 data (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) the requirements regarding independence and integrity are fulfilled

(2) the long term availability of the data

(3) the data collection and management process

(4) the QC requirements of the data processing are fulfilled

When indicated, recommendations for improvements are made and implementation of these measures is assessed.

Since 2007, Statistik Austria (energy balance, agricultural statistical data), the administrators of the landfill database as well as the electronic data management for landfills and the Institute for Industrial Ecology have been audited. The audited data suppliers cover about 80% of the GHG emissions, suppliers of data for additional 12% have certified QMS in place or the data has been indenpendently verified, respectively. Further audits of data suppliers are planned.

1.6.5 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: some of them 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 inspection body (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 are notified to the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

1.6.6 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 judgments etc. to allow full reproduction and understanding of choices,
- recalculations,
- planned improvements,
- QC activities.

Documentation of expert judgements:

- name of the expert and institution/department,
- date,
- basis of judgement (references to relevant studies etc.),
- underlying assumptions.

Expert judgements by an expert of the inventory team or another expert of the Umweltbundesamt have to be made in a written form and documented/archived (as a formal 'note' or in the calculation file). Judgements made by external experts are documented in studies. Relevant literature has to be archived and references to be stated in the internal documentation as well as in the NIR.

1.6.7 Focus of QA/QC activities in the year 2014

In 2014 an **external audit** led by a representative appointed by the accreditation body has taken place to assess the QM system with regard to compliance with the underlying standard ISO 17020, to check its implementation in practice and to assure that measures and recommendations as set out in previous audits have been implemented accordingly. Such an audit is obligatory every 15 months. The final judgement of the auditor confirmed the compliance and practicability of the QM system and stressed the high competence of the personnel.

In addition, the following QA/QC measures were implemented in 2014:

- QMS: Improvements in the QA/QC Manual were made related to the implementation of internal audits, the procedure regarding monitoring of personnel, and the records of inventory preparation (documentation of expert judgements, communication with data suppliers and internal communication).
- Test Emission Time Series: As a follow up to the risk analysis 2013, an internal test ("dummy") submission was carried out by the deputy of the data manager. The aim was to test and improve the technical competence of the deputy and to enhance the resilience of the inventory system.
- Mutual Review New Zealand – Austria: From 6 to 8 October 2014, two inventory experts from New Zealand visited the IBE to discuss the national systems and QA/QC issues as well as other issues on implementation of the IPCC 2006 GL in the sectors Energy and IPPU. Recommendations, especially on transparency, are planned to be addressed in the NIR. The organization of the IBE, in particular the sector expertise, double and permanent occupation of responsibilities, regular participation in international reviews and the distribution of 'general' roles (Data Manager, Quality Manager, 'KCA/UA Officer', HI, Inventory Support) were judged particularly positive.
- Input Data Audit Waste: In 2014 an audit of the procedure of collection, processing and evaluation of landfilled waste data was carried out to determine the QA/QC activities implemented and quality of activity data used for CRF 5.A SWDS (category-specific QC on AD). It was conducted at the Umweltbundesamt (unit waste and material flow management, responsible for data base query) as well as at the premises of BMLFUW, responsible for validation and analysis of the data query and data and official data supplier. In the course of the audit it became apparent that overall sufficient QA/QC measures are taken to achieve and maintain high quality data on landfilled waste amounts. In the documentation, however, some improvement needs were identified and finally recommended.
- "Stakeholder Exchange Agriculture": In September 2014, an event on the implementation of the IPCC 2006 GL in the sector Agriculture took place at the Umweltbundesamt, organised by the IBE, involving relevant national experts and stakeholders. The aim was to get feedback on the new agricultural model (peer review of method) and define further improvement

(research) needs. Improvements have been included in the IBE internal sectoral improvement plan.

1.6.8 Treatment of confidentiality issues

The Inspection Body ensures confidentiality of sensitive information – that is data declared as confidential – obtained in the course of its inspection activities. 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[31].

- Security of data

  Confidentiality of sensitive data used to calculate the emissions is a legal obligation: Ensuring confidentiality through technical and organisational measures is obligatory for the 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.

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

For the submission 2015 the uncertainty calculation was performed applying the 'Tier 1' approach of the IPCC 2006 GL, for all sectors except LULUCF. As a result of the uncertainty analysis, table 8 shows a total uncertainty of 4.27 % for the year 2013.

A Tier 1 uncertainty calculation for all sectors including LULUCF and a 'Tier 2' approach (Monte Carlo Simulation) as well as a detailed description will be submitted in 2016.

[31] 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.

Table 9: Tier 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 uncertain	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emission
		%	%	%		%
1.A Stationary Combustion - Biomass	CH4	5.0	50.0	50.25	0.02	0.01
1.A Stationary Combustion - Biomass	N2O	5.0	50.0	50.25	0.02	0.01
1.A Stationary Combustion - Gaseous Fuels	CH4	2.0	50.0	50.04	0.00	0.00
1.A Stationary Combustion - Gaseous Fuels	CO2	2.0	0.5	2.06	0.15	0.28
1.A Stationary Combustion - Gaseous Fuels	N2O	2.0	50.0	50.04	0.00	0.00
1.A Stationary Combustion - Liquid Fuels	CH4	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion - Liquid Fuels	CO2	0.5	0.5	0.71	0.01	0.01
1.A Stationary Combustion - Liquid Fuels	N2O	0.5	50.0	50.00	0.01	0.00
1.A Stationary Combustion - Other fuels	CH4	10.0	50.0	50.99	0.00	0.00
1.A Stationary Combustion - Other fuels	CO2	10.0	20.0	22.36	0.35	0.26
1.A Stationary Combustion - Other fuels	N2O	10.0	50.0	50.99	0.00	0.00
1.A Stationary Combustion - Solid Fuels	CH4	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion - Solid Fuels	CO2	0.5	0.5	0.71	0.00	0.00
1.A Stationary Combustion - Solid Fuels	N2O	0.5	50.0	50.00	0.00	0.00
1.A.3.a Transport - Civil Aviation	CH4	3.0	30.0	30.15	0.00	0.00
1.A.3.a Transport - Civil Aviation	CO2	3.0	3.0	4.24	0.00	0.00
1.A.3.a Transport - Civil Aviation	N2O	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport - Road Transportation - Diesel	CH4	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport - Road Transportation - Diesel	CO2	3.0	3.0	4.24	0.81	1.02
1.A.3.b Transport - Road Transportation - Diesel	N2O	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport - Road Transportation - Gaseous	CO2	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport - Road Transportation - Gaseous	CH4	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport - Road Transportation - Gaseous	N2O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport - Road Transportation - Gasoline	CH4	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport - Road Transportation - Gasoline	CO2	3.0	3.0	4.24	0.07	0.08
1.A.3.b Transport - Road Transportation - Gasoline	N2O	3.0	70.0	70.06	0.00	0.01
1.A.3.b Transport - Road Transportation - LPG	CO2	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport - Road Transportation - LPG	CH4	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport - Road Transportation - LPG	N2O	3.0	50.0	50.09	0.00	0.00
1.A.3.c Transport - Railw ays	CH4	3.0	30.0	30.15	0.00	0.00
1.A.3.c Transport - Railw ays	CO2	3.0	3.0	4.24	0.00	0.00
1.A.3.c Transport - Railw ays	N2O	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport - Navigation	CH4	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport - Navigation	CO2	3.0	3.0	4.24	0.00	0.00
1.A.3.d Transport - Navigation	N2O	3.0	70.0	70.06	0.00	0.00
1.A.3.e Transport - Other Transportation	CH4	2.0	50.0	50.04	0.00	0.00
1.A.3.e Transport - Other Transportation	CO2	2.0	0.5	2.06	0.00	0.00
1.A.3.e Transport - Other Transportation	N2O	2.0	50.0	50.04	0.00	0.00
1.A.5.b Mobile	CH4	1.0	50.0	50.01	0.00	0.00
1.A.5.b Mobile	CO2	1.0	0.5	1.12	0.00	0.00
1.A.5.b Mobile	N2O	1.0	50.0	50.01	0.00	0.00
1.B.1.a Fugitive Emission - Coal Mining and Handling	CH4	5.0	50.0	50.25	0.00	0.05
1.B.2.a Fugitive Emission - Oil	CH4	0.5	50.0	50.00	0.00	0.00
1.B.2.a Fugitive Emission - Oil	CO2	0.5	0.5	0.71	0.00	0.00
1.B.2.b Fugitive Emission - Natural Gas	CH4	5.0	10.0	11.18	0.00	0.00
1.B.2.b Fugitive Emission - Natural Gas	CO2	5.0	0.5	5.02	0.00	0.00
2.A.1 Mineral Industry - Cement Production	CO2	1.1	2.0	2.28	0.00	0.00
2.A.2 Mineral Industry - Lime Production	CO2	1.6	5.0	5.25	0.00	0.00
2.A.3 Mineral Industry - Limestone and Dolomite Use	CO2	10.0	1.0	10.05	0.00	0.00
2.A.4.a Other Process Uses of Carbonates - Ceramics	CO2	2.0	5.0	5.39	0.00	0.00
2.A.4.b Other Process Uses of Carbonates - Soda ash	CO2	10.0	5.0	11.18	0.00	0.00
2.A.4.c Other Process Uses of Carbonates - Non Metallurgical Magnesia Production	CO2	2.0	5.0	5.39	0.00	0.00
2.A.4.d Other Process Uses of Carbonates - other	CO2	20.0	2.0	20.10	0.01	0.02
2.B.1 Chemical Industry - Ammonia Production	CH4	2.0	5.0	5.39	0.00	0.00
2.B.1 Chemical Industry - Ammonia Production	CO2	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry - Nitric Acid Production	CO2	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry - Nitric Acid Production	N2O	2.0	5.0	5.39	0.00	0.00
2.B.5 Chemical Industry - Carbide Production	CO2	5.0	10.0	11.18	0.00	0.00
2.B.8 Chemical Industry - Petrochemical and Carbon Black Production	CH4	10.0	10.0	14.14	0.00	0.00
2.B.10 Chemical Industry - Other	CH4	2.0	5.0	5.39	0.00	0.00
2.B.10 Chemical Industry - Other	CO2	2.0	5.0	5.39	0.00	0.00
2.C.1 Metal Industry - Iron and Steel Production	CO2	0.5	0.5	0.71	0.01	0.01
2.C.2 Metal Industry - Ferroalloys Production	CO2	5.0	25.0	25.50	0.00	0.00
2.C.3 Metal Industry - Aluminium Production	CO2	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.4 Metal Industry - Magnesium Production	SF6	5.0	5.0	7.07	0.00	0.00
2.C.5 Metal Industry - Lead Production	CO2	10.0	50.0	50.99	0.00	0.00
2.C.7 Metal Industry Other - Non-ferrous metals	SF6	5.0	5.0	7.07	0.00	0.00

IPCC category/Group	Gas	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	Combined uncertain	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emission
		%	%	%		%
2.D Non-Energy Products from Fuels and Solvent Use	CO2	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	SF6	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	1.20	1.40
2.F.2 Foam Blow ing	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	SF6	25.0	50.0	55.90	0.03	0.02
2.G. Other Product Manufacture and Use	CO2	0.0	20.0	20.00	0.00	0.00
2.G. Other Product Manufacture and Use	N2O	20.0	0.0	20.00	0.00	0.00
3.A.1 Enteric Fermentation - Cattle	CH4	10.0	20.0	22.36	1.18	0.52
3.A.2 Enteric Fermentation - Sheep	CH4	10.0	40.0	41.23	0.00	0.00
3.A.3 Enteric Fermentation - Sw ine	CH4	10.0	40.0	41.23	0.00	0.00
3.A.4.1 Enteric Fermentation - Poultry	CH4	10.0	20.0	22.36	0.00	0.00
3.A.4.2 Enteric Fermentation - Horses	CH4	10.0	40.0	41.23	0.00	0.00
3.A.4.3 Enteric Fermentation - Goats	CH4	10.0	40.0	41.23	0.00	0.00
3.A.4.4 Enteric Fermentation - Deer	CH4	10.0	40.0	41.23	0.00	0.00
3.B.1.1 Manure Management - Cattle	CH4	10.0	20.0	22.36	0.01	0.00
3.B.1.1 Manure Management - Cattle	N2O	10.0	100.0	100.50	0.11	0.00
3.B.1.2 Manure Management - Sheep	CH4	10.0	30.0	31.62	0.00	0.00
3.B.1.2 Manure Management - Sheep	N2O	10.0	100.0	100.50	0.00	0.00
3.B.1.3 Manure Management - Sw ine	CH4	10.0	20.0	22.36	0.00	0.00
3.B.1.3 Manure Management - Sw ine	N2O	10.0	100.0	100.50	0.00	0.00
3.B.1.4.1 Manure Management - Poultry	CH4	10.0	30.0	31.62	0.00	0.00
3.B.1.4.1 Manure Management - Poultry	N2O	10.0	100.0	100.50	0.00	0.00
3.B.1.4.2 Manure Management - Horses	CH4	10.0	30.0	31.62	0.00	0.00
3.B.1.4.2 Manure Management - Horses	N2O	10.0	100.0	100.50	0.00	0.00
3.B.1.4.3 Manure Management - Goats	CH4	10.0	30.0	31.62	0.00	0.00
3.B.1.4.3 Manure Management - Goats	N2O	10.0	100.0	100.50	0.00	0.00
3.B.1.4.4 Manure Management - Deer	CH4	10.0	30.0	31.62	0.00	0.00
3.B.1.4.4 Manure Management - Deer	N2O	10.0	100.0	100.50	0.00	0.00
3.B.2.5 Indirect N2O Emissions	N2O	5.0	200.0	200.06	0.08	0.00
3.D.1 Direct N2O Emissions from Managed Soils	N2O	5.0	200.0	200.06	13.32	0.54
3.D.2 Indirect N2O emissions from Managed Soils	N2O	5.0	200.0	200.06	0.57	0.01
3.F Field Burning of Agricultural Residues	CH4	100.0	40.0	107.70	0.00	0.00
3.F Field Burning of Agricultural Residues	N2O	100.0	50.0	111.80	0.00	0.00
3 Total Agriculture - Liming and Urea application	CO2	100.0	10.0	100.50	0.02	0.04
5.A Solid Waste Disposal	CH4	12.0	25.0	27.73	0.22	0.80
5.B Biological Treatment of Solid Waste	CH4	20.0	50.0	53.85	0.00	0.00
5.B Biological Treatment of Solid Waste	N2O	20.0	50.0	53.85	0.00	0.00
5.C Incineration and Open Burning of Waste	CH4	7.0	0.0	7.00	0.00	0.00
5.C Incineration and Open Burning of Waste	CO2	7.0	20.0	21.19	0.00	0.00
5.C Incineration and Open Burning of Waste	N2O	7.0	0.0	7.00	0.00	0.00
5.D Waste Water Treatment and Discharge	CH4	20.0	50.0	53.85	0.00	0.00
5.D Waste Water Treatment and Discharge	N2O	20.0	100.0	101.98	0.04	0.01
Total					**18.24**	**5.65**
Total Uncertainties				Uncertainty in total inventory %:	**4.27**	**2.38**

1.8 General assessment of the completeness

CRF-Table 9 (Completeness) has been used to give 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 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 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 allocated to '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.

A completeness analysis, covering a transparency and a completeness index trying to quantify the quality of the inventory, could not be implemented this year due to numerous gaps in the reporting of notation keys by the new CRF Reporter, especially in the reporting of fluorinated gases.

2 TREND IN TOTAL 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). Austria has to reduce its greenhouse gase emissions in the Non-EU-ETS by 2020 by 16% compared to 2005.

2.1 Emission Trends for Aggregated GHG Emissions

In 2013 Austria's total greenhouse gas (GHG) emissions (without LULUCF) amounted to 79.6 Mt CO_2 equivalents (CO_2e). Compared to 1990 GHG emissions have increased by 1.2%, compared to 2012 GHG emissions have slightly decreased (–0.2%).

Table 10: Summary of Austria's anthropogenic greenhouse gas emissions from 1990–2013 (emissions without LULUCF).

GHG		Total	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
1990	[kt CO_2 equivalent]	78 683.26	62 216.94	10 613.92	4 196.58	2.44	1 182.79	470.61	0.00
1991		82 395.48	65 803.11	10 416.36	4 365.37	3.89	1 192.62	614.14	0.00
1992		75 621.95	60 311.47	10 070.59	4 067.51	5.64	510.47	656.27	0.00
1993		75 703.86	60 699.97	9 971.86	3 989.24	235.26	63.52	744.00	0.00
1994		76 131.09	61 099.47	9 586.15	4 186.47	261.11	70.96	926.17	0.76
1995		79 456.34	64 147.44	9 470.88	4 290.19	357.93	83.35	1 100.11	6.44
1996		82 646.81	67 590.96	9 192.48	4 177.50	420.79	80.25	1 176.90	7.93
1997		82 123.83	67 396.05	8 817.38	4 190.19	500.83	117.47	1 086.40	15.53
1998		81 415.54	66 976.00	8 648.72	4 245.64	610.34	55.53	869.88	9.43
1999		79 746.47	65 580.31	8 464.97	4 235.58	701.82	79.18	676.37	8.24
2000		80 123.87	66 229.10	8 296.30	4 212.50	713.63	87.32	574.53	10.51
2001		84 107.21	70 266.40	8 135.75	4 085.78	863.10	116.34	629.33	10.51
2002		85 921.27	72 122.22	8 019.09	4 085.40	968.78	101.97	613.30	10.51
2003		91 899.08	78 037.22	8 007.41	4 084.88	1 072.19	126.38	549.44	21.56
2004		91 523.36	78 417.79	7 792.37	3 486.73	1 158.34	157.57	484.01	26.54
2005		92 495.55	79 596.32	7 573.98	3 499.91	1 145.76	157.79	493.63	28.16
2006		89 713.22	76 968.46	7 438.29	3 495.43	1 152.47	172.39	453.46	32.73
2007		86 933.08	74 270.64	7 306.17	3 503.65	1 195.89	230.33	367.01	59.39
2008		86 756.64	74 039.95	7 162.10	3 670.97	1 248.53	208.19	373.43	53.47
2009		80 032.27	67 849.61	7 046.97	3 446.60	1 306.85	36.02	341.68	4.54
2010		84 788.00	72 690.78	6 946.86	3 250.66	1 481.67	78.05	335.87	4.12

GHG	Total	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
2011	82 582.58	70 581.60	6 744.74	3 315.17	1 556.11	73.51	307.35	4.10
2012	79 792.99	67 843.27	6 634.36	3 288.92	1 655.28	50.72	311.88	8.56
2013	79 599.18	67 767.98	6 530.26	3 263.51	1 674.27	49.23	304.19	9.75

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 following Figure 3 depicts the trend of total Austria's GHG emissions as reported under the UNFCCC (figure excludes emission sources and sinks from LULUCF) and additionally shows emissions according to Article 2(1) of the EU Effort-Sharing Decision.

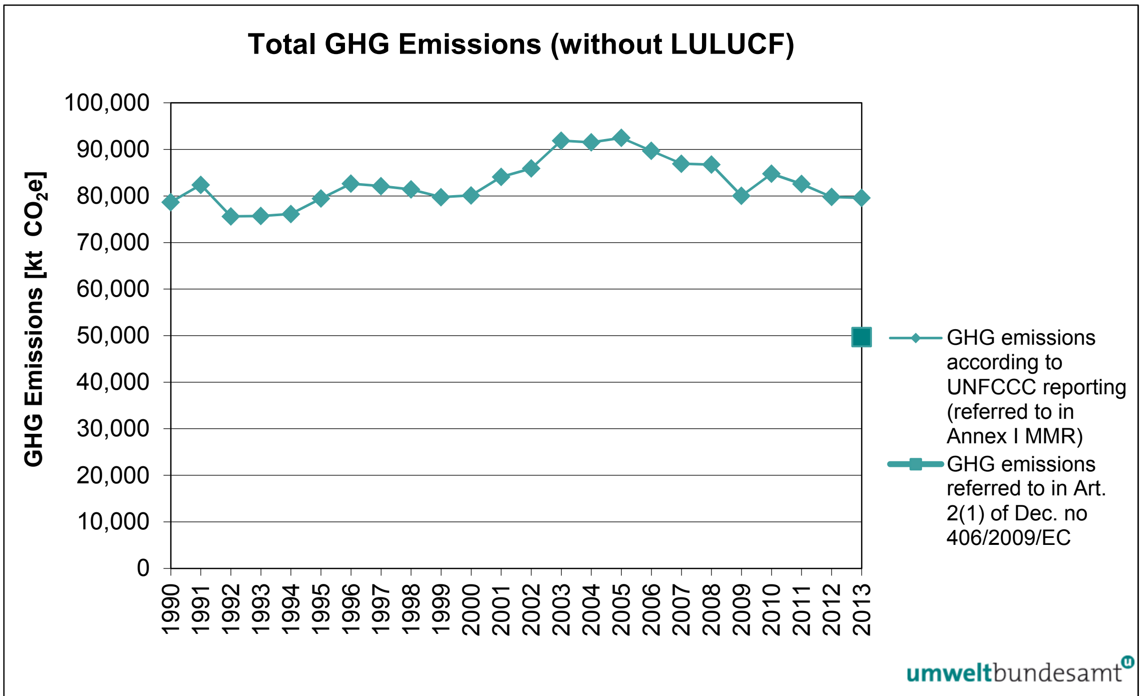


Figure 3: Trend in total GHG emissions 1990–2013 without LULUCF.

GHG emissions according to Article 2(1) of Decision No. 406/2009/EC amounted to 49.7 Mt CO_2 equivalents in 2013, which is 0.4% or 0.19 Mt more than in 2012. In the first year of the Effort-Sharing Decision Target period (2013-2020) emissions are thus below the annual emission allocation (AEA) of 2013[32] of 52.6 Mt CO_2 equivalents.

[32] 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).

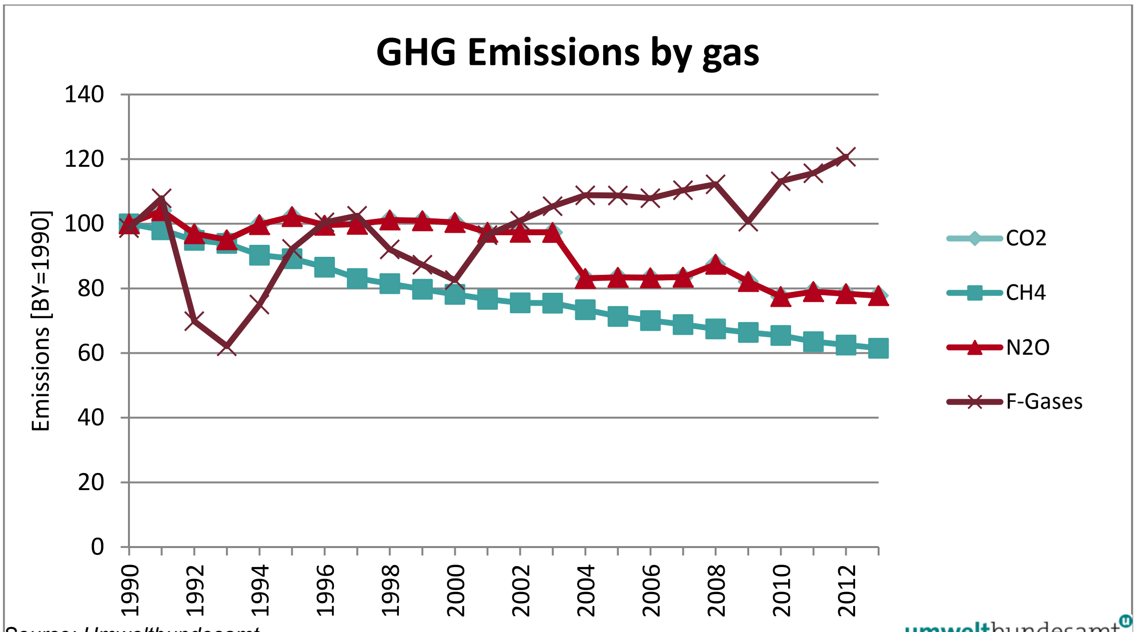
2.2 Emission Trends by Gas

The most important GHG in Austria is carbon dioxide (CO_2) with a share of 85.1% in 2013. 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 4.1% in 2013. 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 11: Austria's greenhouse gas emissions by gas 1990 and 2013.

GHG	1990	2013	1990	2013
	CO_2 equivalent [kt]		Share [%]	
Total	**78 683**	**79 599**	**100.0**	**100.0**
CO_2	62 217	67 768	79.1%	85.1%
CH_4	10 614	6 530	13.5%	8.2%
N_2O	4 197	3 264	5.3%	4.1%
F-Gases	1 656	2 037	2.1%	2.6%

Emissions without LULUCF



Source: Umweltbundesamt

Figure 4: Trend in greenhouse gas emissions 1990–2013 by gas in index form (base year = 100).

CO_2

CO_2 emissions increased by 8.9% from 1990 to 2013. In absolute figures, CO_2 emissions increased from 62 217 to 67 768 kt during the period from 1990 to 2013 mainly due to higher emissions from transport, which increased by 63.2%.

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

CH_4

CH_4 emissions decreased steadily during the period from 1990 to 2013 from 10 614 to 6 530 kt CO_2 equivalents. In 2013, CH_4 emissions were 38.5% 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 3 264 kt CO_2 equivalents in 2013 compared to 4 197 in 1990 (−22.2%). 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. Between 2012 and 2013 emissions decreased by 0.8%.

The main source of N_2O emissions are agricultural soils with a share of 53.7% (2013) in national total N_2O emissions. Manure management has a share of 13.6% and fuel combustion, which is another important source of N_2O emissions, has a share of 18.9%.

HFCs

HFC emissions increased remarkably during the period from 1990 to 2013 from 2.4 to 1 674 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 2013, from 1 183 to 49 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 1997 emissions increased steadily reaching 1 086 kt CO_2 equivalents. Since then they have been decreasing. In 2013 SF_6 emissions amounted to 304 kt CO_2 equivalents, which was 35.4% 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 has been emitted in Austria. NF_3 emissions solely arise from semiconductor manufacture, and have been in use in Austria since 1994. In 2013, NF_3 emissions amounted to 9.8 kt CO_2 equivalents.

2.3 Emission Trends by Source

Table 12 presents a summary of Austria's anthropogenic greenhouse gas emissions by sector.

Table 12: Summary of Austria's anthropogenic greenhouse gas emissions by sector from 1990–2013.

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO_2 equivalents (kt)					
1990	52 906	13 593	7 959	-13 042	4 226	0
1995	54 439	13 566	7 815	-14 119	3 636	0
2000	55 304	14 606	7 292	-16 888	2 922	0
2001	59 542	14 501	7 231	-19 610	2 833	0
2002	60 777	15 172	7 119	-14 760	2 854	0
2003	66 696	15 314	6 980	-5 331	2 909	0
2004	66 970	14 844	6 943	-9 674	2 766	0
2005	67 374	15 611	6 878	-11 142	2 632	0
2006	64 029	16 301	6 855	-5 806	2 528	0
2007	60 720	16 931	6 889	-5 942	2 394	0
2008	60 235	17 265	6 980	-4 747	2 276	0
2009	57 082	13 834	7 002	-4 688	2 115	0
2010	60 072	15 870	6 852	-6 167	1 993	0
2011	57 742	16 066	6 889	-6 439	1 884	0
2012	55 471	15 710	6 826	-6 016	1 785	0
2013	55 095	16 013	6 807	-4 978	1 684	0

The dominant sector regarding GHG emissions in Austria is *Energy*, causing 69.2% of total national GHG emissions in 2013 (67.2% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (20.1% in 2013) and *Agriculture* (8.6% in 2013).

Table 13: Austria's greenhouse gas emissions by sector in 1990 and in 2013 as well as their share and trend.

GHG	1990	2013	Trend 1990–2013	1990	2013
	Emissions [kt CO_2e]			Share [%]	
Total	78 683	79 599	+1.2%	100.0%	100.0%
Energy	52 906	55 095	4.1%	67.2%	69.2%
IPPU	13 593	16 013	17.8%	17.3%	20.1%
Agriculture	7 959	6 807	−14.5%	10.1%	8.6%
LULUCF	−13 042	−4 978	−61.8%	–	–
Waste	4 226	1 684	−60.1%	5.4%	2.1%

Total emissions without emissions from LULUCF

A description and interpretation of emissions trends per sector is given in the following subchapters.

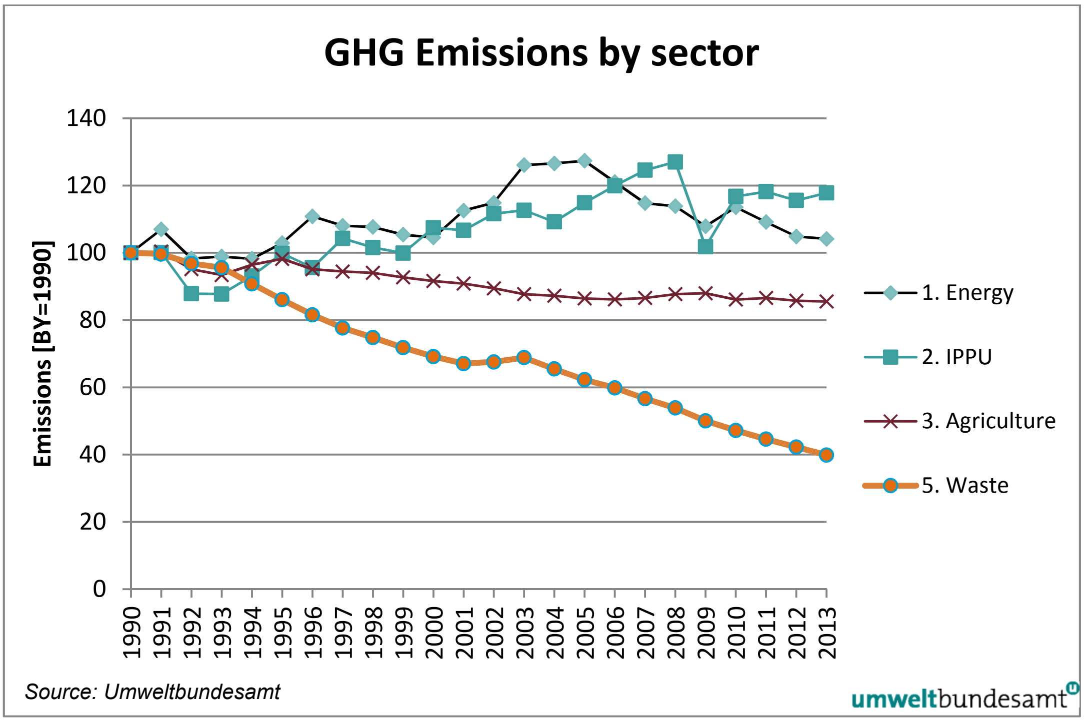


Figure 5: Trend in greenhouse gas emissions 1990–2013 by sector in index form (base year = 100).

2.3.1 Energy

In 2013, greenhouse gas emissions from sector *Energy* amounted to 55 095 kt CO_2 equivalents which correspond to 69.2% of the total national emissions. 99.0% 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 41.4% in 2013, followed by *energy industries* (20.5%), *manufacturing industries and construction* (20.2%) and the sub-category *other sectors* (16.8%). The most important **greenhouse gas** is CO_2, contributing 97.9% to the total sectoral GHG emissions, followed by N_2O (1.1%) and CH_4 (1.0%).

From 2012 to 2013, emissions from this sector decreased by 0.7%. Main drivers are the lower electricity production by thermal power plants, especially coal and gas fired plants, as well as the lower use of natural gas and heating oil. The nearly constant demand for electricity was covered by increased electricity imports. In addition, the paper industry shows production and emissions reductions between 2012 and 2013.

The **overall trend** in GHG emissions from the sector *Energy* shows increasing emissions with a plus of 4.1% from 1990 to 2013. The **main driver** for this trend is road transport with a strong increase of emissions (+63.0%) from 1990 to 2013. 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 climate change-friendly electricity from hydro power plants
- the economic situation as reflected in the gross domestic product (GDP)

Trend 1990–2013 by sub-category

In 2013 emissions from sub-category ***energy industries*** were 18.2% 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 25% (2013), the contribution of hydro and wind power plants to total public electricity production increased from 69% (1990) to 80% (2013). Electricity consumption increased by 47% since 1990. Since 2002 the increase is mainly covered by imports from abroad. The increase in GHG emissions in other energy supply is due to enhanced refinery activity and rising demand for natural gas supply.

Energy related GHG emissions from ***manufacturing industries and construction*** increased by 12.8% from 1990 to 2013, mainly in the chemical and other industries. Fuel consumption increased by 45.1% 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 (+63.2%) 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. However, from 2005 onwards GHG are 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, less consuming cars (with less specific fuel consumption). In 2013 however, fuel sales have reached again the level of 2006.

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 2013 were 36.2% lower than in 1990. This reduction is mainly attributable to the declining consumption of heating oil and solid fuels and the increase in the consumption of biomass and natural gas as well as the growing importance of district heating. Total fuel consumption of this sub-category decreased by 12.1% since 1990.

Fugitive emissions decreased by 24.2% since 1990 due to the closure of coal mines until 2006.

2.3.2 Industrial Processes and Other Product Use

In 2013, greenhouse gas emissions from *Industrial Processes and Other Product Use* amounted to 16 013 kt CO_2 equivalents, which correspond to 20.1% of total national emissions.

The most important **sub-categories** of this sector are the *metal industry* and the *mineral industry*, generating 63.9% and 17.0% of total sectoral emissions (2013). The most important **greenhouse gas** of this sector is CO_2 with a contribution of 85.8% to total sectoral emissions (2013), followed by HFCs with 10.5%, SF_6 with 1.9%, N_2O with 1.2%, PFCs and CH_4 with 0.3% each. NF_3 – reported for the first time in this year's submission – contributes 0.1% to total emissions from this sector.

From 2012 to 2013, overall emissions from this sector increased by 1.9%, mainly due to increased production volumes in the iron and steel industry. The chemical industry shows the largest decrease in emissions between 2012 and 2013 (–8.3 %), primarily in ammonia production.

The **overall trend** in GHG emissions from *Industrial Processes and Other Product Use* shows increasing emissions of 17.8% from 1990 to 2013. Within this period, emissions fluctuated, showing a minimum in 1993. **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 25.1% higher GHG emissions in 2013 compared to 1990 and (iv) a strong increase of HFC emissions in the period 1992 to 2013 from 2.4 to 1 674 kt CO_2 equivalents.

Trend 1990–2013 by sub-category

The largest increase in GHG emissions between 1990 and 2013 can be observed in the *metal industry* due to increased emissions from iron and steel production (+54.2%). The sub-categories *mineral industry* and the *chemical industry* however show declining emissions by 12% and 55% in that period. Emissions of *fluorinated gases* increased by 23.0% since 1990 due to the use of HFCs as cooling agents that replaced Ozone Depleting Substances. Emissions from *solvents* decreased by 3% due to decreased use of solvents and solvent containing products (legal measures), as well as nitrous oxide.

2.3.3 Agriculture

In 2013, greenhouse gas emissions from *Agriculture* amounted to 6 807 kt CO_2 equivalent, which corresponds to 8.6% of total national emissions.

The **most important sub-categories** of this sector are *enteric fermentation* (60%) and *agricultural soils* (26%). In the Austrian **greenhouse gas** inventory the sector agriculture is the largest source for both N_2O and CH_4 emissions: In 2013 67% (7.4 kt) of total N_2O emissions and 69% (180.0 kt) of total CH_4 emissions in Austria originated from this sector. 66% of GHG emissions from the sector are CH_4, 32% are N_2O.

From 2012 to 2013 emissions remained quite constant (–0.3%).

The **overall trend** in GHG emissions from *Agriculture* is decreasing, with a decrease of 14.5% from 1990 to 2013. 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 volatility in prices.

2.3.4 LULUCF

In 2013, net removals from the category LULUCF amounted to –4 978 kt CO_2 equivalents, which corresponds to 6.3% of the national total GHG emissions (without LULUCF) in 2013 compared to 17% in 1990.

The **overall trend** in net removals from LULUCF is minus 62% 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 −4 386 kt CO_2 equivalents in 2013. *Harvested Wood Products (4.G)* contributed −1 266 kt CO_2. CH_4 and N_2O emissions amounted to 20 kt CO_2 equivalents. Total net emissions arising from the other sub-sectors amounted to 674 kt CO_2 equivalents (654 kt CO_2) in 2013.

Regarding **LULUCF activities pursuant to Decision No 529/2013/EU**, Austria decided to account of greenhouse gas emissions and removals from af-/reforestation, deforestation and forest management activities only. Due to the difficulties with the CRF Reporter, no greenhouse gas emissions by source and removals of CO_2 by sinks resulting from LULUCF activities in accordance with Decision No 529/2013/EU and with Article 3(3) and (4) of the Kyoto Protocol could be reported with this submission (KP LULUCF are thus excluded from the CRF).

2.3.5 Waste

In 2013, greenhouse gas emissions from *Waste* amounted to 1 684 kt CO_2 equivalent, which corresponds to 2.1% of total national emissions.

The **most important sub-category** of the waste sector is *solid waste disposal*, which caused 79% of the emissions from this sector in 2013, followed by *waste water treatment and discharge* (11%) and *biological treatment of solid waste* (10%). The most important **greenhouse gas** is CH_4 with a share of 84% in emissions from *waste* (2013), followed by N_2O with 16%.

From 2012 to 2013 GHG emissions continued to decrease (−5.6%) as a result of reduced waste volumes as well as decreased carbon content in deposited waste.

The **overall trend** in GHG emissions from *waste* is decreasing, with a decrease of 60.1% from 1990 to 2013. 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). Furthermore, methane recovery has improved. 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).

2.4 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) 2015, Submission under the UNECE/CLRTAP Convention*, published in spring 2015 (UMWELTBUNDESAMT 2015).

Table 14: Total emissions and trends 1990–2013 of indirect GHGs and SO_2 as well as emission targets for air pollutants covered by the Multi-Effect Protocol and CO.

		NO_x	CO	NMVOC	SO_2
1990	[kt]	214.62	1 286.43	280.90	74.39
1991		222.40	1 285.24	265.89	71.48
1992		209.73	1 215.46	232.64	55.10

	NO_x	CO	NMVOC	SO_2
1993	200.80	1 149.46	226.16	53.47
1994	193.62	1 084.00	205.16	47.82
1995	192.98	986.11	204.31	47.41
1996	211.15	991.79	196.10	44.72
1997	199.59	922.32	183.13	40.18
1998	211.67	884.71	169.01	35.54
1999	203.44	782.55	157.04	33.66
2000	208.77	783.58	163.49	31.58
2001	218.55	758.19	165.03	32.66
2002	224.16	724.85	167.46	31.79
2003	233.69	728.54	166.67	31.96
2004	231.16	707.60	149.52	27.32
2005	233.19	697.38	158.88	26.59
2006	219.03	670.71	169.03	27.62
2007	210.26	636.28	156.16	24.57
2008	193.55	617.60	147.36	22.23
2009	177.43	579.72	119.02	16.91
2010	177.99	593.56	130.42	18.60
2011	168.15	572.55	125.14	17.83
2012	162.88	579.58	132.17	17.29
2013	160.56	580.11	125.94	17.14
Trend 1990–2013	***–25.2%***	***–54.9%***	***–55.2%***	***–77.0%***

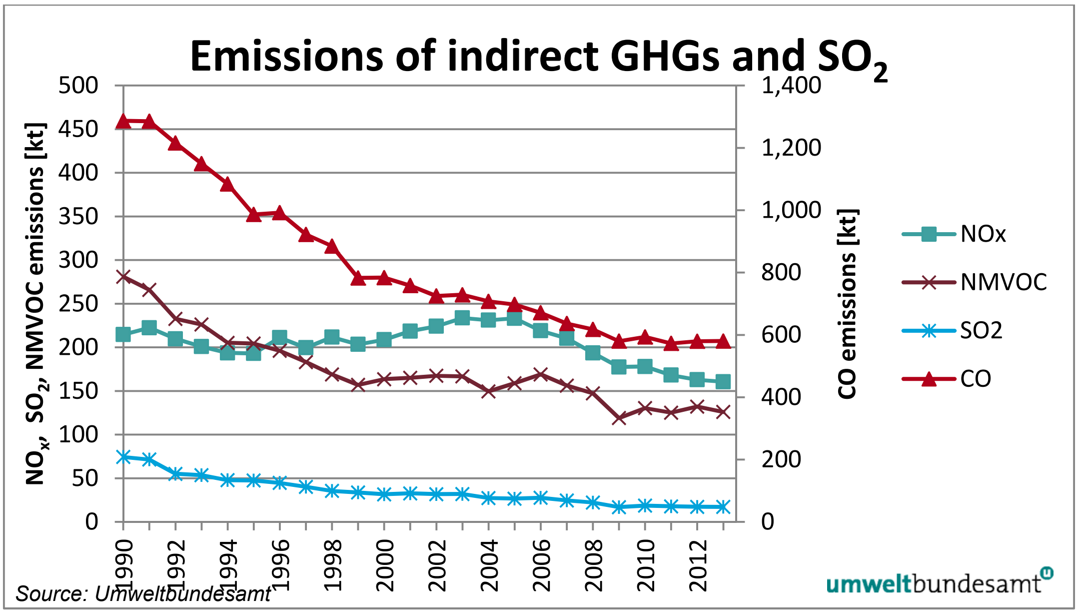


Figure 6: Emissions of indirect GHGs and SO_2 1990–2013.

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 215 to 161 kt during the period from 1990 to 2013. In 2013 the NO_x emissions were 25.2% below the level of 1990.

In 2013 about 96% of NO_x emissions in Austria originated from fossil fuel combustion, with the major part originating from mobile combustion – road transport (53% in national total NO_x emission).

CO

CO emissions decreased from 1 286 to 580 kt during the period from 1990 to 2013. In 2013 CO emissions were 54.9% below the level of 1990.

In the year 2013, 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 sector (51% in national total CO emission) followed by 1.A.2 manufacturing industries and construction with 27% and 1.A.3 Transport with 16% share in national total CO emissions.

NMVOC

NMVOC emissions decreased from 281 to 126 kt during the period from 1990 to 2013. In 2013 NMVOC emissions were 55.2% below the level of 1990.

The most important emission sources for NMVOC emissions are solvent use (2.D.3) and fossil fuel combustion, contributing 58% and 34% respectively of national total NMVOC emissions in 2013.

SO_2

SO_2 emissions decreased from 74 to 17 kt during the period from 1990 to 2013. In 2013 SO_2 emissions were 77.0% below the level of 1990.

The decrease is mainly due to lower emissions from residential heating (–94%), combustion in the manufacturing industries and construction (–37%) and energy industries (–83%).

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 1% of total emissions from this sector.

Emissions from the energy sector are the main source of GHGs in Austria: in the year 2013 about 69.2% of national total GHGs emissions and 79.6% of national total CO_2 emissions from Austria arose from the energy sector.

Emission trends

Emissions from the energy sector increased by 4.1% from 52.9 Mt CO_2 equivalents in 1990 to 55.1 Mt CO_2 equivalents in 2013, which is mainly caused by increasing emissions from transport.

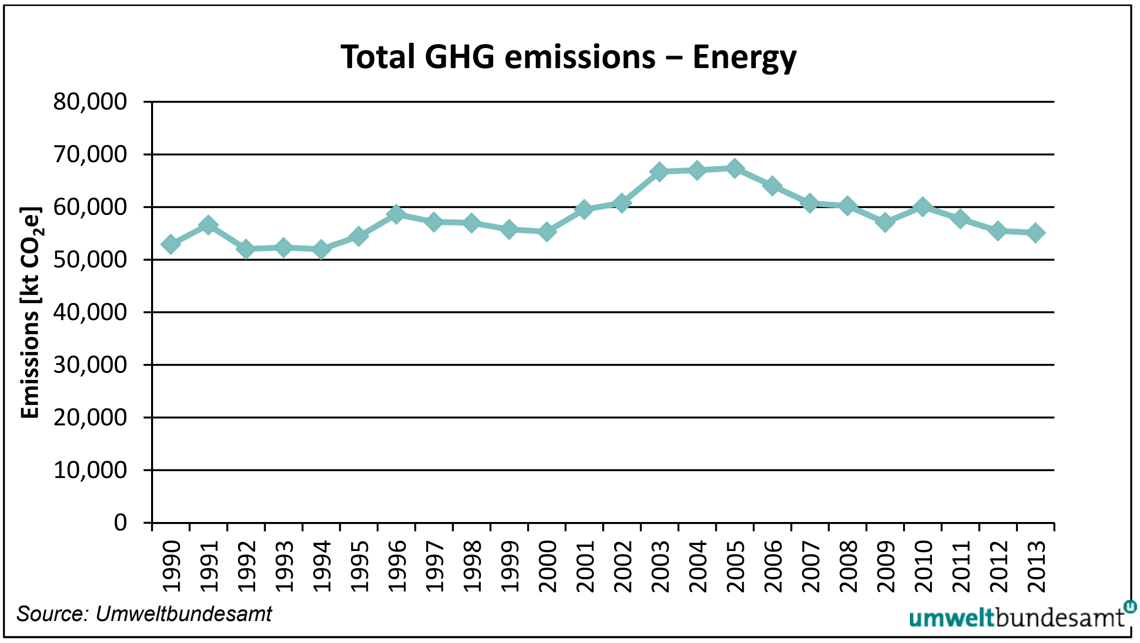


Figure 7: Trend of GHG emissions from 1990–2013 for energy.

Total emissions from energy mainly consist of CO_2 whereas N_2O and CH_4 emissions only make up about 1.1% and 1.0%, respectively. The increase of CO_2 and 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 2013 emissions from public electricity production, manufacturing industries, road transport and the residential/commercial sector decreased. Between 2012 and 2013 emissions from public electricity production mainly decreased due to less electricity generation from gas CHP plants, which was mainly compensated by higher electricity net imports. Between 2012 and 2013 emissions from road transport increased due to higher fuel sales.

Table 15: Emissions of greenhouse gases and their trend from 1990–2013 from IPCC Category 1 Energy.

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	kt CO_2 equivalent
1990	51 293	45.58	1.59	52 906
1991	55 036	41.51	1.74	56 592
1992	50 495	40.76	1.69	52 016
1993	50 814	39.25	1.72	52 309
1994	50 642	32.37	1.70	51 957
1995	53 101	32.67	1.75	54 439
1996	57 269	32.90	1.83	58 636
1997	55 918	28.25	1.78	57 153
1998	55 722	27.98	1.82	56 965
1999	54 499	28.29	1.84	55 755
2000	54 071	27.69	1.82	55 304
2001	58 279	27.88	1.90	59 542
2002	59 548	26.73	1.88	60 777
2003	65 456	26.47	1.94	66 696
2004	65 770	24.69	1.95	66 970
2005	66 162	23.96	2.06	67 374
2006	62 839	23.22	2.05	64 029
2007	59 539	22.74	2.06	60 720
2008	59 058	22.28	2.08	60 235
2009	55 936	21.88	2.01	57 082
2010	58 864	23.22	2.11	60 072
2011	56 583	21.91	2.05	57 742
2012	54 282	22.88	2.07	55 471
2013	53 917	22.40	2.07	55 095
Trend 1990–2013	**5.1%**	**-50.9%**	**30.7%**	**4.1%**

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.

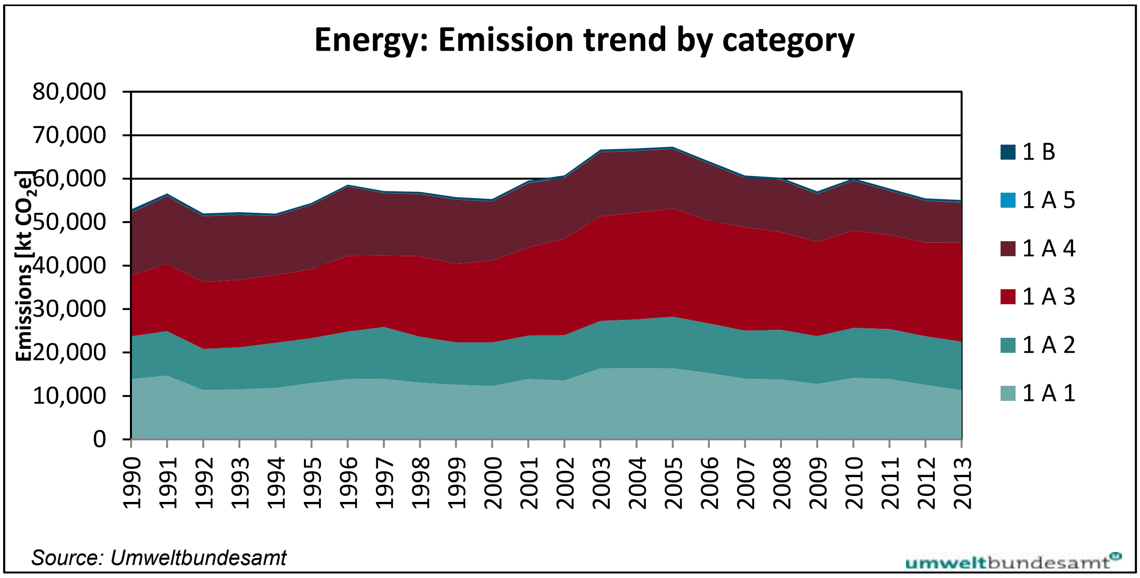


Figure 8: GHG emissions in [kt CO_2 equivalent] from 1990–2013 from Energy by sub categories.

Table 16: Total GHG emissions in [kt CO_2 equivalent] from 1990–2013 by sub categories of energy.

	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	52 906	52 204	13 842	9 881	13 974	14 471	36	702	333	369
1991	56 592	56 023	14 678	10 228	15 456	15 623	38	569	181	388
1992	52 016	51 404	11 361	9 455	15 426	15 128	35	612	192	420
1993	52 309	51 728	11 513	9 674	15 559	14 943	40	580	164	416
1994	51 957	51 487	11 809	10 423	15 607	13 605	43	470	56	414
1995	54 439	53 975	12 970	10 316	15 888	14 767	33	464	37	427
1996	58 636	58 245	13 857	10 948	17 442	15 958	40	392	24	367
1997	57 153	56 717	13 925	11 944	16 454	14 356	38	436	25	412
1998	56 965	56 501	13 058	10 545	18 563	14 291	43	464	25	439
1999	55 755	55 259	12 580	9 768	18 024	14 844	43	496	25	472
2000	55 304	54 808	12 275	10 029	18 820	13 642	42	496	27	469
2001	59 542	59 027	13 887	9 996	20 311	14 791	42	515	26	488
2002	60 777	60 278	13 543	10 453	22 224	14 016	43	499	31	468
2003	66 696	66 132	16 367	10 901	24 077	14 744	43	565	25	539
2004	66 970	66 459	16 407	11 177	24 592	14 238	44	511	5	506
2005	67 374	66 892	16 364	11 847	24 939	13 698	45	482	NO	482
2006	64 029	63 512	15 247	11 436	23 634	13 150	45	517	NO	517
2007	60 720	60 196	13 975	11 064	23 791	11 320	46	524	NO	524
2008	60 235	59 753	13 773	11 428	22 513	11 992	46	482	NO	482
2009	57 082	56 541	12 742	11 033	21 705	11 015	47	540	NO	540
2010	60 072	59 551	14 150	11 517	22 379	11 458	47	521	NO	521
2011	57 742	57 228	13 875	11 502	21 696	10 107	48	515	NO	515
2012	55 471	54 943	12 524	11 205	21 589	9 576	48	528	NO	528
2013	55 095	54 563	11 320	11 147	22 809	9 238	49	532	NO	532
Trend 1990–2013	4.1%	4.5%	- 18.2%	12.8%	63.2%	-36.2%	36.5%	- 24.2%	-100%	44.3%

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 1990–2013. Solid fuels show the most significant deviation.

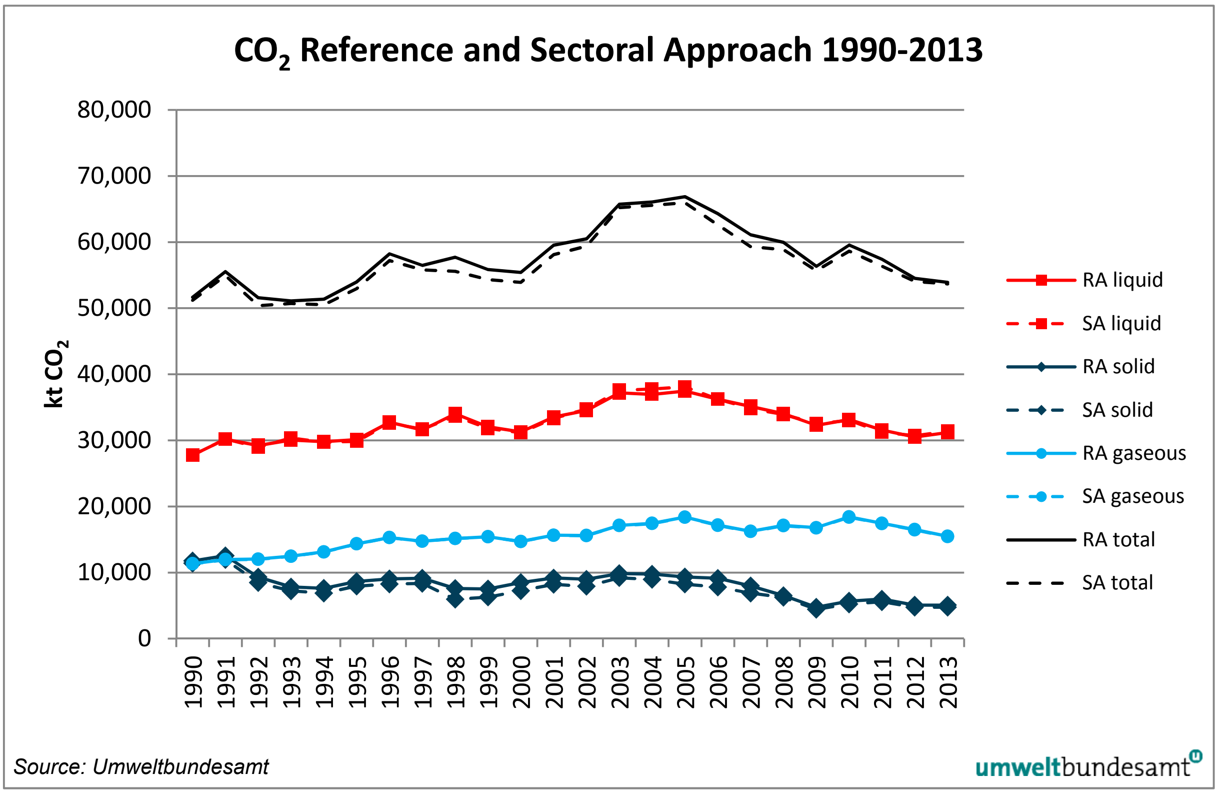


Figure 9: CO_2 Reference and Sectoral Approach 1990 to 2013.

Table 17 presents CO_2 emissions of the sectoral and reference approach.

Table 17: CO_2 emissions [kt] of sectoral and reference approach.

	Reference Approach					Sectoral Approach *1 A Fuel Combustion*				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
1990	27 771	11 766	11 360	758	51 655	27 746	11 412	11 301	732	51 191

	Reference Approach					Sectoral Approach *1 A Fuel Combustion*				
	Liquid	Solid	Gase-ous	Waste	Total	Liquid	Solid	Gase-ous	Waste	Total
1991	30 172	12 549	11 984	836	55 541	30 218	11 961	11 940	805	54 925
1992	29 227	9 325	12 041	994	51 586	28 950	8 466	12 000	957	50 374
1993	30 042	7 826	12 483	741	51 092	30 356	7 219	12 453	673	50 702
1994	29 804	7 622	13 135	814	51 376	29 702	6 881	13 111	819	50 514
1995	30 115	8 657	14 354	848	53 975	29 846	7 950	14 339	838	52 973
1996	32 748	9 053	15 307	1 108	58 216	32 589	8 247	15 287	1 074	57 198
1997	31 582	9 152	14 741	1 005	56 481	31 695	8 366	14 720	1 017	55 797
1998	34 030	7 597	15 157	927	57 711	33 667	5 952	15 144	817	55 581
1999	32 050	7 522	15 424	857	55 854	31 802	6 291	15 412	825	54 329
2000	31 277	8 493	14 708	936	55 414	31 156	7 248	14 686	816	53 906
2001	33 534	9 180	15 659	1 162	59 535	33 315	8 213	15 632	937	58 096
2002	34 522	8 990	15 623	1 373	60 509	34 751	7 918	15 582	1 129	59 381
2003	37 188	9 847	17 139	1 559	65 734	37 566	9 226	17 092	1 338	65 223
2004	36 965	9 764	17 461	1 889	66 079	37 786	8 952	17 404	1 418	65 560
2005	37 451	9 341	18 396	1 691	66 879	38 087	8 258	18 354	1 257	65 957
2006	36 226	9 136	17 194	1 754	64 310	36 247	7 802	17 136	1 422	62 607
2007	35 138	7 988	16 253	1 737	61 116	34 804	6 889	16 198	1 409	59 302
2008	34 051	6 516	17 148	2 258	59 973	33 915	6 245	17 087	1 599	58 846
2009	32 272	4 764	16 797	2 509	56 342	32 551	4 439	16 740	1 940	55 670
2010	33 154	5 682	18 426	2 290	59 553	33 022	5 241	18 363	1 999	58 626
2011	31 541	5 989	17 457	2 401	57 389	31 246	5 578	17 401	2 125	56 350
2012	30 514	5 078	16 514	2 399	54 505	30 696	4 745	16 456	2 148	54 045
2013	31 192	5 078	15 495	2 135	53 900	31 380	4 749	15 441	2 095	53 666

Table 18 presents the difference of CO_2 emissions in percent between reference and sectoral approach.

Table 18: Difference of CO_2 emissions by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	0.09%	3.10%	0.52%	3.58%	0.91%
1991	-0.15%	4.91%	0.37%	3.83%	1.12%
1992	0.95%	10.14%	0.34%	3.84%	2.41%
1993	-1.03%	8.41%	0.24%	9.98%	0.77%
1994	0.34%	10.77%	0.18%	-0.59%	1.71%
1995	0.90%	8.90%	0.10%	1.21%	1.89%
1996	0.49%	9.77%	0.13%	3.15%	1.78%
1997	-0.35%	9.40%	0.14%	-1.12%	1.23%
1998	1.08%	27.63%	0.08%	13.45%	3.83%
1999	0.78%	19.58%	0.08%	3.99%	2.81%
2000	0.39%	17.18%	0.15%	14.67%	2.80%
2001	0.66%	11.78%	0.17%	24.02%	2.48%
2002	-0.66%	13.54%	0.26%	21.62%	1.90%
2003	-1.01%	6.73%	0.28%	16.47%	0.78%
2004	-2.17%	9.07%	0.33%	33.24%	0.79%
2005	-1.67%	13.12%	0.23%	34.49%	1.40%
2006	-0.06%	17.10%	0.34%	23.29%	2.72%
2007	0.96%	15.95%	0.34%	23.29%	3.06%

Year	Liquid	Solid	Gaseous	Waste	Total
2008	0.40%	4.34%	0.35%	41.18%	1.91%
2009	-0.86%	7.30%	0.34%	29.33%	1.21%
2010	0.40%	8.40%	0.34%	14.56%	1.58%
2011	0.95%	7.37%	0.32%	13.00%	1.84%
2012	-0.59%	7.02%	0.35%	11.69%	0.85%
2013	-0.60%	6.92%	0.35%	1.89%	0.44%

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

Explanation of differences

- *Solid fuels:* The Reference Approach includes process emissions from blast furnaces and steel production, which are included in category *2.C Metal Production,* as well as process emissions from coke used for carbide production which are included in category *2.B.4 Carbide Production*. 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 2013 about 8.3 Mt of solid fuels CO_2 from integrated iron plants are considered in 2.C.1 and 0.5 Mt CO_2 are considered in 1.A.2.a.

- *Liquid Fuels:* The energy balance is mass-balanced but not carbon balanced. Fuel category *Other Oil* is an aggregation of several fuel types and therefore it is difficult to quantify a reliable carbon emission factor for the reference approach. The reference approach takes a share of feedstocks used for plastics and solvent production as non-carbon stored. In the sectoral approach emissions from plastics waste incineration are reported as „other fuels" but in the reference approach it is included in „liquid fuels". Emissions from solvent use are included in category *2.D.3* under subcategory *Solvent Use*. In the sectoral approach a share of municipal solid waste without energy recovery is considered in category *5.C Waste Incineration* for 1990 and 1991.
- 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.

Currently 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 19 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 20 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 19: 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	393.76	130.30	203.98	8.07	736.12	368.12	115.87	203.98	8.99	696.97
1991	429.31	138.50	215.53	8.98	792.32	400.49	121.67	215.53	10.08	747.78
1992	423.35	101.83	216.61	10.69	752.48	384.07	87.17	216.61	12.01	699.86
1993	430.95	86.34	224.79	8.35	750.43	400.63	74.40	224.79	9.78	709.60
1994	428.11	84.04	236.67	9.08	757.90	391.84	71.01	236.67	10.53	710.05
1995	430.51	96.56	258.83	9.43	795.34	393.70	81.66	258.83	10.92	745.11
1996	468.48	101.03	275.94	12.20	857.67	434.93	85.11	275.94	14.01	810.00
1997	457.53	102.75	265.71	11.26	837.26	422.72	86.52	265.71	13.12	788.08
1998	488.11	85.94	273.36	10.47	857.89	448.48	61.79	273.36	12.28	795.92
1999	460.56	83.34	278.19	9.79	831.88	423.97	64.22	278.19	11.59	777.98
2000	448.99	94.02	262.32	10.51	815.85	416.98	74.72	265.10	12.27	769.07
2001	481.45	99.86	282.17	12.63	876.11	446.83	84.47	282.17	14.49	827.96
2002	497.57	96.31	281.27	14.81	889.97	464.07	81.52	281.27	16.78	843.64
2003	532.00	108.99	308.19	16.59	965.77	501.80	95.20	308.51	19.40	924.92
2004	531.96	108.11	313.07	20.35	973.49	504.25	93.08	314.16	24.56	936.06
2005	535.07	101.78	328.33	18.65	983.83	510.32	87.46	331.29	20.50	949.58
2006	528.12	101.51	307.23	20.42	957.29	486.28	83.21	309.31	24.25	903.05
2007	517.25	93.65	290.36	20.40	921.66	467.73	73.88	292.39	24.34	858.34
2008	498.62	89.03	306.61	25.81	920.08	455.77	67.13	308.43	27.37	858.71
2009	480.32	67.10	298.41	29.28	875.12	436.37	47.58	302.16	33.80	819.91
2010	492.67	79.36	328.06	27.68	927.78	442.64	56.10	331.47	32.81	863.02
2011	466.25	83.24	312.00	29.53	891.03	419.00	59.81	314.10	35.43	828.34
2012	455.55	72.74	297.14	29.14	854.57	410.86	51.01	297.03	34.89	793.80
2013	465.64	73.47	276.56	26.15	841.83	420.19	51.32	278.71	32.31	782.54

Table 20: Difference of energy consumption by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	7.0%	12.4%	0.0%	-10.2%	5.6%
1991	7.2%	13.8%	0.0%	-10.9%	6.0%
1992	10.2%	16.8%	0.0%	-11.0%	7.5%
1993	7.6%	16.1%	0.0%	-14.6%	5.8%
1994	9.3%	18.3%	0.0%	-13.8%	6.7%
1995	9.4%	18.2%	0.0%	-13.6%	6.7%

Year	Liquid	Solid	Gaseous	Waste	Total
1996	7.7%	18.7%	0.0%	-12.9%	5.9%
1997	8.2%	18.8%	0.0%	-14.2%	6.2%
1998	8.8%	39.1%	0.0%	-14.8%	7.8%
1999	8.6%	29.8%	0.0%	-15.5%	6.9%
2000	7.7%	25.8%	-1.0%	-14.4%	6.1%
2001	7.7%	18.2%	0.0%	-12.8%	5.8%
2002	7.2%	18.2%	0.0%	-11.7%	5.5%
2003	6.0%	14.5%	-0.1%	-14.5%	4.4%
2004	5.5%	16.1%	-0.3%	-17.1%	4.0%
2005	4.8%	16.4%	-0.9%	-9.0%	3.6%
2006	8.6%	22.0%	-0.7%	-15.8%	6.0%
2007	10.6%	26.8%	-0.7%	-16.2%	7.4%
2008	9.4%	32.6%	-0.6%	-5.7%	7.1%
2009	10.1%	41.0%	-1.2%	-13.4%	6.7%
2010	11.3%	41.5%	-1.0%	-15.6%	7.5%
2011	11.3%	39.2%	-0.7%	-16.7%	7.6%
2012	10.9%	42.6%	0.0%	-16.5%	7.7%
2013	10.8%	43.2%	-0.8%	-19.1%	7.6%

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

The main differences are due to a switch from the IPCC 1996 Guidelines to the IPCC 2006 Guidelines. This switch results insignificantly lower differences between sectoral and reference approach because:

- Waste is considered in the RA
- CRF Table 1.(d) considers the feedstocks, reductants and other non-energy use of fuels more adequately.

3.2.2 International bunker fuels

3.2.2.1 International aviation

The share of international aviation in the total fuel consumption in the aviation sector in Austria represents 97 % (defined on energy content) also in 2013 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 21Table 1.

Table 21: Greenhouse gas emissions and activity from international bunkers-aviation 1990–2013.

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
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
1990-2013	***225%***	***111%***	***200%***	**-**	***130%***	***111%***	***123%***

Methodological Issues

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

3.2.2.2 International navigation

In 2013, the share of international navigation in the total fuel consumption in the navigation sector in Austria represented 85% (defined on energy content). Greenhouse gas emissions and activity data from navigation assigned to international bunkers are presented in the following table.

Table 22: Greenhouse gas emissions from international bunkers-marine 1990–2013.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1990	49.5	0.0025	0.018	55.0
1991	43.1	0.0021	0.016	47.9

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2e [kt]
1992	41.9	0.0021	0.016	46.6
1993	43.0	0.0021	0.016	47.8
1994	54.7	0.0027	0.020	60.8
1995	61.6	0.0030	0.023	68.4
1996	63.1	0.0030	0.023	70.1
1997	61.5	0.0030	0.023	68.4
1998	67.2	0.0032	0.025	74.7
1999	66.4	0.0031	0.025	73.9
2000	72.4	0.0034	0.027	80.6
2001	76.5	0.0036	0.029	85.2
2002	86.1	0.0039	0.032	95.8
2003	68.6	0.0030	0.026	76.4
2004	81.9	0.0036	0.030	91.1
2005	80.4	0.0034	0.029	89.2
2006	70.3	0.0029	0.026	78.0
2007	75.4	0.0031	0.027	83.5
2008	69.7	0.0028	0.024	77.0
2009	59.5	0.0024	0.020	65.5
2010	70.5	0.0027	0.023	77.5
2011	62.2	0.0024	0.020	68.3
2012	63.9	0.0024	0.020	69.9
2013	70.2	0.0025	0.022	76.8
1990–2013	**18%**	**-4%**	**17%**	**16%**

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 kilometer → (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 2014b). 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 f.*

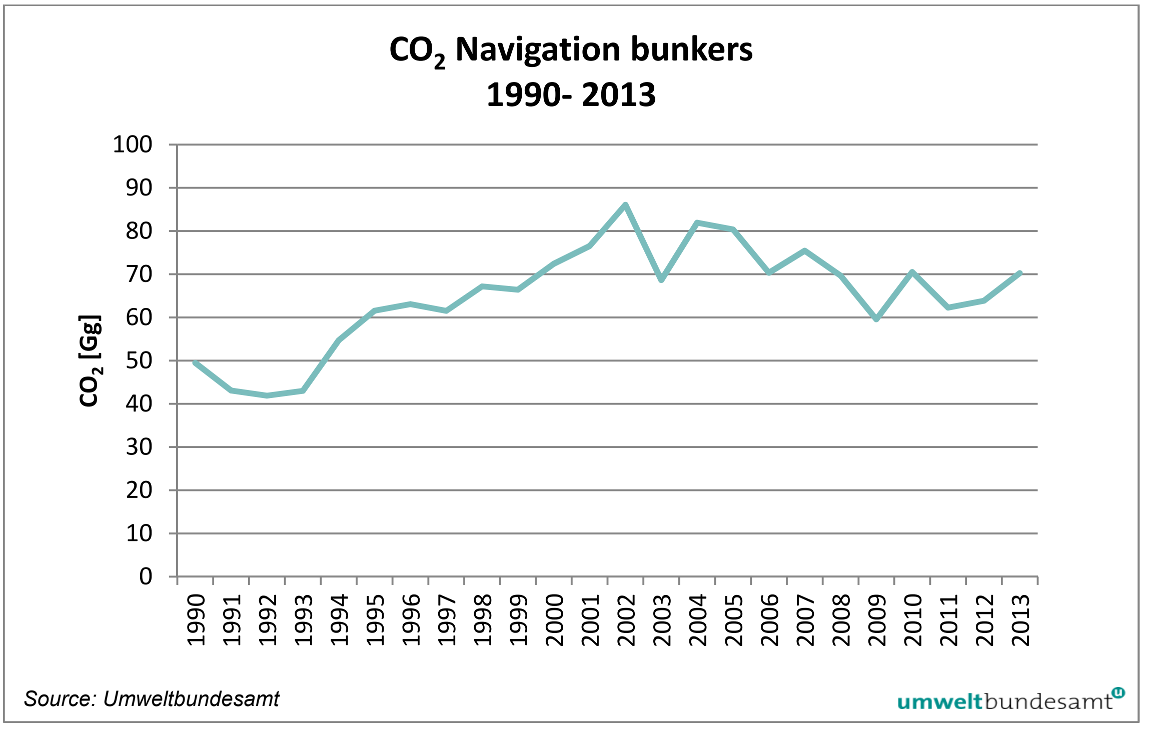


Figure 10: CO_2 emissions from navigation bunkers, 1990-2013

Activity Data & Emission Factors

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

Table 23: Emission factors and activity data for mobile sources of Household and Gardening 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	667	74.2	3.7	27.2
1991	581	74.2	3.7	27.5
1992	565	74.2	3.7	27.6
1993	580	74.2	3.6	27.5
1994	737	74.2	3.6	27.3
1995	830	74.2	3.6	27.3
1996	851	74.2	3.6	27.4
1997	830	74.2	3.6	27.5
1998	906	74.2	3.5	27.6
1999	895	74.2	3.5	27.7
2000	976	74.2	3.5	27.8
2001	1 032	74.2	3.5	27.9

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2002	1 160	74.2	3.4	27.8
2003	925	74.2	3.3	27.8
2004	1 105	74.2	3.2	27.5
2005	1 084	74.2	3.2	27.2
2006	948	74.2	3.1	26.9
2007	1 017	74.2	3.0	26.4
2008	939	74.2	3.0	26.0
2009	803	74.2	2.9	24.7
2010	951	74.2	2.9	24.3
2011	839	74.2	2.8	23.8
2012	861	74.2	2.7	23.4
2013	947	74.2	2.7	23.0

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.

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 fuels or in category *6.C* respectively 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 that should be reported in categories *2.A.5* and *2.A.6* are included in sector *3 solvent and other product 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 2014] 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 waste incineration without energy recovery is considered in category *5.C*.

Other oil products (solvents)

manufacture: emissions from the production of ethylene and propylene are included in total emissions of category *1.A.1.b petroleum refinery*. CO_2 emissions from solvent use are considered in sector *3 solvent and other product use*.

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* and from the use of plastic as a fuel in *1.A-other fuels*; emissions from the incineration of solvents without energy recovery is included in *5.C*.

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 0, where point source emissions as well as the CO_2 emission trading system (ETS) are considered.

3.2.6 Source Category Description

Transport

In 2013 the most important source of GHGs was transport, with a share of 28.7% in national total GHG emissions. 14.4% of national GHG emissions were released by passenger cars, 1.7% by light duty vehicles, 11.4% by heavy-duty vehicles and 0.2% by mopeds and motorcycles. Austria's railway system is mainly driven by electricity, only 0.2% of overall GHGs originate from this sector. Fuels used by ships on inland waterways have a share of 0.02% 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 2013 with a share of 14.2% total GHG emissions of was energy industries, were fossil fuels are used for electrical power and district heating production. In the year 2013 overall gross public electricity production was 60 201 GWh[33] of which 45 187 GWh (75%) were generated by hydro plants, 11 281 GWh (19%) by thermal power plants and 3 733 GWh (6%) by solar, geothermal and wind power plants. Industrial auto producers generated 8 100 GWh of electricity in the year 2013. 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 8.6 Mt in 2013. 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 14% in 2013 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 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 11.6% in 2013 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.

[33] Source: IEA Questionnaire November/2014 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 2013.

3.2.7 Key Categories

The methodology and results of the key category analysis is presented in Chapter 1.5. Table 24 presents the key source categories of *1.A Fuel Combustion Activities*.

Table 24: Key sources of 1.A Fuel combustion activities (KCA CRF Table 7).

IPCC Category	Category Name	GHG	Key source Assessment
1.A.1 liquid	Energy Industries	CO_2	LA; TA
1.A.1 solid	Energy Industries	CO_2	LA; TA
1.A.1 gaseous	Energy Industries	CO_2	LA; TA
1.A.1 other fossil	Energy Industries	CO_2	LA; TA
1.A.2 liquid	Manufacturing Industries and Construction	CO_2	LA; TA
1.A.2 solid	Manufacturing Industries and Construction	CO_2	LA; TA
1.A.2 gaseous	Manufacturing Industries and Construction	CO_2	LA; TA
1.A.2 other fossil	Manufacturing Industries and Construction	CO_2	LA; TA
1.A.3.b	Road Transportation	CO_2	LA; TA
1.A.3.e	Other Transportation	CO_2	LA; TA
1.A.4 liquid	Other Sectors	CO_2	LA; TA
1.A.4 solid	Other Sectors	CO_2	TA
1.A.4 gaseous	Other Sectors	CO_2	LA; TA
1.A.4 other fossil	Other Sectors	CO_2	TA
1.A.4 biomass	Other Sectors	CH_4	TA

LA = Level Assessment (2013)

TA = Trend Assessment

3.2.8 Completeness

Table 25 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 25: 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		NO	NO	NO
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		NO	NO	NO
1.A.2.b Other Fuels		NO	NO	NO
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		✓	✓	✓

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

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
1.A.3.b Gasoline		✓	✓	✓
1.A.3.b Diesel Oil		✓	✓	✓
1.A.3.b Natural Gas		✓	✓	✓
1.A.3.b Biomass		✓	IE(1)	IE(1)
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.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.e Other	**010506 Pipeline Compressors**			
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		✓	✓	✓

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

(1) CH_4 and N_2O emissions from biomass are included in gasoline and diesel (liquid fuels)

3.2.9 Methodological Issues

3.2.9.1 Choice of Method

In general the CORINAIR methodologies are applied: in the inventory area sources as well as point sources are considered. However, the applied methodologies are equivalent to the IPCC Tier 2 and Tier 3 methodologies, respectively.

Tier 2 methodology

For the following categories and pollutants the IPCC Tier 2 methodology is used:

- *1.A.1.a Public Electricity and Heat Production, plants >= 50 MW_{th}:* CO_2, CH_4, N_2O, NMVOC;
- *1.A.1.a Public Electricity and Heat Production, plants < 50 MW_{th}:* All Pollutants;
- *1.A.1.b Petroleum Refining:* CO_2, CH_4, N_2O;
- *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries:* All Pollutants;
- *1.A.2 Manufacturing Industries and Construction – Stationary sources:* All Pollutants;
- *1.A.3.c Railways:* All Pollutants;
- *1.A.3.d Navigation:* All Pollutants;
- *1.A.3.e Other Transportation – Pipeline compressors:* All Pollutants;
- *1.A.4 Other Sectors – Stationary sources:* All Pollutants;

Methodology of emission calculation: Each activity (fuel input) of each sub-category is multiplied by an emission factor.

Activity data are taken from official energy statistics.

Calorific values used for conversion of fuel activity data from [tonnes] and [cubicmetres] into [Terajoule] are country specific.

Emissions factors are country specific, fuel and technology dependent.

Regarding the above listed criteria this methodology is equivalent to a Tier 2 methodology as defined in (IPCC 2006 GUIDELINES) Volume 2, Figure 1.2.

Model Tier 3 approach

For the following categories a model Tier 3 methodology is used.

- *1.A.3.a Civil Aviation (Tier 3a);*
- *1.A.3.b Road Transport;*
- *1.A.2.f Industry – Mobile machinery;*
- *1.A.4.b Residential – Mobile machinery;*
- *1.A.4.c Agriculture and Forestry – mobile machinery;*
- *1.A.5 Other Mobile – Military;*
- *Memo item – International Bunkers – Aviation.*

Methodology of emission calculation: Each activity (fuel input) of each sub-category is multiplied by an emission factor.

Emissions factors are fuel and technology dependent.

Calorific values used for conversion of fuel activity data from [tonnes] into [Terajoule] are country specific.

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.

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.

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).

Description of received ETS data

ETS data is submitted by means of a standard calculation sheet which includes numerical data about multiple fuels, processes and material flows. Additionally a written QA/QC report has to be submitted.

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 2005–2013 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 $Default\_EF_{fuel}$ + $Σi(ETS\_CO_{2plant i, fuel})$.

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 CO_2 and CH_4 emission factors are national studies (BMWA-EB 1990, 1996, 2003, UMWELTBUNDESAMT 2001a, UMWELTBUNDESAMT 2004a). N_2O emission factors are also taken from national studies (STANZEL et al. 1995) and (BMUJF 1994). Detailed figures are included in the relevant chapters.

CO_2 emission factors for stationary sources per fuel type

Natural Gas (fossil)

For all stationary sources of natural gas combustion a CO_2 emission factor of 55.4 t CO_2/TJ (UMWELTBUNDESAMT 2001a) has been applied. Table 26 shows the typical composition of natural gas as reported by the national natural gas supplier company *GAS CONNECT AUSTRIA GmbH*.

Table 26: Typical natural gas composition 2013

Component	Share
CH_4	96.66%
C_2H_6	1.52%
C_3H_8	0.40%
$C_4H_{10}n$	0.08%
$C_4H_{10}i$	0.06%
CO_2	0.33%
N_2	0.95%

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: A default carbon content of 29.9 t C/TJ for peat is taken from (IPCC Guidelines 1997).

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

The fossil and non fossil carbon content of each fraction is taken from (ÖKOINSTITUT 2002). This leads to a fossil share of 45% of the overall carbon content of 261 kg C/t $MSW_{wet\ matter}$. The CO_2 emission factor is converted into t CO_2/TJ by means of a heating value of 9.8 GJ/t. The heating value is a personal information of STATISTIK AUSTRIA to the Umweltbundesamt and consistent with the energy balance (IEA JQ 2013). STATISTIK AUSTRIA quotes that the heating value was obtained from the plant operator.

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 3.2.11.1.

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 GPG, Table 5.6 for hazardous waste 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)

[34] 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.

Sewage sludge is incinerated in one waste incineration plant and a couple of public power plants. A default carbon content of 29.9 t C/TJ for solid biomass is taken from (IPCC Guidelines, 1997).

Black Liquor (non fossil)

Black liquor is incinerated in pulp and paper industry and in wood products manufacturing industry. A default carbon content of 29.9 t C/TJ for solid biomass is taken from (IPCC Guidelines, 1997).

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

Biogas reported by (IEA JQ 2013) is used for energy recovery in all subcategories of Category *1 A.* A default carbon content of 30.6 t C/TJ for biogas is taken from (IPCC Guidelines 1997).

CO_2 emissions reported by the ETS

The following Table 27 shows certificated CO_2 emissions from the ETS (UMWELTBUNDESAMT 2015b) 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 emissions could not be allocated to a specific category but are assumed to be included elsewhere in the inventory (e.g. carburisation material) or negligible (e.g. pyrolisis material).

Table 27: 2005–2013 CO_2 emissions [kt] as reported under theEU- ETS.

	Category	2005	2008	2009	2010	2011	2012	2013
Total ETS[1)]		33 387	32 106	27 336	30 845	30 543	28 325	29 815
1.A	FUEL COMBUSTION ACTIVITIES	20 969	18 151	16 327	18 038	17 578	15 785	15 721
1.A.1.a	Public Electricity and Heat Production	11 482	8 973	7 825	9 335	8 772	6 975	6 363
1.A.1.b	Petroleum refining	2 827	2 806	2 809	2 724	2 768	2 836	2 827
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	43	47	54	47	42	43	199
1.A.2.a	Iron and Steel	1 381	1 133	919	1 121	1 240	1 269	1 592
1.A.2.b	Non-ferrous Metals	–	–	–	–	–	–	66
1.A.2.c	Chemicals	665	611	631	654	620	628	966
1.A.2.d	Pulp, Paper and Print	2 245	2 128	1 999	2 044	2 027	1 966	1 467
1.A.2.e	Food Processing, Beverages and Tobacco	316	295	304	352	349	333	303
1.A.2.f	Non-metallic minerals	1 656	1 845	1 554	1 528	1 546	1 530	1 552
1.A.2.g.8	Other: Stationary	354	311	232	234	214	207	388
1.A.3.e	Pipeline compressors	–	–	–	–	–	–	605
1.A.4.a	Commercial/Institutional	22	19	17	15	13	13	54
2	INDUSTRIAL PROCESSES	12 395	13 937	10 992	12 792	12 952	12 527	13 432
2.A.1	Cement Production	1 797	2 133	1 799	1 622	1 666	1 673	1 659
2.A.2	Lime Production	579	621	507	574	605	569	587
2.A.3	Glass Production	35	44	41	40	36	37	39
2.A.4	Other Process Uses of Carbonates							
2.A.4.a	Ceramics	128	110	94	81	99	93	80
2.A.4.b	Other uses of soda ash							
2.A.4.c	Non-metallurgical Magnesium							

	Category	2005	2008	2009	2010	2011	2012	2013
2 A.4.d	Other	310	332	244	314	345	305	344
2.B.1	Ammonia Production	–	–	–	–	–	–	344
2.B.10	Other Chemical Industry	–	–	–	–	–	–	108
2.C.1.a	Steel	9 501	10 639	8 266	10 113	10 152	9 804	10 151
2.C.1.f.1	Electric furnace steel plant	45	57	42	47	49	46	40
2.C.3	Aluminium Production	–	–	–	–	–	–	3

[1)] *Source: UMWELTBUNDESAMT (2014b). These data do not include N_2O emissions from nitric acid production.*

CO_2 emission factors reported within the ETS

Table 28 and Table 29 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 28: 2013 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	**92.48**	**97.32**	**108.19**	**95.12**	**87.54**	**55.46**
010101 Public Power plants >= 300 MW_{th}	92.10	-	-	-	-	55.40
010102 Public Power plants >= 50 MW_{th} < 300 MW_{th}	-	-	-	-	106.00	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	-	-	-	-	-	55.40
010504 Other Energy Industries – Gas Turbines	-	-	-	-	-	55.40
010506 Pipeline Compressors	-	-	-	-	-	55.40
020103 Commercial plants < 50 MW_{th}	-	-	-	-	67.36	55.40
0301 Industry – Steel	116.93	-	-	-	-	55.40
0301 Industry – Non ferrous metals	-	-	104.00	-	79.23	55.40
0301 Industry – Chemicals	95.34	-	-	-	99.82	55.40
0301 Industry – Pulp and Paper	87.21	-	-	-	128.46	55.40
0301 Industry – Food and Beverages	-	-	108.58	-	68.65	55.40
03010 Industry – Other	-	-	-	-	78.11	55.40
030311 Cement kilns	95.41	97.25	-	94.75	83.71	55.40
030312 Lime kilns	96.03	97.53	-	94.45	89.20	55.40
030317 Glass	-	-	-	-	-	55.40

SNAP	102A Hard Coal	105A Brown Coal	107A Coke Oven Coke	110A Petrol Coke	115A Ind. Waste	301A Natural Gas
030319 Bricks and Tiles	-	97.00	-	104.00	102.82	55.40
030323 Dolomite Treatment	-	-	104.00	94.68	96.30	55.40
030326 Integrated Iron & Steel works	92.91	-	108.21	-	104.39	55.96

Table 29: 2013 CO_2 implied emission factors calculated from ETS data. Oil products.

SNAP	203B light fuel oil	203C Medium fuel oil	203D Heavy fuel oil	204A Gasoil	2050 Diesel	224A other liquid	303A LPG
Weighted average	**77.87**	**78.00**	**80.07**	**75.00**	**73.72**	**19.48**	**64.00**
010101 Public Power plants >= 300 MW_{th}	-	-	80.03	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}	-	-	80.00	75.00	73.70	-	-
010202 Public District Heating plants >= 50 MW_{th} < 300 MW_{th}	77.00	-	78.89	75.00	73.70	-	-
010203 Public District Heating plants < 50 MW_{th}	77.00	-	-	75.00	73.70	-	64.00
010301 Refinery	-	-	81.42	-	74.10	87.24	-
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	-	-	-	-	73.70	-	-
0301 Industry – Non ferrous metals	-	-	-	-	73.70	77.27	-
0301 Industry – Chemicals	-	-	79.21	75.00	73.70	-	-
0301 Industry – Pulp and Paper	78.00	78.00	78.93	75.00	73.79	-	-
0301 Industry – Food and Beverages	78.00	-	-	75.00	73.69	-	-
03010 Industry – Other	78.00	-	-	75.00	73.70	-	64.00
030311 Cement kilns	78.00	-	78.00	75.00	73.70	-	-
030312 Lime kilns	-	-	78.00	75.00	-	-	-
030317 Glass	78.00	-	-	75.00	73.72	-	-
030319 Bricks and Tiles	78.00	-	78.00	75.00	-	-	-
030323 Dolomite Treatment	77.72	-	-	-	73.86	0.22	64.00
030326 Integrated Iron & Steel works	77.00	-	76.91	74.94	-	-	-

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 2014). 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 0.

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 20.9% for the year 1990 and 15% for the year 2013. The increased CH_4 emissions are due to increased natural gas and biomass combustion in plants smaller 50 MW_{th}.

Methodology

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

For the years 2005–2013 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 0.

Emission factors

National emission factors for CO_2 and CH_4 are taken from (BMWA-EB, 1990, 1996, (UMWELTBUNDESAMT 2001a) and (GEMIS, 2002). N_2O emission factors are taken from a national study (STANZEL et al. 1995). The selected emissions factors for 2012 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 30: Default emission factors of Category 1.A.1.a for the year 2013.

Fuel	Default CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil in plants ≥ 50 MW_{th}	77.00	1.00	1.00
Light Fuel Oil in plants ≤ 50 MW_{th}	78.00	0.80	0.60
Medium Fuel Oil	78.00	1.00	1.00
Heavy Fuel Oil in plants ≥ 50 MW_{th}	80.00	0.60–1.00	1.80
Heavy Fuel Oil in plants ≤ 50 MW_{th}	78.00	2.00	1.00
Gasoil	75.00	1.20	1.00
Diesel oil	75.00	0.20	0.60
Liquified Petroleum Gas	64.00	1.50	1.00
Hard coal in power and CHP plants	95.00	0.10	0.50
Hard coal in district heating plants.	93.00	0.30	5.00
Lignite and brown coal in power and CHP plants ≥ 50 MW_{th}	110.00	0.10	0.50
Lignite and brown coal in district heating plants ≥ 50 MW_{th}	108.00	0.20	2.00
Lignite, brown coal and brown coal briquettes in plants < 50 MW_{th}	97.00	7.00	1.40
Natural Gas in power and CHP plants ≥ 50 MW_{th}	55.40	0.18	0.50
Natural Gas in district heating plants ≥ 50 MW_{th}	55.40	1.50	1.00
Natural Gas in plants ≤ 50 MW_{th}	55.40	1.50	0.10
Fuel Wood	100.00[1)]	21.00	3.00
Wood Waste	110.00[1)]	2.00	4.00
Sewage Sludge	110.00[1)]	12.00	1.40
Biogas, Sewage Sludge Gas, Landfill Gas	112.00[1)]	1.50	1.00
Municipal Solid $Waste_{wet}$	48.88[2)]	12.00	1.40
Industrial Waste	104.17[2)]	12.00	1.40

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

Activity data

Total fuel consumption of Category *1.A.1.a* is taken from (IEA JQ 2014) 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 31 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.

Table 31: 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	56 050	37 700	17 396	2	18	934	51 786
2005	58 097	37 787	18 956	2	21	1 331	56 987
2006	56 075	37 089	17 209	3	22	1 752	55 119
2007	55 914	38 066	15 785	2	24	2 037	54 600
2008	57 951	39 481	16 427	2	30	2 011	61 628
2009	60 603	42 414	16 184	2	49	1 954	62 423
2010	61 649	40 500	18 995	1	89	2 064	75 249
2011	56 353	36 816	17 426	1	174	1 936	71 587
2012	64 043	47 167	14 076	1	337	2 462	73 656
2013	60 201	45 187	11 281	0	582	3 151	76 313

[1)] *including pumped storage; Source: STATISTIK AUSTRIA 2014*

As shown in Table 32 electricity supply increased by 12 002 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 2011 shows an historical maximum of net imports which contribute to 12% of total electricity supply.

Table 32: Electricity supply, gross production imports, exports and net imports [GWh].

Year	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
1990	46 489	50 294	6 839	7 298	-459
1991	48 793	51 483	8 503	7 738	765
1992	48 197	51 190	9 175	8 621	554
1993	49 073	52 421	8 072	8 804	-732
1994	49 596	53 132	8 219	9 043	-824
1995	50 979	56 225	7 287	9 757	-2 470
1996	52 515	54 880	9 428	8 476	952
1997	53 069	56 704	9 008	9 775	-767
1998	54 039	57 001	10 304	10 467	-163
1999	55 167	60 944	11 608	13 507	-1 899
2000	55 750	61 257	13 824	15 192	-1 368

Year	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
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	64 151	16 629	13 548	3 081
2005	62 865	66 409	20 397	17 732	2 665
2006	65 595	64 499	21 257	14 407	6 850
2007	66 706	64 757	22 130	15 511	6 619
2008	66 144	66 877	19 796	14 933	4 863
2009	64 433	69 088	19 542	18 762	780
2010	67 028	71 128	19 898	17 567	2 331
2011	66 915	65 813	24 972	16 777	8 195
2012	67 752	72 617	23 264	20 454	2 810
2013	67 759	68 301	24 960	17 688	7 272

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 2.

Sector specific QA/QC procedures

Large point source data are used for validation of energy consumption. 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 ≥ *50 MW to 300 MW* of thermal capacity. Currently 56 boilers between 35 and 1 760 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 50 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 CO_2 and N_2O emissions from fuel combustion, flaring and thermal cracking of the only petroleum refining plant in Austria. CH_4 emissions are included in category *1.B.2.a Fugitive Emissions from Fuels – Oil*. 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 2013. Crude oil input was 8 megatons in 1990 and 8.6 megatons in 2013.

Methodology

The IPCC Tier 2 bottom up 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 country specific default emission factors are used.

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 33: 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 33. 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 34. The IEF fluctuations reflect changes in refinery gas composition.

Table 34: Implied emission factors for refinery gas.

Year	t CO_2/TJ
1990	65.8
1991	66.3
1992	66.4
1993	75.4
1994	78.5
1995	82.1
1996	61.7
1997	59.9
1998	62.9
1999	61.5
2000	60.2
2001	53.6
2002	63.5
2003	62.4
2004	63.5
2005	63.6
2006	63.6
2007	63.7
2008	63.5
2009	63.7
2010	63.4
2011	63.7
2012	63.4
2013	63.4

N_2O and CH_4 emissions are calculated by multiplying fuel consumption by the emission factors presented in Table 35 (they are selected according to chapter 3.2.9).

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 35: 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	2.00
Gas oil	75.00	0.60	1.20
Diesel	78.00	0.60	0.20
Other Oil Products	78.00	0.60	0.20
LPG	64.00	1.00	1.50
Petrol Coke	100.88	3.00	2.00
Refinery gas 2013	63.38	0.10	0.20
Natural Gas	55.40	0.10	1.50

Activity data

Fuel consumption is taken from (IEA JQ 2014) 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 36: Refinery input/output mass balance.

Material flow [kt]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total Input	**9 149**	**9 259**	**8 889**	**9 282**	**9 120**	**9 221**	**9 423**	**9 079**	**8 434**	**9 261**	**9 152**	**9 247**
Crude oil	7 952	8 619	8 240	8 743	8 472	8 548	8 666	8 306	7 749	8 298	8 349	8 566
NGL	41	43	107	78	88	141	78	93	89	194	124	81
Feedstocks	1 156	597	542	412	461	347	436	461	317	505	395	331
Biofuel (blending)	0	0	0	49	99	185	243	219	279	264	284	269
Total Output	**8 865**	**8 914**	**8 524**	**9 021**	**8 817**	**8 831**	**9 130**	**8 980**	**8 169**	**9 008**	**9 083**	**9 185**
Fuel oil	1 913	1 502	979	1 045	915	844	738	989	815	822	953	1 011
Gas oil	1 239	1 454	1 062	997	1 004	612	991	835	761	738	689	820
Diesel	1 531	1 920	2 662	2 931	2 780	2 976	3 108	3 164	2 741	3 367	3 317	3 219
Other Kerosene	31	8	1	1	1	1	3	3	3	0	16	18
Aviation kerosene	291	420	544	592	526	604	472	313	476	615	618	654
Aviation gasoline	0	0	0	0	0	0	0	0	0	0	0	0
Motör gasoline	2 631	2 271	1 815	1 798	1 615	1 704	1 684	1 739	1 519	1 614	1 635	1 631
White spirit	0	5	0	0	0	0	0	64	70	65	0	0
Bitumen	269	254	343	466	392	411	444	420	292	376	366	314

Material flow [kt]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Other petroleum products	7	29	15	36	125	138	194	10	59	23	32	57
Naphtha	475	621	710	637	913	937	909	870	892	844	1 009	1 011
LPG	47	60	34	143	91	113	138	137	87	101	67	66
Refinery gas	373	305	312	309	390	417	383	369	392	381	311	311
Petroleum Coke	57	66	48	66	65	73	66	67	62	62	70	73
Input-Output	**284**	**345**	**365**	**261**	**303**	**390**	**293**	**99**	**265**	**253**	**69**	**62**

Recalculations

Recalculations of activity data are following the revisions of the energy balance as described in Annex 2 which results in minor shifts (0.4 kt CO_2 in 2012) between liquid and gaseous fuels while overall CO_2 emissions have been unchanged.

Planned improvements

No improvements are planned.

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

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

Category *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries* enfolds emissions from fuel combustion in the oil and gas extraction sector (reported by companies as 'own use'), compressors used for natural gas storage tanks and fuel use of gas processing facilities („gas refineries"). For 1990 to 1995 transformation losses/own use in gas works are included too. The share in sector *1.A* overall GHG emissions is 1% for the year 1990 and 0.5% for the year 2013.

Methodology

CORINAIR simple methodology is applied.

For 2005 to 2013 CO_2 emissions and activity data of natural gas storage compressors are taken from ETS data.

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996).

The N_2O emission factor is taken from a national study (BMUJF 1994).

Table 37: 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	1.50	0.10
Heavy Fuel Oil	78.00	2.00	1.00

Activity data

Fuel consumption is taken from (IEA JQ 2014).

Transformation losses in gas works are calculated by subtracting final energy use from transformation input. Since the energy balance (IEA JQ 2014) 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 2014).

Recalculations

The change of natural gas activity data from 2005 onwards is following the revision of the energy balance as described in Annex 2. The corresponding change in GHG emissions is +12 kt CO_2 in the year 2005 and −2 kt CO_2 in 2012.

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 4% for the year 1990 and 3.6% for the year 2013.

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 CORINAIR simple 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 2013 are reported by plant operators.

N_2O and CH_4 emissions are calculated with the CORINAIR simple methodology.

Point source CO_2 emissions 2003 and 2004

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

Mass balance of integrated iron and steel plant

The following Figure 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*.

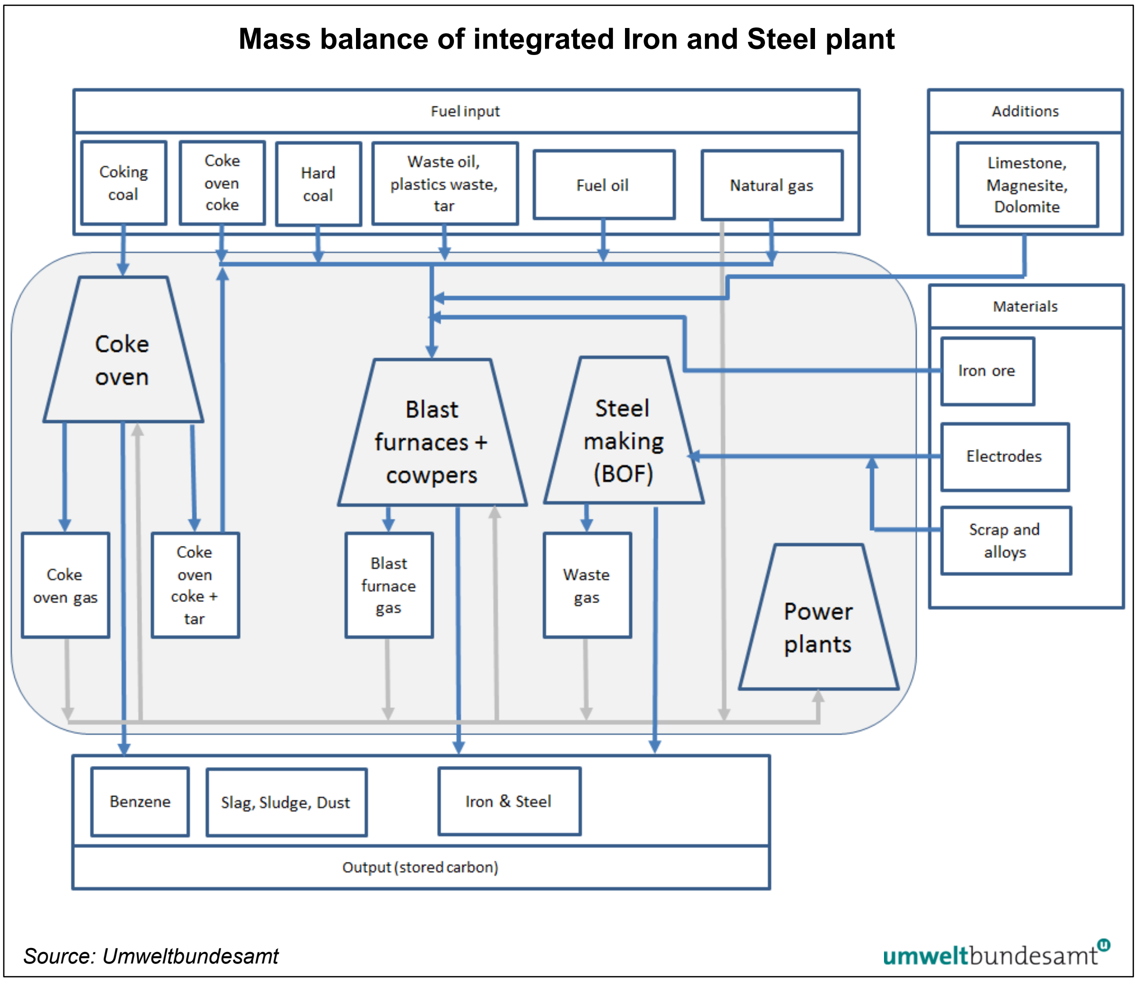


Figure 11: Mass balance of integrated Iron and Steel plant.

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 38: 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	191	0.005	0.001	1 870	0.015	0.015
1991	250	0.007	0.001	1 435	0.013	0.011
1992	202	0.005	0.001	1 152	0.013	0.008
1993	222	0.006	0.002	1 308	0.013	0.010
1994	234	0.006	0.002	1 299	0.015	0.009
1995	291	0.007	0.002	1 217	0.016	0.008
1996	445	0.012	0.003	1 363	0.017	0.009
1997	465	0.012	0.002	1 421	0.019	0.009
1998	424	0.011	0.002	737	0.020	0.001
1999	316	0.008	0.001	977	0.020	0.004
2000	413	0.011	0.002	819	0.018	0.003

Year	other sources			Integrated steel plants		
	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 [kt]	CH_4 [kt]	N_2O [kt]
2001	303	0.008	0.001	1 013	0.020	0.004
2002	397	0.011	0.001	1 230	0.018	0.007
2003	368	0.010	0.001	1 287	0.019	0.008
2004	300	0.008	0.001	1 524	0.024	0.009
2005	410	0.011	0.002	1 696	0.022	0.011
2006	459	0.012	0.002	1 267	0.021	0.007
2007	343	0.010	0.001	1 087	0.020	0.005
2008	358	0.010	0.002	1 165	0.020	0.006
2009	313	0.008	0.001	944	0.018	0.004
2010	303	0.008	0.001	1 159	0.022	0.005
2011	326	0.009	0.001	1 296	0.025	0.006
2012	336	0.009	0.001	1 325	0.026	0.006
2013	462	0.013	0.002	1 509	0.027	0.007

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002), N_2O emission factors are taken from the national study (BMUJF 1994).

The selected and calculated emission factors for 2013 are presented in Table 39 and Table 40.

Activity data

Total fuel consumption is taken from (IEA JQ 2014).

Point source activity data are reported by plant operators which are widely consistent with (IEA JQ 2014).

Table 39: 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	0.20	0.60
Heavy Fuel Oil	78.00	2.00	1.00
Gas oil	75.00	1.20	1.00
Petroleum	78.00	0.20	0.60
LPG	64.00	1.50	1.00
Hard Coal	94.00	5.00	1.40
Lignite and brown coal	97.00	7.00	1.40
Coke	104.00	2.00	1.40
Natural Gas	55.40	1.50	0.10
Wood Waste	110.00[1)]	2.00	4.00

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

Table 40: 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
Natural Gas	55.40	1.5	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 76 kt CO_2 equivalents in 2012 (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

Recalculations are following the new IPCC 2006 Guidelines. In the previous submission a share of emissions from reducing agents (coke oven coke, coke oven gas, residual fuel oil, hard coal) used in blast furnaces were reported under category *1.A.2.a* while in this submission the consumption used for on plant power generation (natural gas, coke oven gas) is considered only under 1.A.2.a.

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 0.5% for the year 2013.

Methodology

CORINAIR simple methodology is applied. Fuel consumption is taken from (IEA JQ 2014). For the year 2013 CO_2 ETS data are considered.

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002).

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

The emission factors for 2013 are presented in the following table.

Table 41: Emission factors of Category 1.A.2.b

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil	78.00	0.20	0.60
Medium Fuel Oil	78.00	2.00	1.00
Heavy Fuel Oil	78.00	2.00	1.00
Gas oil	75.00	1.20	1.00
Petroleum	78.00	0.20	0.60
LPG	64.00	1.50	1.00
Hard Coal	94.00	5.00	1.40
Coke	104.00	2.00	1.40
Natural Gas	55.40	1.50	0.10

Activity data

Fuel consumption is taken from (IEA JQ 2014).

Recalculations

Minor changes of activity data are based on a revision of the energy balance 2009 to 2012 and result in −2 kt CO_2 emissions in the year 2012.

3.2.11.3 1.A.2.c Chemicals

Key Sources: CO_2 from 1.A.2.c gaseous, solid and liquid 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 3.4% for the year 2013. Larger fluctuations in emission trends occur because economic main activity of combined pulp and viscose manufacturing plants is changing over time and therefore allocated either to sector *1.A.2.c* or *1.A.2.d* of the energy balance.

Methodology

CORINAIR simple methodology is applied. For the years 2005 to 2013 CO_2 ETS data are considered.

CO_2 emissions from industrial waste: Table 42 shows the composition of the implied emissions factor 2000–2013 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 42: Composition of 1.A.2.c Chemical industries – industrial waste – CO_2 IEF for the years 2000 to 2013.

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	3781)	70.62	380	52.09	89.79
2001	2 815	1 500	104.17	3781)	70.62	937	52.09	82.33
2002	4 129	1 500	104.17	3781)	70.62	2 251	52.09	72.70
2003	5 821	1 500	104.17	3781)	70.62	3 943	52.09	66.71
2004	7 257	1 500	104.17	3781)	70.62	5 378	52.09	44.94
2005	3 431	1 500	104.17	378	70.62	1 553	52.09	76.90
2006	3 480	1 500	104.17	560	74.59	1 420	52.09	78.16
2007	2 794	1 500	104.17	528	75.01	766	52.09	84.38
2008	6 049	1 500	104.17	299	84.88	4 250	52.09	66.62
2009	7 208	1 500	104.17	271	76.38	5 438	52.09	63.84
2010	6 460	1 500	104.17	276	77.47	4 684	52.09	65.26
2011	6 550	1 500	104.17	210	75.10	4 840	52.09	64.75
2012	4 294	1 500	104.17	259	82.92	2 535	52.09	72.14
2013	3 309	1 500	104.17	259	82.92	1 550	52.09	78.11

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

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002). N_2O emission factors are taken from a national study (BMUJF 1994).

Table 43: Emission factors of Category 1.A.2.c for 2013.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil	78.00	0.20	0.60
Medium Fuel Oil	78.00	2.00	1.00
Heavy Fuel Oil	78.00	2.00	1.00
Gas oil	75.00	1.20	1.00
LPG	64.00	1.50	1.00
Hard Coal	94.00	5.00	1.40
Lignite and brown coal	97.00	7.00	1.40
Brown Coal Briquettes	97.00	7.00	1.40
Coke	104.00	2.00	1.40
Natural Gas	55.40	1.50	0.10
Fuel Wood	100.00[1)]	2.00	4.00
Wood Waste	110.00[1)]	2.00	4.00
Black Liquor	110.00[1)]	2.00	1.40
Biogas	112.00[1)]	1.50	1.00
Industrial Waste	78.11[2)]	12.00	1.40

1) *Reported as CO_2 emissions from biomass*

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

Activity data

Fuel consumption is taken from (IEA JQ 2014).

Recalculations

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

These recalculations due to revision of the energy balance mainly affect CO_2 emissions from natural gas (−87 kt CO_2 in 2012), and other fuels (−82 kt CO_2 in 2012) which results in an overall decrease of -171 kt CO_2 in 2012.

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 2.8% for the year 2013.

Methodology

The CORINAIR simple methodology is applied. For the years 2005 to 2013 CO_2 ETS data are considered.

CO_2 emissions from industrial waste: The following Table 44 shows the composition of the implied emissions factor 2000–2013 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 44 shows fuel waste consumption as provided by energy statistics and fuel waste consumption, CO_2 emissions and the calculated IEF from ETS.

Table 44: Composition of 1.A.2.d Pulp, Paper and Print – industrial waste – CO_2 IEF for the years 2000 to 2013.

Year	Total energy use (energy balance)	ETS		CO_2 IEF	CO_2
	[TJ]	[TJ]	CO_2 IEF	[t/TJ]	[kt]
2000	0			NO	0.00
2001	113			104.17	11.82
2002	121			104.17	12.65
2003	202			104.17	21.03
2004	246			104.17	25.65
2005	88	111	64.29	64.29	7.15
2006	66	149	43.85	43.85	6.53
2007	177	170	65.52	65.52	11.14
2008	96	101	88.78	88.78	8.92
2009	243	96	91.72	91.72	8.79
2010	169	79	100.85	100.85	7.93
2011	188	91	87.79	87.79	7.99
2012	143	60	116.27	116.27	6.98
2013	236	170	128.46	128.46	21.83

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELT-

BUNDESAMT 2002). N_2O emission factors are taken from a national study (BMUJF 1994).

Emission factors for 2013 are presented in the following table.

Table 45: 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	5.00	1.40
Lignite and brown coal	97.00	7.00	1.40
Brown Coal Briquettes	97.00	7.00	1.40
Coke	104.00	2.00	1.40
Light Fuel Oil	78.00	0.20	0.60
Heavy Fuel Oil	78.00	2.00	1.00
Gas oil	75.00	1.20	1.00
Petroleum	78.00	0.20	0.60
Diesel	75.00	0.20	0.60
LPG	64.00	1.50	1.00
Natural Gas	55.40	1.50	0.10
Fuel Wood	100.00[1)]	2.00	4.00
Wood Waste[2)]	110.00[1)]	2.00	4.00
Black Liquor	110.00[1)]	2.00	1.40
Biogas	112.00[1)]	1.50	1.00
Landfill Gas	112.00[1)]	1.50	1.00
Industrial Waste	128.46	12.00	1.40

1) *Reported as CO_2 emissions from biomass*

2) *Including sewage sludge from paper mills*

Activity data

Fuel consumption is taken from (IEA JQ 2014).

Recalculations

Changes of activity data are based on a recalculation of the energy balance as described in Annex 2. The most significant recalculation for the year 2012 is –3 kt CO_2 from liquid fuels.

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

Key Source: CO_2 from 1.A.2.e gaseous, solid 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 1.7% for the year 2013.

Methodology

CORINAIR simple methodology is applied. For the years 2005 to 2013 CO_2 ETS data are considered.

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELT-BUNDESAMT 2002). N_2O emission factors are taken from a national study (BMUJF 1994).

Emission factors for 2013 are presented in the following table.

Table 46: Emission factors of Category 1.A.2.e.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil	78.00	0.20	0.60
Medium Fuel Oil	78.00	2.00	1.00
Heavy Fuel Oil	78.00	2.00	1.00
Gas oil	75.00	1.20	1.00
Petroleum	78.00	0.20	0.60
Diesel	75.00	0.20	0.60
LPG	64.00	1.50	1.00
Hard Coal	94.00	5.00	1.40
Lignite and brown coal	97.00	7.00	1.40
Brown Coal Briquettes	97.00	7.00	1.40
Coke	104.00	2.00	1.40
Natural Gas	55.40	1.50	0.10
Fuel Wood	100.00[1)]	2.00	4.00
Wood Waste	110.00[1)]	2.00	4.00
Biogas	112.00[1)]	1.50	1.00
Industrial Waste	104.17	12.00	1.40

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

Activity data

Fuel consumption is taken from (IEA JQ 2014).

Recalculations

Changes of activity data are based on a revision of the energy balance as described in Annex 2. The most significant recalculation for the year 2013 is +0.3 kt CO_2 from liquid fuels.

3.2.11.1 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 2.9 % for the year 2013.

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

2013 clinker production was falling by 20% from 4 Mt to 3.2 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). 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 2013.

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.

CO_2 emissions

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

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

CO_2 emissions 2004 to 2012 are taken from the ETS allocation plan survey and ETS data.

CH_4 and N_2O emissions are calculated with the simple CORINAIR methodology.

Activity data

Calculated thermal energy intake of cement kilns is between 3.46 GJ/t clinker in 1990 and 3.72 GJ/t clinker in 2013.

Hard Coal, Brown Coal, Petrol Coke and Industrial Waste

In (IEA JQ 2014) 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 47 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 an 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 47: Industrial waste used as fuel in cement kilns 1990–2013.

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 fossile 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

[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 2014).

Activity data 2005–2013

For the years 2005–2013 ETS data are taken which covers 100% of cement plants.

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996).

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

Recalculations

Revision of CO_2 emissions from lime production 2008 - 2012 to be in line with ETS data (consideration of fuel waste, lignite and petrol coke) which results in +51 kt CO_2 in 2012.

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

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

This category enfolds emissions due to fuel combustion of the industrial branches as specified in Table 48. The share in total GHG emissions from Sector *1.A* is 3.3 % for the year 1990 and 3.4 % for the year 2013.

Table 48: 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

The CORINAIR simple methodology is applied. For 2005 to 2013 ETS data are considered.

Activity data

Fuel consumption is taken from (IEA JQ 2014).

Since the energy balance (IEA JQ 2014) 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 2014).

Emission factors

CO_2 and CH_4 emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002). N_2O emission factors are taken from a national study (BMUJF 1994).

The emission factors for 2013 are presented in the following table.

Table 49: Emission factors 2013 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	5.00	1.40
Lignite and brown coal	97.00	7.00	1.40
Brown Coal Briquettes	97.00	7.00	1.40
Coke	104.00	2.00	1.40

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Light Fuel Oil	78.00	0.20	0.60
Medium Fuel Oil	78.00	2.00	1.00
Heavy Fuel Oil	78.00	2.00	1.00
Gas oil	75.00	1.20	1.00
Diesel	75.00	0.20	0.60
Petroleum	78.00	0.20	0.60
LPG	64.00	1.50	1.00
Gas Works Gas	64.00	0.20	1.00
Petrol Coke	100.88	0.00	0.00
Natural Gas	55.40	1.50	0.10
Fuel Wood	100.00[1)]	2.00	4.00
Wood Waste	110.00[1)]	2.00	4.00
Black Liquor	110.00[1)]	2.00	1.40
Biogas	112.00[1)]	1.50	1.00
Sewage Sludge Gas	112.00[1)]	1.50	1.00
Landfill Gas	112.00[1)]	1.50	1.00
Industrial Waste – fossil	104.17	12.00	1.40
Industrial Waste – IEF	13.77[2)]	12.00	1.40

[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 2.

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

Key Source: No

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 2.2% for the year 2013. All GHG emissions originate from liquid fossil fuel combustion.

Table 50: Greenhouse gas emissions from category 1.A.2.g.vii mobile sources 1990–2013

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 e [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

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 e [kt]
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
Trend 1990–2013	***340%***	***80%***	***91%***	***316%***

Methodological Issues

The used methodology conforms 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 (PISCHINGER 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 (PISCHINGER 2000),
- Interviews with experts and expert judgment validating the questionnaire results (PISCHINGER 2000) and
- Information from vehicle and machinery manufacturers (PISCHINGER 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.

Table 51: Implied emission factors and activities from industrial mobile off-road sources 1990–2013.

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	11 028	73.40	2.23	21.31
2006	13 736	71.10	1.94	17.76
2007	14 884	71.05	1.78	15.60
2008	16 419	70.86	1.67	14.04
2009	16 079	69.64	1.62	13.01
2010	15 422	69.61	1.60	12.51
2011	15 501	69.54	1.58	12.02
2012	16 067	69.36	1.55	11.29
2013	16 155	69.60	1.51	10.67

In 2013, the total avoided fossil CO_2 emissions from the use of biofuels amounted to 1 728 kt in Austria (BMLFUW 2014a). 5% of these emissions are attached to mobile off-road sources in the industry sector. For more details about the use of biofuels see chapter *1.A.3.b Road Transport*.

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.

Table 52: Emission factors for diesel engines > 80 kW.

Year	NO_x	NH_3	NMVOC	PM
	[g/kwh]			
1993	10.193	0.003	1.577	1.623
2001	12.392	0.002	1.183	0.885
2003	7.845	0.002	0.307	0.295
2006	5.187	0.001	0.502	0.173
2011	3.292	0.001	0.502	0.173

Table 53: Emission factors for diesel engines < 80 kW.

Year	NO_x	NH_3	NMVOC	PM
	[g/kwh]			
1993	11.992	0.006	1.892	2.184
2001	10.923	0.005	1.446	1.682
2003	8.103	0.004	1.179	0.545
2006	6.300	0.003	0.653	0.277
2011	5.250	0.002	0.653	0.277

Table 54: Emission factors for 4-stroke-petrol engines.

Year	NO_x	NH_3	NMVOC	PM
	[g/kwh]			
1993	3.070	0.002	15.917	0.025
2001	4.110	0.002	12.738	0.025
2003	4.490	0.002	12.167	0.025
2006	4.490	0.002	11.748	0.025
2011	4.490	0.002	10.844	0.025

Table 55: Emission factors for 2-stroke-petrol engines.

Year	NO_x	NH_3	NMVOC	PM
	[g/kwh]			
1993	1.035	0.002	247.797	0.439
2001	1.135	0.002	174.290	0.291
2003	1.675	0.001	164.637	0.291
2006	1.395	0.001	50.490	0.291
2011	1.395	0.000	50.490	0.291

Recalculations

Revisions of the national energy balance for the years 2009 and 2012 resulted in minor adjustments of the sectorial diesel consumption data applied in the national off-road model GEORG (0.1% in 2012) (HAUSBERGER/ SCHWINGSHACKL/REXEIS 2015a).

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 2013.

Table 56: Greenhouse gas emissions from 1.A.3.a domestic Civil Aviation by subcategories 1990–2013.

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	6.4	41.6	0.0048	0.0000	-	0.0023	0.0002	0.001
2001	15.8	5.9	38.4	0.0039	0.0000	-	0.0020	0.0002	0.001
2002	16.4	7.5	38.2	0.0041	0.0001	-	0.0021	0.0002	0.001
2003	16.1	8.2	38.3	0.0040	0.0001	-	0.0020	0.0002	0.001
2004	17.2	7.6	39.5	0.0043	0.0001	-	0.0020	0.0002	0.001
2005	16.4	8.8	41.6	0.0041	0.0001	-	0.0020	0.0002	0.001
2006	19.6	9.0	43.2	0.0049	0.0001	-	0.0021	0.0002	0.001
2007	20.0	9.0	44.7	0.0050	0.0001	-	0.0021	0.0002	0.001
2008	22.2	9.3	39.3	0.0055	0.0001	-	0.0021	0.0003	0.001
2009	20.4	10.3	36.8	0.0051	0.0001	-	0.0021	0.0003	0.001
2010	19.4	9.2	34.9	0.0048	0.0001	-	0.0021	0.0003	0.001
2011	16.8	13.9	31.2	0.0042	0.0001	-	0.0016	0.0004	0.001
2012	16.9	8.0	29.7	0.0042	0.0001	-	0.0016	0.0002	0.001
2013	16.9	8.2	29.5	0.0042	0.0001		0.0016	0.0002	0.001

Methodological Issues

The used methodology conforms 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[35] (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 vari-

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

ous flight lengths, for an array of representative aircraft categories.

VFR – Visual Flight Rules

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

Activity Data

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

Table 57: Activity data from 1.A.3.a Civil Aviation by subcategories 1990–2013.

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
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
Trend 1990-2013	***69%***	***5%***	***108%***

<u>IFR flights</u>

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.

The number of flight movements per aircraft type and airport (national and international) was obtained from special analyses by Statistik Austria (STATISTIK AUSTRIA 2008[36], 2009, 2010, 2011, 2012, 2013, 2014) and by Austro Control (AUSTRO CONTROL 2007[37], 2008, 2009, 2010, 2011, 2012, 2013, 2014). Moreover, for the calculation of passenger kilometres and ton kilometres input data was taken from the Austrian transport statistics (STATISTIK AUSTRIA 2014a). The total amount of jet kerosene and gasoline was taken from the energy balance (STATISTIK AUSTRIA 2000–2014).

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.

Table 58: Fuel consumption for VFR and IFR flights and number of IFR LTO cycles, 1990–2013.

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

[36] for the years 2000–2007

[37] for the years 2000–2006

Year	Activity			
	VFR Gasoline [kt]	nat. LTO Kerosene [kt]	dom. cruise Kerosene [kt]	domestic LTO IFR [no.]
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

Emission Factors

From 2000 onwards emissions from VFR flights (gasoline) and military flights are estimated by applying the IEFs of the year 2000 taken from (KALIVODA/KUDRNA 2002).

CO_2

IFR/VFR

CO_2 emissions covered in this sub-category were calculated separately for VFR-flights and IFR-flights, for domestic LTO and domestic cruise.

For the calculation of CO_2 emissions an emission factor of 3 150 kg CO_2/t fuel has been used for IFR and VFR flights (CORINAIR, KALIVODA/KUDRNA2002). This factor equals the IEF (t CO2/t fuel) for VFR and military flights of the year 2000.

CH_4

IFR

The emission factor for national and international LTO follows the EMEP/EEA 2013 Guidelines (10% of total VOC (HC) emissions).

Following the EMEP/EEA 2013 Guidelines CH_4 emissions for domestic and international cruise are assumed to be Zero.

VFR

CH_4 emissions for VFR aviation are estimated with the Tier 1 default value of 0.5 kg/TJ fuel (IPCC 2006 GL). CH_4 emissions for military aviation are estimated with the IEF of 0.0001 t/t fuel of the year 2000 taken from (KALIVODA/KUDRNA 2002).

N_2O

IFR

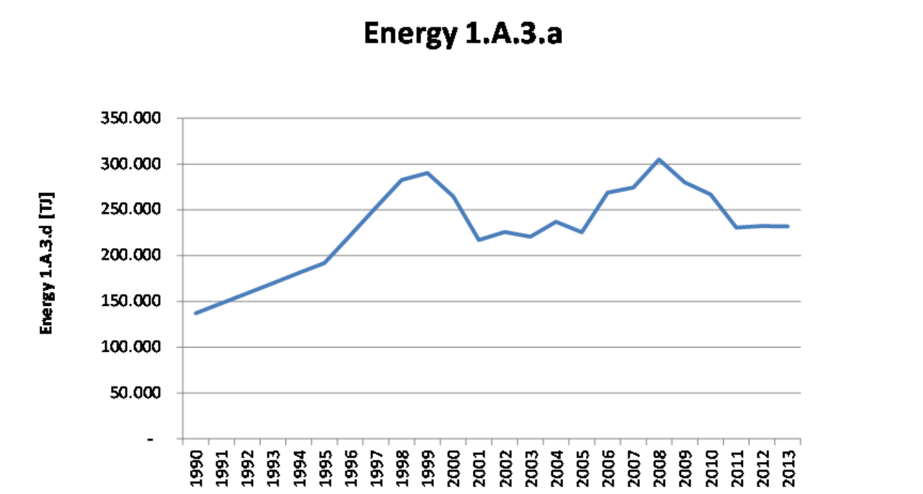
The applied emission factors for domestic/international cruise and domestic/international LTO were taken from the old CORINAIR Guidebook. They are based on LTO cycles and fuel used for cruise (0.1 kg N_2O/LTO for LTO and 0.1 kg N_2O/Mg fuel for cruise).

VFR

N_2O emissions for VFR aviation are estimated with the Tier 1 default value of 2.0 kg/TJ fuel (IPCC 2006 GL). N_2O emissions for military aviation are estimated with the IEF of 0.0002 t/t fuel of the year 2000 taken from (KALIVODA/KUDRNA 2002).

Quality Assurance and Quality Control (QA/QC)

Time series consistency



Source: Umweltbundesamt

Figure 12: Activity data from 1.A.3.a domestic Civil Aviation 1990–2013.

From 1999 onwards a different methodology of emissions estimation has been applied. 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 59: 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]			%
OLI2014 (1990–2013)	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.

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 this cannot be guaranteed due to late data delivery for the bottom-up calculation in the inventory Statistics Austria may have to use a simple extrapolation of the previous years' data and send the current split to the IEA the following year. It is common practice to not report revised data to the IEA after the regular submission date at the end of October, i.e. outside the regular reporting deadlines.

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.

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 harbours as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals[38], an underestimation of emissions can be excluded.

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

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.

Recalculations

No recalculations have been made in this years' submission.

Planned improvements

Update of aircraft types and emission factors. For calculating emissions from *1.A.3.a Civil aviation* emission factors are currently taken from the EMEP/CORINAIR Emission Inventory Guidebook 2006 (EEA 2006), but are planned to be adapted according to the EMEP/EEA air pollutant emission inventory guidebook 2013 (EEA 2013).

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 (+64.0%) 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. In 2013 GHG emissions from road transport increased by 4.8% compared to 2012. This means that fuel consumption has increased substantially in contrast to the last few years where there has been a decreasing trend from 2005 onwards mainly driven by the gradual replacement of vehicles by newer, less consuming cars with less specific fuel consumption as well as the increased use of biofuels from 2005 onwards.

Table 60: Greenhouse gas emissions from Category 1.A.3.b Road Transport 1990–2013.

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 e [kt]
1990	13 328	2.56	0.38	13 505
1991	14 799	2.58	0.45	14 997
1992	14 776	2.30	0.45	14 969
1993	14 917	2.07	0.46	15 106
1994	14 966	1.89	0.47	15 153
1995	15 239	1.75	0.48	15 424
1996	16 801	1.57	0.47	16 981
1997	15 819	1.41	0.45	15 987
1998	17 797	1.39	0.47	17 972
1999	17 181	1.22	0.44	17 343
2000	18 090	1.12	0.44	18 248
2001	19 434	1.08	0.45	19 594
2002	21 544	1.08	0.48	21 714

Year	CO_2 [kt]	CH_4 [kt]	N_2O [kt]	CO_2 e [kt]
2003	23 298	1.05	0.49	23 472
2004	23 812	0.98	0.49	23 983
2005	24 147	0.90	0.49	24 314
2006	22 735	0.80	0.49	22 900
2007	22 913	0.72	0.50	23 081
2008	21 525	0.63	0.49	21 687
2009	20 877	0.57	0.49	21 038
2010	21 659	0.52	0.52	21 827
2011	20 920	0.49	0.53	21 090
2012	20 815	0.45	0.55	20 990
2013	21 815	0.43	0.61	22 008
Trend 1990–2013	**64%**	**-83%**	**59%**	**63%**

In 2013, 52% of the total greenhouse gas emissions from *1.A.3 Transport* are caused by passenger cars (petrol and diesel) and 41% 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;* heavy duty vehicles 27%. In 2013, the total avoided fossil CO_2 emissions from the use of biofuels amounted to 1 728 kt in Austria (BMLFUW 2014a)

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 61: Greenhouse gas emissions from 1.A.3.b Road Transport differentiated by means of transportation 1990–2013.

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	fuel export	inland	inland	fuel export	inland
	CO_2e [kt]					
1990	8 414	406	939	2 612	1 046	63
1991	8 704	1 200	968	2 824	1 210	63
1992	8 989	667	996	2 898	1 324	66
1993	9 157	339	1 010	2 941	1 560	69
1994	9 508	-42	1 051	3 008	1 523	74
1995	9 609	-124	1 069	3 089	1 669	80
1996	9 784	-621	1 088	3 154	3 446	86
1997	9 953	-837	1 121	3 218	2 407	91
1998	10 166	-205	1 159	3 290	3 424	99
1999	10 438	-735	1 202	3 344	2 947	107
2000	10 587	-702	1 240	3 449	3 519	112
2001	10 717	-141	1 258	3 486	4 111	116
2002	10 894	1 231	1 255	3 586	4 563	121
2003	11 008	2 242	1 265	3 741	5 017	125
2004	11 096	2 645	1 278	3 828	4 947	128

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	fuel export	inland	inland	fuel export	inland
			CO_2e [kt]			
2005	11 109	2 840	1 306	3 836	5 029	131
2006	10 849	2 812	1 319	3 842	3 877	135
2007	10 908	2 890	1 356	3 920	3 801	139
2008	10 855	2 057	1 325	3 788	3 447	141
2009	10 552	2 061	1 288	3 419	3 500	146
2010	10 651	1 642	1 314	3 571	4 428	149
2011	10 727	1 054	1 327	3 666	4 090	154
2012	10 601	967	1 325	3 641	4 220	160
2013	10 663	711	1 315	3 614	5 465	161
Trend 1990–2013	***27%***	***75%***	***40%***	***38%***	***423%***	***156%***

In 2013 the total share of fuel export in *1.A.3.b* amounted to 28% or 6 176 Gg CO_2 equivalents of which 12% are attributed to passenger road transport and 88% to road freight transport.

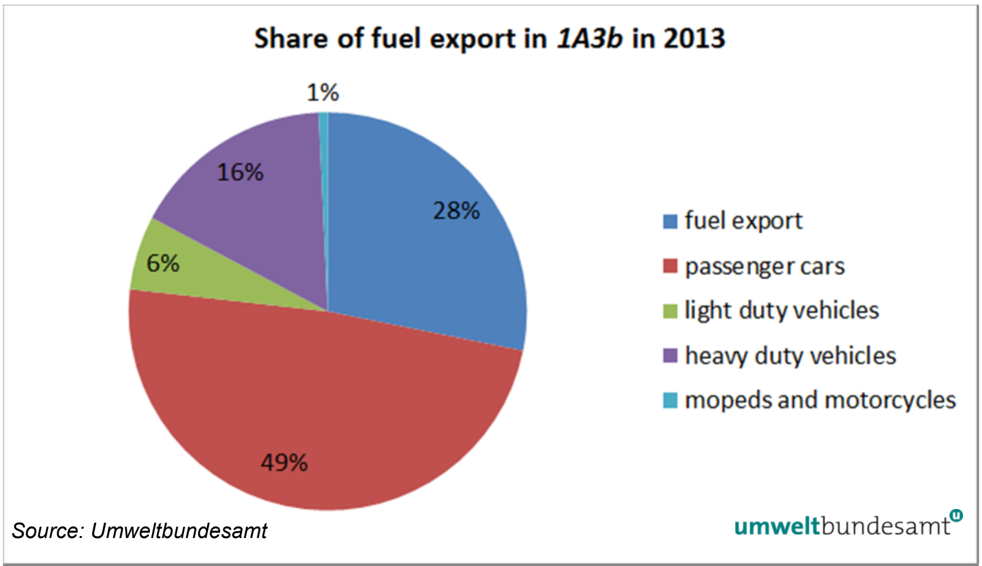


Figure 13: Share of fuel export in 1.A.3.b Road Transport in 2013.

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 2012).

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 national statistics; STATISTIK AUSTRIA 2000–2014) 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.

NEMO - Network Emission Model

Emissions from *Mobile Combustion* have so far been calculated with the model GLOBEMI (HAUSBERGER 1997; HAUSBERGER/SCHWINGSHACKL/REXEIS 2014). 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 2015a, 2015b). 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) Number of passengers per vehicle and tons payload per vehicle;
4) 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 14 shows a schematic picture of the methodology of NEMO.

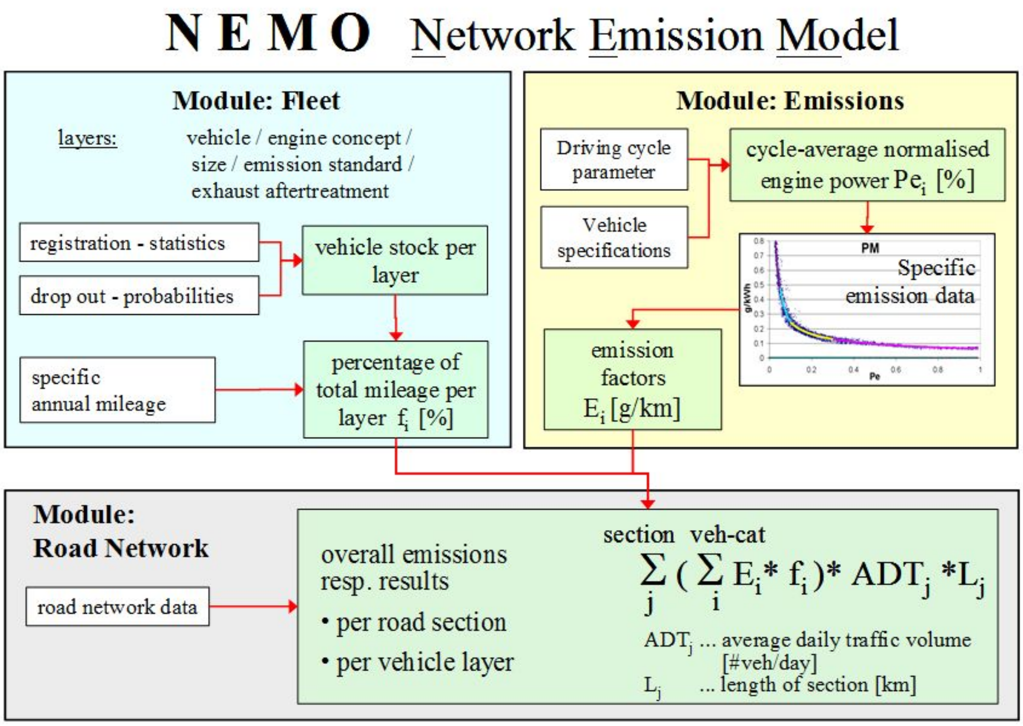


Figure 14: Schematic picture of the NEMO model.

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.

$$stock_{Jg_i, year\ i} = stock_{Jg_i, year\ i-1} \times survival\ \ probabilit\ y_{Jg_i}$$

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)

$$totalmileage_{E_i} = \sum_{Jg=start.}^{end} (stock_{Jg,yeari} \times km/vehicle_{Jg_i,yeari})$$

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

$$Emission_{E_i} = total\ mileage_{E_i} \times emission\ factor_{K_j, E_i}$$

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

$$Emission_{veh.category} = \sum_{E_i=1}^{end} Emission_{E_i}$$

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

$$transportvolumes_{veh.category} = \sum_{E_i=1}^{end} (vehiclemileage_{E_i} \times loading_{E_i})$$

7) Summation over all vehicle categories

with Jg_j.. *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 2012 to 2013 fuel consumption (gasoline, diesel and alternative fuels) by road transport and mobile off-road vehicles increased by 3.9%. Specific consumption per vehicle kilometer declined between 2012 and 2013 by 0.9% for diesel passenger cars, by 1.3% for gasoline passenger cars and by approximately 2% for light and heavy duty vehicles. Pure biofuels were assigned exclusively to passenger cars, light and 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 62: Activity data from category 1.A.3.b Road Transport differentiated by fuel type 1990–2013.

	Fuel consumption (based on fuel sold) [TJ]					
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**biomass**
1990	176 819	103 892	72 514	413	-	-
1991	196 381	113 956	81 998	428	-	-
1992	196 209	108 954	86 811	444	-	-
1993	198 238	104 514	93 273	451	-	-
1994	199 002	100 769	97 772	462	-	-
1995	202 785	97 334	104 957	494	-	-
1996	224 089	90 034	133 386	670	-	-
1997	210 958	85 336	125 092	530	-	-
1998	237 518	89 280	147 648	590	-	-
1999	229 398	82 978	145 799	622	-	-
2000	241 744	80 171	160 901	672	-	-
2001	259 853	80 752	178 379	722	-	-
2002	288 168	86 945	200 239	984	-	-
2003	311 790	88 914	221 744	1 132	-	-
2004	318 768	86 496	231 311	947	14	-
2005	325 933	84 057	238 304	977	16	2 579
2006	314 196	80 668	222 731	1 005	15	9 776
2007	317 782	78 769	227 069	968	76	10 901
2008	301 741	70 766	216 503	1 002	138	13 332
2009	297 003	70 550	207 994	945	201	17 314
2010	308 718	69 415	219 691	889	276	18 447
2011	298 461	66 862	212 364	854	295	18 086
2012	297 858	65 083	212 706	900	346	18 823

	Fuel consumption (based on fuel sold) [TJ]					
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**biomass**
2013	311 109	63 797	227 558	883	398	18 472
Trend 1990-2013	***76%***	***-39%***	***214%***	***114%***	***2670%***[39]	***616%***[40]

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 2013 the energetic substitution by biofuels amounted to 6.19% in the road transport sector.[41] 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (UMWELTBUNDESAMT 2006b, BMLFUW 2014a).

For the year 2013 a consumption of 443 389 tons of HVO[42] & biodiesel (for blending with diesel) and 88 842 tons of bioethanol (for blending with gasoline) are used as input data in the calculation models based on.[43] Following amounts are used in pure form: 17 842 tons of plant oil; 62 694 tons of biodiesel; pure bioethanol in E85 was not reported in 2013 and is included in bioethanol used for blending with gasoline (BMLFUW 2014a).

Table 63: Use of biofuels in absolute figures 2005–2013.

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**
Trend 2005–2013	**374%**	**491%**	**336%**	**566%**

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) Version 3.2 (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 V3.2 has been applied.

[39] Trend 2004-2013

[40] Trend 2005-2013

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

[42] HVO…Hydrotreated Vegetable Oils

[43] Models: NEMO and GEORG (see *1.A.2.g.vii*)

Moreover, specific CO_2 emission factors of new passenger cars and light duty vehicles has been implemented according to the national CO_2 monitoring data for the Austrian fleet (BMLFUW 2014b).

Cold-start emissions

Cold-start emissions according to IPCC 2006 GL are calculated as separate emissions in addition to the emissions that would be expected if all vehicles were only operated with hot engines and warmed-up catalysts. Cold-start emissions are only allocated for urban and rural driving, as the number of starts in highway conditions seems to be relatively limited. Cold-start emissions are calculated in NEMO for each vehicle category and each pollutant as follows:

Additional impact per start [g / km] =
cold-start surcharge [g / start] / average trip length per cold start [km / start]

The cold start influence is in NEMO included in the calculation of fuel consumption and emissions of CO_2, NO_x, CO, hydrocarbons and PM. For N_2O and NH_3 no cold start emission factors were found in the literature. Thus, the cold-start influence on the greenhouse effects of N_2O emissions could not be taken into account.

The values used for cold-start surcharges come from:

- PC and LDV: cold-start model from 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

Implied emission factors for the different means of road transportation are listed in the following tables. In the following tables the activity data always includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 64: Implied emission factors of passenger cars 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	114 521	75.7	19.08	2.90
1991	128 610	75.7	17.25	3.06
1992	125 484	75.6	15.51	3.19
1993	123 500	75.6	14.00	3.29
1994	123 245	75.5	12.68	3.34
1995	123 646	75.4	11.50	3.35
1996	119 843	75.2	10.29	3.25
1997	119 305	75.2	9.20	3.11
1998	130 580	75.2	8.24	2.97
1999	127 477	75.1	7.24	2.81
2000	130 128	75.0	6.37	2.67
2001	139 464	74.9	5.64	2.53
2002	160 295	74.8	4.99	2.39
2003	175 496	74.7	4.39	2.26
2004	182 040	74.7	3.91	2.17
2005	186 108	74.2	3.46	2.09
2006	185 821	72.8	3.01	2.04
2007	188 757	72.5	2.66	1.95
2008	179 658	71.3	2.35	1.87
2009	177 896	70.3	2.13	1.79
2010	173 790	70.2	1.93	1.70
2011	166 723	70.1	1.88	1.69
2012	164 317	69.9	1.74	1.66
2013	160 842	70.2	1.68	1.66

Table 65: Implied emission factors of light duty vehicles 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	12 427	75.0	11.1	1.2
1991	12 827	74.9	9.9	1.1
1992	13 221	74.8	8.8	1.0
1993	13 429	74.8	7.8	0.9
1994	13 987	74.7	7.0	0.9
1995	14 233	74.6	6.2	1.1
1996	14 497	74.6	5.6	1.2
1997	14 938	74.5	4.9	1.3
1998	15 458	74.5	4.4	1.4
1999	16 028	74.4	3.8	1.4
2000	16 545	74.4	3.3	1.5

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2001	16 794	74.4	2.9	1.6
2002	16 764	74.3	2.5	1.6
2003	16 902	74.3	2.2	1.7
2004	17 080	74.3	1.9	1.7
2005	17 622	73.5	1.7	1.8
2006	18 326	71.4	1.5	1.9
2007	18 873	71.3	1.2	1.9
2008	18 545	70.9	0.9	1.9
2009	18 330	69.7	0.8	1.9
2010	18 704	69.6	0.6	1.9
2011	18 907	69.6	0.5	1.9
2012	18 933	69.4	0.5	1.9
2013	18 730	69.6	0.4	1.9

Table 66: Implied emission factors of heavy duty vehicles 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	49 103	74.2	1.5	0.7
1991	54 168	74.2	1.5	0.7
1992	56 688	74.2	1.5	0.7
1993	60 451	74.2	1.5	0.7
1994	60 854	74.2	1.4	0.7
1995	63 911	74.2	1.4	0.7
1996	88 677	74.2	1.3	0.7
1997	75 568	74.2	1.2	0.7
1998	90 231	74.2	1.1	0.7
1999	84 543	74.2	1.1	0.7
2000	93 657	74.2	1.0	0.7
2001	102 124	74.2	0.9	0.6
2002	109 575	74.2	0.9	0.6
2003	117 805	74.2	0.8	0.5
2004	118 027	74.2	0.8	0.5
2005	120 538	73.4	0.8	0.5
2006	108 331	71.0	0.7	0.6
2007	108 378	71.0	0.6	0.9
2008	101 735	70.8	0.5	1.1
2009	98 916	69.5	0.5	1.4
2010	114 317	69.5	0.4	1.6
2011	110 859	69.4	0.3	1.9
2012	112 564	69.2	0.3	2.1

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
2013	129 472	69.4	0.2	2.3

Table 67: Implied emission factors of mopeds and motorcycles 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	777	75.5	202.8	1.2
1991	784	75.5	190.7	1.2
1992	824	75.5	177.4	1.2
1993	866	75.5	164.0	1.3
1994	925	75.5	151.3	1.3
1995	1 005	75.5	138.4	1.3
1996	1 082	75.5	128.2	1.3
1997	1 158	75.5	119.8	1.3
1998	1 261	75.5	111.3	1.3
1999	1 364	75.5	103.1	1.3
2000	1 428	75.5	97.5	1.3
2001	1 487	75.5	92.8	1.3
2002	1 550	75.5	88.4	1.3
2003	1 603	75.5	84.7	1.3
2004	1 637	75.5	81.0	1.3
2005	1 682	75.5	78.2	1.3
2006	1 735	75.5	74.9	1.3
2007	1 805	75.0	71.2	1.3
2008	1 879	73.2	67.7	1.3
2009	1 950	72.8	64.3	1.3
2010	2 017	72.1	60.8	1.3
2011	2 087	72.1	57.5	1.3
2012	2 167	72.0	53.9	1.3
2013	2 237	70.3	50.1	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

Update/Improvement of activity data

In the national energy balance the levels for liquefied petroleum gas (LPG) were revised upwards for the years 2009 − 2012. Compressed natural gas (CNG) activity data was revised upwards for 2012.

Overall revisions of the sector road transport show a slight decrease of GHG emissions (−0.3% for 2012) due to the model updates described below.

Update of methodology and emission factors

With the new model NEMO, energy use and emissions for domestic road transport can be calculated more precisely than before (HAUSBERGER/SCHWINGSHACKL/REXEIS 2015a). The transition to the new emissions calculation model NEMO for road transport has not changed the method itself, but is characterised by some essential improvements, which are integrated over individual partial modules in NEMO as follows:

1) Updated fleet model

Change in the assumptions for age- and size-dependent vehicle failure probabilities used for the extrapolation of the vehicle fleet depending on the year of first registration, engine type and other distinguishing characteristics (engine capacity or gross vehicle weight) of the fleet stock structure has led to a change in age distribution. Furthermore, through the possibility of the implementation of electric vehicles as a single-car model category and through a methodical shift in the new registration of gasoline and diesel car units in the fleet stock changes for each drive and emission category arise. However, the total fleet stock for each vehicle category agrees except for rounding differences with the previous inventory.

2) Updated fuel consumption and emission factors

The application of the new emission factors from the manual "Emission Factors Road Transport (HBEFA)" Version V3.2 leads to changes in specific fuel consumption and specific emissions per vehicle kilometre for all vehicle categories.

3) Updated HDV (heavy duty vehicles) size classes

Weight size classes of the vehicle category HDV were adjusted to the HBEFA logic and the associated emission factors. This restructuring affects HDV > 3.5 t maximum gross weight and all

HDV <> 18 t maximum gross weight instead of the current structure in GLOBEMI <> 14 t maximum gross weight. In addition, the HDV class "buses" has been divided exactly into two vehicle categories "coaches" and "service buses" with associated specific emission factors from HBEFA V3.2.

4) Updated vehicle driving distance distribution according to road categories

Changed fleet shares mentioned under 1) result in a different driving distance distribution between vehicle and road categories.

In the present inventory emission factors of the manual "Emission Factors Road Transport (HBEFA)", Version V3.2 has been used. This version was finally released by INFRAS (Bern) in July 2014 and shows changes to those emission factors that were used in the previous year in the inventory model GLOBEMI. Mistakenly, the description of the previous year's inventory was pointing out that HBEFA Version 3.2 had been integrated, but in fact this was an update of Version 3.1.

The analysis of each potential change to the modified total emission level in *1.A.3.b Road Transport* is not possible because of overlapping effects. However, the use of updated EFs changed the emissions for the whole time series explicitly. For passenger cars the update resulted in significantly higher CO_2 emissions per vehicle kilometre from 2001 onwards. For light duty vehicles the update led to decreased CO_2 emissions per vehicle kilometre, whereas CO_2 emissions per vehicle kilometre from heavy duty vehicles increased.

Exemplarily, the differences of fuel consumption factors of passenger cars are shown in the following table. It shows how fuel consumption of diesel and gasoline passenger cars had been underestimated for most emission (EURO) classes so far.

Table 68: Comparison of specific fuel consumption (g/km) for passenger cars (diesel – left, gasoline – right)

FC	NEMO HBEFA3.2	GLOBEMI
ECE15/04	59.26	64.37
US 83	58.43	59.28
Gesetz A	57.46	59.28
EURO 2	58.31	55.16
EURO 3	57.27	52.01
EURO 4	57.64	52.11
EU4+DPF	58.19	51.94
EURO 5	53.38	45.40
EURO 6	50.63	42.20
EURO 6c	39.93	37.60

FC	NEMO HBEFA3.2	GLOBEMI
ECE15/04	62.74	70.88
US 83	63.90	66.63
Gesetz A	63.31	66.63
EURO 2	63.17	61.55
EURO 3	61.39	56.02
EURO 4	60.30	52.44
EU4+DPF	57.36	50.10
EURO 5	53.48	43.42
EURO 6	50.27	39.66
EURO 6c	39.68	35.06

Planned improvements

In response to the ERT's question on an update on the progress of CH_4 and N_2O emissions associated with biomass (ARR 2014 para 30), Austria does not plan to separate emissions from biomass fuels, because most of these fuels is used in blended diesel and gasoline and therefore a separation of N_2O and CH_4 emissions from this fuels would be 'artificial'. From Austria's viewpoint the current reporting is more transparent in the manner that emissions from gasoline and diesel cars are reported adequately to the according fuels.

No further improvements are planned.

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 69: Greenhouse gas emissions from 1.A.3.c Railways 1990–2013.

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	178
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
2003	141	0.006	0.05	156
2004	140	0.006	0.05	155
2005	161	0.007	0.06	178
2006	157	0.007	0.06	174
2007	156	0.007	0.06	172
2008	155	0.007	0.06	172
2009	150	0.006	0.05	166
2010	143	0.006	0.05	158
2011	121	0.005	0.04	133
2012	124	0.005	0.04	137
2013	114	0.004	0.04	125
Trend 1990–2013	***-36%***	***-50%***	***-37%***	***-36%***

Methodological Issues

The used methodology conforms 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. 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 70: Implied emission factors and activity data for 1.A.3.c Railways 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	2 311	77.0	3.9	26.1
1991	2 120	77.0	3.9	26.1
1992	2 099	77.2	3.9	26.1
1993	2 051	76.9	3.8	26.1
1994	2 071	76.9	3.8	26.2
1995	1 926	77.2	3.8	26.4
1996	1 736	77.5	3.8	26.5
1997	1 753	76.0	3.7	26.5
1998	1 730	75.9	3.7	26.6
1999	1 788	75.7	3.6	26.8
2000	1 788	75.5	3.6	26.9
2001	1 728	75.2	3.5	27.0
2002	1 869	75.2	3.4	27.0
2003	1 880	75.0	3.4	26.9
2004	1 880	74.5	3.2	26.7
2005	2 186	73.6	3.2	26.4
2006	2 196	71.3	3.1	26.1
2007	2 184	71.2	3.1	25.7
2008	2 181	71.0	3.0	25.3
2009	2 144	69.9	3.0	24.9
2010	2 046	69.8	2.9	24.5
2011	1 730	69.8	2.9	24.0
2012	1 780	69.6	2.8	23.6
2013	1 633	69.9	2.7	23.2

Recalculations

Revised diesel consumption of railways in the national energy balance, for 2005 − 2012 resulted in slightly reduced GHG emissions from railways (− 0.1% in 2012).

3.2.12.4 1.A.3.d Navigation

Key Source: No

This sector includes emissions from diesel, gasoline and gas fuelled ships used by vessels/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 71: Greenhouse gas emissions from 1.A.3.d Domestic Navigation 1990–2013.

Year	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2e [kt]
1990	14.8	0.007	0,002	15.3
1991	15.0	0.007	0,002	15.6
1992	15.0	0.007	0,002	15.5
1993	14.2	0.007	0,002	14.7
1994	13.9	0.007	0,002	14.4
1995	14.0	0.007	0,002	14.5
1996	14.1	0.007	0,002	14.5
1997	15.0	0.007	0,002	15.6
1998	15.2	0.007	0,002	15.8
1999	14.3	0.006	0,002	14.8
2000	14.8	0.006	0,002	15.3
2001	14.0	0.006	0,002	14.5
2002	13.2	0.006	0,002	13.6
2003	12.8	0.006	0,002	13.2
2004	15.8	0.006	0,003	16.4
2005	15.5	0.006	0,003	16.2
2006	14.7	0.005	0,002	15.3
2007	14.7	0.005	0,002	15.3
2008	12.6	0.005	0,002	13.0
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
Trend 1990–2013	***–17%***	***–47%***	***–20%***	***–16%***

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 (PISCHINGER 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 2000–2014b). The energy consumption of the domestic navigation on the River Danube has undergone an update over the entire time series. Accordingly, the fuel consumption increases during the year 2011, to a value of 9.7 g diesel/tkm, which represents an increase of about 28% compared to last year's submission. 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 2015a). 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 f.*

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 fuelling stations for ships operating in Austria and the Ministry of Economy is collecting information on the fuel sold in those fuelling 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 72: Implied emission factors and activity data for 1.A.3.d Domestic Navigation 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	T/TJ	kg/TJ	kg/TJ
1990	196	75.5	37.3	10.4
1991	199	75.4	36.5	10.7
1992	198	75.5	36.6	10.7
1993	189	75.5	38.1	10.0
1994	185	75.5	38.5	9.7
1995	186	75.5	37.5	10.0
1996	186	75.5	36.7	10.2
1997	199	75.4	33.9	11.3
1998	202	75.4	32.9	11.7
1999	190	75.5	34.1	10.9
2000	196	75.4	32.5	11.5
2001	186	75.5	33.4	10.9
2002	175	75.5	34.6	10.0
2003	170	75.6	34.9	9.6
2004	209	75.3	28.0	12.9
2005	206	75.2	27.2	12.7
2006	196	74.9	27.3	12.0
2007	198	74.4	26.0	12.1
2008	173	72.9	28.0	10.2
2009	159	72.2	28.9	8.9
2010	162	72.1	27.2	9.2
2011	167	72.1	25.3	9.5
2012	170	72.0	23.8	9.8
2013	170	72.4	22.8	9.6

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 this cannot be guaranteed due to late data delivery for the bottom-up calculation in the inventory Statistics Austria may have to use a simple extrapolation of the previous years' data and send the current split to the IEA the following year. It is common practice to not report revised data to the IEA after the regular submission date at the end of October, i.e. outside the regular reporting deadlines.

The inconsistency for 2012 is therefore removed with this years' submission of the energy statistics (of data 1990-2013) to the IEA.

Completeness

In response to a question raised by the ERT (ICR 2013) it was explained that emissions of ground activities at domestic harbours 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 (GLOBEMI, 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 harbours as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals[44], 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

By adapting the diesel consumption factor (in g/tkm) for freight transport on the River Danube based on new calculations with NEMO Ship the entire time series of domestic navigation changed. CO_2 emissions increased by 6.4% in 2012 (HAUSBERGER & SCHWINGSHACKL 2015a).

Planned improvements

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.

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

3.2.12.1 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 total GHG emissions from sector *1.A* is 0.4% for the year 1990 and 0.7% for the year 2012. The increase of emissions is mainly caused by the increase of natural gas transfer through Austria.

Methodology

CORINAIR simple methodology is applied.

Activity data

Activity data (fuel consumption) is taken from (IEA JQ 2014).

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 73: Emission factors of Category 1.A.3.e for all years.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
Natural Gas	55.40	1.50	0.10

Recalculations

Changes of activity data are based on a revision of the energy balance and led to minor revisions of CO_2 emissions in 2012 of 0.09 kt CO_2e.

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 26.2% for the year 1990 and 16% for the year 2012.

3.2.13.1 1.A.4 Other sectors – stationary sources

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

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 heatings is collected by micro census surveys and 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

The CORINAIR simple methodology is applied.

There are three technology dependent subcategories (heating types) for this category:

- Central Heatings (CH)
- Apartment Heatings (AH)
- Stoves (ST)

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

There is no information about the structure of devices within these categories. Therefore it is assumed that the whole fuel consumption reported in (IEA JQ 2014) is combusted in devices similar to central heatings.

1.A.4.b Residential

Energy consumption by type of fuel and by type of heating is taken from a statistical evaluation of micro census data 1990, 1992, 1999/2000, 2004, 2006, 2008, 2010 and 2012 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. For 2013 the share of 2012 has been used. Because the newest census data is always reconsidered to improve previous years census data evaluation this implies a periodic recalculation in time series.

Emission factors

CO_2, CH_4 and VOC emission factors are taken from studies (BMWA-EB 1990, 1996) and (UMWELTBUNDESAMT 2002). N_2O emission factors are taken from a national study (BMUJF 1994). CO_2 emission factors are identical for the three different heating types. The studies provide VOC and C_{org} emission factors for different fuels and heating types.

The C_{org} (Organic Carbon) emission factors provided in (BMWA-EB 1996) 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.

CH_4 emission factors are determined assuming that a certain percentage of VOC emissions is methane. The split follows closely (STANZEL et al. 1995).

From 2001 on new biomass boiler types are considered which have lower VOC emissions and thus lower CH_4 emissions than conventional boiler types.

Table 74: Share of CH_4 and NMVOC on VOC for small combustion devices.

	CH_4	NMVOC	VOC
Coal	25%	75%	100%
Gas oil; Petroleum	20%	80%	100%
Residual Fuel Oil	25%	75%	100%

	CH_4	NMVOC	VOC
Natural Gas; LPG	80%	20%	100%
Biomass	25%	75%	100%

The selected emission factors for 2013 are presented in the following table.

Table 75: Emission factors of Category 1.A.4 conventional boilers/stoves for the year 2013.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]		N_2O [kg/TJ]	
		CH and AH	Stove	CH and AH	Stove
Hard Coal	93.00	90.00	110.00	2.00	1.00
Hard Coal Briquettes	93.00	90.00	110.00	2.00	1.00
Lignite and brown coal	108.00	90.00	110.00	4.00	1.00
Brown Coal Briquettes	97.00	90.00	110.00	4.00	4.00
Coke	92.00	90.00	110.00	2.00	2.00
Peat	106.00	–	90.00	–	1.00
Light Fuel Oil	77.00	0.25	–	0.60	–
Medium Fuel Oil	78.00	2.00	–	1.00	–
Heavy Fuel Oil	78.00	2.00	–	1.00	–
Gas oil	75.00	0.20	0.50	1.00	1.00
Petroleum	78.00	0.20	–	0.60	–
LPG	64.00	1.50	–	1.00	–
Gas Works Gas	64.00	0.20	–	1.00	–
Natural Gas	55.40	0.80	0.80	1.00	1.00
Fuel Wood	100.00[1)]	139.22[2)] 137.92[2)]	171.49[2)]	3–5	7.00
Wood Waste	110.00[1)]	17.42[2)]	171.49[2)]	3–7	7.00
Char coal	112.00[1)]		200.00		1.00
Landfill Gas	112.00[1)]	1.50	–	1.00	–
Industrial Waste	104.17	12.00	–	1.40	–

[1)] reported as CO_2 emissions from biomass

[2)] Implied emission factor

Because no measurements are available, CH_4 emission factors for new biomass heatings (Table 76) are derived from conventional boiler emission factors with the ratio of conventional boiler and new biomass heatings NMVOC emission factors:

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

Table 76: Emission factors of Category 1.A.4 new biomass boilers.

Fuel	CO_2 [t/TJ]	CH_4 [kg/TJ]		N_2O [kg/TJ]	
		CH/AH	Stove	CH and AH	Stove
Fuel Wood	100.00[1)]	112.7/108.2	115.6	3.00	7.00
Wood Chips	110.00[1)]	27.06	–	2.00	–
Pellets	110.00[1)]	12.14	–	2.00	–

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

Activity data

Total fuel consumption for each of the sub categories of *1.A.4* is taken from (IEA JQ 2014).

Since (IEA JQ 2014) 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 2014).

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 77 shows the selected share of each heating type for category *1.A.4.b.*

Table 77: Share of 1.A.4.b heating type on fuel category for the year 2013.

	Central Heating	Appartement Heating	Stove
Hard Coal Brown Coal Brown Coal Briquettes Coke	75%	5%	20%
Gas oil	95%	3%	2%
Residual Fuel Oil, Gas Works Gas, LPG, Petroleum	100%	–	–
Natural Gas	49%	47%	4%
Fuel Wood	81%	5%	14%
Wood Chips, Pellets, other solid biomass	95%	3%	1%

The following table shows biomass boiler sales from 2000 which are considered with lower CO, NMVOC and CH_4 emissions than equipment installed before 2000. The estimated accumulated consumption in 2011 is 47 PJ which is 75% of total biomass consumption of *1.A.4.b residential*. The average yearly consumption is calculated by average consumption per household. In case of boilers it is assumed that a building contains 2.12 households which are heated by a single boiler. The selected factors are derived from the 2008 household census.

Table 78: Number of biomass boiler sales 2000–2013 and fuel consumption estimate.

Year	Pellet boilers	Pellet stoves	Wood chip boilers	Log wood boilers
2000	3 466	0	0	0
2001	4 932	0	2 645	5 364
2002	4 492	997	2 615	4 276
2003	5 193	1 827	2 890	4 144
2004	6 077	3 245	3 224	4 555
2005	8 874	3 780	4 509	6 078
2006	10 467	5 640	4 726	6 937
2007	3 915	1 750	3 578	4 835
2008	11 101	3 045	4 096	7 405
2009	8 446	2 600	4 328	8 530
2010	8 131	2 000	3 656	6 211
2011	10 400	2 700	3 744	6 328
2012	11 971	4 000	3 573	6 328
2013	11 971	4 000	3 573	6 328
Accumulated total number	**109 436**	**35 584**	**47 157**	**77 319**
Avg. estimated yearly consumption per boiler or stove [GJ]	203	48	331	236
Total estimated consumption of new boilers 2013 [TJ]	22 226	1 708	15 596	18 211

Figure 15 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 2013.

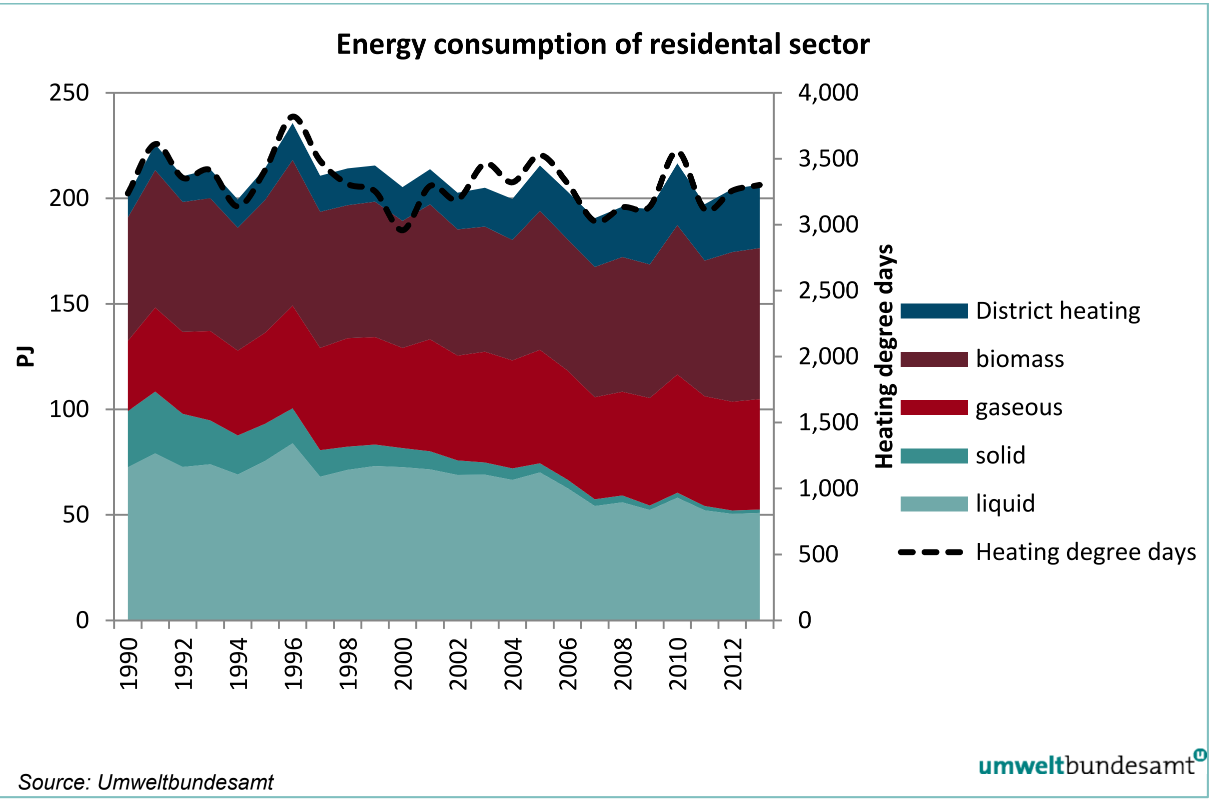


Figure 15: Energy consumption [PJ] of residential sector by type of fuel and number of heating degree days 1990–2013.

Recalculations

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

Recalculations due to the revised energy balance affect activity data 2009 to 2012 which mainly implies changes in CO_2 emissions for natural gas 2009 (–154 kt CO_2) to 2011 (–107 kt CO_2) and liquid fuels in 2010 (+102 kt CO_2). Total recalculations 2012 resulted in +43 kt CO_2.

1.A.4 Other sectors – mobile sources

1.A.4.b.ii Residential

Key Source: No

In addition to vehicles used in household and gardening this category contains ski slope machineries and snow vehicles.

Table 79: Greenhouse gas emissions from mobile sources of 1.A.4.b.ii Residential 1990–2013.

Year	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	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
Trend 1990–2013	***-15%***	***-60%***	***-48%***	***-17%***

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 80: Emission factors and activity data for mobile sources of 1.A.4.b.ii Residential 1990–2013.

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	1 845	75.0	24.6	12.6
2006	1 823	73.9	23.2	12.1
2007	1 801	73.4	21.7	11.5
2008	1 777	72.0	20.1	10.9
2009	1 756	71.1	18.6	10.2
2010	1 740	70.9	17.2	9.4
2011	1 731	70.9	16.2	8.6
2012	1 724	70.7	15.4	7.9
2013	1 727	71.1	15.0	7.1

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

Key Source: No

In this category emissions from off-road machinery in agriculture and forestry (mainly tractors) are considered.

Table 81: Greenhouse gas emissions from mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2013.

Year	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2e [kt]
1990	771	0.07	0.25	849
1991	768	0.07	0.26	846
1992	775	0.07	0.26	853
1993	778	0.07	0.26	858
1994	785	0.07	0.26	866
1995	752	0.07	0.26	830
1996	782	0.07	0.27	864
1997	821	0.07	0.29	909
1998	806	0.07	0.29	893
1999	813	0.06	0.30	903
2000	789	0.06	0.29	877
2001	813	0.06	0.30	904
2002	809	0.06	0.30	900
2003	778	0.06	0.28	863
2004	800	0.06	0.28	885
2005	842	0.06	0.29	930
2006	822	0.06	0.28	907
2007	830	0.06	0.27	912
2008	838	0.06	0.26	916
2009	757	0.06	0.23	826
2010	741	0.06	0.21	804
2011	803	0.06	0.21	869
2012	768	0.06	0.19	827
2013	766	0.06	0.18	821
Trend 1990–2013	***-1%***	***-18%***	***-29%***	***-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. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.vii*.

Table 82: Emission factors and activity data for mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2013.

Year	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	TJ	T/TJ	kg/TJ	kg/TJ
1990	10 384	74.3	7.0	24.5
1991	10 344	74.2	6.4	24.7
1992	10 435	74.2	6.5	24.7
1993	10 486	74.2	6.5	24.8
1994	10 576	74.2	6.6	24.9
1995	10 122	74.2	6.6	25.3
1996	10 527	74.2	6.5	25.7
1997	11 054	74.2	6.2	26.2
1998	10 852	74.2	6.1	26.6
1999	10 955	74.2	5.9	27.0
2000	10 625	74.2	5.8	27.3
2001	10 950	74.2	5.7	27.5
2002	10 902	74.2	5.7	27.3
2003	10 474	74.3	5.9	26.7
2004	10 777	74.2	5.6	26.0
2005	11 463	73.5	5.3	25.1
2006	11 535	71.3	5.4	24.2
2007	11 657	71.2	5.5	23.0
2008	11 812	70.9	5.5	21.9
2009	10 863	69.7	5.2	20.8
2010	10 624	69.7	5.4	19.6
2011	11 538	69.6	5.3	18.5
2012	11 055	69.4	5.4	17.5
2013	10 992	69.7	5.4	16.5

3.2.14 1.A.5 Other

In this category emissions of 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 conforms to the requirements of the IPCC 2006 GL Tier 1 (simple) methodology.

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 (PISCHINGER 2000). 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 conforms to the requirements of the IPCC 2006 GL Tier 3 methodology.

For the years 1990–1999 fuel consumption for military flights was reported by the Ministry of Defence. Calculation of emissions from military aviation did not distinguish between LTO and cruise.

Table 83 shows GHG emissions for the complete military sector (sum of ground activities and military aviation).

Table 83: Greenhouse gas emissions from 1.A.5.b Military 1990–2013.

Year	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	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
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
Trend 1990–2013	***37%***	***32%***	***13%***	***36%***

Activity Data

Also 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 motorcycles the yearly road performance as calculated for civil cars was used. The yearly road performance for such 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).

Activities used for estimating the emissions and the emissions of *1.A.5.b Mobile combustion – Military* are presented in Table 84 (activity data includes all energy sources). The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 84: Emission factors and activity data for 1.A.5.b Military 1990–2013.

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	615	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	646	72.6	2.3	4.9
2012	653	72.5	2.3	4.8
2013	661	72.6	2.3	4.8

Emission Factors

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

For the calculation of military aviation CO_2 emissions an emission factor of 3 150 kg CO_2/Mg fuel has been used; it was taken from (KALIVODA et al. 2002). CH_4 emission factor follows the EMEP/EEA Guidelines 2013 (10% of total VOC emissions, simple methodology). For calculating of N_2O emissions of military flights the IEF of civil aviation domestic LTO was applied as no military specific emission factor was available.

3.2.15 Quality Assurance/Quality Control and Verification

For general QA/QC see Chapter 1.6.

In 2008 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 85. For transport, the respective factors are new and have been taken from an assessment of the overall transport GHG emissions (HAUSBERGER 2005).

Table 85: 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.

Revision of the Energy Balance

Main revisions affect the years 2009 to 2012 which results between +6.1 and −3.7 PJ of total gross inland consumption. Minor revisions affect the year 2005 (−0.5 PJ of total gross inland coal consumption).

Natural gas

2009: +3.4 PJ gross inland consumption (revision of imports).

2009–2011: Shift of natural gas from *Total Other sectors* to *chemicals industry* (between 1.4 and 1.9 PJ).

2010 and 2012: Shift from *Transformation Sector* (Industrial auto producers) to final energy consumption of Manufacturing Industries which is 3 PJ in 2012. This shift does not affect total consumption of Manuf. Industries.

Liquid fuels

Petrol coke 2011: +1.5 PJ of Manufacturing Industries final consumption.

Solid fuels

Coke oven coke 2005: Revision of final energy consumption of *non metallic mineral industries* by -0.5 PJ.

Other fuels

Industrial waste: Revision of final energy consumption of *manufacturing industries* by +2.5 PJ in 2009 and by +1.0 PJ in 2012. Revision of *industrial autoproducers* 2009 – 2012 with a maximum of +0.8 PJ in 2010 and +0.2 PJ in 2012.

Biomass

Fuel wood 2011–2012: Revision of final energy consumption of *other sectors* (+0.8 PJ in 2011 and +0.2 PJ in 2012).

Other solid biomass 2005: Revision of transformation input into public power plants by -3.2 PJ. This revision is due to the change from national energy balance data to IEA data use.

3.2.17.2 CO_2 emissions

Table 86 shows the recalculations of CO_2 emissions for the subcategories of sector *1.A Fuel Combustion.*

Table 86: 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	-2 878.20	-0.02	-2 882.45	5.26	-1.00	0.00
1991	-2 926.85	-1.41	-2 930.62	5.75	-0.57	0.00
1992	-2 570.69	0.42	-2 577.63	6.99	-0.47	0.00
1993	-2 651.69	0.14	-2 663.80	9.94	2.03	0.00
1994	-2 896.40	0.17	-2 906.34	11.21	-1.44	0.00
1995	-3 254.54	-0.33	-3 266.50	10.46	1.84	0.00
1996	-2 842.89	0.28	-2 860.83	14.16	3.49	0.00
1997	-3 381.43	0.12	-3 402.96	18.90	2.50	0.00
1998	-3 533.78	-0.21	-3 555.53	19.78	2.18	0.00
1999	-3 546.07	-0.77	-3 567.91	20.77	1.84	0.00
2000	-3 961.85	-0.33	-3 984.95	24.17	-0.74	0.00
2001	-3 851.02	-1.70	-3 875.75	25.02	1.41	0.00
2002	-3 723.92	4.80	-3 754.52	28.63	-2.83	0.00
2003	-3 922.54	5.11	-3 954.36	27.82	-1.11	0.00
2004	-4 055.00	1.76	-4 077.74	25.18	-4.19	0.00
2005	-4 322.86	56.84	-4 459.86	76.51	3.64	0.00
2006	-4 462.85	77.16	-4 589.47	51.83	-2.37	0.00
2007	-4 679.63	38.64	-4 752.34	31.58	2.47	0.01
2008	-4 602.86	34.44	-4 657.71	14.89	5.50	0.02
2009	-3 439.45	36.12	-3 345.54	0.79	-130.83	0.02
2010	-4 325.65	77.28	-4 405.19	2.81	-0.55	0.01
2011	-4 267.25	27.74	-4 200.45	0.68	-95.23	0.01
2012	-4 252.33	78.70	-4 355.52	-19.00	43.49	0.00

3.2.17.3 CH_4 emissions

Table 87 shows the recalculations of CH_4 emissions for the subcategories of sector *1.A Fuel Combustion.*

Table 87: Recalculation difference of CH_4 emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	-0.47	0.02	-0.01	-0.48	0.00	0.00
1991	-0.77	0.02	0.00	-0.79	0.00	0.00
1992	-1.04	0.02	0.00	-1.06	0.00	0.00
1993	-1.26	0.02	0.00	-1.29	0.00	0.00
1994	-1.38	0.02	0.00	-1.39	0.00	0.00
1995	-1.30	0.02	0.00	-1.31	0.00	0.00
1996	-1.15	0.03	0.00	-1.18	0.00	0.00
1997	-1.02	0.03	0.00	-1.04	0.00	0.00
1998	-0.98	0.03	0.00	-1.00	0.00	0.00
1999	-0.83	0.03	0.00	-0.86	0.00	0.00
2000	-0.75	0.03	-0.01	-0.77	0.00	0.00
2001	-0.67	0.03	-0.01	-0.69	0.00	0.00
2002	-0.64	0.03	-0.01	-0.66	0.00	0.00

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2003	-0.61	0.03	-0.05	-0.59	0.00	0.00
2004	-0.53	0.03	-0.06	-0.49	0.00	0.00
2005	-0.47	0.03	-0.10	-0.40	0.00	0.00
2006	-0.38	0.04	-0.09	-0.33	0.00	0.00
2007	-0.30	0.04	-0.07	-0.26	0.00	0.00
2008	-0.23	0.04	-0.07	-0.20	0.00	0.00
2009	-0.17	0.04	-0.04	-0.17	0.01	0.00
2010	-0.16	0.04	-0.05	-0.16	0.02	0.00
2011	-0.02	0.03	-0.06	-0.12	0.14	0.00
2012	-0.11	0.03	-0.05	-0.14	0.05	0.00

3.2.17.4 N_2O emissions

Table 88 shows the recalculations of N_2O emissions for the subcategories of sector *1.A Fuel Combustion.*

Table 88: 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	-0.21	0.00	-0.03	-0.18	0.00	0.00
1991	-0.26	0.00	-0.03	-0.23	0.00	0.00
1992	-0.29	0.00	-0.03	-0.26	0.00	0.00
1993	-0.32	0.00	-0.03	-0.29	0.00	0.00
1994	-0.36	0.00	-0.03	-0.33	0.00	0.00
1995	-0.38	0.00	-0.04	-0.34	0.00	0.00
1996	-0.41	0.00	-0.03	-0.38	0.00	0.00
1997	-0.42	0.00	-0.04	-0.39	0.00	0.00
1998	-0.50	0.00	-0.05	-0.45	0.00	0.00
1999	-0.51	0.00	-0.04	-0.46	0.00	0.00
2000	-0.54	0.00	-0.05	-0.49	0.00	0.00
2001	-0.56	0.00	-0.05	-0.51	0.00	0.00
2002	-0.60	0.00	-0.04	-0.55	0.00	0.00
2003	-0.62	0.00	-0.04	-0.58	0.00	0.00
2004	-0.60	0.00	-0.04	-0.56	0.00	0.00
2005	-0.60	-0.01	-0.05	-0.53	0.00	0.00
2006	-0.51	0.00	-0.05	-0.45	0.00	0.00
2007	-0.45	0.00	-0.06	-0.39	0.00	0.00
2008	-0.36	0.00	-0.05	-0.30	0.00	0.00
2009	-0.28	0.00	-0.04	-0.24	0.00	0.00
2010	-0.23	0.00	-0.05	-0.17	0.00	0.00
2011	-0.17	-0.01	-0.05	-0.11	0.00	0.00
2012	-0.10	0.00	-0.05	-0.06	0.01	0.00

3.2.17.5 Emissions in kt CO_2 equivalent

Table 89 shows the recalculations in [kt CO_2 equivalent] for the subcategories of sector *1.A Fuel Combustion.* The GWPs from the 4th AR have been used for calculation.

Table 89: Recalculation difference of GHG emissions in [kt CO_2 equivalent] 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	-2 951.52	0.01	-2 890.48	-59.98	-1.07	0.00
1991	-3 023.84	-1.37	-2 939.83	-82.06	-0.58	0.00
1992	-2 681.99	0.45	-2 585.77	-96.10	-0.56	0.00
1993	-2 777.90	-0.27	-2 671.85	-107.91	2.13	0.00
1994	-3 039.50	-0.40	-2 915.53	-122.09	-1.48	0.00
1995	-3 400.63	-0.85	-3 277.59	-124.10	1.90	0.00
1996	-2 993.82	0.55	-2 870.16	-127.80	3.59	0.00
1997	-3 533.20	0.45	-3 414.15	-122.07	2.57	0.00
1998	-3 707.26	-0.02	-3 568.99	-140.48	2.24	0.00
1999	-3 717.35	-0.21	-3 581.13	-137.90	1.90	0.00
2000	-4 142.26	0.09	-4 000.37	-141.21	-0.77	0.00
2001	-4 033.15	-1.00	-3 890.27	-143.33	1.45	0.00
2002	-3 917.44	5.93	-3 767.45	-152.99	-2.93	0.00
2003	-4 123.17	6.26	-3 968.97	-159.31	-1.16	0.00
2004	-4 246.73	3.51	-4 092.58	-153.33	-4.33	0.00
2005	-4 513.07	53.59	-4 477.97	-92.33	3.65	0.00
2006	-4 624.56	77.63	-4 608.01	-91.71	-2.48	0.00
2007	-4 820.63	38.79	-4 771.32	-90.47	2.37	0.01
2008	-4 714.49	34.95	-4 675.71	-79.30	5.55	0.02
2009	-3 528.10	36.73	-3 358.21	-75.32	-131.32	0.02
2010	-4 398.58	76.98	-4 422.31	-53.06	-0.19	0.01
2011	-4 319.28	26.67	-4 218.21	-36.53	-91.23	0.01
2012	-4 286.06	79.72	-4 371.64	-41.41	47.28	0.00

3.2.18 Planned Improvements

Currently no relevant improvements are planned.

Statistik Austria announced that revisions of the energy balance will be carried out for the year - 1 in the future if necessary. Revisions of older data will be considered only if major errors would be detected or statistical data of better quality would become available.

3.3 Fugitive Emissions (Category 1.B)

3.3.1 Emission Trends

In 2013, 0.7 % of national total emissions arose from IPCC category *1.B Fugitive Emissions*. Table 90 presents GHG emissions arising from this category and the trend from 1990 to 2013.

Table 90: Greenhouse gas emissions from Category 1.B Fugitive Emissions.

	GHG emissions [kt CO_2 equivalent]		
	Total	**CO_2**	**CH_4**
1990	701.74	102.09	599.65
1991	569.03	111.09	457.94
1992	611.93	120.13	491.80
1993	580.35	112.13	468.21
1994	470.26	127.64	342.61
1995	463.96	127.15	336.81
1996	391.57	71.15	320.42
1997	436.21	120.63	315.58
1998	463.54	141.95	321.59
1999	496.28	170.65	325.62
2000	496.40	164.65	331.75
2001	514.53	182.86	331.67
2002	498.77	167.16	331.61
2003	564.53	233.16	331.37
2004	510.85	210.16	300.69
2005	482.23	205.16	277.07
2006	517.18	232.16	285.02
2007	524.10	237.16	286.94
2008	482.27	212.16	270.11
2009	540.42	265.17	275.25
2010	521.40	237.17	284.23
2011	514.64	233.18	281.46
2012	528.04	237.18	290.86
2013	531.71	251.18	280.53
Trend 1990–2013	–24 %	146 %	–53 %

3.3.2 Completeness

Table 91 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 91: 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.1.b Solid Fuel Transformation		IE[2)]	IE[2)]
1.B.2.a Oil			
1 Exploration	0502 Extraction, 1st treatment and loading of liquid fossil fuels	IE[3)]	IE[3)]
2 Production and Upgrading		IE[3)]	IE[3)]
3 Transport	050601_X50 Oil pipelines	✓	✓
4 Refining	0401 Processes in Petroleum Industries	NA[4)]	✓
5 Distribution of Oil Products	050502 Transport and depots 050503 Service stations	NA	NA[5)]
1.B.2.b Natural Gas			
1 Exploration	0503 Extraction, 1st treatment and loading of gaseous fossil fuels	NA[3)]	IE[3)]
2 Production		✓[3)]	✓[3)]
3 Processing		✓	NA
4 Transmission and Storage	050601 Pipelines/Storage	✓	✓
5 Distribution	050603 Distribution networks	✓	✓
6 Other		NO	NO
1.B.2.c Venting/Flaring		IE[6)]	IE[7)]
1.B.2.d Other		NA[8)]	NA[8)]

[1)] *according to an expert judgement all abandoned underground mines in Austria are flooded*

[2)] *the production of coke oven coke is included in 1.A.2.a Iron and Steel*

[3)] *included in 1.B.2.b.2 are: 1.B.2 a.1 Oil Exploration, 1.B.2.a.2 Oil Production and Upgrading, 1.B.2.b.1 Natural Gas Exploration (CH_4 emissions only, CO_2 emissions are NA), and 1.B.2.b.3 Natural Gas Processing, except CH_4 (NA) and CO_2 emissions from processing of sour gas*

[4)] *CO_2 emissions due to combustion are included in 1.A.1.b Petroleum Refining, fugitive CO_2 emissions are assumed to be negligible*

[5)] *also includes storage in storage tanks and refinery dispatch station – only NMVOC emissions are estimated as CH_4 emissions are assumed to be negligible.*

[6)] *included in 1.A.1.b Petroleum Refining*

[7)] *included in 1.B.2.a.iv Refining/Storage*

[8)] *fugitive emissions from geo thermal energy are assumed to be negligible*

3.3.3 Methodology

Category 1.B.1.a Fugitive Emissions from Fuels – Coal Mining covers methane emissions from one brown coal surface mine and 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

1.B.1.a.i Underground mines

Emissions: CH_4

Key Source:No

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 $0.67 x 10^{-6} Gg/m^3$. 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 the multiplication of the underground coal production with the average default emission factor of 2.5 m^3/t and the conversion factor of $0.67 x 10^{-6}$ Gg/m^3.

Table 92: Activity data (brown coal produced) and CH_4 emissions from mining and post mining activities for Fugitive Emissions from underground mines 1990-2013

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

Year	Coal Mined [t]	CH_4 emissions from mining [kt]	CH_4 emissions from post-mining seam gas emissions [kt]
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

1.B.1.a.ii Surface mines

Emissions: CH_4

Key Source: No

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 93.

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 0.67x10-6Gg/m^3. Activity data are taken from the national energy balance and statistical year books (e.g. WKÖ 2005, WKÖ 2006, WKÖ 2007, BMWFJ 2008, BMWFJ 2010, BMWFJ 2011, BMWFJ 2012, BMWFJ 2013).

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 0.67x10-6Gg/m^3.

Activity data are taken from the national energy balance and statistical year books (e.g. WKÖ 2005, WKÖ 2006, WKÖ 2007, BMWFJ 2008, BMWFJ 2010, BMWFJ 2011, BMWFJ 2012, BMWFJ 2013).

Table 93: Activity data (brown coal produced) and CH_4 emissions from mining and post mining activities for Fugitive Emissions from surface mines 1990-2013

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

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 2012 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 $5.4*10^{-06}$ Gg per $1000m^3$ oil transported by pipeline is used. For the calculation of CO_2 emissions, the default emission factor of $4.9*10^{-07}$ Gg per 1000 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 $41.0*10^{-6}$ Gg per 103 m^3 oil refined. (The conversion from Gg per 103 m^3 to g per t was calculated with a density for crude oil of $840kg/m^3$). 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 94: Activity data (Crude Oil Refined) and emissions for Fugitive Emissions from Fuels – Oil Transport and Refining 1990–2013

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
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

Year	Crude Oil Refined [kt]	Transport CH_4 [kt]	Refining CH_4 [kt]
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

1.B.2.b Fugitive Emissions from Fuels – Natural Gas

Emissions: CH_4, *CO_2*

Key Source: No

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.

CH_4 emissions contributed 52% to total GHG emissions from *1.B.2.b* in 2013. In 2013 fugitive CH_4 and CO_2 emissions from natural gas contributed 0.7% to total greenhouse gas emissions in Austria. CH_4 emissions from natural gas increased between 1990 and 2013 by 5% 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).

Due to the implementation of technical measures there is only a slight increase of 46 % in CH_4 emissions from storage between 1990 and 2013 although the storage capacity and volume increased by 283% 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 2013)* (see Table 95). 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 [FVMI 1999-2012] 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 95: Activity data (natural gas produced) and emissions for Fugitive Emissions from Fuels – Production 1990–2013

	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	133	66
2004	1 963	6.55	122	62
2005	1 637	5.80	122	75
2006	1 819	6.14	140	77
2007	1 848	6.20	142	77
2008	1 531	5.56	135	88
2009	1 670	5.83	163	98
2010	1 816	6.24	145	80
2011	1 684	5.86	145	86
2012	1 807	6.07	145	80
2013	1 467	5.38	163	111

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 96. Small emission sources are also connections to dwellings, pressure regulating valves and accidental releases.

Emissions were calculated applying a Tier 3 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.

Table 96 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 96: 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**	**2013**	**1990–2013**	
Insulated steel	2 881	3 760	3 488	+21%	25
Plastics (HDPE,PVC)	6 368	18 501	24 414	283%	13
Ductile cast iron	2 213	1 720	1 490	-33%	701
Grey cast iron	210	118	5	-98%	892
Total	**11 672**	**24 099**	**29 416**	**+152%**	

Table 97: Activity data and emissions for Fugitive Emissions from Fuels – Natural Gas Distribution and Sour Gas Processing 1990–2013.

Year	Natural Gas Distribution		Sour Gas Processing	
	Gas network [km]	CH_4 Emissions [kt]	Sour Gas Prod. [1 000 m³]	CO_2 Emissions [kt]
1990	11 672	1.99	248 090	59
1991	12 700	1.93	285 901	68
1992	13 893	1.99	357 135	80
1993	15 178	1.95	321 653	75
1994	16 589	1.87	363 582	80
1995	17 778	1.85	405 638	89
1996	18 995	1.82	136 737	30
1997	20 219	1.76	406 177	89
1998	21 339	1.74	367 195	81
1999	22 701	1.73	352 318	81
2000	24 099	1.74	358 357	93
2001	25 042	1.73	393 492	95
2002	24 216	1.68	347 513	83
2003	25 699	1.71	408 198	100
2004	26 158	1.62	373 099	88
2005	26 958	1.63	338 349	83
2006	27 413	1.63	402 990	92
2007	27 945	1.62	444 029	95
2008	28 348	1.61	372 406	77
2009	28 533	1.60	466 628	102
2010	28 733	1.59	397 132	92
2011	29 023	1.60	375 168	88
2012	29 260	1.58	375 420	92

Year	Natural Gas Distribution		Sour Gas Processing	
	Gas network	CH_4 Emissions	Sour Gas Prod.	CO_2 Emissions
	[km]	[kt]	[1 000 m³]	[kt]
2013	29 417	1.56	335 874	88

Table 98: Activity data and emissions for Fugitive Emissions from Fuels – Natural Gas Transmission and Storage 1990–2013.

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	0.64
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	2.70	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

3.3.4 QA/QC

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 in the IPCC GPG. 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 neither provided in the IPPC GPG nor 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.1. Coal Mining

1.B.1.a Historical emissions from mining activities (1.B.1.a) were revised due to a refined methodology, calculating surface and underground mining separately (2006: +0.001 kt CH_4).
1.B.1.b Solid fuel transformation is now included in 1.A, leading to lower emissions under 1.B.1.b (–0.04 kt CH_4).

1.B.2 Oil and natural gas

Reporting of oil and natural gas exploration and production is now under 1.B.2.b.2 (previously reported under 1.B.2.a.2) due to the fact, that gas emissions hold >80% of total emissions. Under 1.B.2.a.3 emissions from crude oil transport are reported for the first time which leads to an increase of emissions in 2012 by 1.25 kt CO_2.

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 2013.

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).

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 105.

4.1.1 Emission Trends

In 2013, greenhouse gas emissions from Sector *2 Industrial Processes and Product Use* amounted to 16 013 kt CO_2 equivalent, compared to 13 593 kt in 1990. These emissions constituted 20.1% of Austria's total greenhouse gas emissions (excluding LULUCF) in 2013 and 17.3% 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.

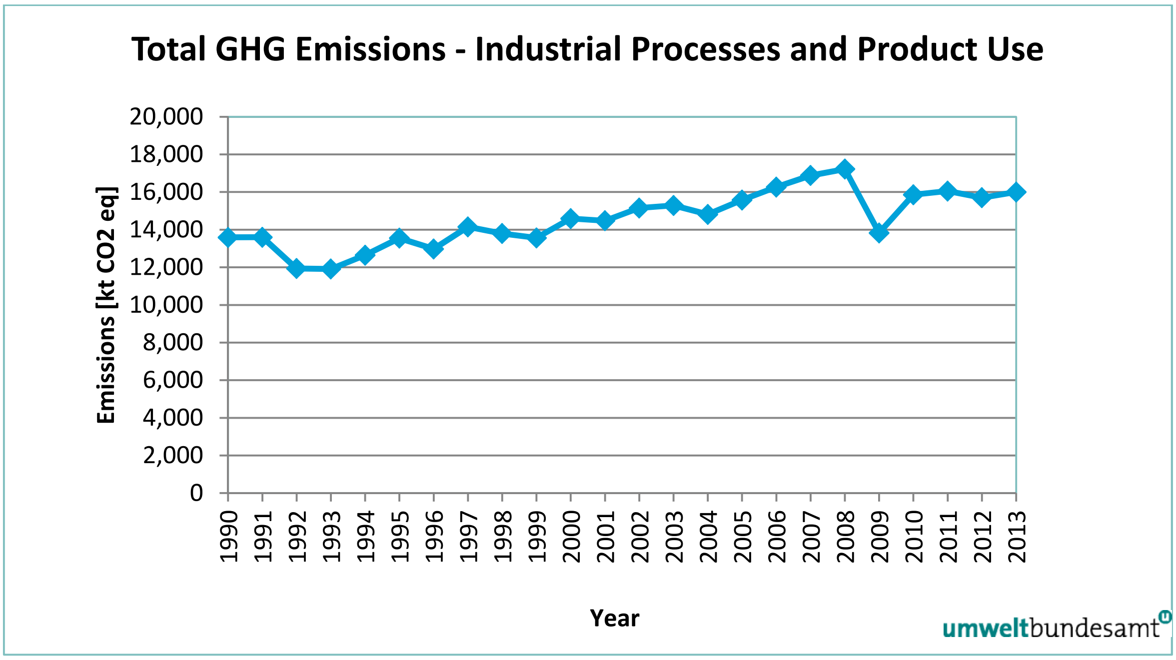


Figure 16: GHG emissions from Sector 2 Industrial Processes and Product Use 1990–2013.

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 2013.

Table 99: GHG emissions from Sector 2 Industrial Processes and Product Use by gas

GHG	Emissions [kt CO_2e]		Percent of total	
	1990	2013	1990	2013
Total	13 593	16 013	*100%*	*100%*
CO_2	10 802	13 741	*79.5%*	*85.8%*
CH_4	35	49	*0.3%*	*0.3%*
N_2O	1 100	186	*8.1%*	*1.2%*
HFCs	2	1 674	*0.0%*	*10.5%*
PFCs	1 183	49	*8.7%*	*0.3%*
SF_6	471	304	*3.5%*	*1.9%*
NF_3	0	10	*0.0%*	*0.1%*

Carbon dioxide constitutes the most important greenhouse gas of the IPPU sector, contributing 85.9% of emissions to this sector in 2013, followed by HFCs with 10.5%, SF_6 with 1.9%, N_2O with 1.2%, CH_4 with 0.3%, PFCs with 0.3% and finally NF_3 with 0.1%.

Table 100: Emissions from IPCC Sector 2 Industrial Processes and Product Use by gas from 1990 to 2013 and overall trend.

	Emissions [kt CO_2 equivalent]							
	Total	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
1990	13 593	10 802	35	1 100	2	1 183	471	NO,NA
1991	13 606	10 646	35	1 115	4	1 193	614	NO,NA
1992	11 944	9 709	34	1 029	6	510	656	NO,NA
1993	11 924	9 779	35	1 068	235	64	744	NO,NA
1994	12 660	10 349	35	1 017	261	71	926	1
1995	13 566	10 936	35	1 048	358	83	1 100	6
1996	12 995	10 211	35	1 064	421	80	1 177	8
1997	14 174	11 366	35	1 053	501	117	1 086	16
1998	13 807	11 140	36	1 086	610	56	870	9
1999	13 579	10 967	35	1 111	702	79	676	8
2000	14 606	12 047	35	1 138	714	87	575	11
2001	14 501	11 879	34	968	863	116	629	11
2002	15 172	12 466	35	977	969	102	613	11
2003	15 314	12 471	35	1 039	1 072	126	549	22
2004	14 844	12 534	35	448	1 158	158	484	27
2005	15 611	13 319	36	430	1 146	158	494	28
2006	16 301	14 015	48	427	1 152	172	453	33
2007	16 931	14 617	48	414	1 196	230	367	59
2008	17 265	14 871	47	464	1 249	208	373	53
2009	13 834	11 800	46	299	1 307	36	342	5
2010	15 870	13 718	47	205	1 482	78	336	4
2011	16 066	13 892	47	187	1 556	74	307	4
2012	15 710	13 451	47	186	1 655	51	312	9
2013	16 013	13 741	49	186	1 674	49	304	10
1990-2013	**+2 420**	**+ 2 939**	**+14**	**-914**	**+1 672**	**-1 134**	**-167**	**+10**

Concerning sub-categories of the sector, approx. 64% of GHG emissions (expressed in CO_2 equivalent) originate from *Metal Industry* (mainly *Iron and Steel Production*) and approx. 17% from *Mineral Industry*. 10.4 % originate Product uses as substitutes for ODS, and 4.3% from *Chemical Industry* (mainly *Ammonia Production*).

CO_2 emissions

As can be seen in Figure 17, 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

2013, CO_2 emissions from industrial processes amounted to 13 741 kt, which corresponds to an increase of 27% 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 17, 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 2013 were 40% 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 17, 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
- installation of a second catalyst in the nitric acid plant in May 2009
- full operation of the second catalyst in 2010
- 2011 further optimisation of the production process as well as slightly reduced production

In 2013, N_2O emissions from *Industrial Processes* were 83% below the level of 1990.

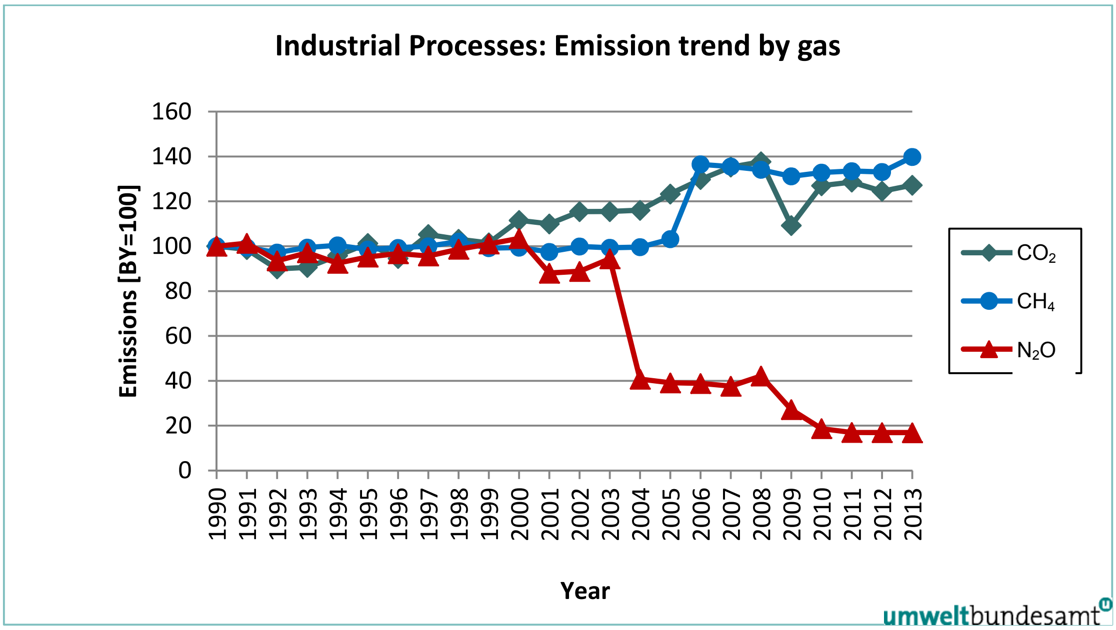


Figure 17: CO_2, CH_4 and N_2O emissions from Industrial Processes 1990–2013 (base year = 100).

HFC emissions

As can be seen in Figure 18, HFC emissions increased remarkably during the period from 1990 to 2013 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 18, PFC emissions decreased remarkably during the period from 1990 to 1993 – from 1 183 kt CO_2 equivalent to approx. 49 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 2013, PFC emissions amounted to 49 kt CO_2 equivalents, which is 96% below the level of 1990.

SF_6 emissions

As depicted in Figure 18, 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 2013, SF_6 emissions amounted to 304 kt CO_2 equivalents which is 35% 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 2013, NF_3 emissions amounted to 9.75 kt CO_2.

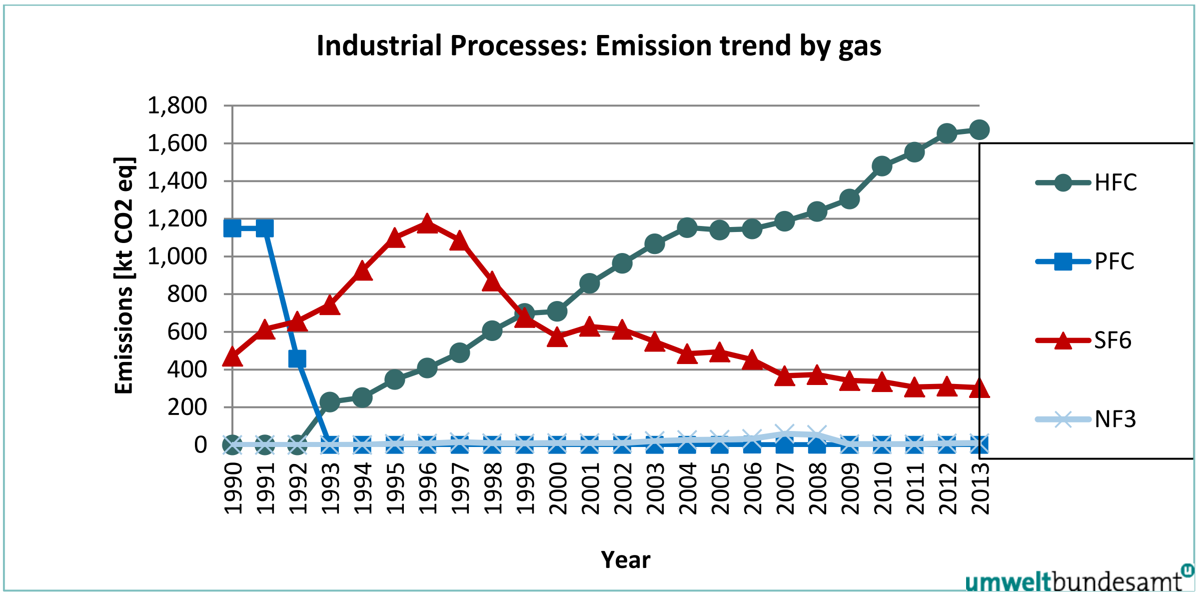


Figure 18: HFC, PFC, SF_6 and NF_3 emissions from Industrial Processes 1990–2013.

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 2013 (see Table 101).

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 1.5).

Table 101: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use by Category, their share and trend for 1990 and 2013.

	Emissions [kt CO_2e]		Share [%]		Trend 1990–2013
	1990	2013	1990	2013	
2 Industrial Processes	13 593	16 013	100%	100%	+18%
A Mineral Industry	3 092	2 720	23%	17%	-12%
B Chemical Industry	1 555	696	11%	4%	-55%
C Metal Industry	8 177	10 232	60%	64%	+25%
D Non-Energy Products from Fuels and Solvent Use	279	176	2%	1%	-37%
E Electronics Industry	134	90	1%	1%	-33%
F Product Uses as Substitutes for ODS	NO	1 672	0%	10%	
G Other Product Manufacture and Use	355	427	3%	3%	+20%

Figure 19 and Table 102 present greenhouse gas emissions from IPCC Sector *2 Industrial Processes and Product Use* by category for the years 1990 to 2013.

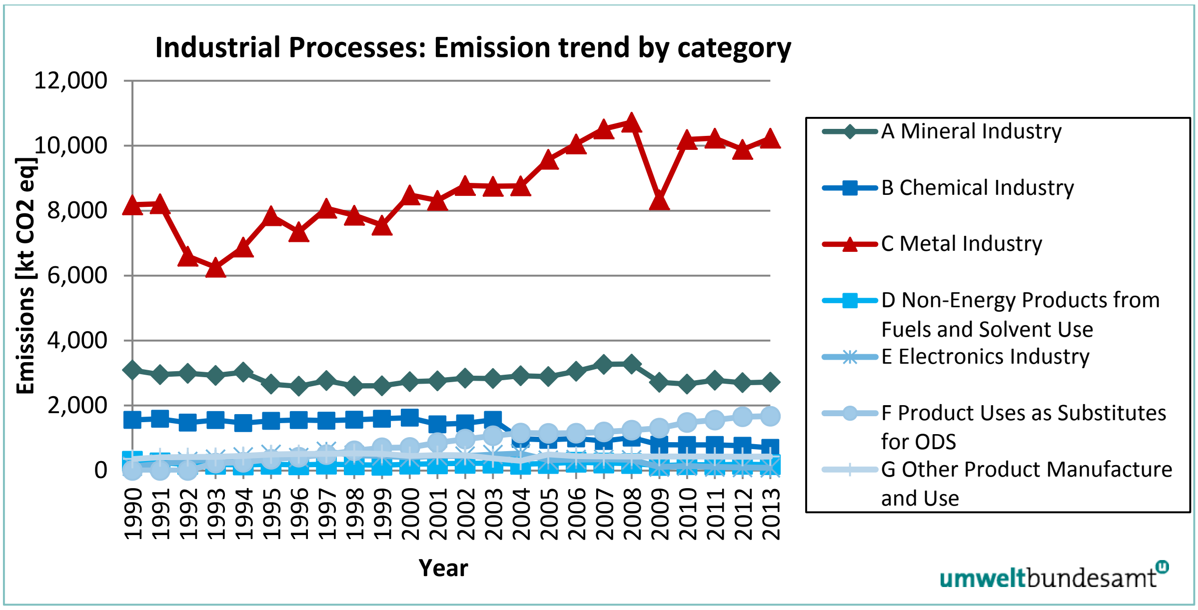


Figure 19: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use per category 1990–2013.

Table 102: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes (total and per category),1990–2013.

Year	GHG emissions [kt CO_2 equivalent]							
	2 Total	2A	2B	2C	2D	2E	2F	2G
1990	13 588	3 092	1 555	8 177	279	128	NO	355
1991	13 599	2 950	1 591	8 211	233	207	NO	406
1992	11 934	2 990	1 471	6 600	185	277	0	410
1993	11 912	2 925	1 553	6 259	186	346	228	415
1994	12 646	3 027	1 460	6 877	171	415	252	445
1995	13 549	2 657	1 528	7 842	190	492	347	492
1996	12 978	2 594	1 552	7 349	173	397	408	505
1997	14 150	2 765	1 534	8 072	192	587	489	511
1998	13 795	2 602	1 560	7 858	174	467	607	526
1999	13 563	2 606	1 591	7 554	160	444	698	510
2000	14 590	2 733	1 624	8 483	193	403	709	445
2001	14 478	2 759	1 419	8 315	204	452	857	472
2002	15 153	2 843	1 448	8 775	218	440	964	465
2003	15 288	2 829	1 559	8 748	221	488	1 067	375
2004	14 811	2 916	973	8 762	189	519	1 153	299
2005	15 578	2 889	943	9 578	213	319	1 141	495
2006	16 265	3 053	983	10 055	251	334	1 146	443
2007	16 882	3 266	909	10 516	228	343	1 187	434
2008	17 222	3 276	1 012	10 724	211	328	1 239	432
2009	13 827	2 715	793	8 334	153	106	1 305	421
2010	15 855	2 661	785	10 189	177	135	1 480	429
2011	16 053	2 779	786	10 230	173	105	1 554	425
2012	15 700	2 703	759	9 883	189	91	1 653	421
2013	16 003	2 720	696	10 232	176	80	1 672	427

2.A Mineral Industry

Greenhouse gas emissions decreased by 12% from 1990 to 2013 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 62% to total emissions from this category in 2013. Minor sources include nitric acid, carbide and ethylene production. In 2012, emissions were 55% 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* (+54%). The overall trend from 1990 to 2013 shows an increase by 25%. 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 37% below 1990 level. This is due to several legal measures (see chapter 4.5) that resulted in a decrease of emissions due to less solvent 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 2013 are 38% 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 20% 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 sources in IPCC Sector *2 Industrial Processes and Product Use*.

Table 103: Key sources of Sector 2 Industrial Processes and Product Use.

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
2.A.1	Cement Production	CO_2	LA;TA
2.A.2	Lime Production	CO_2	LA;TA
2.A.4	Other Process Uses of Carbonates	CO_2	LA;TA
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	PFC	LA 1990
2.C.7	Other (casting)	SF_6	TA
2.F.1	Refrigeration and Air conditioning	HFC	LA 2013;TA

LA = Level Assessment

TA = Trend Assessmen 1990–2013

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 2005–2013. 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 2013, 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 104, for explanations see the respective subchapters).

Table 104: 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.a	Ceramics - CO_2	2.0	5.0	5.4
2.A.4.b	Soda ash - CO_2	10.0	5.0	11.2
2.A.4.c	Non Metallurgical Magnesia Production - CO_2	2.0	5.0	5.4
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.7	Metal Industry : Other - SF_6	5.0	5.0	7.1
2.F.1	Refrigeration and Air conditioning - HFC	20.0	50.0	53.9

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 1.6.

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[45] and the Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions[46].

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

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

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

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.A.4.b Soda ash use

The amount of total soda ash used in 2012 was revised, resulting in lower CO_2 emissions (−1.7 kt).

2.F.1 Refrigeration and air conditioning equipment

Updated activity data for Transport refrigeration for the past years resulted in a revised trend for activity data.

2.F.3. Fire Protection

Due to a remark during the last ESD review previously reported use of R227ea in the years 1991 and 1996 was moved to 1998. The use of this agent earlier than 1998 seemed unlikely (even though reported by the company). So data was aligned with information from the German market.

2.F.4.b *Aerosols*

Same as for 2.F.3: first use of 134a for aerosols was changed to 1995 in line with the German market.

2.F.5 Solvents

Same as for 2.F.3: first use of HFC-43-10-mee was changed to 2000.

2.G.1 Electrical Equipment

Changes in the timeline are due to a recalculation of stock data of the association of energy suppliers and industrial facilities (where all data is gathered).

2.D.4 Solvents-other: Use of N_2O for anesthesia – N_2O emissions

Updated information for the usage of N_2O for medical purpose leads to a reduction of N_2O emissions. as quantities for export were also included (−0.02 kt N_2O in 2012) in the past.

Improvements of methodologies and emission factors

2.B.1 Ammonia production

In line with the 2006 IPCC Guidelines, CO_2 emissions from urea use are subtracted from ammonia production. Only those emissions are subtracted which are reported elsewhere in the inventory. i.e. urea use in the transport sector (2.G.4) and urea application in agriculture

(3.H). As CH_4 emissions reported under fertilizer production originate from one single carbon input to the integrated ammonia/fertilizer plant, these emissions are subtracted from the emissions reported under ammonia production in order to avoid double counting (−40 kt in 2012).

2.B.8.b Petrochemical and Carbon Black production – Ethylene

In line with the 2006 IPCC Guidelines, CH_4 emissions from ethylene production were estimated using the default emission factor. This resulted in higher CH_4 emissions for the whole time series (+1.5 kt in 2012)

2.B.10 Other

New source categories were introduced (production of formaldehyde, maleic anhydride and phthalic anhydride). which resulted in higher CO_2 emissions (+142 kt in 2012).

2.C.1 Iron and Steel Production

In line with the 2006 IPCC guidelines, CO_2 emissions were estimated based on a carbon balance. All emissions except those related to the coke oven and on-site power plants were taken into account. Consequently, parts of the emissions that had previously been reported under sector 1 are now included in sector 2. This resulted in revised emissions for the whole time series. The increase in 2012 was 4 404 kt CO_2.

According to the 2006 IPCC Guidelines, VOC emissions in electric steel production consist of NMVOC only. Likewise, in rolling mills emissions are restricted to NMVOC (i.e. no methane emissions). Hence, CH_4 emissions of electric steel production and rolling mills were revised to "NA" for the whole time series and higher NMVOC emissions were reported instead.

2.C.3 Aluminium Production

The default CO_2 emission factor for primary aluminium production was updated in line with the 2006 IPCC Guidelines and secondary aluminium production was introduced as a new category resulting in revised emissions for the whole time series (lower emissions 1990-1992, higher emissions 1992-2012, +4.1 kt in 2012).

2.F.1 Refrigeration and air conditioning equipment

A transcription error in the calculation of R134a stock in mobile air conditioning for passenger cars was corrected. This resulted in lower stocks and lower emissions in the years 2006-2012 (−12.2 t of R134a emitted in 2012).

4.1.7 Completeness

Table 105 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 105: 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
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	NA	NA	NO
2.B.4	Caprolactam. Glyoxal and Glyoxylic Acid Production			NO	NA	NO
2.B.5	Carbide Production					
	2.B.5.a Silicon Carbide			NO	NO	NA
	2.B.5.b Calcium Carbide	040412	Calcium carbide production	✓	NA	NA
2.B.6	Titanium Dioxide Production			NO	NA	NA
2.B.7	Soda Ash Production	040619	Soda ash production and use	NA	NA	NA
2.B.8	Petrochemical and Carbon Black Production					
	2.B.8.a Methanol			NO	NO	NA
	2.B.8.b Ethylene	040501	Ethylene production	IE	✓	NA
	2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer			NO	NO	NA
	2.B.8.d Ethylene Oxide			NO	NO	NA
	2.B.8.e Acrylonitrite			NO	NO	NA
	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

	IPCC Category	SNAP		Status		
				CO_2	CH_4	N_2O
2.C	**METAL INDUSTRY**					
2.C.1	Iron and Steel Production					
	2.C.1.a Steel	040206	Basic oxygen furnace steel plant	✓	NA	NA
	2.C.1.b Pig Iron	040202	Blast furnace charging	IE[3]	NA	NA
	2.C.1.c Direct Reduced Iron			NO	NO	NA
	2.C.1.d Metal Industry Other - Sinter and Pelletizing Plant	040209	Sinter and pelletizing plant	NO	NA	NA
	2.C.1.e Pellet			NO	NA	NA
	2.C.1.f Metal Industry – Other (Foundries)	040210	Other iron cast etc.	✓	✓	NA
	2.C.1.f.1 Electric Furnace Steel	040207	Electric furnace steel plant	✓	✓	NA
	2.C.1.f.2 Rolling Mills	040208	Rolling mills	✓	✓	NA
2.C.2	Ferroalloys Production	040302	Ferro alloys	✓	NA	NA
2.C.3	Aluminium Production					
	2.C.3.a Aluminium Production - CO_2 emissions	040301	Aluminium Production	✓	NA	NA
	2.C.3.b Aluminium Production - By-product emissions	040301	Aluminium Production	✓/NO [4)] (PFC)		
2.C.4	Magnesium Production			✓ (F-Gases)		
2.C.5	Lead Production			✓	NA	NA
2.C.6	Zinc Production			NO	NA	NA
2.C.7	Other – Non-ferrous metals	40309 X42	SF6 Used in Aluminium and Magnesium Foundries	✓ (F-Gases)		
2.D	**Non-Energy Products from Fuels and Solvent Use**					
2.D.1	Lubricant Use			IE	NA	NA
2.D.2	Paraffin Wax Use			IE,NE	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	IE[5)]	NA	NA
	2.D.3.3 Roof covering with asphalt materials	040610	Roof covering with asphalt materials	IE[5)]	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)		

	IPCC Category		SNAP	Status		
				CO_2	CH_4	N_2O
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
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 2013. In 2013, CO_2 emissions from cement production contributed 2.1% 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 $CaCO_3$) is 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 106 presents process-related CO_2 emissions from cement production for the period from 1990 to 2013.

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 106: CO_2 emissions from decarbonising in cement production, clinker production, raw meal used and implied emission factor, 1990–2013.

Year	Process specific CO_2 emissions [Gg]	Clinker [t/a]	Raw meal used [t/a]	IEF [kg CO_2/t Clinker]
1990	2 033	3 693 539	5 832 777	551
1991	2 005	3 635 462	5 748 943	552
1992	2 105	3 820 397	6 037 658	551
1993	2 032	3 678 293	5 830 089	552
1994	2 102	3 791 131	6 032 917	555
1995	1 631	2 929 973	4 671 693	557
1996	1 634	2 915 956	4 688 132	560
1997	1 761	3 103 312	5 056 336	567
1998	1 599	2 869 035	4 614 457	557
1999	1 607	2 891 785	4 648 493	556
2000	1 712	3 052 974	4 890 919	561
2001	1 720	3 061 338	4 911 083	562
2002	1 736	3 118 227	5 014 871	557
2003	1 754	3 119 808	5 016 291	562
2004	1 790	3 222 802	5 179 877	555
2005	1 797	3 221 167	5 175 628	558
2006	1 954	3 653 477	5 804 052	535
2007	2 131	3 992 376	6 297 527	534
2008	2 133	3 996 243	6 326 187	534
2009	1 799	3 428 140	5 376 515	525
2010	1 622	3 097 043	4 854 280	524
2011	1 666	3 175 642	4 947 150	525
2012	1 673	3 206 055	4 942 334	522
2013	1 659	3 156 286	4 858 175	526

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 2013 is minus 18.4%. Production decreased by 14.5% 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 20, the IEF largely follows the trend of the raw meal/clinker ratio as it is a result of the raw materials used.

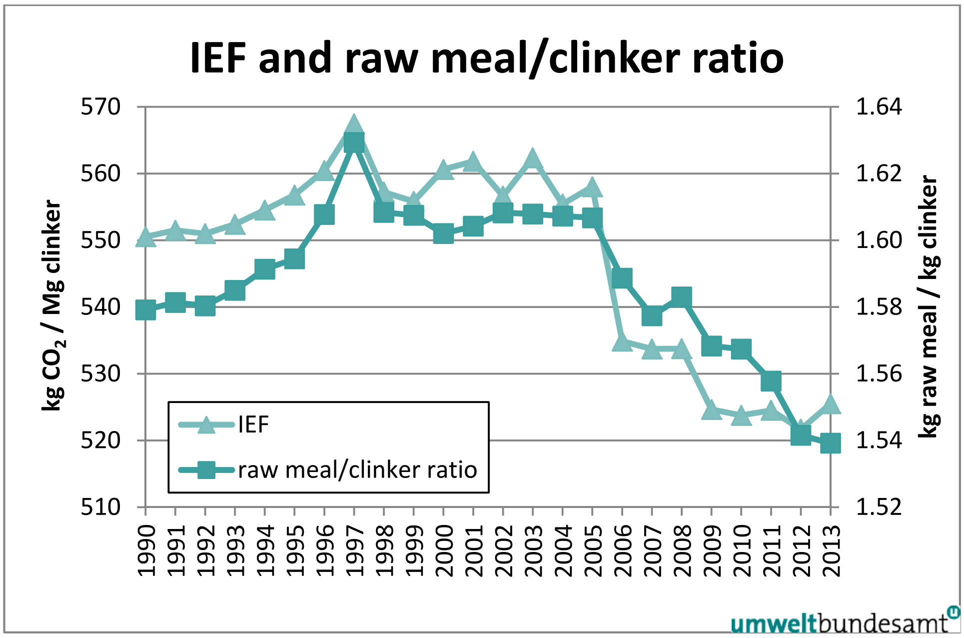


Figure 20: Time series of the implied emission factor (IEF) for cement production and ratio of raw meal used to clinker produced.

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 the nine plants in operation in that year.

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.

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:

$$M_{(CO2\ calc)} = \sum_k (m_{(raw\ meal)})_k \bullet (x_{(MeCO3)k} \bullet M)$$

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. However, in the Austrian plants cement kiln dust is returned back into the process.

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 2004–2013 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 2014). 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 was checked 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 2005–2013, 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 5.4%.

4.2.1.5 Recalculations

No recalculations have been required 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 2013, as well as because of their contribution in terms of their trend. In the year 2013, 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 107 presents activity data for this category (lime produced) as well as CO_2 emissions from lime production for the period from 1990 to 2013.

Table 107: CO_2 emissions, activity data and implied emission factors for lime production 1990–2013.

Year	CO_2 emissions [kt]	Lime Produced [t/a]	IEF [kg CO_2/t lime produced]
1990	396	512 610	773
1991	361	477 135	757
1992	355	462 392	768
1993	365	479 883	761
1994	390	518 544	753
1995	395	522 934	755
1996	383	505 189	758
1997	412	549 952	750
1998	454	594 695	763
1999	453	595 978	760
2000	498	654 437	760
2001	507	666 633	760
2002	543	718 662	755
2003	572	754 156	758
2004	595	785 931	757
2005	579	788 328	734
2006	570	780 565	730
2007	596	816 370	730
2008	621	846 298	734
2009	507	695 019	730
2010	574	764 845	751
2011	605	809 982	747
2012	569	761 040	748
2013	587	779 299	754

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 2013, emissions were 48% higher than in 1990 (see Table 107).

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 2005–2013, 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. All 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, lime is added to the raw sugar solution and, in a subsequent step, all CO_2 collected during decarbonisation is injected into the solution. In this step, CO_2 and lime react to limestone, which is sedimented and collected (see Figure 21).

At this point, excess CO_2 leaves the system. It has to be noted that this excess CO_2 corresponds to the amount of CO_2 from coke combustion, which is reported as combustion emission in the energy sector. The share of CO_2 originating from lime production is contained in the sedimented limestone and no lime leaves the system.

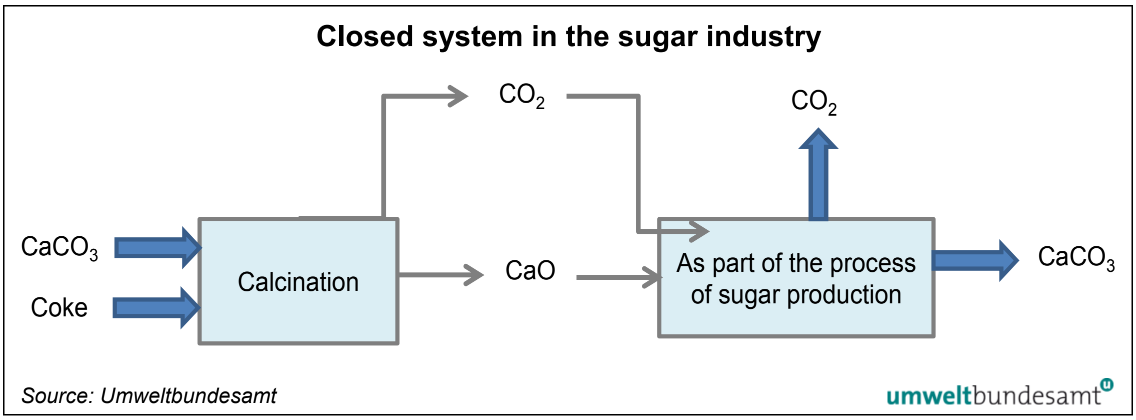


Figure 21: Lime production and reaction of CO_2 and lime back to limestone in a closed system in the sugar industry.

Following the recommendation by the Expert Review Team, mass balance data were obtained from the producer. A complete mass balance is available in tonnes per year. However, for confidentiality reasons, the mass balance is presented in the NIR in percent of limestone input, instead of tonnes.

Table 108: Mass balance of limestone use in the sugar industry, in percent of limestone input.

$CaCO_3$ input	CaO produced[1]	CO_2 produced by calcination[2]	Coke consumed[2]	Total solid output from the process[2]	Total solid output (dry mass)[2]	Calcium carbonate produced (lower limit)[4]	Calcium carbonate produced (upper limit)[4]
100.0 %	56.0 %	44.0 %	C	187.1 %	127.3 %	84.0 %	103.1 %

[1]Using a stoichiometric ratio of 56/100.

[2]This value is confidential, but all emissions resulting from combustion of coke in the sugar industry are calculated and verified according to the rules of the European Emissions Trading System (ETS) and are reported in Sector 1.

[3]Includes organic substances, minerals and water.

[4]Dry mass fraction is 68 % (Wasner 2009).

[5]The dry mass contains between 66 % and 81 % of $CaCO_3$ (Wasner 2009).

Description of the use of total amount of $CaCO_3$ obtained: The solid mixture leaving the system contains the total amount of $CaCO_3$ obtained, but also organic substances and minerals (WASNER 2009). This mixture (known as "Carbokalk") is used as a fertilizer.

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%.

To address the possibility of non-identified, non-marketed lime production (see section 4.2.2.2, above), a systematic uncertainty of plus 15% is added to the previously mentioned random uncertainty of 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 20.6%.

4.2.2.5 Recalculations

No recalculations have been required for this years´ submission.

4.2.3 Glass Production

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.

4.2.3.2 Methodological Issues

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 default emission factors of 415 kg CO_2/t soda ash, 440 kg CO_2/t limestone and 477 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. 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). 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 2005–2013, 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 109 presents activity data and CO_2 emissions from this category for the period from 1990 to 2013. To increase transparency (in response to a question in the course of the UNFCCC review 2012) data on glass production was added.

Table 109: CO_2 emissions and carbonate use in glass production 1990–2013.

Year	Glass Prod. [t]	Limestone [t]	Dolomite [t]	Soda ash [t]	Other Carbonates [t]	CO_2 Emissions [Gg]
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

Year	Glass Prod. [t]	Limestone [t]	Dolomite [t]	Soda ash [t]	Other Carbonates [t]	CO_2 Emissions [Gg]
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
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	20 364	26 218	34 328	609	37
2013	487 359	19 671	30 628	37 184	517	39

4.2.3.3 Source specific QA/QC

Limestone and dolomite use in glass industry is checked 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%.

4.2.3.4 Recalculations

No recalculations have been 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 110 presents CO_2 emissions from bricks production for the period from 1990 to 2013. CO_2 emissions from bricks production showed a maximum in 1995/1996, which coincided with a peak in brick production. In 2013, emissions from this category contributed 0.1 % to total greenhouse gas emissions in Austria.

Methodological Issues

No IPCC methodology is available for this source.

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 2005–2013, verified CO_2 emissions, reported under the ETS, were used for the inventory. These data cover the complete brick industry in Austria.

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.

Table 110 presents activity data for production of bricks and CO_2 emissions for this category for the period from 1990 to 2013.

Table 110: Activity data and CO_2 emissions for bricks production 1990–2013.

Year	CO_2 emissions [kt]	Bricks [t/a]	CO_2 IEF
1990	116	2 230 000	52
1991	122	2 333 852	52
1992	126	2 412 902	52
1993	135	2 593 236	52
1994	140	2 675 473	52
1995	149	2 848 716	52
1996	149	2 848 716	52
1997	137	2 625 046	52
1998	134	2 557 448	52
1999	122	2 184 773	56
2000	116	1 954 855	59
2001	124	1 959 395	63
2002	120	1 904 142	63
2003	116	1 833 557	63
2004	134	2 116 786	63
2005	128	2 170 069	59
2006	130	2 130 866	61
2007	130	2 331 709	56
2008	110	2 029 947	54
2009	94	1 729 542	54
2010	81	1 789 882	45
2011	99	2 371 494	42
2012	93	1 749 297	53
2013	80	1 671 812	48

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.

Recalculations

No recalculations have been required 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 2013, 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 111: Activity data and CO_2 emissions for soda ash use 1990–2013.

Year	Soda ash used [t/a]	CO_2 emissions [kt]
1990	12 374	5
1991	10 837	4
1992	13 081	5
1993	13 545	6
1994	13 062	5
1995	13 531	6
1996	14 007	6
1997	15 465	6
1998	15 941	7
1999	15 102	6
2000	18 247	8
2001	16 195	7
2002	18 533	8
2003	19 876	8
2004	37 552	16
2005	30 208	13
2006	29 241	12
2007	27 489	11
2008	24 814	10
2009	22 269	9

Year	Soda ash used [t/a]	CO_2 emissions [kt]
2010	23 325	10
2011	27 234	11
2012	29 585	12
2013	24 816	10

Methodological Issues

Emissions were estimated using the methodology and the default emission factor of the IPCC guidelines (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 - 2013. 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. 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*).

Recalculations

The amount of total soda ash used in 2012 was revised, resulting in lower CO_2 emissions (–1.7 kt).

4.2.4.3 Magnesia Sinter Production

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 2013 and also with regard to the trend assessment. In 2013, 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 112 presents CO_2 emissions from production of magnesia sinter for the period from 1990 to 2013. CO_2 emissions from magnesia sinter plants vary over the period from 1990 to 2013, 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 2005–2013, 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[47]. The composition of the oxides is measured using X-ray fluorescence analysis.

Table 112 presents activity data and CO_2 emissions from this category for the period from 1990 to 2013.

Table 112: CO_2 emissions from magnesia sinter production 1990–2013.

Year	CO_2 Emissions [Gg]	Magnesite [t]	IEF [kg CO_2/t magnesite]
1990	481	966 066	498
1991	392	795 932	492
1992	336	675 284	498
1993	325	670 294	484
1994	323	669 260	482
1995	410	753 575	544
1996	355	744 726	477
1997	384	801 273	480
1998	345	716 869	482
1999	350	716 959	488
2000	339	699 707	485
2001	334	691 278	483
2002	374	766 887	487
2003	311	651 332	478
2004	329	655 236	501
2005	310	638 749	485
2006	312	608 737	513
2007	329	691 994	476
2008	332	648 704	512
2009	244	461 482	529
2010	314	627 612	500
2011	345	710 573	486
2012	305	625 259	488
2013	305	669 414	494

[47] 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.

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 required for this year's submission.

4.2.4.4 Other (2.A.4.d)

Source Category Description

Emissions: *CO_2*

Key Source: *Yes (CO_2)*

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.

Table 113: Activity data and CO_2 emissions from limestone and dolomite use 1990–2013.

Year	Limestone Used (Desulfurisation) [t/a]	CO_2 emissions Desulfurisation [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	30 422	13

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.

Uncertainty Assessment

According to the IPCC 2006 GL the uncertainty of the CO_2 emission factor is ±1.5%. This derives from the uncertainty about the composition and fractional purity of limestone in $CaCO_3$ (or of dolomite in $CaCO_3 \cdot MgCO_3$) per tonne of total raw material. Uncertainty of activity data derives mainly from omission of limestone and dolomite use in unidentified industries. For limestone, the uncertainty range is assumed to be plus 20% and minus 10%, as the use in iron and steel industry covers the major part and this is included. This approach results in a combined uncertainty of emissions of 20.1% (based on plus 20% for activity data).

Recalculations

No recalculations have been required for this years´ submission. However, part of the emissions formerly reported under "Limestone and Dolomite Use" is now reported under "*2.C.1 Iron and Steel Production*".

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*

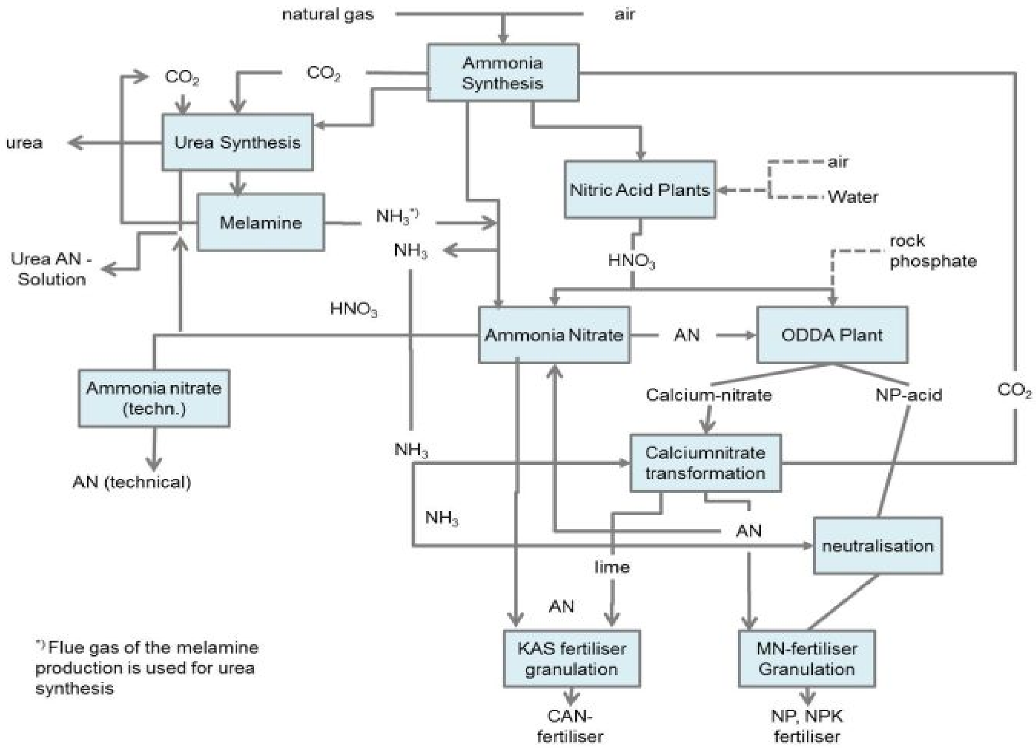
Key source: *Yes (CO_2)*

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 2013. In 2013, this category contributed 0.54% 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 22) 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.

Scheme of ammonia synthesis and downstream processes



Source: Umweltbundesamt

umweltbundesamt

Figure 22: Scheme of ammonia synthesis and downstream processes at Austria's integrated ammonia plant.

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 114 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 2013.

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 2013, CO_2 emissions are 10% lower than in 1990.

4.3.1.2 Methodological Issues

Activity data (ammonia production and natural gas input) for the whole time series and CH_4 emission data from 1994 onwards were reported directly to the Umweltbundesamt by the only ammonia producer in Austria and thus represent plant specific data. The composition of the synthesis gas is measured regularly.

CH_4 emissions are calculated from the measured synthesis gas composition and the number and duration of start-ups. The implied emission factor for CH_4 that was calculated from activity and emission data from 1994 was applied to calculate emissions of the years 1990 to 1993 as no emission data was available for these years.

CH_4 emission factors of ammonia plants largely depend on the number of shutdowns and start-ups during the year. Especially a start up after a turn around with exchange of catalyst in some of the reactors of the plant needs a prolonged start up procedure resulting in an increase of the IEF.

CO_2 emissions are calculated 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:

- CO_2 emissions from ammonia production
- Fugitive CH_4 emissions during start-ups of the ammonia production
- CO_2 emissions from nitric acid production (downstream process at the same site). These emissions are reported under CRF category *2.B.2,* see section 4.3.2 below).
- 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*, see section 4.3.4 below).
- CO_2 emissions from fertilizer production (downstream process at the same site). These emissions are reported under CRF category *2.B.5,* see section 4.3.4 below).
- Carbon stored in melamine.[48]

Consequently, CO_2 emissions from ammonia production were calculated by subtracting the outputs under bullet points number 2 to 6, above, from the overall carbon input.

The urea produced as a downstream product contains carbon which will be converted into CO_2 during urea use. 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 listed in Table 114 are subtracted from CO_2 emissions reported under category *2.B.1*.

Table 114: 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 1990 [kt CO_2]	Emissions in 2013 [kt CO_2]
Urea use in selective catalytic reduction (SCR) in the transport sector	2.G.4 other	NO	22
Application of urea to soils in the agriculture sector	3.H Urea application	467	422

Table 115 shows relevant parameters for the calculation of CO_2 emissions from ammonia production. The resulting CO_2 IEF (with respect to ammonia) decreases over time because of increasing melamine production.

[48] 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.

Table 115: Activity data, emissions and implied emission factor for ammonia production 1990–2013.

Year	Ammonia produced [t]	Natural gas input [TJ]	CO_2 IEF [kg/t ammonia]	CO_2 Emissions [kt]	CH_4 Emissions [t]
1990	461 000	10 193	1 014	467	62. 2
1991	475 000	10 441	1 034	491	64. 1
1992	432 000	9 528	1 022	441	58. 3
1993	469 000	10 321	1 052	493	63. 3
1994	444 000	9 882	1 056	469	59. 9
1995	473 000	10 516	1 076	509	61. 2
1996	484 772	10 779	1 056	512	59. 1
1997	479 698	10 666	1 054	505	81. 1
1998	484 449	10 550	1 023	496	102.0
1999	490 493	10 689	1 024	502	54. 8
2000	482 333	10 548	1 017	491	60.0
2001	448 176	9 989	1 001	449	51.0
2002	464 028	10 380	987	458	68. 8
2003	510 887	11 324	970	495	47. 3
2004	510 024	11 364	968	494	56. 4
2005	478 427	10 719	966	462	93. 9
2006	502 286	11 399	978	491	105. 1
2007	441 299	10 015	959	423	140. 6
2008	489 131	11 137	971	475	87. 7
2009	449 395	10 214	958	431	70. 9
2010	495 353	11 248	962	477	69. 5
2011	502 461	11 347	984	495	76. 6
2012	479 475	10 881	982	471	76. 3
2013	435 244	9 840	972	423	225. 4

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

In line with the IPCC 2006 Guidelines CO_2 emissions from urea use are subtracted from ammonia production. Only those emissions are subtracted which are reported elsewhere in the inventory, i.e. urea use in the transport sector (2.G.4) and urea application in agriculture (3.H).

As CH_4 emissions reported under fertilizer production (*2.B.10*) originate from one single carbon input to the integrated ammonia/fertilizer plant, these emissions are subtracted from the emissions reported under ammonia production in order to avoid double counting. This approach resulted in lower CO_2 emissions (40 kt in 2012). The total effect of subtracting emissions reported under *2.B.10*, *2*.G.4 and *3.H* on the CO_2 emissions from ammonia production is shown in Figure 23.

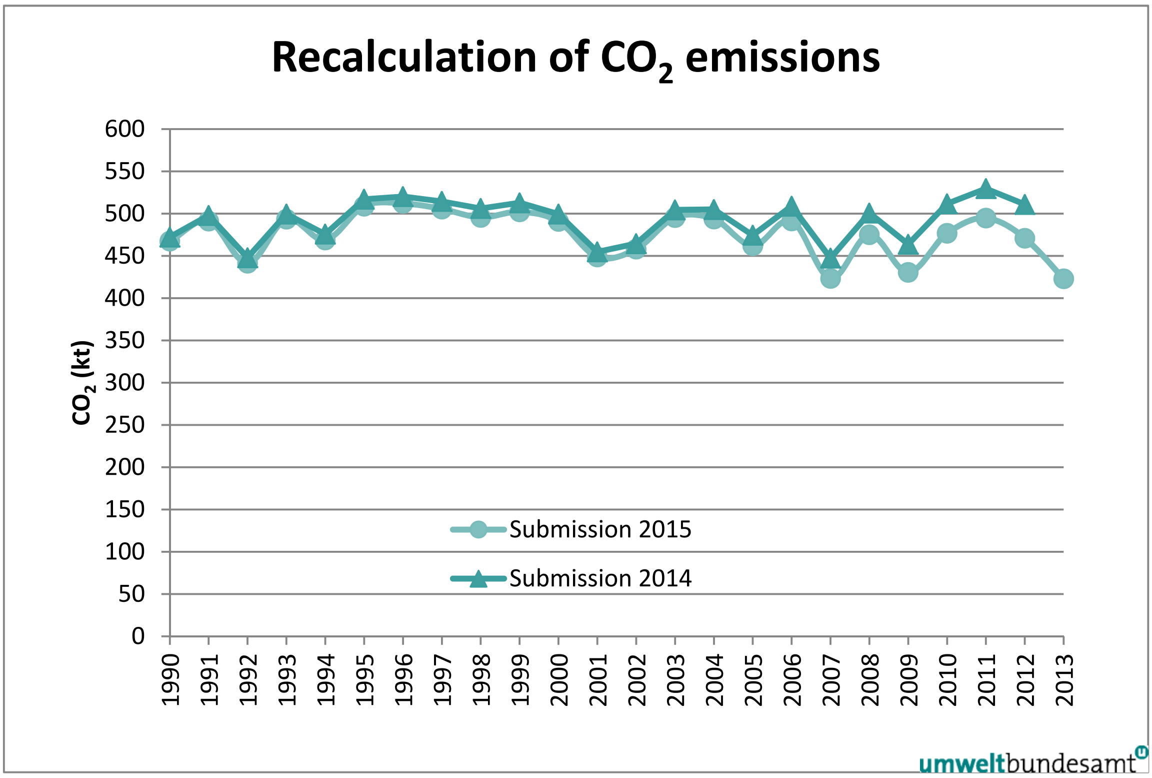


Figure 23: CO_2 emissions reported under category 2.B.1 Ammonia Production.

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 2013, they contributed 0.06% to the total amount of greenhouse gas emissions in Austria, down from 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. By burning ammonia on an alloy catalyst – which is the basis of the nitric acid process – a small amount of CO_2 is produced and leads to CO_2 emissions in the tail gas. 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 116 presents N_2O and CO_2 emissions from production of nitric acid for the period from 1990 to 2013.

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[49] called Uhde process (Envinox® process) for the combined removal of N_2O and NO_x from the tail gas of nitric acid plants. The IEF decreased from an average of 5.0 kg N_2O/t nitric acid, to approx. 1.6 kg N_2O/t nitric acid.
- May 2009: installation of a second catalyst in the nitric acid plant
- 2010: full operation of the second catalyst
- 2011 further optimisation of the production process as well as slightly reduced activities

The increase of the IEF (increase of N_2O emissions despite lower activities) in 2012 can be attributed to a combination of various reasons with the last option being the predominant one:

- Reduced activity of the catalyst over time
- Reduced activity of the catalyst at lower productivity
- Emissions dependent on which of the two plants was in operation as their N_2O emissions differ

In 2013, N_2O emissions were 95% below the emissions in 1990.

CO_2 emissions also varied over the period from 1990–2013, 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 116).

4.3.2.2 Methodological Issues

Following the IPCC Guidelines and monitoring and reporting guidelines[50] 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 vol-

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[49] This facility is documented as example in BAT Reference Document LVIC-AAF, section 3.4.7 (EUROPEAN COMMISSION, 2007)

[50] Commission Decision 2007/587/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.

umetric 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.

Table 116: Activity data, emissions and implied emission factors for N_2O and CO_2 from nitric acid production 1990–2013.

Year	Nitric acid produced [t]	N_2O emissions [t]	CO_2 emissions [kt]	N_2O IEF [kg/t]	CO_2 IEF [kg/t]
1990	529 998	2 942	0.41	5.55	0.78
1991	534 910	2 991	0.42	5.59	0.78
1992	484 731	2 702	0.38	5.57	0.78
1993	513 224	2 835	0.40	5.52	0.78
1994	467 391	2 662	0.36	5.70	0.78
1995	484 016	2 765	0.37	5.71	0.76
1996	495 738	2 820	0.38	5.69	0.76
1997	489 376	2 783	0.36	5.69	0.73
1998	504 977	2 893	0.38	5.73	0.75
1999	512 797	2 979	0.40	5.81	0.78
2000	533 715	3 070	0.37	5.75	0.69
2001	510 800	2 537	0.36	4.97	0.71
2002	522 410	2 604	0.37	4.98	0.70
2003	558 226	2 850	0.41	5.10	0.73
2004	572 719	906	0.41	1.58	0.71
2005	557 870	884	0.41	1.59	0.74
2006	579 623	904	0.42	1.56	0.72
2007	499 402	871	0.36	1.74	0.71
2008	561 749	1 051	0.40	1.87	0.71
2009	495 711	534	0.35	1.08	0.70
2010	547 699	205	0.40	0.37	0.73
2011	542 289	154	0.40	0.28	0.74
2012	534 641	170	0.39	0.32	0.74
2013	475 254	161	0.34	0.34	0.72

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[51], the requirements for laboratories carrying out the analysis are described in § 15 and in Annex 2, section 5 the methods for determination of the flue gas are described.

Furthermore at Austrian plants, continuous measurements of N_2O and NO_x are state-of-the-art technology and the emission values are forwarded online to the local authority.

Order of magnitude and time-series checks are performed and the operator is contacted in case of inconsistencies.

Further QA/QC checks:

- Comparison with BAT
  - Modern M/H-type plant complies with BAT
  - For older L/M-type plants no BAT conclusions have been drawn
- Comparison with international studies: ENTEC UK LIMITED (2006) page 15 and ECOFYS et al. (2009)

4.3.2.4 Uncertainty assessment

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 analyses of N_2O concentrations changed from discontinuous measurements to online spectroscopic measurements.

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 2013, it contributed 0.07% 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:

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

- 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 117: Activity data and CO_2 emissions from calcium carbide production 1990–2013.

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

4.3.3.3 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; in 2013, emissions contributed 0.03% to national total emissions.

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. However, at the Austrian ethylene plant, all by-products are returned to the refinery. As the refinery and its related emissions are covered under sector 1, all CO_2 emissions related to by-products of ethylene production are reported in this sector. Hence, "IE" is reported under CO_2 emissions from category *2.B.8.b Ethylene*.

4.3.4.3 Recalculations

In line with the PCC 2006 Guidelines, CH_4 emissions from ethylene production were estimated using the updated default emission factor of 3 kg CH_4/t ethylene produced. This resulted in higher CH_4 emissions for the whole time series (+1.5 kt in 2012)

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

4.3.5.1 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 128 kt in 2013.

4.3.5.1 Methodological Issues

Detailed information on process emissions for the year 2013 is available as these processes were 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.

4.3.5.2 Recalculations

New source categories were introduced (production of formaldehyde, maleic anhydride and phthalic anhydride), which resulted in higher CO_2 emissions (+142 kt in 2012).

4.3.6 Chemical Industry – Other: Production of Fertilizers and Urea (2.B.10.ii)

4.3.6.1 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 2013, total emissions from this category contributed 0.03% 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 2013, emissions from this category significantly decreased again and were 33% 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.

4.3.6.2 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 2002–2013. 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 2013, 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 2013 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 2002–2013; 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 118 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 2013.

Table 118: Activity data, emissions and implied emission factors for CO_2 and CH_4 from NPK fertilizer production and urea production 1990–2013.

Year	Urea Production			Fertilizer Production			
	Urea production [t]	CO_2 [kt]	CH_4 [t]	Fertilizer production [t]	CO_2 [kt]	IEF CO_2 [kg/t]	CH_4 [t]
1990	282 000	0.27	108	1388 621	30.26	21.79	183.5
1991	295 000	0.29	113	1273 467	27.75	21.79	168.3
1992	259 000	0.25	100	1182 595	37.75	31.92	156.3
1993	305 000	0.30	117	1250 804	33.53	26.81	165.3
1994	360 000	0.35	138	1222 578	22.27	18.22	161.6
1995	393 000	0.40	151	916 265	19.55	21.34	121.1
1996	417 705	0.30	161	940 313	18.07	19.22	124.3
1997	392 017	0.35	151	924 856	17.22	18.62	122.2
1998	395 288	0.29	152	977 212	18.68	19.12	129.2
1999	408 386	0.24	157	988 662	19.65	19.88	130.7
2000	390 185	0.22	150	1022 983	20.59	20.13	135.2
2001	367 218	0.26	141	959 698	19.75	20.58	126.9
2002	389 574	0.35	150	1013 767	23.61	23.29	134.
2003	447 450	0.18	163	1073 940	24.07	22.41	134.
2004	442 252	0.14	166	1090 069	24.03	22.05	126.
2005	416 407	0.21	156	1043 916	23.94	22.93	148.6
2006	429 243	0.22	162	1092 182	26.32	24.1	149.4
2007	384 402	0.43	144	892 680	20.16	22.58	118.2
2008	419 711	0.34	157	1042 098	25.41	24.38	137.9
2009	400 420	0.29	151	859 852	16.13	18.75	120.3
2010	419 997	0.49	156	1051 087	26.03	24.76	139.9
2011	426 861	0.26	160	1058 249	25.75	24.33	137.9
2012	421 659	0.22	156	1034 833	27.54	26.61	136.5
2013	351 921	0.46	131	890 501	18.84	21.15	106.4

4.3.6.3 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

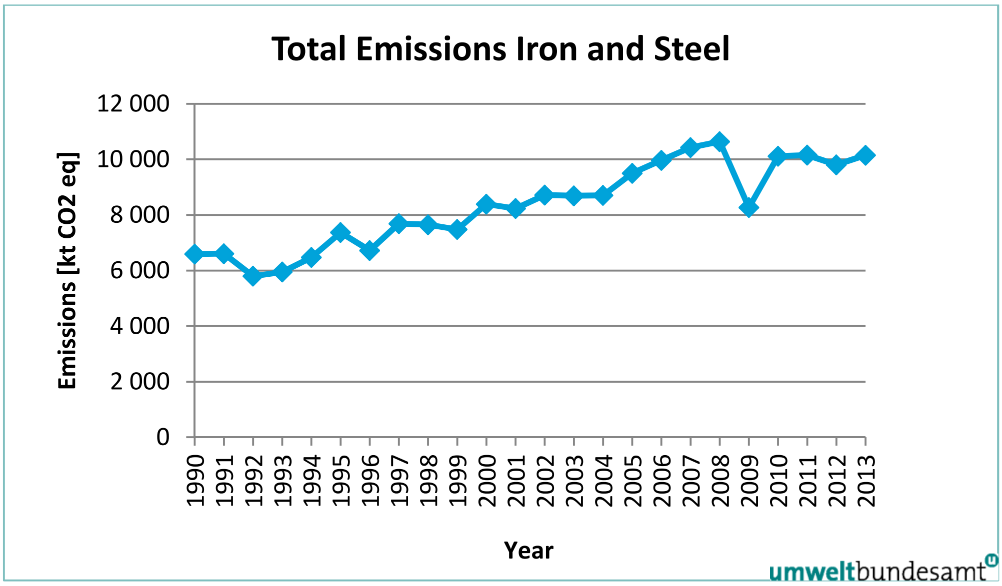
Emissions: CO_2, CH_4

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 2013 and in terms of their trend. In the year 2013, CO_2 emissions from production of iron and steel contributed 12.8% 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 2013. 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 2013, emissions were 54% 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.

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, 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 2005–2013, 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 2013 (approx. 0.075 Gg CO_2 per kt steel) is close to the IPCC default value of 0.08.

Table 119 presents iron, steel and electric steel production and CO_2 emissions from this category.

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

Table 119: Activity data, emissions and implied emission factors for CO_2 and CH_4 from steel production 1990–2013.

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
2002	4 669	5 656	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	9 501	622	45	9 546
2006	5 565	6 487	9 966	643	49	10 014
2007	5 888	6 871	10 428	708	58	10 486
2008	5 846	6 873	10 639	723	57	10 697
2009	4 376	5 077	8 266	588	42	8 307
2010	5 644	6 570	10 113	637	47	10 160
2011	5 822	6 786	10 152	689	49	10 201
2012	5 751	6 746	9 804	674	46	9 850
2013	6 144	7 290	10 151	675	40	10 191

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 2005–2013, 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[52]).

4.4.1.4 Uncertainty Assessment

The iron and steel industry is related to the energy sector, as the major share of CO_2 emissions results from the use of fossil fuel as reducing agent and for combustion. Thus, the same uncertainty values as for solid fuel combustion in large point sources have been applied, namely 0.5% for activity data and 0.5% for emission factor; this leads to an overall uncertainty for CO_2 emissions of 0.7% (WINIWARTER 2007).

4.4.1.5 Recalculations

In line with the IPCC 2006 Guidelines CO_2 emissions were estimated based on a carbon balance. All emissions except those related to the coke oven and on-site power plants were taken into account. Consequently, parts of the emissions that had previously been reported under sector 1 are now included in sector 2. This resulted in revised emissions for the whole time series. The increase in 2012 was 4 404 kt CO_2.

According to the IPCC 2006 Guidelines, VOC emissions in electric steel production consist of NMVOC only. Likewise, in rolling mills, emissions are restricted to NMVOC (i.e. no methane emissions). Hence, CH_4 emissions of electric steel production and rolling mills were revised to "NA" for the whole time series and higher NMVOC emissions were reported instead.

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 2013, emissions from this source contributeed 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 and 2013 were obtained by personal communication from the British Geological Survey, as the report had not been published at the time of emission calculation.

[52] World Steel Association statistics archive, http://www.worldsteel.org/statistics/statistics-archive.html

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 120: Activity data and emissions from ferroalloys production 1990–2013..

Year	Ferroalloys production [kt]	CO_2 emissions [kt]
1990	15.3	20.8
1991	15.3	20.8
1992	15.3	20.8
1993	15.3	20.8
1994	15.3	20.8
1995	15.3	20.8
1996	13.8	18.8
1997	14.2	19.3
1998	14.1	19.2
1999	13.9	18.9
2000	13.9	18.9
2001	13.3	18.1
2002	12.6	17.1
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

4.4.2.3 Recalculations

No recalculations have been required for this year's submission.

4.4.3 Aluminium Production (2.C.3)

4.4.3.1 Source Category Description

Emissions: *PFCs and CO_2*

Key Source: *Yes (PFCs)*

This category includes emissions of CO_2 and PFCs from aluminium production. Primary aluminium production in Austria was terminated in 1992. However, CO_2 emissions also occur during secondary aluminium production.

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.

This category 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.

Table 121 presents PFC and CO_2 emissions from primary aluminium production for the period from 1990 to 1992.

Table 121: PFC emissions from primary aluminium production from 1990 to 1992.

	1990	1991	1992
PFC emissions [Gg CO_2 equivalent]	994	994	395
CO_2 emissions [Gg]	158	158	63

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.

4.4.3.3 Uncertainty Assessment

The uncertainty for the PFC emission factors („Søderberg" process) is between 30–80% according to the IPCC GPG (p.3.43). 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

The default CO2 emission factor for primary aluminium production was updated in line with the IPCC 2006 Guidelines and secondary aluminium production was introduced as a new category, resulting in revised emissions for the whole time series (lower emissions 1990-1992, higher emissions 1993-2012, +4.11 kt in 2012).

4.4.4 SF_6 Used in Aluminium and 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 and aluminium foundries.

This source is a key category in terms of its trend in emissions.

In 1990, SF_6 emissions from aluminium and magnesium foundries contributed 0.3% to the total amount of greenhouse gas emissions in Austria, in the year 2013 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.

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). In some cases a purification system of inert gases is used to which SF_6 is added in concentrations of 1–2.5%.

Table 122 presents SF_6 emissions from magnesium and aluminium foundries for the period from 1990 to 2013.

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 2013 they decreased by nearly 100%. This decreasing trend is explained by technological advances and the replacement of SF_6 by other substances used for surface protection; since 2008 the use of SF_6 per foundry is limited to 850 kg per year in Europe[53].

Table 122: SF_6 emissions from magnesium and aluminium foundries 1990–2013.

Year	SF_6 emissions [t] from magnesium production	SF_6 emissions [t] from aluminium production
1990	10.00	0.60
1991	11.00	0.60
1992	10.00	0.60
1993	11.00	0.60
1994	15.00	0.60
1995	17.94	0.60
1996	24.95	0.60
1997	14.01	0.60
1998	6.10	0.77
1999	0.24	0.69
2000	1.55	0.00
2001	1.20	0.00
2002	0.30	0.00
2003	0.15	0.00
2004	0.00	0.00
2005	0.20	0.00
2006	0.50	0.03
2007	0.00	0.01
2008	0.00	0.01
2009	0.02	0.00
2010	0.00	0.01
2011	0.00	0.01
2012	0.19	0.00
2013	0.39	0.00

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 aluminium and magnesium producers in Austria and thus represents plant-specific data (for verification, data was checked against data from SF_6 suppliers).

[53] Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenho use gases.

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 may use SF_6 from the technical process as fire-extinguishing cover gas. One company relied on a $N_2/CO_2/SO_2$-system. The other company changed over in former times to fluorinated ketone (Novec) as an alternative cover gas system but used SF_6 to quench fires of molten magnesium. SF_6 has been used until 2006.

For aluminium casting the same method was applied until 1999, when it was not further used by companies. From the 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).

4.4.4.3 Source specific QA/QC

The amount of SF_6 used was cross-checked with data from SF_6 suppliers. The IEFs for magnesium casting (based on the amount of magnesium cast) range between 0.1 and 7.4 kg SF_6/t and are all within the range of the Norsk Hydro survey (0.1 to 11 kg/t Mg) cited in the IPCC GPG (p.3.47).

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.

4.5 Non-Energy Products from Fuels and Solvent Use (Category 2.D)

4.5.1 Source Category Description

Emissions: CO_2 (indirect)

Key source: No

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. Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (including 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.

In the year 2013, 0.22% of total GHG emissions in Austria (176.44 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 37% from 1990 to 2013. This is due to several legal measures that resulted in a decrease of emissions.

- Convention on Long-range Transboundary Air Pollution (LRTAP) 1979, extended by eight protocols from which the following have relevance

  ~ The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes;

  ~ The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.
- Solvent Ordinance 1991: Federal Law Gazette 492/1991.
- Federal Ozone Law: Federal Law Gazette 309/1994, amendment of Federal Law Gazette 210/1992;
- Ordinance for paint finishing systems [Lackieranlagen-VO]: Federal Law Gazette 873/1995, repealing the Solvent Ordinance 1991
- VOC Solvent Emissions Directive: Council Directive 1999/13/EC of March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations;

  National implementation by VOC-Installations-Ordinance [VOC-Anlagen-Verordnung (VAV)], BGBl. II Nr. 301/2002, repealing the ordinance for paint finishing system
- Paints Directive: Council Directive 2004/42/CE 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 certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC; The Paints Directive has amended the VOC Solvent Emissions Directive through its article 13: vehicle-refinishing activities are deleted from the scope of Directive 1999/13/EC.

  National implementation by Solvent Ordinance 2005 Federal Law Gazette II No. 398/2005
- Commission Directive 2010/79/EU on industrial emissions (the Industrial Emissions Directive or IED) which repealed the VOC Solvent Emissions Directive.

  National implementation by amendment of the Solvent Ordinance 2005 by Federal Law Gazette II Nr. 25/2013

From 2012 to 2013 emissions decreased by 6.6% due to less solvent use.

4.5.2 Methodological Issues

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. Figure 25 presents an overview of the methodology.

The ***bottom up approach*** is based on an extensive survey on the use of solvents in the year 2000 (WINDSPERGER et al. 2002b). This study combined data on the solvent use of 1 300 Austrian companies, which were then categorized depending on the industrial branch and extrapolated using the total number of employees. These values for 2000 were then extrapolated for three pillar years (1980, 1990, 1995) as "solvent use per employee" (numbers of total employment of the relevant branches taken from national employment statistics (WINDSPERGER et al. 2004a, STATISTIK AUSTRIA 2000&1998) and combined with emission factors. In a second study

(WINDSPERGER et al. 2002a), domestic solvent use (i.e. cosmetic, do-it-yourself, household cleaning, car, gardening etc) of 1 800 households were analysed.

The ***top down approach*** provides total quantities of solvents and non-energy products from fuels used in Austria. The top-down approach is based on

1. import-export statistics (foreign trade balance) of substances and products containing solvents
2. production statistics on solvents (substances) in Austria
3. a survey on non-solvent-applications in companies (WINDSPERGER et al. 2004a, WINDSPERGER et al. 2008) and regularly questionnaires
4. survey on the solvent content in products and preparations at producers and retailers (WINDSPERGER et al. 2002a, WINDSPERGER et al. 2008)

It results in the total amount of solvents consumed in Austria per year (for solvent relevant applications).

The comparison of top down and bottom up approach helped to identify several additional applications, like windscreen wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism, cement and pulp industries.

For the calculation of annual emissions the top down value obtained mainly from national statistics is allocated to the different categories according to the results of the bottom up approach. Finally the emission factors obtained in the survey of the bottom up approach are applied.

For a comprehensive explanation of methods used, please refer to the Informative Inventory Report (UMWELTBUNDESAMT 2015)

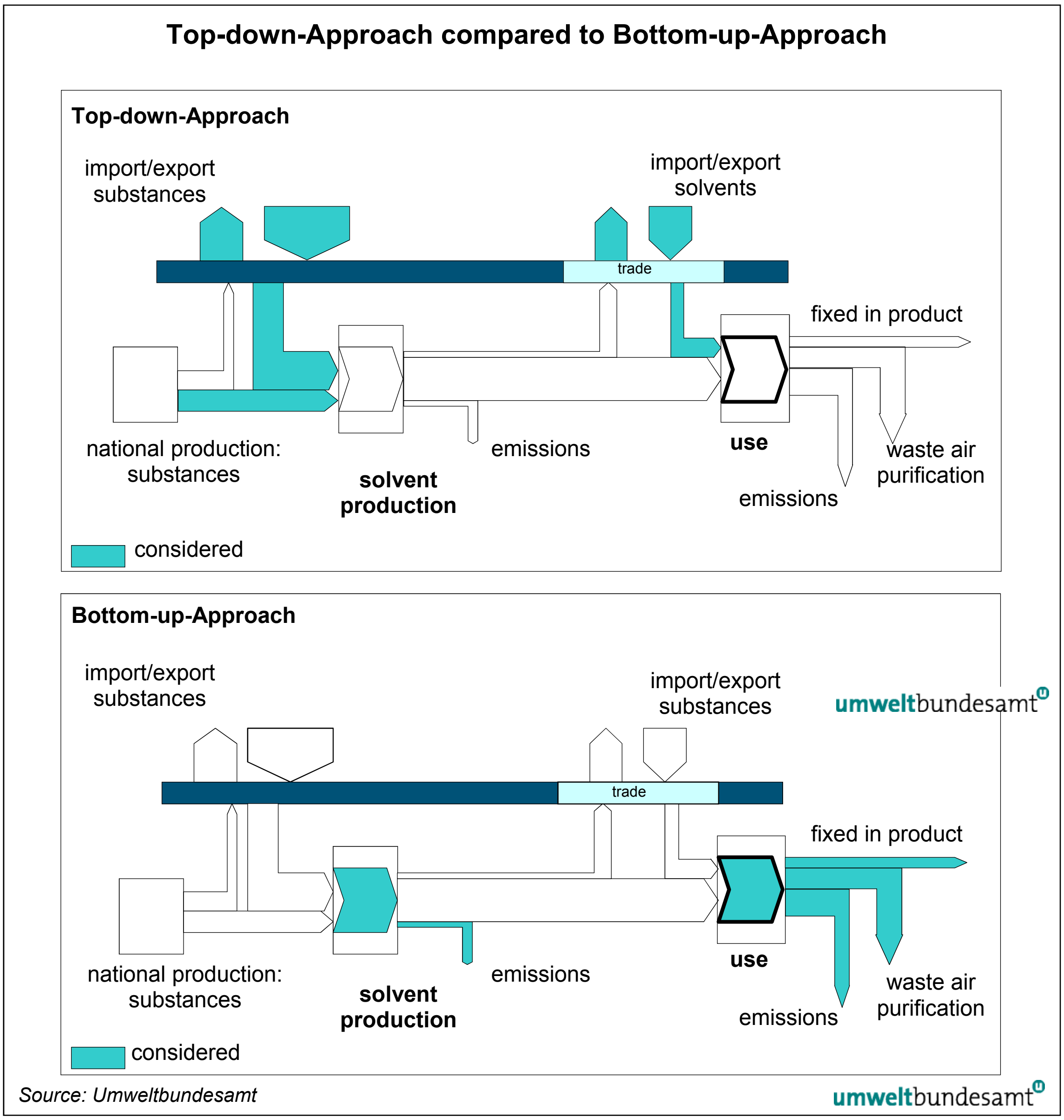


Figure 25: Top-down-Approach compared to Bottom-up-Approach.

Table 123 presents the trend in total greenhouse gas emissions by subcategories.

Table 123: Total greenhouse gas emissions and trend from 1990–2013

	2 D 1	2 D 2	2 D 3 a	2 D 3 b	2 D 3 c
Year	Lubricant Use	Paraffin Wax Use	Solvent use	Road paving with asphalt	Asphalt roofing
1990	IE	IE/NE	279.30	IE	IE
1991	IE	IE/NE	233.48	IE	IE
1992	IE	IE/NE	185.15	IE	IE
1993	IE	IE/NE	185.98	IE	IE
1994	IE	IE/NE	170.76	IE	IE
1995	IE	IE/NE	189.95	IE	IE
1996	IE	IE/NE	173.16	IE	IE
1997	IE	IE/NE	191.87	IE	IE
1998	IE	IE/NE	173.82	IE	IE
1999	IE	IE/NE	159.76	IE	IE
2000	IE	IE/NE	192.62	IE	IE
2001	IE	IE/NE	204.10	IE	IE
2002	IE	IE/NE	218.14	IE	IE
2003	IE	IE/NE	221.26	IE	IE
2004	IE	IE/NE	188.85	IE	IE
2005	IE	IE/NE	212.99	IE	IE
2006	IE	IE/NE	250.73	IE	IE
2007	IE	IE/NE	228.07	IE	IE
2008	IE	IE/NE	210.69	IE	IE
2009	IE	IE/NE	153.46	IE	IE
2010	IE	IE/NE	176.89	IE	IE
2011	IE	IE/NE	173.21	IE	IE
2012	IE	IE/NE	189.00	IE	IE
2013	IE	IE/NE	176.44	IE	IE

Emissions from Lubricant Use are accounted for under the waste sector as well as the uses of petroleum jelly, and similar products. Paraffin waxes are not yet estimated. NMVOC emissions from road paving (*2.D.3.b*) with asphalt are accounted for in the solvent model (as chemical products) therefore emissions are reported as "IE".

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 2013 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:

4.5.3 Source 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.

4.5.4 Uncertainty Assessment

In the latest study on uncertainties of the Austrian inventory (WINIWARTER 2007) (see Chapter 1.7) the uncertainties of solvent emissions in Austria were determined, and were compared with the results of the detailed analysis of solvent emissions in Austria (WINDSPERGER et al. 2004) (see also NIR 2006). Differences between bottom-up and top-down methodology to estimate emissions were calculated at less than 10%, which is compatible with expert estimates on the uncertainties presented for national statistics. Additional uncertainty has been attributed to the released fraction of solvents employed, reflecting an emission factor (solvents are released as volatile organic compounds, which eventually are converted into CO_2 in the atmosphere).

Using the WINDSPERGER et al. (2004) data, an uncertainty of 5% is attributed to the activity data, and 10% to the emission factor of solvents. According to WINDSPERGER et al. (2004), the uncertainty should decrease and the overall quality improve between 1990 and current data. But according to WINIWARTER (2007) a general decrease in the quality of the import-export statistics, and a decrease in the released fraction of solvents (reflecting the emission factor) over the year's results in a constant uncertainty. In Table 125 the results of the studies are presented whereas the results of WINIWARTER (2007) are used for calculating the total uncertainty of the Austrian GHG inventory.

Table 124: Uncertainties of Sector 2 D Non-Energy Products from Fuels and Solvent Use (WINDSPERGER et al. 2004).

	1990	1995	2000
Uncertainty solvent emissions	-21 to +24%	-18 to +21%	-13 to +14%

Table 125: Uncertainties of Sector 2 D Non-Energy Products from Fuels and Solvent Use (WINIWARTER 2007).

IPCC Source category	Gas	AD	EF	Combined
		Uncertainty [%]		
2.D Non-Energy Products from Fuels and Solvent Use	CO_2	5.0	10.0	11.2

4.5.5 Planned Improvements

Currently, the model is being re-evaluated and updated, this process will continue over the next 2 years.

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: yes

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, C_4F_6, 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 1% of the emissions of the IPPU sector, and to 0.11% of the national total. Emissions in 2013 were 32.5% 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 126: 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**

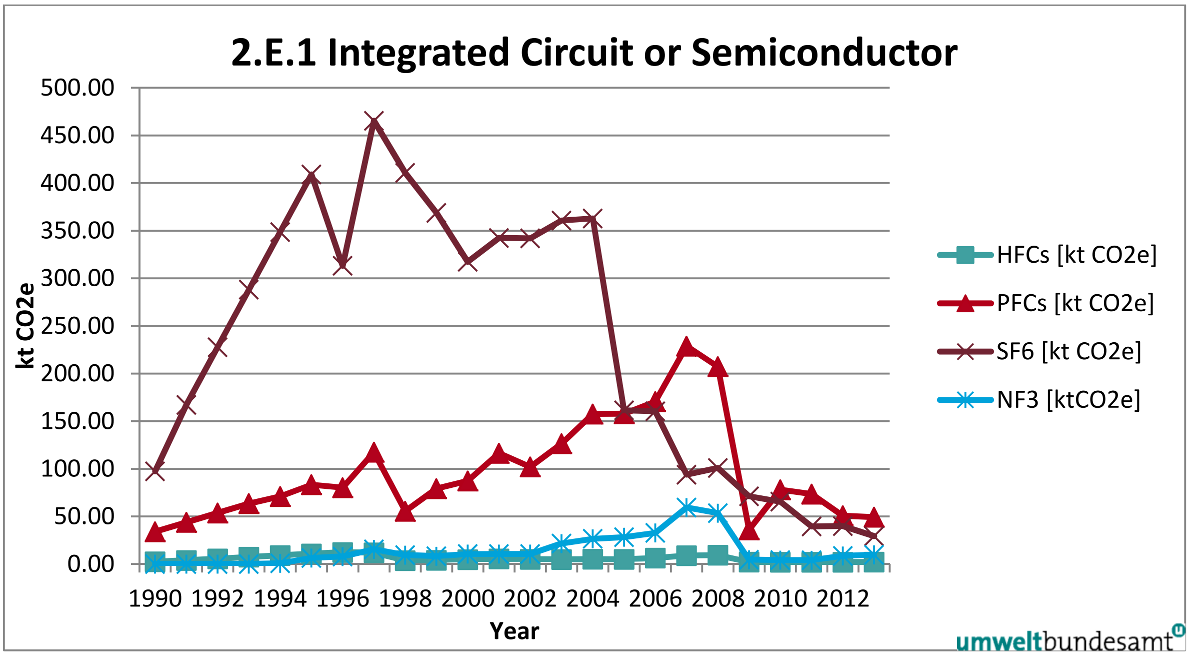


Figure 26: Emissions from 2.E.1 Integrated Circuit or semiconductor.

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 Source 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%.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (Category 2.F)

4.7.1 Source Category Description

Emissions: HFC, PFC

Key Source: yes

This category is similar to the former category *2.F Consumption of Halocarbons and SF_6*, except that the former subcategory *2.F.7 Electronics Industry* is now reported under *2.E* and the former subcategories *2.F.8 Electrical Equipment* and *2.F.9 Other sources of SF_6* are now reported under *2.G*.

Under category *2.F.2 Foam Blowing Agents*, two new gases, HFC-245fa und HFC-365mfc have to be reported. HFC-245fa and HFC-365mfc emissions were estimated by LEISEWITZ & SCHWARZ (2010), based on information obtained from industry.

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[54] 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).[55]

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 2013, F-Gas emissions from Category 2.F amounted to 1.67 Mio t CO_2 equivalents. Emissions have been increasing since 1993 (+1.1% from 2012 to 2013) as HCF have been used increasingly as refrigerant, as well as other uses described below.

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[54] 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. 411/200555.
- F-Gas Regulation 2006, replaced by F gas regulation 2015

Table 127: 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.b 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	8.98	0.00
1996	56.91	12.93	326.05	0.00	12.58	0.00
1997	98.88	23.59	350.24	0.00	16.18	0.00
1998	175.34	35.76	375.70	0.00	19.78	0.00
1999	243.07	51.83	379.29	0.17	23.39	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	513.83	112.12	299.65	2.38	33.79	1.90
2003	636.38	130.61	265.08	0.42	32.50	2.29
2004	711.83	157.96	243.69	4.56	34.03	1.15
2005	754.71	181.32	155.03	7.39	42.28	0.00
2006	764.45	268.31	49.26	6.95	57.13	0.00
2007	785.64	293.51	49.17	6.47	52.16	0.00
2008	809.01	364.45	28.94	12.79	24.00	0.00
2009	842.81	395.66	33.99	12.78	19.45	0.00
2010	956.88	455.44	34.43	12.78	20.09	0.00
2011	999.60	501.58	17.58	15.11	20.18	0.00
2012	1 080.58	522.07	17.40	12.74	20.41	0.00
2013	1 094.77	523.75	17.22	12.78	23.63	0.00

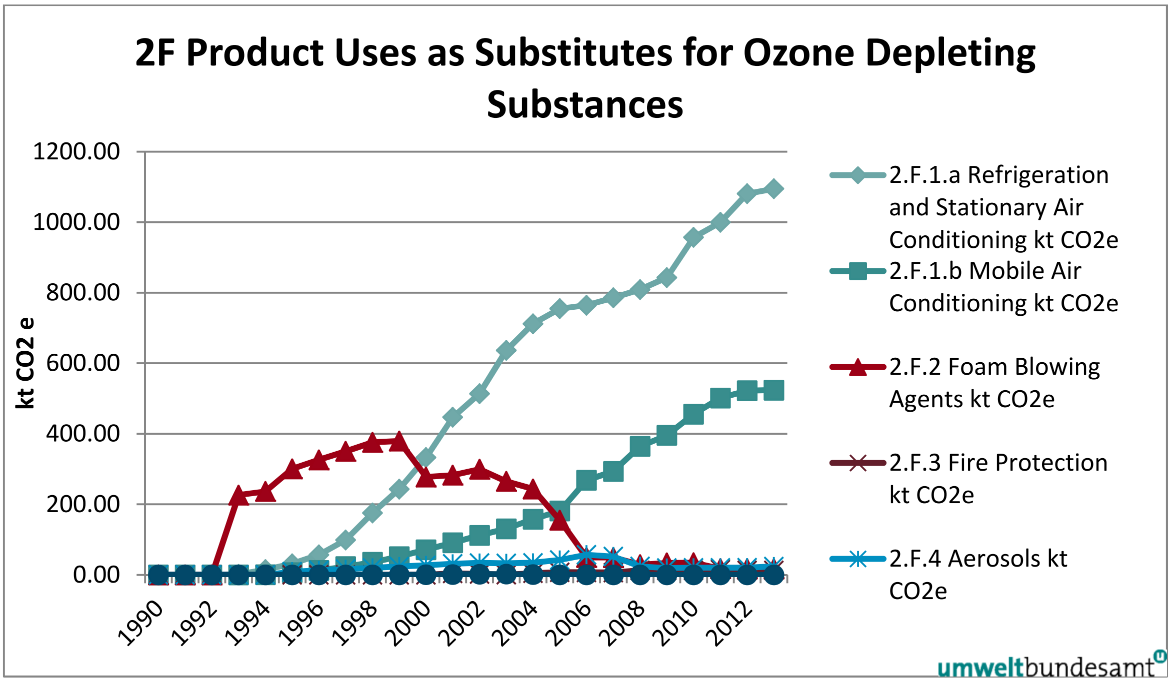

Figure 27: Emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances.

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[56] 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[57]. 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 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

[56] 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

[57] 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).

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 128 provides the data sources and interpolation methods for each subcategory and each year.

Table 128: 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	1990–2013			
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)] 2010-2013	1990–1999	2001–2003, 2005–2006, 2008–2009	Exponential (1990–1999) Linear (other years)
Commercial refrigeration	2000, 2003–2013	1990–1999	2001–2002	Exponential (1990–1999) Linear (2001–2002)
Room air conditioning	2000, 2008	2009–2013	2001–2007	Linear

Category	Data source			
	collected	extrapolated	interpolated	technique
				Note: No HFCs prior to 2000
Heat pumps	1990–2013			
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, 2013	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	1993–2013			Note: No HFCs in vehicles prior to 1993
2.F.2 Foam blowing agents	2000–2013	1995–1999		Linear[2]. Note: No HFCs in foams prior to 1995
2.F.3 Fire protection	1990–2013			
2. F.4 Aerosols	2000–2013	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, 2003–2013		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, 2000–2013		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 129: Emissions of IPCC Category 2.F by sub-category 1990, 1995, 2000, 2003–2006

GHG	GWP	Unit	1990	1995	2000	2003	2004	2005	2006
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
HFC-125	3 500	t	0.00	2.22	26.03	57.15	62.61	68.71	75.54
HFC-134a	1 430	t	0.00	9.04	91.83	149.01	170.46	168.48	139.03
HFC-152a	124	t	0.00	0.01	0.04	0.04	0.04	0.04	0.04
HFC-143a	4 470	t	0.00	2.37	23.81	47.41	53.05	58.24	64.24
HFC-23	14 800	t	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
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
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
HFC-152a	124	t	0.00	81.68	595.17	637.09	429.03	204.65	247.77
HFC-245fa	1 030		0.00	0.00	1.50	3.02	3.71	4.55	2.36
HFC-365mfc	794		0.00	0.00	1.50	3.02	3.81	4.57	2.38
2.F.3 Fire Protection									
HFC-23	14 800	t	0.00	0.00	0.00	0.00	0.19	0.43	0.33
HFC-227ea	3 220	t	0.00	0.00	0.00	0.13	0.54	0.31	0.63
2.F.4 Aerosols									
HFC-134a	1 430	t	0.00	6.28	18.87	22.73	23.80	29.57	39.95
2.F.5 Solvents									
HFC-43-10mee	1 640	t	0.00	0.00	0.23	1.39	0.70	0.00	0.00
Total Gg CO_2e			**0.00**	**347.14**	**708.85**	**1 067.28**	**1 153.21**	**1 140.73**	**1 146.10**

Table 130: Emissions of IPCC Category 2.F by sub-category 2007–2013.

GHG	GWP	Unit	2007	2008	2009	2010	2011	2012	2013
2.F.1 Refrigeration and Air Conditioning Equipment									
Stationary									
HFC-32	675	t	24.67	27.25	32.57	38.92	47.55	56.90	57.04
HFC-125	3 500	t	80.15	88.20	98.44	116.73	127.45	142.45	143.02
HFC-134a	1 430	t	137.77	112.88	90.76	78.26	70.08	64.81	71.93
HFC-152a	124	t	0.05	0.04	0.03	0.02	0.00	0.00	0.00
HFC-143a	4 470	t	65.20	71.70	77.52	91.75	94.24	100.88	101.31
HFC-23	14 800	t	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
2.F.1.b Mobile Air Conditioning									
HFC-134a	1 300	t	205.25	254.86	276.68	318.49	350.76	365.08	366.26
2.F.2 Foam Blowing Agents									
HFC-134a	1 430	t	9.87	9.80	9.73	9.66	9.60	9.53	9.47
HFC-152a	124	t	248.65	87.11	129.34	134.36	0.00	0.00	0.00
HFC-245fa	1 030		2.31	2.26	2.21	2.16	2.11	2.06	2.01
HFC-365mfc	794		2.33	2.28	2.22	2.17	2.12	2.08	2.03
2.F.3 Fire Protection									
HFC-23	14 800	t	0.41	0.86	0.86	0.86	0.86	0.86	0.86
HFC-227ea	3 220	t	0.11	0.00	0.00	0.00	0.74	0.00	0.00
2.F.4 Aerosols									
HFC-134a	1 430	t	36.48	16.78	13.60	14.05	14.11	14.27	16.53
2.F.5 Solvents									
HFC-43-10mee	1 640	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Gg CO_2e			**1 186.95**	**1 239.19**	**1 304.69**	**1 479.61**	**1 554.05**	**1 653.20**	**1 672.15**

4.7.2.1 2.F.1 Refrigeration and Air Conditioning

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 and 2013. 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).

   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 131.

Table 131: 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[58]	0	44	4	52	3 922
Other blends with medium GWP (R410,R407C, R413A, R422D and others)[59]	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[60] 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) Estimation of emissions

The refrigerant consumption equals the sum of refrigerants filled in the new equipment plus refrigerants used for refilling.

In the first year, total consumption is used for filling into new equipment. For the subsequent years a part is used for refilling, where the amount refilled has to equal the amount emitted, and the remaining amount is used for filling of new equipment.

Total consumption was allocated to first-fill and re-fill by an iterative methodology, where the resulting emissions from stock (= the amounts refilled) have to be in such a relation to the calculated stock that implied emission factors correspond to the EF (expert judgement by LEISEWITZ & SCHWARZ (2010)).

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[58] 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%

[59] 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.

[60] 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)

Values for lifetime of equipment per sector, which are required to calculate the refrigerant stock, as well as EF for emissions from manufacturing (= emissions from first fill), and EF for disposal emissions were also taken from LEISEWITZ & SCHWARZ (2010).

Table 132: 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, as shown in Figure 28. Up to the submission in 2012, a different approach had been used, for which inconsistencies had been pointed out by reviewers. These inconsistencies were addressed and removed using the present approach. The previous approach is shown in the figure for comparison.

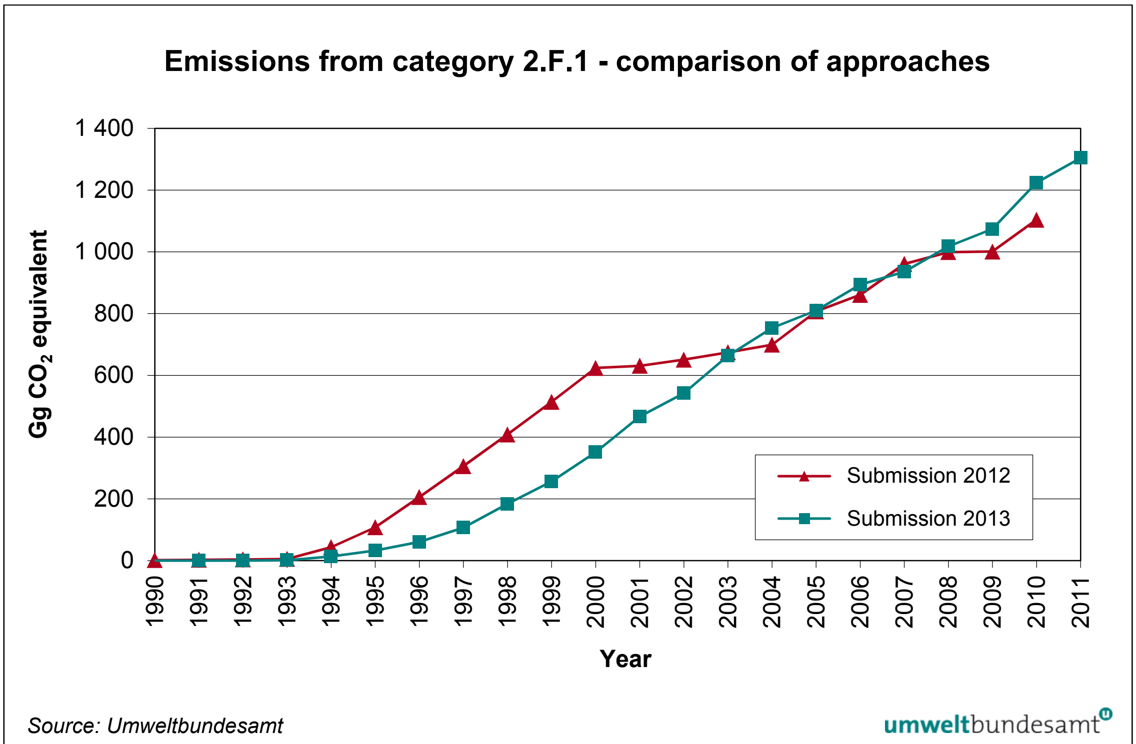


Figure 28: Emissions from category 2.F.1 according to submission 2012 (old approach) and according to submission 2013 and following submissions (new approach as described here) (calculation includes old GWPs)

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 2.F.2 Foam Blowing Agents

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).

2.F.2.a Close Cell Foams

XPS plates

For many years the main blowing agent for manufacturing of XPS hard foam has been 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 133).

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 133).

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 133). 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 133: 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%

2.F.2.b Open Cell Foams

<u>*PU one component foam*</u>

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 have been used as blowing agents for OCF since 1993 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 Mio cans in 1993 (where the first HFC containing cans were sold) 6 Mio. 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 2.F.3 Fire Protection

Stationary fire protection systems for flooding indoor spaces today mainly use inert gases. Formerly used ozone layer depleting halones have been 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 $\pm$ 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 2.F.4 Aerosols

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. 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 2.F.5 Solvents

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 Source specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values. The total consumption of HFC, PFC and SF_6 was obtained by the main importers and this data 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

Update of activity data

2.F.1 Refrigeration and air conditioning equipment

Updated activity data for transport refrigeration for the past years resulted in a revised trend in activity data.

2.F.3. Fire Protection

Due to a remark during the last ESD review, previously reported use of R227ea in the years 1991 and 1996 was moved to 1998. The use of this agent earlier than 1998 seemed unlikely (even though reported by the company), so data was moved in line with the German market.

2.F.4. Aerosols

Same as for 2.F.3: first use of 134a for aerosols was changed to 1995, in line with the German market.

2.F.5 Solvents

Same as for 2.F.3: first use of HFC-43-mee was changed to 2000.

Improvements of methodologies and emission factors

2.F.1 Refrigeration and air conditioning equipment

A transcription error in the calculation of R134a stock in mobile air conditioning for passenger cars was corrected. This resulted in lower stocks and lower emissions in the years 2006-2012 (−12.2 t of R134a emitted in 2012).

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

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) and CO_2 emissions from Other uses (AdBlue emissions).

Emission Trends

Emissions from this category amount to 2.7% of the IPPU sector, which equals 0.54% of total emissions. Between 2012 and 2013, emissions increased by 1.5%. Emission trends are described in depth in the different subcategory chapters.

Table 134: 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	2.G.4 Other	Total
	SF_6	kt CO_2e	SF_6	C_3F_8	kt CO_2e	N_2O	CO_2	kt CO_2e
	[22 800]		[22 800]	[8 830]		[298]		
1990	0.47	**10.80**	5.30	0.00	**120.73**	750.00	0.00	**355.03**
1991	0.51	**11.54**	7.50	0.00	**170.95**	750.00	0.00	**405.99**
1992	0.54	**12.29**	7.66	0.00	**174.67**	750.00	0.00	**410.46**
1993	0.57	**13.03**	7.82	0.00	**178.39**	750.00	0.00	**414.92**
1994	0.60	**13.78**	9.13	0.00	**208.15**	750.00	0.00	**445.43**
1995	0.63	**14.30**	11.14	0.00	**254.06**	750.00	0.00	**491.86**
1996	0.62	**14.25**	11.71	0.00	**266.93**	750.00	0.00	**504.68**
1997	0.63	**14.44**	11.99	0.00	**273.46**	750.00	0.00	**511.40**
1998	0.70	**16.05**	12.57	0.00	**286.57**	750.00	0.00	**526.12**
1999	0.69	**15.79**	11.87	0.00	**270.65**	750.00	0.00	**509.94**
2000	0.75	**17.02**	8.98	0.00	**204.73**	750.00	0.00	**445.25**
2001	0.78	**17.82**	10.60	0.00	**241.72**	750.00	0.00	**483.03**
2002	0.82	**18.66**	10.79	0.00	**245.90**	750.00	0.00	**488.07**
2003	0.85	**19.40**	7.28	0.00	**165.94**	750.00	0.00	**408.84**
2004	0.91	**20.75**	4.40	0.00	**100.39**	750.00	0.00	**344.65**
2005	0.97	**22.20**	13.40	0.00	**305.49**	560.00	0.36	**494.93**
2006	1.00	**22.82**	11.32	0.21	**259.94**	530.00	2.14	**442.84**
2007	1.07	**24.50**	10.89	0.17	**249.84**	517.00	5.72	**434.13**
2008	1.13	**25.87**	10.81	0.11	**247.33**	505.00	8.75	**432.44**
2009	1.17	**26.61**	10.68	0.00	**243.40**	470.00	10.86	**420.93**
2010	1.28	**29.12**	10.57	0.00	**240.93**	484.60	14.96	**429.41**
2011	1.28	**29.27**	10.46	0.00	**238.45**	472.70	16.13	**424.71**
2012	1.39	**31.58**	10.35	0.00	**235.96**	454.01	17.87	**420.70**
2013	1.43	**32.61**	10.24	0.00	**233.50**	461.43	23.33	**426.94**

4.8.2 Methodological Issues

Due to the diversity of this sector, methodological issues are described in each sub-category.

4.8.2.1 2.G.1. Electrical Equipment (SF_6)

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.

The operating EF of HV and MV GIS correspond to the default emission factors of the IPCC GL 2006 at 0.7% (HV) and 0.1% (MV) per year, respectively.

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 2.G.2 SF_6 and PFCs from Other Product Uses

2.G.2.b Accelerators (Research)

SF_6 is used in particle accelerators (linear accelerators, linacs) as insulating gas to prevent electrical flash over. A small number of high voltage equipment (0.3→ 23 MV) is or has been used in Austria in academic research, in industry and medical therapy. The larger HV equipment for research and industrial purposes normally operates with an accelerator and HV generator situated in a tank insulated with SF_6 that is mostly pressurized. Gas losses occur at servicing, repair or adjustment of the device. Linear accelerators for medical radiotherapy (cancer therapy) are industrially made and prefilled. Their waveguide is SF_6 insulated; the filling volume is in the order of ~3 litres – much smaller than the above-mentioned equipment in research and industry. Electronic microscopes (> 100 kV) have a high voltage tank filled with ~5 kg SF_6.

Manufacturers and operators provided the number of devices operating in Austria. Data on filling volume and refilling have been collected from the institutions and companies operating the equipment, from manufacturers and from service companies. The annual F-gas consumption (first filling of new products) normally is very small (in the order of kg) and exceeded 400 kg in one year only. The stock is below 1 t for all years. The implied EF is in the order of 6%, but there is a wide difference between the several types of equipment.

Emissions from bank are equal to the amounts provided in company reports for refilling of losses.

2.G.2.c Other

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 2.G.3 N_2O from Product Uses

2.G.3.a Medical Applications

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.

2.G.3.b Propellant for Pressure and Aerosol Products

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.

4.8.2.4 2.G.4 Other

This contains emissions of the lubricant '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).

4.8.3 Source 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).

2.G.4 Other

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).

4.8.5 Recalculations

Update of activity data

2.G.1 Electrical Equipment

Changes in the timeline are due to a recalculation of stock data of the association of energy suppliers and industrial facilities (where all data for electrical equipment is gathered).

2.G.4 Use of N_2O for anesthesia – N_2O emissions

Updated information for the usage of N_2O for medical purpose leads to a reduction of N_2O emissions, as quantities for export were also included (−0.2kt N_2O in 2012).

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 in the NIR 2014, Annex 6. Methodological details regarding the calculation of gaseous N losses of NH_3 and NO_X are extensively described in Austria's Informative Inventory Report 2015 (UMWELTBUNDESAMT 2015).

To give an overview of Austria's agricultural sector some information is provided below (BMLFUW 2000–2014):

Agriculture in Austria is rather small-structured: 167 500 farms are managed, 57.8% of these farms manage less than 20 ha and whereas only 5.0% of the Austrian farms manage more than 100 ha cultivated area. 129 117 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 2.88 million hectares that is a share of ~ 39% of the total territory (forestry ~ 46%, other area ~ 14%). The shares of the different agricultural activities are as follows:

- 48% arable land,
- 20% grassland (meadows mown several times and seeded grassland),
- 30% 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 2013 the sector agriculture contributed 8.6% to the total of Austria's greenhouse gas emissions (without LULUCF). The trend of GHG emissions from 1990 to 2013 shows a decrease of 14.5% for this sector (see Figure 29 and Table 136) due to a decrease in activity data.

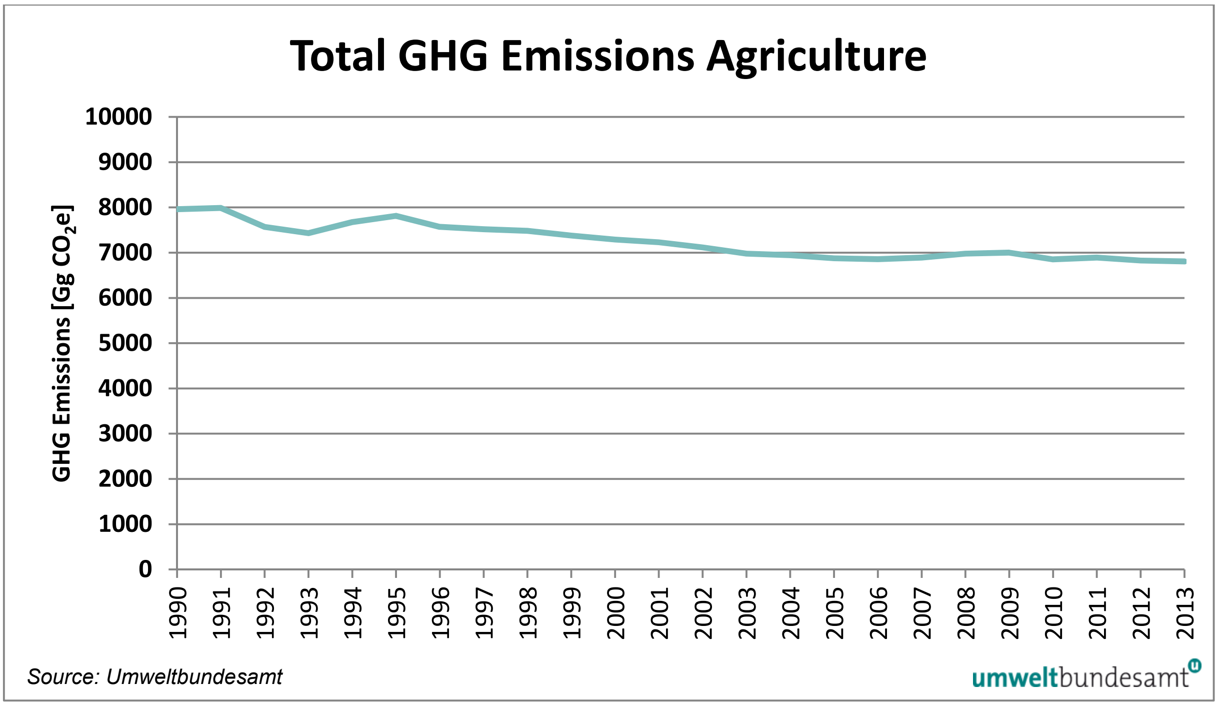


Figure 29: Trend of total GHG emissions from agriculture.

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 2012 to 2013 emissions decreased slightly by 0.3% due to decreased livestock numbers of swine and a reduced amount of N-fertilizer.

Emission trends per gas

From 1990 to 2013 CH_4 emissions from agriculture decreased by 16.0%, N_2O emissions decreased by 12.2% and CO_2 emissions increased by 14.2 %. Trends are presented in Table 135.

Table 135: Emissions of greenhouse gases from 1990–2013 from agriculture.

Year	GHG emissions [Gg]		
	CH_4	N_2O	CO_2
1990	214.38	8.41	94.42
1991	211.13	8.76	97.38
1992	202.57	8.08	97.34
1993	202.50	7.63	96.60
1994	202.49	8.45	97.94
1995	205.92	8.62	99.80
1996	202.47	8.08	99.75
1997	198.84	8.20	100.76

Year	GHG emissions [Gg]		
	CH_4	N_2O	CO_2
1998	197.37	8.21	101.20
1999	195.13	8.05	101.28
2000	193.80	7.88	98.72
2001	191.26	7.90	95.90
2002	187.23	7.86	96.35
2003	185.13	7.56	98.72
2004	184.81	7.46	101.03
2005	182.57	7.42	102.95
2006	181.84	7.40	104.26
2007	182.53	7.45	106.97
2008	181.87	7.81	104.58
2009	184.18	7.68	109.66
2010	183.63	7.23	107.20
2011	181.19	7.57	105.20
2012	179.86	7.46	108.02
2013	180.02	7.38	107.86
Trend 1990–2013	***-16.0%***	***-12.2%***	***14.2%***

Emission trends per sub category

Table 136 presents total GHG emissions and trend 1990–2013 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* (2.2%) followed by *3.B manure management* (1.1%).

Table 136: GHG emissions 1990–2013 of agriculture by categories.

Year	GHG emissions [Gg CO_2 equivalent] by categories						
	3	3.A	3.B	3.D	3.F	3.G	3.H
1990	7 958.66	4 820.53	990.75	2 051.27	1.69	89.97	4.45
1991	7 986.76	4 749.17	982.60	2 155.97	1.64	91.15	6.23
1992	7 570.58	4 550.32	957.51	1 963.75	1.65	91.17	6.17
1993	7 431.90	4 547.37	965.67	1 820.76	1.50	90.81	5.79
1994	7 677.47	4 552.90	962.57	2 062.44	1.62	91.35	6.60
1995	7 815.04	4 638.25	977.91	2 097.48	1.61	91.85	7.95
1996	7 569.41	4 563.33	960.95	1 943.88	1.50	92.05	7.70
1997	7 515.69	4 481.74	951.12	1 980.48	1.59	92.08	8.67
1998	7 483.06	4 447.96	948.74	1 983.62	1.55	91.08	10.12
1999	7 378.58	4 410.82	922.28	1 942.60	1.59	90.87	10.41
2000	7 291.53	4 386.67	910.53	1 894.22	1.40	90.35	8.37
2001	7 230.99	4 326.99	908.55	1 898.00	1.56	90.26	5.64
2002	7 118.54	4 239.51	888.51	1 892.69	1.47	90.22	6.13
2003	6 980.19	4 196.41	878.76	1 804.92	1.39	90.09	8.62
2004	6 943.14	4 196.35	870.21	1 773.42	2.12	90.19	10.84
2005	6 878.05	4 143.41	866.40	1 763.94	1.35	91.19	11.76
2006	6 854.82	4 129.87	862.81	1 756.62	1.26	89.34	14.91
2007	6 889.08	4 145.16	870.74	1 764.93	1.28	89.05	17.92
2008	6 980.11	4 137.39	859.77	1 877.09	1.28	88.03	16.55
2009	7 001.75	4 190.19	870.91	1 829.82	1.16	87.69	21.97

Year	GHG emissions [Gg CO_2 equivalent] by categories						
	3	3.A	3.B	3.D	3.F	3.G	3.H
2010	6 852.37	4 178.56	867.90	1 697.60	1.12	87.63	19.56
2011	6 889.50	4 125.29	853.86	1 804.24	0.90	86.84	18.36
2012	6 826.28	4 097.01	845.33	1 775.22	0.70	86.33	21.69
2013	6 806.92	4 103.19	842.09	1 753.12	0.66	86.36	21.51
Share in Austrian Total 2013	*8.6%*	*5.2%*	*1.1%*	*2.2%*	*0.0%*	*0.1%*	*0.0%*
Trend 1990–2013	***-14.5%***	***-14.9%***	***-15.0%***	***-14.5%***	***-60.8%***	***-4.0%***	***383.2%***

As can be seen in Figure 30 and Table 136 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).

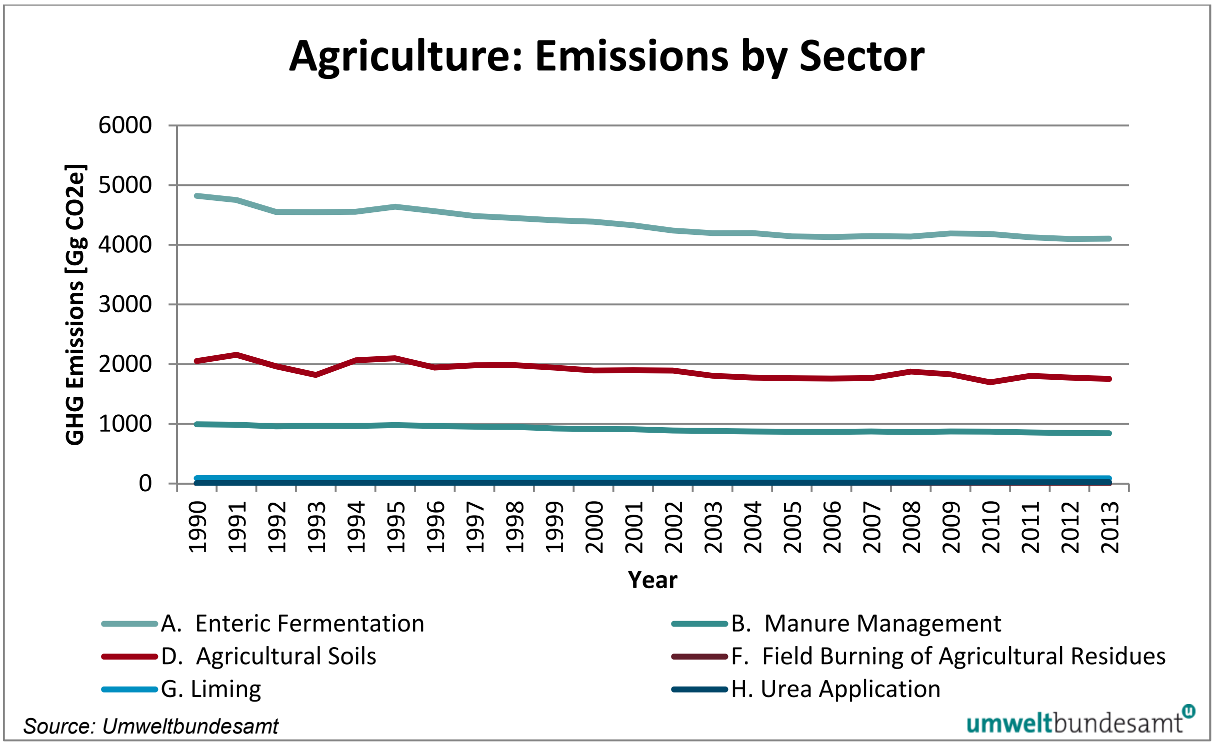


Figure 30: Emission trends of agriculture by categories.

As can be seen in Table 137, in 2013 about 60% of emissions from agriculture originate from enteric fermentation and 26% 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 (1.3%, 0.3% and 0.01%, respectively in 2013).

Table 137: Share of categories of agriculture,1990 and 2013.

GHG emissions [%] by sub categories							
Year	**3**	**3.A**	**3.B**	**3.D**	**3.F**	**3.G**	**3.H**
1990	100.0%	60.6%	12.4%	25.8%	0.0%	1.1%	0.1%
2013	100.0%	60.3%	12.4%	25.8%	0.0%	1.3%	0.3%

5.1.2 Key Categories

The key category analysis (based on CRF Table 7) is presented in Chapter 1.5. This chapter includes information about the agriculture sector. Key sources within this category are presented in Table 138.

Table 138: Key sources of agriculture (KCA CRF Table 7).

IPCC Category	Source Categories	Key Categories	
		GHG	**KS-Assessment***
3.A	Enteric Fermentation	CH_4	LA; TA
3.B	Manure Management	CH_4	LA; TA
3.B	Manure Management	N_2O	LA
3.D.1	Direct Soil Emissions	N_2O	LA; TA
3.D.2	Indirect Emissions	N_2O	LA

LA = Level Assessment (2013)

TA = Trend Assessment 1990–2013

5.1.3 Methodology

For enteric fermentation and manure management IPCC Tier 1 methods and IPCC default emission factors were used, except for key sources of these categories. For swine in sector manure management the more detailed Tier 2 method and country specific emission factors were used. N_2O emissions from animal manure applied to soils were calculated using a country specific methodology following the N-flow approach.

For the calculation of emissions from enteric fermentation – poultry, Tier 2 emission factors from Switzerland (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 139: 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)	Amount of digested manure	AMON (2002), E-CONTROL (2014)
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	N content data	UMWELTBUNDESAMT (1997)
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 2000–2014),
- ✓ 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;

3) Results (emissions)

- ✓ Check of recalculation differences,
- ✓ Plausibility checks of dips and jumps;

4) 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 extern 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.

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 1.6.

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

Animal numbers have been estimated at 10% uncertainty and have been considered statistically independent (WINIWARTER 2007). 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. and for N_2O emissions a lognormal distribution with a low at 50% and a high of 200% of the best estimate was chosen derived from IPCC, 2000 (note: „low" stands for the 2.5-percentile and „high" for the 97.5-percentile of the distribution).

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. Indirect emissions in this context are again soil emissions, which occur after evaporation/leaching of N from the soil to which fertilizer originally has been applied to. 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 140 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 140: 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	+/-22.4%	–	–	+/-20%	–	–
3.B.1.1	Cattle	+/-22.4%	+/- 100.5%	–	+/-20%	+/-100%	–
3.D.1	Direct Soil Emissions	–	+/- 200.1%	–	–	+/-200%	–
	Activity Data						
Animal Population			+/-10%				
Area Data & Fertilizer Input (combined)			+/-5%				

5.1.6 Recalculations

Based on a new study (AMON & HÖRTENHUBER 2014[61]) the Austrian inventory model for the sector agriculture was revised according to the IPCC 2006 GL and the EMEP/EEA GB 2013 as described below. Recalculations resulted in higher emissions of NH_3 and lower ones of N_2O.

Update of activity data

Annual livestock data (CRF 3.A, 3.B)

The two previous categories "chicken" and "other poultry" were divided into "layers", "broilers", "turkeys" and "other poultry" (i.e. the rest including ducks, geese, etc.).

3.D Agricultural Soils

Other organic fertilizers applied to soils (CRF 3.D.a.2.c)

In addition to N from digested manure, which has been already accounted for in previous submissions, this revision implements additional N inputs from energy crops that are digested in biogas plants, and applied to soils as fertilizer after the digestion process (biogas slurry). This update resulted in additional N_2O emissions of 107 tonnes in 2013.

Crop Residues (CRF 3.D.a.4)

Direct N_2O emissions from plant residues left on the fields and mineralized (after incorporation). In contrast to the 1996 IPCC Guidelines, the new 2006 IPCC Guidelines account for the nitrogen of both, above and below ground biomass.

The estimation of N from crop residues is now covering the following sources:

(a) residues from harvest crops which have already been considered in the previous National Inventory, and additionally

(b) N from legume crops in rotations on arable land

(c) N from meadows ploughed every few years

(d) N from crop residues of cover crops

The source category 'N-fixing crops' has been removed as a direct source of N_2O. Anyhow, the N in crop residues of N-fixing crops has to be accounted for under 'crop residues'.

Improvements of methodologies and emission factors

3.A.1 Enteric Fermentation- Cattle

In Austria no country specific methane conversion factor is available. The IPCC default values are used, which were increased from 6.0% according to the 1996 IPCC GL to 6.5% according to the 2006 IPCC GL. As a result, CH_4 emissions increased by about 8% within this source category.

3.B CH_4 emissions from Manure Management

Country specific MCFs have been applied for liquid systems of cattle and swine (as used in previous submissions). For all other systems the 2006 IPCC default values have been used:

[61] AMON & HÖRTENHUBER: Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft, Wien 2014

The IPCC default MCF for cattle/swine – solid storage untreated increased from 0.01 to 0.02. Additionally there were several revisions of the IPCC default Tier 1 methane EFs. These changes, especially the higher MCF for solid storage, lead to an increase of CH_4 emissions within this source category (+0.5 kt in 2012).

3.B Direct N_2O emissions from manure management

The 2006 IPCC default values have been used for the calculations. Almost all of the updated EFs in the 2006 IPCC GL were revised downwards. N_2O emissions of this source category decreased significantly compared to previous inventories, mainly due to lower N_2O EF for solid systems (decreased from 0.02 to 0.005 kg N_2O-N /kg N_{ex}) compared to the 1996 IPCC GL.

3.B.5 Indirect N_2O emissions from manure management

The IPCC 2006 Guidelines introduce the estimation of indirect N_2O emissions from the N volatilization from manure management systems. According to the 1996 IPCC Guidelines all indirect N_2O emissions caused by atmospheric deposition of nitrogen and nitrogen leaching from soils were reported under CRF category *4.D.3 Indirect soil emissions*.

The IPCC 2006 Guidelines require a split of indirect N_2O emissions into:

- Sector Manure Management including nitrogen losses through both, deposition (i.e. gaseous NH3-N and NOX-N losses) and leached NO3-N.
- Sector Agricultural Soils including deposition and leaching/run-off. The following N inputs are considered: application of organic and mineral fertilizers, N in crop residues (above- and below-ground), urine and dung N deposited on pasture, range and paddock by grazing animals.

3.D.a Agricultural Soils (direct soil emissions – N_2O)

According to the 1996 IPCC Guidelines all N_2O emissions were calculated from N applied to soils after subtraction of volatile losses through NH_3-N and NO_x-N during and after application. 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 a consequence, the emission factor was reduced to 0.01 kg N_2O-N per kg N applied to soils. The new methodology leads to a decrease in N_2O emissions (–0.9 kt in 2012).

3.D.b Agricultural Soils (indirect soil emissions – 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. In the 2006 IPCC Guidelines the overall value for the emission factor for leached N has been changed from 0.025 to 0.0075 kg N_2O–N/kg N leached. Furthermore, Austria introduced a national value for $Frac_{Leach}$ (0.15154) based on a national study (EDER, A.; et al 2014)[62], substituting the previously used default factor of 0.30.

Due to the already explained revisions and the reallocation of nitrogen volatilized at housings, which is accounted under sector manure management according to the IPCC 2006 Guidelines, indirect N_2O emissions from agricultural soils decreased (–2.7 kt in 2012).

[62] Eder, A.; Blöschl, G.; Feichtinger, F.; Herndl, M.; Klammler, G.; Hösch, J.; Erhart, E. & Strauss, P (2014). Indirect nitrogen losses of managed soils contributing to greenhouse emissions of agricultural areas in Austria: results from lysimeter studies. Article in Nutr Cycl Agroecosyst. DOI 10.1007/s10705-015-9682-9. 2015

New emission sources

3.G Liming

Up to now, liming was reported under CRF category 5.B.1 *Cropland remaining Cropland* in sector LULUCF and is now reported under subcategory 3.G *Liming*. Liming is a source of CO_2 emissions.

3.H Urea Application

CO_2 emissions from urea application are reported in accordance with the IPCC 2006 Guidelines for the first time in sector Agriculture. Emissions from urea use are reallocated according to the sectors where the urea is used. Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. In the previous inventory CO_2 emissions were reported in the Industrial Processes and Product Use Sector (IPPU Sector).

5.1.7 Completeness

Table 141 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 141: 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**
3.D	**AGRICULTURAL SOILS**	**1001** **1002**	**CULTURES WITH FERTILIZERS** **CULTURES WITHOUT FERTILIZERS**	**NA**	**NA**	✓

IPCC Category		SNAP		CO_2	CH_4	N_2O
3.D.a	Direct N_2O emissions from managed soils	1001/1002	Cultures with and without fertilizers	NA	✓3)	✓
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	✓	✓
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	NO	NO	✓
3.D.a.5	Cultivation of Histosols	–	–	NO4)	NO4)	NO4)
3.D.a.6	Mineralization of soil organic matter	–	–	NO5)	NO5)	NO5)
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*

3) *CH_4 emissions from sewage sludge spreading*

4) *3.D.a.5 Cultivation of Histosols is not occurring in Austria („NO"): Assessments of the Austrian agricultural soil inventories showed that there is no cropland on organic soils in Austria.*

5) *3.D.a.6 Mineralization of soil organic matter is not occurring in Austria („NO"): Nitrogen input from mineralisation in agriculturally used areas remaining in the same type of land use does not occur in Austria, as an increase in the carbon stock over the whole time series could be found.*

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. It is planned to use the results for the preparation of the submission 2018.

5.2 Enteric fermentation (Category 3.A)

This chapter describes the estimation of CH_4 emissions from enteric fermentation. In 2013 91.2% 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 14.9% to 164.1 kt in 2013. Almost all emissions of category 3.A (94.1% in 2013) 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 41.7% in 2013.

Table 142: Greenhouse gas emissions from enteric fermentation by sub-categories 1990–2013.

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	189.97	92.20	87.88	2.61	5.46	0.28	1.04	0.20	0.30
1992	182.01	89.14	82.94	2.50	5.58	0.26	1.11	0.20	0.30
1993	181.89	87.84	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	167.85	65.99	92.14	2.62	4.69	0.26	1.55	0.28	0.34
2005	165.74	65.45	90.51	2.61	4.75	0.26	1.54	0.28	0.34
2006	165.19	65.22	90.36	2.50	4.71	0.26	1.53	0.27	0.35
2007	165.81	65.35	90.27	2.81	4.93	0.27	1.51	0.30	0.36
2008	165.50	66.40	89.39	2.67	4.60	0.27	1.50	0.31	0.37
2009	167.61	66.79	90.88	2.76	4.71	0.28	1.48	0.34	0.37
2010	167.14	66.93	90.15	2.87	4.70	0.28	1.47	0.36	0.38
2011	165.01	66.94	88.18	2.89	4.51	0.28	1.47	0.36	0.38
2012	163.88	67.44	86.55	2.92	4.47	0.28	1.47	0.37	0.38
2013	164.13	68.47	85.97	2.86	4.34	0.28	1.47	0.36	0.38
Share 2013	*100%*	*41.7%*	*52.4%*	*1.7%*	*2.6%*	*0.2%*	*0.9%*	*0.2%*	*0.2%*
90–13	***-14.9%***	***-28.1%***	***-2.3%***	***15.3%***	***-21.5%***	***6.0%***	***65.9%***	***93.0%***	***28.2%***

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 143: Greenhouse gas emissions from non-dairy cattle (3.A.1.2) by sub-categories 1990–2013.

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
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
Share 2013	*100%*	*28.5%*	*25.6%*	*15.6%*	*19.8%*	*10.5%*
1990–2013	***-2.3%***	***419.0%***	***-33.8%***	***-26.4%***	***-21.4%***	***-11.1%***

The rise in suckling cow numbers (see Table 144) 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' (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. The agricultural practices related to poultry 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 more than 60% of the farms manage less than 20 ha. No IPCC default values are available.

Activity data

The Austrian official statistics (STATISTIK AUSTRIA 2013) provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year[63].

In Table 144 and Table 145 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 increasing milk yield per cow: For the production of milk according to Austria's milk quota every year a smaller number of cows is needed.

1991: A minimum counting threshold for poultry was introduced. Farms with less than 11 poultry were not considered any more. However, the contribution of these small farms is negligible, both with respect to the total poultry number and to the trend.
The increase of the soliped population between 1990 and 1991 is caused by a better data collection from riding clubs and horse breeding farms.

1993: New characteristics for swine and cattle categories were introduced in accordance with Austria's entry into the European Economic Area and the EU guidelines for farm animal population categories. In 1993 part of the „Young cattle < 1 yr" category was included in the „Young cattle 1–2 yr" category. This shift is considered to be insignificant: no inconsistency in the emission trend of „Non-Dairy Cattle" category was recorded.
In the same year „Young swine < 50 kg" were shifted to „Fattening pigs > 50 kg" (before 1993 the limits were 6 months and not 50 kg which led to the shift) causing distinct inconsistencies in time series. Following a recommendation of the Centralized Review 2003, the age class split for swine categories of the years 1990–1992 was adjusted using the split from 1993.

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

[63] 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).

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 144: Domestic livestock population and its trend 1990–2013 (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
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
90–13	***-41.5%***	***-14.9%***	***403.3%***	***-32.2%***	***-25.2%***	***-20.2%***	***-10.8%***

* *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 145: Domestic livestock population and its trend 1990–2013 (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
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	86 296	42 102
2005	3 169 541	2 091 225	315 731	762 585	325 728	55 100	85 519	43 014
2006	3 139 438	2 038 170	321 828	779 440	312 375	53 108	84 743	43 926
2007	3 286 292	2 171 519	318 349	796 424	351 329	60 487	83 966	44 839
2008	3 064 231	2 023 536	297 830	742 865	333 181	62 490	83 190	45 751
2009	3 136 967	2 083 459	293 901	759 607	344 709	68 188	82 413	46 663
2010	3 134 156	2 084 923	284 691	764 542	358 415	71 768	81 637	47 575
2011	3 004 907	2 011 138	275 874	717 895	361 183	72 358	81 637	47 575
2012	2 983 158	2 001 150	263 200	718 808	364 645	73 212	81 637	47 575
2013	2 895 841	1 956 862	254 373	684 606	357 440	72 068	81 637	47 575
90–13	***-21.5%***	***-16.6%***	***-33.5%***	***-28.6%***	***15.3%***	***93.0%***	***65.9%***	***28.2%***

** 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 2004-2009: interpolated values

2) for the years 1991-1993, 2000-2002 and 2004-2009: interpolated values

Table 146: Domestic livestock population and its trend 1990–2013 (III).

Year	Livestock category – Population size [heads] *					
	Total Poultry	**Chicken****	**Laying hens****	**Broilers****	**Turkeys*****	**Other Poultry *****
1990	13 820 961	13 139 151	8 392 369	4 746 782	524 616	157 194
1991	14 397 143	13 478 820	8 340 068	5 138 752	759 307	159 016
1992	13 683 900	12 872 100	7 853 673	5 018 427	671 215	140 585
1993	14 508 473	13 588 850	8 307 661	5 281 189	793 431	126 192

Year	Livestock category – Population size [heads] *					
	Total Poultry	**Chicken****	**Laying hens****	**Broilers****	**Turkeys*****	**Other Poultry *****
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	14 644 413	13 918 813	7 061 377	6 857 436	615 813	109 787
2012	14 644 413	13 918 813	7 061 377	6 857 436	615 813	109 787
2013	14 644 413	13 918 813	7 061 377	6 857 436	615 813	109 787
90–13	***6.0%***	***5.9%***	***-15.9%***	***44.5%***	***17.4%***	***-30.2%***

* *adjusted age class split for swine as recommended in the centralized review (October 2003)*

*** interpolated values for the years 2004-2009*

****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*

Information about the extent of organic farming in Austria was provided in the Austrian INVEKOS[64] 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 2000–2014). These data for expansion development of organic farming in Austria were applied to derive a trend of the animal 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 2000–2014) was used. In this report data on organic animal

[64] 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 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 147 shows the results of the shares of organic farming in the relevant livestock categories for 1990 and 2013.

Table 147: Share of cattle population under organic farming systems 1990 and 2013.

IPCC Category	% organic 1990	% organic 2013
CATTLE	1%	19%
Dairy Cattle > 2 yr	1%	18%
Suckling Cows > 2 yr	2%	34%
Other Cattle > 2 yr	1.5%	17%
Young Cattle < 1 yr	1%	17%
Young Cattle 1–2 yr	1%	17%

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 2013, emissions from enteric fermentation – cattle contributed 4.9% 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 144 and Table 145.

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).

$EF = [GE * (Y_m/100) * 365\ days/yr)/55.65]$ 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 148: 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
animal weight	kg/cow/yr	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
forage intake	kg dry matter day^{-1}	13.9	14.0	14.0	13.9	13.8	13.8	13.8	14.1
concentrate intake	kg dry matter day^{-1}	0.4	0.7	0.9	1.3	1.8	2.3	2.8	3.1
net energy intake	MJ NEL* day^{-1}	80.3	82.8	85.3	88.5	91.7	95.8	99.8	103.9
gross energy intake	MJ GE day^{-1}	235.3	242.5	249.8	259.2	268.7	280.7	292.3	304.2

* *net energy lactation*

Austrian dairy cattle show average milk yields from 3 791 kg/cow (1990) to 6 460 kg/cow (2013). The time series of average milk yields per dairy cow was taken from national statistics and are presented in Table 149. For dairy cattle there was a 22.9% increase of GE intake between 1990 and 2013 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 149: Annual milk yield, gross energy intake and emission factors of dairy cattle 1990–2013.

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	3 800	246.88	105.25
1992	3 905	248.39	105.90
1993	3 948	248.79	106.07
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	278.17	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
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

[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 150).

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 150).

Table 150: Annual milk yield, gross energy intake and emission factors of suckling cows 1990–2013.

Year	Milk Yield	Gross Energy Intake	Emission Factor
	[kg/cow*yr]	[MJ/head*day]	[kg CH_4/head*yr]

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

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 151 and Table 152 (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 151: 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 152: 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 1990–2013, 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 153: 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 142, 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 5.9% to total emissions from this category in 2013. The most important sub-category is swine, with a contribution of 2.6%, followed by sheep (1.7%), horses (0.9%) and goats, poultry as well as deer with each about 0.2% (figures are also presented in Table 142).

The IPCC Tier 1 methodology and default emission factors have been used (see Table 154):

Table 154: 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 Ym 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 144 and Table 145.

The agricultural practices related to poultry 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 more than 60% of the farms 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 140.

5.2.5 Recalculations

Update of activity data

The two previous categories "chicken" and "other poultry" were divided into "layers" and "broilers" and "turkeys" and "other poultry" (i.e. the rest including ducks, geese, etc.).

Improvements of methodologies and emission factors

In Austria no country specific methane conversion factor is available. The IPCC default values are used, which were increased from 6.0% according to the IPCC 1996 GL to 6.5% according to the IPCC 2006 GL. As a result, CH_4 emissions increased by about 8% within this source category.

5.3 Manure management (Category 3.B)

This chapter describes the estimation of CH_4 and N_2O emissions from animal manure. In 2013 8.8% of the agricultural CH_4 emissions and 20.3% of the agricultural N_2O emissions were caused by this category.

5.3.1 Source Category Description

From 1990 to 2013 CH_4 emissions from manure management decreased by 26.2% to 15.87 kt.

Table 155: CH_4 emissions from manure management 1990–2013.

Year	CH_4 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	21.50	8.95	6.04	0.06	5.96	0.40	0.08	0.00	0.01
1991	21.11	8.67	6.06	0.06	5.80	0.42	0.09	0.01	0.01
1992	20.50	8.36	5.73	0.06	5.85	0.40	0.10	0.01	0.01
1993	20.55	8.24	5.79	0.06	5.92	0.43	0.10	0.01	0.01
1994	20.32	8.07	5.93	0.07	5.72	0.42	0.10	0.01	0.01
1995	20.33	7.09	7.00	0.07	5.65	0.40	0.11	0.01	0.01
1996	19.89	7.00	6.83	0.07	5.49	0.37	0.11	0.01	0.01

Year	CH$_4$ 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
1997	19.52	7.23	6.23	0.07	5.43	0.42	0.11	0.01	0.01
1998	19.40	7.33	5.98	0.07	5.51	0.40	0.12	0.01	0.01
1999	18.64	7.03	6.14	0.07	4.88	0.39	0.12	0.01	0.01
2000	18.28	6.27	6.81	0.06	4.66	0.33	0.13	0.01	0.01
2001	18.12	6.07	6.76	0.06	4.74	0.35	0.13	0.01	0.01
2002	17.60	5.99	6.55	0.06	4.52	0.34	0.13	0.01	0.01
2003	17.22	5.68	6.60	0.06	4.39	0.35	0.13	0.01	0.01
2004	16.89	5.49	6.74	0.06	4.09	0.35	0.13	0.01	0.01
2005	16.79	5.45	6.66	0.06	4.11	0.36	0.13	0.01	0.01
2006	16.61	5.39	6.65	0.06	4.00	0.36	0.13	0.01	0.01
2007	16.68	5.36	6.66	0.07	4.08	0.37	0.13	0.01	0.01
2008	16.33	5.43	6.59	0.06	3.73	0.37	0.13	0.01	0.01
2009	16.53	5.46	6.69	0.07	3.79	0.38	0.13	0.01	0.01
2010	16.45	5.47	6.64	0.07	3.75	0.38	0.13	0.01	0.01
2011	16.15	5.44	6.49	0.07	3.62	0.38	0.13	0.01	0.01
2012	15.96	5.44	6.37	0.07	3.56	0.38	0.13	0.01	0.01
2013	15.87	5.51	6.30	0.07	3.46	0.38	0.13	0.01	0.01
Share 2013	*100%*	*41.6%*	*28.1%*	*0.3%*	*27.7%*	*1.8%*	*0.4%*	*0.0%*	*0.0%*
90–13	***-26.2%***	***-38.4%***	***4.3%***	***15.3%***	***-41.9%***	***-3.9%***	***66.3%***	***93.0%***	***28.2%***

From 1990 to 2013 the N_2O emissions from manure management decreased by 1.8% to 1.49 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 156: Direct N_2O Emissions from manure management per livestock category 1990–2013.

Year	Direct N$_2$O 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	1.163	0.402	0.465	0.016	0.199	0.064	0.015	0.002	0.001
1991	1.161	0.394	0.468	0.017	0.195	0.067	0.017	0.002	0.001
1992	1.132	0.387	0.447	0.016	0.199	0.063	0.018	0.002	0.001
1993	1.145	0.387	0.449	0.017	0.202	0.067	0.019	0.002	0.001
1994	1.153	0.388	0.461	0.018	0.197	0.066	0.020	0.002	0.001
1995	1.195	0.363	0.529	0.019	0.197	0.063	0.022	0.003	0.001
1996	1.181	0.364	0.521	0.020	0.192	0.059	0.022	0.003	0.001
1997	1.174	0.385	0.487	0.020	0.192	0.064	0.022	0.003	0.001
1998	1.173	0.399	0.474	0.019	0.195	0.060	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
1999	1.157	0.391	0.488	0.018	0.174	0.059	0.024	0.003	0.001
2000	1.155	0.357	0.534	0.017	0.168	0.052	0.024	0.003	0.001
2001	1.157	0.353	0.533	0.016	0.172	0.054	0.025	0.003	0.001
2002	1.138	0.354	0.520	0.016	0.165	0.054	0.025	0.003	0.001
2003	1.136	0.343	0.532	0.017	0.162	0.053	0.025	0.003	0.001
2004	1.136	0.339	0.546	0.017	0.152	0.054	0.025	0.003	0.001
2005	1.13	0.340	0.537	0.017	0.154	0.055	0.025	0.003	0.001
2006	1.131	0.342	0.539	0.016	0.151	0.055	0.024	0.003	0.001
2007	1.144	0.346	0.541	0.018	0.155	0.056	0.024	0.003	0.001
2008	1.139	0.355	0.539	0.017	0.143	0.057	0.024	0.003	0.001
2009	1.154	0.357	0.549	0.018	0.145	0.057	0.024	0.003	0.001
2010	1.151	0.358	0.545	0.018	0.143	0.058	0.024	0.003	0.001
2011	1.135	0.358	0.533	0.019	0.138	0.058	0.025	0.003	0.001
2012	1.126	0.362	0.523	0.019	0.135	0.058	0.025	0.004	0.001
2013	1.123	0.367	0.519	0.018	0.132	0.058	0.025	0.003	0.001
Share 2013	*100%*	*24.6%*	*34.7%*	*1.2%*	*8.8%*	*3.8%*	*1.6%*	*0.2%*	*0.1%*
90–13	***-3.4%***	***-8.5%***	***11.7%***	***15.3%***	***-34.0%***	***-10.0%***	***66.4%***	***93.0%***	***28.2%***

Table 157: Direct, indirect and total N_2O Emissions from manure management, 1990–2013.

Year	Direct N_2O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
1990	1.521	1.163	0.358	NO
1991	1.526	1.161	0.365	NO
1992	1.493	1.132	0.361	NO
1993	1.516	1.145	0.371	NO
1994	1.525	1.153	0.372	NO
1995	1.576	1.195	0.380	NO
1996	1.556	1.181	0.375	NO
1997	1.554	1.174	0.381	NO
1998	1.556	1.173	0.383	NO
1999	1.531	1.157	0.374	NO
2000	1.522	1.155	0.366	NO
2001	1.528	1.157	0.372	NO
2002	1.505	1.138	0.367	NO
2003	1.504	1.136	0.368	NO
2004	1.503	1.136	0.367	NO
2005	1.499	1.13	0.369	NO
2006	1.502	1.131	0.371	NO

Year	Direct N_2O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
2007	1.523	1.144	0.379	NO
2008	1.515	1.139	0.376	NO
2009	1.536	1.154	0.382	NO
2010	1.532	1.151	0.381	NO
2011	1.510	1.135	0.375	NO
2012	1.498	1.126	0.372	NO
2013	1.494	1.123	0.371	NO
Share 2013	*100%*	*75.2%*	*24.8%*	NO
90–13	***-1.8%***	***-3.4%***	***3.6%***	**-**

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.

The recent inventory revision (AMON & HÖRTENHUBER 2014) concentrated on implementing the IPCC 2006 Guidelines and the EMEP/EEA GB 2013.

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). Within a new study (AMON & HÖRTENHUBER 2014) the Austrian inventory model for the whole sector agriculture was revised according to the IPCC 2006 GL and the EMEP/EEA GB 2013.

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 new 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 2014). 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). Except for chicken, where a time series has been generated, the AWMS distribution of these animal categories has been kept constant over the entire time series.

The updated AWMS data (see Table 158 and Table 159) reflect the situation in Austria much better than the IPCC default AWMS distribution and the distribution from the study by (KONRAD 1995) used before.

Table 158: Manure Management System distribution in Austria 2013.

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/ Paddock	Other Systems
	[%]	[%]	[%]	[%]
Dairy cattle	32.2	49.0	2.9	15.9
Non-dairy cattle	23.1	44.2	4.8	27.9
Suckling cows	14.6	40.0	14.3	31.0
Cattle < 1 year	15.3	48.0	1.9	34.7
Breeding heifers 1–2 years	30.5	44.4	5.8	19.3
Fattening heifers, bulls and oxen 1–2 years	43.5	38.8	0.2	17.4
Other cattle > 2 years	27.0	44.1	7.1	21.8
Sheep	0.0	50.0	50.0	0.0
Goats	0.0	50.0	50.0	0.0
Horses	0.0	80.0	20.0	0.0
Swine (Total)	80.3	4.2	0.0	15.7
Breeding sows	51.0	21.8	0.0	27.3
Young and fattening pigs	84.1	1.8	0.0	14.2
Chicken	2.2	90.2	0.0	7.6
Layers	4.4	88.1	0.0	7.6
Broilers	0.0	92.4	0.0	7.6
Other poultry	0.0	100.0	0.0	0.0
Turkeys	0.0	100.0	0.0	0.0
Other Poultry	0.0	100.0	0.0	0.0
Other animals	0.0	20.0	80.0	0.0

Table 159: Other systems 2013 in detail.

Livestock category	Yard	Composting	Deep Litter	Aerobic Treatment	Anaerobic Digestion
	[%]	[%]	[%]	[%]	[%]
Dairy cattle	2.0	7.4	1.4	4.6	0.5
Non-dairy cattle	1.9	6.3	16.0	3.3	0.5
Suckling cows	2.3	6.0	20.0	2.2	0.5
Cattle < 1 year	1.8	7.2	22.5	2.7	0.5
Breeding heifers 1–2 years	1.7	6.5	7.5	3.0	0.5
Fattening heifers, bulls and oxen 1–2 years	1.7	4.2	6.8	4.3	0.5
Other cattle > 2 years	2.1	6.3	7.0	5.9	0.5
Sheep	0.0	0.0	0.0	0.0	0.0
Goats	0.0	0.0	0.0	0.0	0.0
Horses	0.0	0.0	0.0	0.0	0.0
Swine (Total)	1.4	0.6	6.1	3.6	4.0
Breeding sows	2.5	3.5	14.0	3.3	4.0

Livestock category	Yard	Composting	Deep Litter	Aerobic Treatment	Anaerobic Digestion
	[%]	[%]	[%]	[%]	[%]
Young and fattening pigs	1.2	0.2	5.1	3.7	4.0
Chicken	0.0	0.0	0.0	0.0	7.6
Layers	0.0	0.0	0.0	0.0	7.6
Broilers	0.0	0.0	0.0	0.0	7.6
Other poultry	0.0	0.0	0.0	0.0	0.0
Turkeys	0.0	0.0	0.0	0.0	0.0
Other Poultry	0.0	0.0	0.0	0.0	0.0
Other animals	0.0	0.0	0.0	0.0	0.0

Small farms more frequently use solid manure systems, whereas large farms make more use of slurry systems. The time series on AWMS shows for cattle a decreasing share of pasture and an increasing share of 'other systems' (see Annex 6 in NIR 2014; Umweltbundesamt 2014a). 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 '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), Annex 6 in NIR 2014 (Umweltbundesamt 2014a) presents fractions of livestock manure per animal categories handled in different AWMS for all reporting years.

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 160: 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 2006-2014). 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 and 2011 was derived from feedstock balances provided by E-CONTROL 2009 and E-CONTROL 2011 (Ökostrombericht 2009 & Rohstoffbilanz 2011). Data for the years in between was derived by interpolation. For 2012 and 2013 average amounts of animal manures digested per biogas plant have been kept constant.

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 (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 161: Numbers of biogas plants and amounts of digested manure 1990–2013.

Year	Biogas plant	Digested manure/plant	Annualy 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
2010	289	1 162	335 812
2011	288	1 182	340 393
2012	291	1 182	343 938
2013	293	1 182	346 302

Table 161 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 2013) provides national data of annual livestock numbers on a very detailed level (see Table 144, Table 145, Table 146). 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 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 (THOMAS AMON 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 162: 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 162). 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 2012.

Table 163: average MCFs for liquid systems 1990 and 2013.

Animal Category	1990 [%]	2013 [%]
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 2013.

Table 164: average MCFs for other systems 1990 and 2013.

Animal Category	1990 [%]	2013 [%]
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})

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)

Volatile solid (VS) excretion – dairy cows

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 148 and Table 165). Within the revision of Austrian N excretion values (following a recommendation of the Centralized Review 2005) in the year 2005 energy intake data and VS excretion data of *dairy* and *suckling cows* were recalculated (PÖTSCH 2005 following GRUBER & STEINWIDDER 1996).

Table 165: VS excretion of Austrian dairy cattle (PÖTSCH 2005 following GRUBER & STEINWIDDER 1996).

Milk yield	**[kg/yr]**	**3 000**	**3 500**	**4 000**	**4 500**	**5 000**	**5 500**	**6 000**	**6 500**
GE intake	[MJ/day]	235.32	242.55	249.77	259.23	268.68	280.72	292.32	304.21
feed digestibility	[%]	65.7	66.0	66.3	67.3	68.2	69.1	70.0	70.6
ash content	[%]	11	11	11	11	11	11	11	11
VS excretion [kg $cow^{-1}day^{-1}$]		3.90	3.98	4.06	4.09	4.12	4.18	4.23	4.31

A time series was generated by adjusting these data to the yearly milk yields (see Table 166).

Table 166: VS excretion of Austrian dairy cows for the period 1990–2013.

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	4.03	2002	5 487	4.18
1991	3 800	4.03	2003	5 638	4.20
1992	3 905	4.04	2004	5 802	4.21
1993	3 948	4.06	2005	5 783	4.21
1994	4 076	4.06	2006	5 903	4.22
1995	4 619	4.10	2007	5 997	4.23

Year	Milk yield [kg yr-1]	VS excretion [kg/cow*day]	Year	Milk yield [kg yr-1]	VS excretion [kg/cow*day]
1996	4 670	4.10	2008	6 059	4.24
1997	4 787	4.11	2009	6 068	4.24
1998	4 924	4.12	2010	6 100	4.25
1999	5 062	4.13	2011	6 227	4.27
2000	5 210	4.15	2012	6 418	4.30
2001	5 394	4.17	2013	6 460	4.31

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 3.90 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 3.98 kg. Values between 1990 and 2004 have been derived by interpolation (see Table 167).

Table 167: VS excretion of Austrian suckling cows for the period 1990–2013.

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	3.90	2002	3 429	3.97
1991	3 036	3.90	2003	3 464	3.97
1992	3 071	3.91	2004	3 500	3.98
1993	3 107	3.91	2005	3 500	3.98
1994	3 143	3.92	2006	3 500	3.98
1995	3 179	3.93	2007	3 500	3.98
1996	3 214	3.93	2008	3 500	3.98
1997	3 250	3.94	2009	3 500	3.98
1998	3 286	3.94	2010	3 500	3.98
1999	3 321	3.95	2011	3 500	3.98
2000	3 357	3.95	2012	3 500	3.98
2001	3 393	3.96	2013	3 500	3.98

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 151).

As no major changes in diets of *Non-Dairy Cattle* occurred in the period from 1990–2013, 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.

The VS excretion rate was calculated from feed intake using the following formula:

$$VS\ [kg\ dm\ day^{-1}] = Intake\ [MJ\ day^{-1}] * (1kg\ (18.45\ MJ)^{-1}) * (1- DE\%/100) * (1- ASH\%/100)$$

VS = *VS excretion per day on a dry weight basis*

Dm = *dry matter*

Intake = *daily average gross energy feed intake [MJ day^{-1}]*

DE% = *digestibility of feed in per cent*

ASH% = *ash content of manure in per cent*

Table 168 presents data for the calculation of VS excretion of the livestock categories *Non-Dairy Cattle*.

Table 168: Austrian VS excretion rates 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}]	0.97	0.86	2.16	1.96	2.13	2.08

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 169: 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 170: 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).

Part of chicken manure is digested in biogas plants. Following (FNR 2010) and expert judgement (AMON 2011), about 2% of CH_4 emissions from anaerobic digestion are lost. CH_4 emissions from anaerobic digestion were considered as follows:

$$CH_4\ emissions_{4.B(i)} = Population_{(i)} * EF_{IPCC\ default\ (i)} * (1-share_{dig\ (i)}) + Population_{(i)} * EF_{IPCC\ default\ (i)} * share_{dig\ (i)} * leakage(\%)$$

(i) = poultry (3.B.4.1)

$share_{dig}$ =% of manure digested

leakage = 2%, see also chapter 5.3.2.1.

Different shares of AWMS are presented in Table 159 and Annex 6 in NIR 2014 (Umweltbundesamt 2014a)

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).

N excretion per animal waste management system:

$$Nex_{(AWMS)} = \sum_{(T)}[N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}]$$

$Nex_{(AWMS)}$ = 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

N_2O emission per animal waste management system:

$$N_2O_{(AWMS)} = \sum[Nex_{(AWMS)} \times EF_{3(AWMS)}]$$

$N_2O_{(AWMS)}$= 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 159).

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 171).

Table 171: Austria specific N excretion values of dairy cows for the period 1990–2013.

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	2002	5 487	91.89
1991	3 800	76.70	2003	5 638	93.24
1992	3 905	77.64	2004	5 802	94.72
1993	3 948	78.03	2005	5 783	94.55
1994	4 076	79.18	2006	5 903	95.63
1995	4 619	84.07	2007	5 997	96.48
1996	4 670	84.53	2008	6 059	97.03
1997	4 787	85.58	2009	6 068	97.11
1998	4 924	86.82	2010	6 100	97.40
1999	5 062	88.06	2011	6 227	98.54
2000	5 210	89.39	2012	6 418	100.26
2001	5 394	91.05	2013	6 460	100.64

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 171 and Table 172 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 172: Austria specific N excretion values of other livestock categories.

Livestock category	Nitrogen excretion [kg/animal*yr]
suckling cows[1)] (1990)	69.5
suckling cows[2)] (2013)	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 poultry[3)]	0.48
deer/furred game[4)]	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 144, Table 145 and Table 146. Data on manure management system distribution is presented in Table 158 and Table 159.

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 173: 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	~0.02*	IPCC 2006, Table 10.21
Solid Storage	0.005	IPCC 2006, Table 10.21
Pasture/Range/Paddock	0.020	IPCC 2006, Table 10.21 and Table 11.1
Composting	0.006	IPCC 2006, Table 10.21
Aerobic Treatment	0.005	IPCC 2006, Table 10.21
Anaerobic Digester	0.0	IPCC 2006, Table 10.21
Deep Litter (no mixing)	0.010	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 158 and Table 159). 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 174: N_2O emission factors used for the calculation of N_2O from yards 1990–2013.

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

Year	Dairy	Non-Dairy	Swine
	[kg N_2O-N per kg N excreted]		
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
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

For the calculation of the losses of gaseous N species (NH_3-N and NO_x-N) the mass-flow procedure pursuant to EMEP/CORINAIR (EEA 2013) has been applied. In 2009 updated data on agricultural practice in Austria (AMON et al. 2007) has been integrated to the ammonia emission model (AMON & HÖRTENHUBER 2008). The latest revision of the model according to the EMEP/EEA GB 2013 was done in submission 2015 (AMON & HÖRTENHUBER 2014). 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 chapter 5.4.2.1.

5.3.2.3 Estimation of indirect N_2O emissions from manure management

Key Source: No

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[65] is directly implemented in the laws of all federal states' in Austria except for Salzburg and Lower Austria. Lower Austria and Salzburg implemented comparable laws, which ensure the closeness of animal housing and storage constructions. A demand on tightness can also be derived from Austrian laws concerning groundwater protection (§ 30) and according to environmental protection regulations of the federal states (KREUZHUBER 2013).

Considering the legal background in Austria, leaching from sector manure management does not occur in Austria and is thus reported as "not occurring".

Indirect N_2O emissions through volatilization losses from manure management

Following the 2006 IPCC GL, indirect N_2O emissions due to volatilization of N from manure management were calculated using Tier 2 methodology. Austria considers a detailed flow of nitrogen throughout the animal housing and manure management systems.

The indirect N_2O emissions from volatilization of N in forms of NH_3 and NO_x are estimated following equation 10.26 (IPCC 2006) multiplied with the default IPCC emission factor presented in the IPCC 2006 GL in Table 11.3, which is 0.01 kg N_2O-N (kg NH_3-N+NO_x-N volatilised).

$$N_{volatilisation\text{-}MMS} = \sum_S[\sum_T[(N_{(T)} * Nex_{(T)} * MS_{(T,S)} * (Frac_{GasMS}/100_{)(T,S)}]] * EF$$

$N_{(T)}$ = 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, %

Total N excretion by livestock that volatizes ($Frac_{GasMS}$) includes:

- NH_3-N losses from housing, storage, grazing
- NO_x-N losses from manure management

Table 175: NH_3-N and NO_x-N volatilisation losses of manure management systems 1990 to 2013.

Year	N losses from manure management systems
	[t N/yr]
1990	22 794
1991	23 257
1992	22 948

[65] http://www.oib.or.at/

Year	N losses from manure management systems
	[t N/yr]
1993	23 590
1994	23 690
1995	24 199
1996	23 895
1997	24 228
1998	24 348
1999	23 785
2000	23 311
2001	23 654
2002	23 385
2003	23 444
2004	23 364
2005	23 483
2006	23 587
2007	24 120
2008	23 929
2009	24 281
2010	24 253
2011	23 887
2012	23 704
2013	23 611

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 by validation of the software tool (calculation sheets) for the new and revised source (indirect N_2O emissions) − in progress (2015)

Sector specific routine control procedures are provided in chapter 5.1.4.

5.3.4 Uncertainties

Uncertainties are presented in Table 140.

5.3.5 Recalculations

Improvements of methodologies and emission factors

CH_4 emissions

For liquid systems, cattle and swine, country specific MCFs have been applied (as in previous submissions). For all other systems and livestock categories the 2006 IPCC default values have been applied. The default MCF for cattle/swine – solid storage increased from 0.01 to 0.02. Furthermore there were several changes of the IPCC default Tier 1 methane EFs. Especially the higher MCF for solid storage caused increased CH_4 emissions within this source category (+0.5 kt in 2012).

Direct N_2O emissions

The 2006 IPCC default values have been used. Almost all of the updated EFs in the 2006 IPCC GL were revised downwards. N_2O emissions of this source category decreased significantly compared to previous inventories, mainly due to the lower N_2O EF for solid systems (decreased from 0.02 to 0.005 kg N_2O-N /kg N_{ex}) compared to the IPCC 1996 GL.

Indirect N_2O emissions

The IPCC 2006 Guidelines introduce the estimation of indirect N_2O emissions from the N volatilization from manure management systems. According to the 1996 IPCC Guidelines all indirect N_2O emissions caused by atmospheric deposition of nitrogen and nitrogen leaching from soils were reported under *agricultural soils*.

The IPCC 2006 Guidelines require a split of indirect N_2O emissions into:

- Sector Manure Management including nitrogen losses through both, deposition (i.e. gaseous NH_3-N and NO_X-N losses) and leached NO_3-N.
- Sector Agricultural Soils including deposition and leaching/run-off. The following N inputs are considered: application of organic and mineral fertilizers, N in crop residues (above- and below-ground), urine and dung N deposited on pasture, range and paddock by grazing animals.

Considering the legal background in Austria, which requires watertight construction of animal housings and manure storage systems, leaching from sector manure management does not occur in Austria and is thus reported as "not occurring" (NO).

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 2013 79.7% of total N_2O emissions from agriculture (53.7% 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 2.2% (1 753.12 Gg CO_2 equivalents) to Austria's total greenhouse gas emissions in the year 2013. This is 25.8% of total GHG emissions of the sector agriculture.

The trend of N_2O emissions from this category is decreasing: in 2013 emissions were 14.5% below 1990 levels.

Table 176 presents N_2O emissions of agricultural soils by sub-category as well as their trends and their share in total N_2O emissions.

Table 176: N_2O emissions from agricultural soils, 1990–2013.

	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**	**3.D.b Indirect Soil Emissions**	**Athm. Deposition**	**Nitrogen Leaching and run-off**
1990	6.88	5.76	2.15	2.32	2.30	0.02	0.00	0.50	0.79	1.12	0.49	0.63
1991	7.23	6.07	2.52	2.30	2.27	0.02	0.00	0.48	0.77	1.16	0.50	0.67
1992	6.59	5.51	2.13	2.24	2.21	0.02	0.00	0.45	0.69	1.08	0.48	0.60
1993	6.11	5.08	1.69	2.27	2.24	0.03	0.01	0.44	0.68	1.03	0.47	0.56
1994	6.92	5.79	2.36	2.28	2.24	0.02	0.02	0.43	0.71	1.13	0.49	0.64
1995	7.04	5.89	2.40	2.33	2.29	0.03	0.02	0.44	0.72	1.15	0.50	0.65
1996	6.52	5.44	1.99	2.30	2.25	0.03	0.02	0.42	0.73	1.08	0.48	0.60
1997	6.65	5.55	2.02	2.29	2.24	0.03	0.03	0.41	0.83	1.10	0.49	0.61
1998	6.66	5.56	2.04	2.30	2.24	0.03	0.03	0.39	0.83	1.10	0.49	0.61
1999	6.52	5.44	1.94	2.26	2.19	0.03	0.04	0.37	0.87	1.08	0.48	0.60
2000	6.36	5.30	1.89	2.24	2.16	0.03	0.05	0.36	0.81	1.05	0.47	0.59
2001	6.37	5.32	1.88	2.24	2.16	0.03	0.06	0.34	0.86	1.05	0.46	0.59
2002	6.35	5.31	1.92	2.20	2.12	0.02	0.06	0.32	0.86	1.04	0.46	0.59
2003	6.06	5.04	1.74	2.20	2.10	0.02	0.07	0.31	0.79	1.01	0.45	0.56
2004	5.95	4.95	1.53	2.18	2.09	0.02	0.07	0.30	0.93	1.00	0.45	0.55
2005	5.92	4.92	1.58	2.17	2.08	0.02	0.08	0.29	0.89	1.00	0.45	0.55
2006	5.89	4.90	1.60	2.18	2.07	0.02	0.08	0.27	0.85	1.00	0.45	0.54
2007	5.92	4.91	1.63	2.21	2.10	0.02	0.09	0.26	0.81	1.01	0.46	0.55
2008	6.30	5.25	1.87	2.20	2.08	0.02	0.10	0.25	0.93	1.05	0.47	0.59
2009	6.14	5.09	1.73	2.25	2.11	0.02	0.12	0.25	0.86	1.05	0.48	0.57
2010	5.70	4.71	1.39	2.24	2.10	0.03	0.11	0.25	0.83	0.99	0.47	0.52
2011	6.05	5.03	1.63	2.20	2.07	0.03	0.11	0.25	0.95	1.03	0.46	0.56
2012	5.96	4.94	1.69	2.19	2.06	0.03	0.11	0.24	0.82	1.02	0.47	0.55
2013	5.88	4.87	1.65	2.18	2.05	0.02	0.11	0.24	0.80	1.01	0.47	0.54
Share 2013	*100%*	*82.8%*	*28.0%*	*37.1%*	*34.9%*	*0.4%*	*1.8%*	*4.1%*	*13.6%*	*17.2%*	*7.9%*	*9.2%*
90–13	*-14.5%*	*-15.4%*	*-23.4%*	*-5.9%*	*-10.7%*	*21.1%*	*3786.6%*	*-51.8%*	*1.3%*	*-10.0%*	*-5.1%*	*-12.4%*

5.4.2 Methodological Issues

Austria uses IPCC Tier 1 and country specific methodologies for the calculation of N_2O emissions from agricultural soils. In response to recommendations of the ERT (ARR 2013, para 51 and 52) additional descriptions of the Austrian N-flow model have been included since NIR 2014 (see Annex 6).

Table 177: N_2O emission factors for agricultural soils.

Category	Emission Factor [t N_2O-N/t 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 (Pasture, range paddock)	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)
3.D.b Indirect N_2O Emissions from managed soils		
1. Atmospheric deposition	0.01/t of volatized nitrogen	IPCC 2006 GL (Table 11.3)
2. Nitrogen leaching (and run-off)	0.0075/t N-loss by leaching	IPCC 2006 GL (Table 11.3)

3.D.a.5 Mineralization/immobilization associated with loss/gain of soil organic matter

Nitrogen input from mineralisation in agriculturally used areas remaining in the same type of land use do not occur in Austria, as an increase in the carbon stock over the whole time series could be found (Umweltbundesamt, 2012).

3.D.a.6 Cultivation of organic soils (i.e. histosols)

Cultivation of organic soils is not occurring in Austria („NO"). There are no annually cultivated organic soils in the Austrian grassland area. Assessments of the Austrian agricultural soil inventories showed that there is no cropland on organic soils in Austria.

Activity Data

Data for necessary input parameters (activity data) were taken from the following sources:

Table 178: Data sources for nitrogen input to agricultural soils.

Category	Activity Data Sources
3.D.a Direct soil emissions	
Inorganic N fertilizers (mineral fertilizers)	Mineral fertilizer consumption: Grüne Berichte (BMLFUW 2000–2014)[1]. Urea application: data from Ministry of Agriculture and expert judgement based on sales data (RWA – Raiffeisen Ware Austria)
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 2011b, 2013a)
Other organic fertilizers applied to soils	Energy crops from biogas plants: Ökostrombericht 2008, 2011; raw material balance for 2011 (E-Control 2008, 2011, 2013)
Urine and dung deposited by grazing animals	Calculations within source category 3.B
Crop residues	Harvest amounts of agricultural crops (BMLFUW 2000–2014) [1]
3.D.b Indirect soil emissions	
Atmospheric deposition	Amount of manure left for spreading calculated within source category *3.B*. Mineral fertilizer data: (BMLFUW 2000–2014)
Nitrogen leaching (and run-off)	see above (synthetic fertilizers, animal waste, sewage sludge)

[1] *www.gruenerbericht.at and http://www.awi.bmlf.gv.at*

Mineral fertilizer application

Data about the total mineral fertilizer consumption are available for amounts (but not for fertilizer types) from the statistical office (Statistik Austria) and from an agricultural marketing association (Agrarmarkt Austria, AMA).

Detailed data of different kind of fertilizers are available until 1994, because until then, a fertilizer tax („Düngemittelabgabe") had been collected. For the years 1994 to 2012 annual sales figures about urea are available from Austria's leading fertilizer trading firm (RWA). Urea fertilizer data for 2013 was provided by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management.

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. Not the whole amount purchased is applied in the year of purchase. The fertilizer tax intensified this effect at the beginning of the 1990ies. Considering this effect, the arithmetic average of each two years is used as fertilizer application data.

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. In the centralized review 2008 the use of fertilizer sales data was considered as an appropriate alternative (ARR 2008, para 50).

The time series for fertilizer consumption is presented in Table 179.

Table 179: Mineral fertilizer N consumption in Austria 1990–2013 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, RWA	120 550	5 328
2001	117 100	3 329	GB, RWA	119 350	3 589
2002	127 600	4 470	GB, RWA	122 350	3 900
2003	94 400	6 506	GB, RWA	111 000	5 488
2004	100 800	7 293	GB, RWA	97 600	6 900
2005	99 700	7 673	GB, RWA	100 250	7 483
2006	103 700	11 310	GB, RWA	101 700	9 491
2007	103 300	11 500	GB, RWA	103 500	11 405
2008	134 400	9 568	GB, RWA	118 850	10 534
2009	86 300	18 400	GB, RWA	110 350	13 984
2010	90 629	6 500	GB, RWA	88 465	12 450
2011	116 751	16 867	GB, RWA	103 690	11 683
2012	97 721	10 733	GB, RWA	107 236	13 800
2013	112 005	16 638	GB, BMLFUW	104 863	13 685

*GB: (BMLFUW 2000–2014): **www.gruenerbericht.at***

RWA: Raiffeisen Ware Austria, sales company

BMLFUW: Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft

Legume cropping areas

The yearly numbers of the legume cropping areas were taken from official statistics (BMLFUW 2000–2014) and (Statistik Austria).

Table 180: Cropped area legume production and others, 1990–2013.

				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	4 154	106 080	16 525	59 169	300 969
2011	11 715	38 123	6 028	104 800	17 162	58 534	303 121
2012	10 704	37 126	6 852	104 808	18 046	56 794	301 810
2013	7 248	42 027	6 194	101 861	17 326	60 087	285 509

** value for 1990 is interpolated as no data is available*

*** (BMLFUW 2000-2014), 1991-1994 and 1996 (STATSTIK AUSTRIA 1990-2014)*

**** greening variants A+B+C+D (BMLFUW 2000-2014). Only small amounts before 1995*

Harvest Data

Harvest data were taken from (BMLFUW 2000–2014) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT 2014) and are presented in Table 181.

Table 181: Harvest Data I, 1990–2013.

				Harvest [1 000 t]				
Year	**corn**	**wheat**	**rye**	**barley**	**oats**	**maize (corn)**	**potato**	**sugar beet**	**fodder beet**
1990	5 290	1 404	396	1 521	244	1 620	794	2 494	171
1991	5 045	1 375	350	1 427	226	1 571	790	2 522	173
1992	4 323	1 325	278	1 342	185	1 118	738	2 605	119
1993	4 206	1 018	292	1 100	191	1 524	886	2 994	129

Harvest [1 000 t]									
Year	corn	wheat	rye	barley	oats	maize (corn)	potato	sugar beet	fodder beet
1994	4 436	1 255	319	1 184	172	1 421	594	2 561	103
1995	4 452	1 301	314	1 065	162	1 474	724	2 886	85
1996	4 493	1 240	156	1 083	153	1 736	769	3 131	62
1997	5 009	1 352	207	1 258	197	1 842	677	3 012	59
1998	4 771	1 342	236	1 212	164	1 646	647	3 314	72
1999	4 806	1 416	218	1 153	152	1 700	712	3 217	70
2000	4 490	1 313	183	855	118	1 852	695	2 634	47
2001	4 827	1 508	214	1 012	128	1 771	695	2 773	43
2002	4 745	1 434	171	861	117	1 956	684	3 043	40
2003	4 246	1 191	133	882	129	1 708	560	2 485	33
2004	5 295	1 719	213	1 007	139	1 945	693	2 902	33
2005	4 880	1 453	164	880	128	2 021	763	3 133	17
2006	4 440	1 396	94	914	131	1 746	655	2 493	22
2007	4 732	1 399	189	811	99	1 995	669	2 739	15
2008	5 714	1 690	219	968	108	2 449	757	3 091	14
2009	5 105	1 523	184	835	109	2 169	722	3 083	13
2010	4 776	1 518	161	778	98	1 956	672	3 132	11
2011	5 669	1 782	202	859	110	2 453	816	3 456	12
2012	4 839	1 275	205	662	93	2 351	665	3 114	10
2013	4 545	1 598	235	734	87	1 639	604	3 437	8

Table 182: Harvest Data II, 1990–2013.

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

				Harvest [1 000 t]					
Year	silo-green maize	clover-hey	rape	Sun-flower	soja bean	horse-/fodder bean	peas	vege-tables	oil pumkin
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

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 2011b, 2013a, 2014a).

Table 183: Amount of sewage sludge (dry matter) produced in Austria, 1990–2013.

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied sewage sludge N [Mg N]
1990	161 936	31 507	19.5	1 231.52
1991	161 936	31 507	19.5	1 231.52
1992	200 000	30 000	15.0	1 170.00
1993	300 000	45 000	15.0	1 755.00
1994	350 000	38 500	11.0	1 501.50
1995	390 500	42 400	10.9	1 653.92
1996	390 500	42 955	11.0	1 675.25
1997	390 500	42 955	11.0	1 675.25
1998	392 909	43 220	11.0	1 685.58
1999	392 909	43 220	11.0	1 685.58
2000	392 909	43 220	11.0	1 685.58
2001	398 800	41 600	10.4	1 622.40
2002	322 096	36 065	11.2	1 406.55
2003	315 130	39 186	12.4	1 528.26
2004	294 942	35 357	12.0	1 378.93
2005	290 110	35 541	12.3	1 386.11
2006	241 364	39 369	16.3	1 535.37
2007	245 202	40 713	16.6	1 587.80
2008	248 169	39 247	15.8	1 530.62
2009	252 181	39 945	15.8	1 557.85

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied sewage sludge N [Mg N]
2010	262 805	44 354	16.9	1 729.80
2011	265 962	43 796	16.5	1 708.04
2012	266 949	41 487	15.5	1 617.99
2013	238 273	38 231	16.0	1 491.02

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*. 82.8% (4.87 kt in 2013) of N_2O emissions from agricultural soils arise from this sub-category (see Table 176).

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.

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 179)

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) 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 184: Animal manure left for spreading on agricultural soils per livestock category 1990–2013 (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	146 243	55 846	2 614	51 083	8 888	19 293
1991	144 665	54 328	3 190	50 556	8 762	19 048
1992	140 902	53 027	3 368	47 580	8 954	19 493
1993	142 592	52 619	3 864	47 860	9 189	19 994
1994	142 729	52 404	5 021	47 500	9 159	19 536
1995	145 489	48 696	11 751	47 090	9 306	19 462
1996	143 293	48 508	11 884	45 606	9 234	19 107
1997	142 634	50 896	9 535	44 221	9 208	19 276
1998	142 786	52 409	8 632	43 411	8 938	20 341
1999	139 585	51 082	9 892	43 181	7 951	18 448
2000	137 553	46 299	14 162	42 921	7 726	17 917
2001	137 282	45 564	14 447	42 034	8 089	18 435

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
2002	134 798	45 444	13 738	41 244	7 873	17 838
2003	133 935	43 828	13 641	42 366	7 714	17 674
2004	132 997	43 075	14 682	42 380	7 311	16 779
2005	132 156	42 857	15 125	40 670	7 277	17 421
2006	131 858	42 924	15 113	40 640	7 413	16 994
2007	133 459	43 207	15 055	40 694	7 329	18 121
2008	132 161	44 077	14 726	40 589	6 852	16 901
2009	134 060	44 341	14 621	41 788	6 762	17 402
2010	133 756	44 452	14 418	41 643	6 550	17 414
2011	131 780	44 523	14 195	40 623	6 347	16 798
2012	130 796	44 954	13 731	40 024	6 056	16 714
2013	130 638	45 658	13 079	40 429	5 853	16 344

Table 185: Animal manure left for spreading on agricultural soils per livestock category 1990–2013 (II).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	poultry	sheep	goats	horses/solipeds	deer
1990	146 243	5 371	1 576	178	1 318	75
1991	144 665	5 303	1 658	195	1 549	76
1992	140 902	4 984	1 586	188	1 645	76
1993	142 592	5 327	1 697	226	1 740	76
1994	142 729	5 266	1 740	238	1 789	77
1995	145 489	5 043	1 857	259	1 943	82
1996	143 293	4 711	1 937	260	1 963	84
1997	142 634	5 166	1 951	279	1 988	114
1998	142 786	4 841	1 835	259	2 019	102
1999	139 585	4 698	1 791	277	2 186	79
2000	137 553	4 232	1 725	268	2 223	81
2001	137 282	4 458	1 629	284	2 260	82
2002	134 798	4 458	1 548	276	2 297	83
2003	133 935	4 378	1 655	261	2 334	84
2004	132 997	4 443	1 664	265	2 313	86
2005	132 156	4 507	1 656	263	2 292	87
2006	131 858	4 572	1 588	254	2 271	89
2007	133 459	4 636	1 786	289	2 251	91
2008	132 161	4 700	1 694	298	2 230	93
2009	134 060	4 765	1 753	326	2 209	95
2010	133 756	4 829	1 822	343	2 188	97
2011	131 780	4 829	1 837	345	2 188	97
2012	130 796	4 829	1 854	350	2 188	97
2013	130 638	4 829	1 817	344	2 188	97

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 2015 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution" (UMWELTBUNDESAMT 2015). 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 2013).

NH_3 emissions from housing (cattle and swine)

Table 186 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 186: 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
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 187.

Table 187: 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 188: 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 189 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[66] group and published in (REIDY et al. 2008, 2009).

Table 189: 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 2013). Table 190 presents the recommended ammonia default emission factors and associated parameters for the different livestock categories given in the EMEP/EEA guidelines (EEA 2013).

[66] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

Table 190: 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	0.34(**)	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 2003-2013*

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 factors per animal category as outlined in the EMEP/ EEA emission inventory guidebook 2013, Table 3-2.

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 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 2013 N_2O emissions from sewage sludge contributed only 0.2% 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 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 183)*

The annual agricultural consumption of sewage sludge is presented in Table 183.

Other organic fertilizers applied to soils (energy crops from biogas plants)

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.

Activity data

The calculation of N from anaerobically digested energy crops was done for the years 2007, 2009 and 2011 on the basis of three detailed raw material and energy balances reported by E-Control (E-CONTROL 2008, 2011 & 2013).

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 for the years before 2007 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) in 2007. N amounts of digested energy crops for the years 2008 and 2010 were calculated by interpolation. For 2012 and 2013 the share of 2011 was used.

Table 191: N from biogas slurry (vegetable part)

Year	manure anaerobically digested [kg N year^{-1}]	N from biogas slurry [kg N year^{-1}]
1990	49 840	175 293
1991	67 837	238 589
1992	75 303	264 850
1993	100 154	352 251
1994	283 275	996 309
1995	327 613	1 152 251
1996	359 014	1 262 692
1997	460 707	1 620 357
1998	546 005	1 920 361
1999	752 947	2 648 198
2000	871 032	3 063 517

Year	manure anaerobically digested [kg N year^{-1}]	N from biogas slurry [kg N year^{-1}]
2001	996 191	3 503 715
2002	1 108 080	3 897 238
2003	1 209 113	4 252 582
2004	1 296 492	4 559 906
2005	1 365 534	4 802 732
2006	1 429 936	5 029 242
2007	1 577 004	5 546 496
2008	1 610 693	6 478 924
2009	1 635 722	7 614 425
2010	1 660 440	7 100 952
2011	1 694 441	6 685 428
2012	1 713 829	6 761 925
2013	1 726 782	6 813 029

Methodology

The method applied for the calculation of the emissions is IPCC Tier 1 with a default emission factor of 1.0% N_2O-N per kg N input to agricultural soils.

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 192*

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 192: Nitrogen excreted during grazing on pasture, range and paddock (N_{exPRP}) 1990–2013.

Year	N excretion grazing [Mg]	Year	N excretion grazing [Mg]
1990	17 458	2002	12 078
1991	16 979	2003	11 770
1992	15 906	2004	11 524
1993	15 850	2005	11 020
1994	15 513	2006	10 476
1995	15 910	2007	10 328
1996	15 461	2008	9 777
1997	15 069	2009	9 902
1998	14 245	2010	9 962
1999	13 762	2011	9 912
2000	13 480	2012	9 832
2001	12 820	2013	9 692

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) already considered in previous submissions the following new sources are included in inventory submission 2015:

- N from other forage crops on arable land
- N from meadows ("seeded pastures") ploughed every five years
- N from crop residues of 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 forage crops on arable land

Activity data on other forage crop area renewed annually was taken from the Green Reports (BMLFUW 2000-2014).

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).

Calculations in line with the 2006 IPCC GL using the default values for forages on arable land result in an amount of 53 kg N input to soils per ha and year of ploughing.

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 2000-2014). 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).

Calculations in line with the 2006 IPCC GL using the default values for forages on arable land result in an amount of 53 kg N input to soils per ha and year of ploughing (which equals to 13.3 kg N in each year average).

N from crop residues of cover crops

Cover crops have lower dry matter yields but a higher N content and therefore result in higher amounts of N input than the forages on arable land (seeded pastures, "Wechselwiesen").

N input amount (20kg 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 the Green Reports of BMLFUW.

Methodology

Austria uses the 2006 IPCC Tier 1 methodology for emission calculation.

Applied parameters are presented in the following table:

Table 193: 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**
Wheat*	1.09	0.88	0.006	0.22	0.009	0.88
Rye	1.09	0.88	0.005	0.25	0.011	0.88
Barley	0.98	0.59	0.007	0.22	0.014	0.89
Oats	0.91	0.89	0.007	0.25	0.008	0.89
Maize (corn)	1.03	0.61	0.006	0.22	0.007	0.87
Potato	0.1	1.06	0.019	0.2	0.014	0.22
Sugarbeet	0.1	1.06	0.019	0.2	0.014	0.45
Fodderbeet	0.1	1.06	0.019	0.2	0.014	0.20
Maize (silo)	1.03	0.61	0.006	0.22	0.007	0.30
Clover-hay	0.29	0	0.027	0.4	0.019	0.86
Rape	1.13	0.85	0.008	0.19	0.008	0.86
Sunflower	1.13	0.85	0.008	0.19	0.008	0.86
Sojabean	0.93	1.35	0.008	0.19	0.008	0.91
Fodderbean	1.13	0.85	0.008	0.19	0.008	0.90
Peas	1.13	0.85	0.008	0.19	0.008	0.90
Vegetables	1.07	1.54	0.016	0.20	0.014	0.20
Oil pumpkin	1.07	1.54	0.016	0.20	0.014	0.80
Other forages	0.30		0.018	0.505	0.0145	1.00
Meadows ploughed every four years	0.30		0.018	0.505	0.0145	1.00

**IPCC default for "grains" chosen, as wheat data do not fit to Austrian conditions*

Activity data

Harvest data were taken from (BMLFUW 2000–2013) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT 2013) and are presented in Table 181 and Table 182. Legume cropping areas were taken from official statistics (BMLFUW 2000–2014) and (STATISTIK AUSTRIA, 1990-2014) and can be found in Table 180.

5.4.2.2 Indirect soil emissions (3.D.b)

Key Source: Yes (N_2O)

According to 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 179)

$Frac_{GASF}$ = 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)

Table 194: NH_3-N and NO_x-N volatilisation losses from synthetic fertilizers and organic N fertilizers (including grazing) 1990 to 2013.

Year	N losses mineral fertilizer (incl. urea)	N losses from applied organic N fertilizer materials and grazing
	[Mg N/yr]	[Mg N/yr]
1990	3 516	27 826
1991	4 204	27 547
1992	3 633	26 754
1993	2 949	27 249
1994	4 006	27 284
1995	4 168	27 682
1996	3 550	27 223
1997	3 674	27 219
1998	3 819	27 205
1999	3 702	26 747
2000	3 465	26 232

Year	N losses mineral fertilizer (incl. urea)	N losses from applied organic N fertilizer materials and grazing
	[Mg N/yr]	[Mg N/yr]
2001	3 212	26 193
2002	3 321	25 754
2003	3 266	25 675
2004	3 142	25 481
2005	3 279	25 316
2006	3 573	25 272
2007	3 863	25 658
2008	4 103	25 564
2009	4 356	26 164
2010	3 653	26 069
2011	3 904	25 638
2012	4 260	25 470
2013	4 191	25 445

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 2015 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution' (UMWELTBUNDESAMT 2015).

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/CORINAIR Emission Inventory Guidebook (EEA 2007). For the calculation of NH_3-N losses from synthetic fertilizers the CORINAIR 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 CORINAIR default value of 0.15 t NH_3-N per ton of fertilizer-N was 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 t NH_3-N per ton of fertilizer-N is applied for fertilizers other than urea (STREBL et al. 2003).

For the calculation of NO_x-N losses the CORINAIR simple methodology is applied. Emissions are calculated as a fixed percentage of total fertilizer nitrogen applied to soil. For all mineral fertilizer types the CORINAIR recommended emission factor of 0.3% (i.e. 0.003 t NO_x-N per ton applied fertilizer-N) is used (EEA 2007).

NH_3-N volatilization losses occurring during manure application

CORINAIR default NH_3 emission factors for spreading of slurry and farmyard manure (expressed as share of TAN) have been applied:

Table 195: 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 196 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 196: 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

NO_x-N-losses were estimated using a conservative emission factor of 1% of animal manure and sewage sludge nitrogen (FREIBAUER & KALTSCHMITT 2001).

NH_3-N and NO_x-N volatilization losses from sewage sludge application

For the calculation of NH_3-N emissions the CORINAIR default emission factor for slurry spreading (0.15 kg NH_3-N per kg sewage sludge N) was applied (EEA 2007).

NO_x-N losses were estimated using the conservative emission factor of 1% of sewage sludge nitrogen (FREIBAUER & KALTSCHMITT 2001).

NH_3-N and NO_x-N volatilization losses from biogas slurry application (energy corn)

NH_3-N and NO_x-N volatilization losses from energy crops that are digested in biogas plants and applied to soils as fertilizer after the digestion process (biogas slurry) were estimated by using the IPCC default value of $Frac_{GASM}$ of 0.2 (2006 IPCC GL, Table 11.3) for organic N fertilizers.

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 $Frac_{LEACH}$.

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 179)

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[67] 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 by validation of the software tool (calculation sheets) for the new and revised source (e.g. crop residues, energy crops) − in progress (2015)

Sector specific routine control procedures are provided in chapter 5.1.4.

5.4.4 Uncertainties

Uncertainties are presented in Table 140.

[67] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

5.4.5 Recalculations

Update of activity data

Other organic fertilizers applied to soils (CRF 3.D.a.2.c)

In addition to N from digested animal manure, which has been already accounted for in previous submissions, this revision implements additional N inputs from energy crops that are digested in biogas plants, and applied to soils as fertilizer after the digestion process (biogas slurry). This update resulted in additional N_2O emissions of 107 tonnes in 2013.

Crop Residues (CRF 3.D.a.4)

Direct N_2O emissions from plant residues left on the fields and mineralized (after incorporation). In contrast to the 1996 IPCC Guidelines, the new 2006 IPCC Guidelines account for the nitrogen of both, above and below ground biomass.

The estimation of N from crop residues is now covering the following sources:

(a) residues from harvest crops which have already been considered in the previous National Inventory, and additionally

(b) N from legume crops in rotations on arable land

(c) N from meadows ploughed every few years

(d) N from crop residues of cover crops

The source category 'N-fixing crops' has been removed as a direct source of N_2O. Anyhow, the N in crop residues of N-fixing crops has to be accounted for under 'crop residues'.

Improvements of methodologies and emission factors

Direct soil emissions – N_2O

According to the 1996 IPCC Guidelines all N_2O emissions were calculated from N applied to soils after subtraction of volatile losses through NH_3-N and NO_x-N during and after application. 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 a consequence, the IPCC default emission factor was reduced to 0.01 kg N_2O-N per kg N applied to soils. Revised calculations led to a decrease in N_2O emissions (-0.9 kt in 2012).

Indirect soil emissions – 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. In the IPCC 2006 Guidelines the overall value for the emission factor for leached N has been changed from 0.025 to 0.0075 kg N_2O–N/kg N leached. Furthermore, Austria introduced a national value for $Frac_{Leach}$, which was reduced from 0.30 (default factor) to 0.15154.

Due to the already explained revisions and the reallocation of nitrogen volatilized in housing and storage to sector manure management (3.B.5) according to the 2006 IPCC GL, indirect N_2O emissions from agricultural soils decreased significantly (-2.7 kt in 2012).

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 2013 total emissions from this category amounted to 0.66 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 2013 are presented in Table 197.

Table 197: Emissions from field burning (3.F) 1990–2013.

Year	CH_4	N_2O
1990	0.06	0.001
1991	0.05	0.001
1992	0.06	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	0.05	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	0.000
2012	0.02	0.000
2013	0.02	0.000
Trend 1990–2013	***-59.5%***	***-67.6%***
Share in Agriculture	***0.01%***	***0.004%***

5.5.2 Methodological issues

5.5.2.1 Cereals (3.F.1)

Key Source: No

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. The values of the carbon fraction were taken from IPCC GPG Table 4-16. For fraction oxidised a default value of 0.90 was used. Dry matter fraction and residue/crop product ratio are presented in section 'crop residues' (see Table 193).

According to the *Presidential Conference of the Austrian Chambers of Agriculture* (personal communication to Mag. Längauer), in Austria about 477 ha were burnt in 2013. This value corresponds to about 0.1% of the relevant cereal area in 2013.

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) are taken from (STATISTIK AUSTRIA 1990-2014). 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 198: Activity data for field burning of agricultural residues 1990–2013.

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	55 628	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
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	49 704	3 728
2009	45 533	3 415
2010	45 533	3 415
2011	45 462	3 410
2012	45 391	3 404
2013	45 320	3 399

The emission factors (4 828 g CH_4/Mg and 49.7 g N_2O/Mg 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

Emissions of this source category were slightly revised compared to last year´s submission due to an update of activity data (viniculture area) for the whole time series 1990-2013.

5.6 Liming (Category 3.G)

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 199: Emissions from Liming (3.G) 1990–2013.

Year	CO_2 emissions [Mg]
1990	89 972
1991	91 146
1992	91 173
1993	90 815
1994	91 346
1995	91 854
1996	92 047
1997	92 082
1998	91 079
1999	90 873
2000	90 347
2001	90 263
2002	90 221
2003	90 093
2004	90 191
2005	91 193
2006	89 345
2007	89 053
2008	88 030
2009	87 687
2010	87 633
2011	86 842
2012	86 334
2013	86 359
Trend 1990–2013	*-4.0%*
Share in Agriculture	*80.1%*

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 Agriculture, Forestry, Environment and Water).

Table 200: 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	1 425 584	886 354	2 311 938
1992	1 416 935	895 683	2 312 618
1993	1 398 526	905 013	2 303 539
1994	1 401 693	915 331	2 317 024
1995	1 404 248	925 649	2 329 897
1996	1 402 817	931 984	2 334 801
1997	1 397 357	938 318	2 335 675
1998	1 386 210	924 036	2 310 246
1999	1 395 274	909 754	2 305 028
2000	1 381 996	909 667	2 291 663
2001	1 379 955	909 581	2 289 536
2002	1 378 983	909 494	2 288 477
2003	1 375 823	909 407	2 285 230
2004	1 379 069	908 656	2 287 725
2005	1 405 234	907 904	2 313 138
2006	1 377 251	889 008	2 266 259
2007	1 388 741	870 112	2 258 853
2008	1 369 021	863 879	2 232 900
2009	1 366 570	857 645	2 224 215
2010	1 371 428	851 412	2 222 840
2011	1 359 686	843 095	2 202 781
2012	1 355 115	834 779	2 189 893
2013	1 364 057	826 462	2 190 519

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 201: 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	570 234	354 541	924 775
1992	566 774	358 273	925 047
1993	559 410	362 005	921 416
1994	560 677	366 132	926 810
1995	561 699	370 260	931 959
1996	561 127	372 793	933 920
1997	558 943	375 327	934 270
1998	554 484	369 614	924 098
1999	558 110	363 902	922 011
2000	552 798	363 867	916 665
2001	551 982	363 832	915 814
2002	551 593	363 798	915 391
2003	550 329	363 763	914 092
2004	551 628	363 462	915 090
2005	562 094	363 162	925 255
2006	550 900	355 603	906 504
2007	555 496	348 045	903 541
2008	547 608	345 551	893 160
2009	546 628	343 058	889 686
2010	548 571	340 565	889 136
2011	543 874	337 238	881 112
2012	542 046	333 911	875 957
2013	545 623	330 585	876 208

Methodology

The Tier 1 methodology following equation 11.12 (IPCC 2006) for calculating the CO_2 emissions has been applied.

$$CO_2\text{–C Emission} = (M_{Limestone} \bullet EF_{Limestone})$$

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.

5.7 Urea Application (Category 3.H)

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 202: Emissions from Urea Application (3.H) 1990–2013.

Year	CO_2 emissions [Mg]
1990	4 451
1991	6 231
1992	6 169
1993	5 786
1994	6 596
1995	7 948
1996	7 698
1997	8 674
1998	10 120
1999	10 409
2000	8 373
2001	5 639
2002	6 128
2003	8 624
2004	10 842
2005	11 759
2006	14 915
2007	17 922
2008	16 553
2009	21 975
2010	19 564
2011	18 360

Year	CO_2 emissions [Mg]
2012	21 686
2013	21 506
Trend 1990–2013	*383.2%*
Share in Agriculture	*19.9%*

5.7.2 Methodological issues

For the CO_2-C emissions from urea usage, the IPCC 2006 Tier 1 methodology is applied using equation 11.13. The amount of urea used is multiplied with an emission factor. The default emission factor of 0.20 for urea, which is equivalent to the carbon content of urea on an atomic weight basis (20% for $CO(NH_2)_2$), is applied.

$$CO_2-C\ Emission = M \cdot EF$$

CO_2–C Emission = annual C emissions from urea application, tonnes C yr-1

M = annual amount of urea fertilisation, tonnes urea yr-1

EF = emission factor, tonne of C (tonne of urea)-1

Activity Data

The activity data taken for the amount of urea used in agriculture are the same as used for the calculation of N containing emissions (see Table 179).

Table 203: Urea used in agriculture

Year	Weighted Urea Consumption [t N/yr]	Urea used in agriculture [t UREA/yr]
1990	2 833	6 070
1991	3 965	8 496
1992	3 926	8 412
1993	3 682	7 890
1994	4 198	8 995
1995	5 058	10 838
1996	4 899	10 498
1997	5 520	11 829
1998	6 440	13 800
1999	6 624	14 194
2000	5 328	11 417
2001	3 589	7 690
2002	3 900	8 356
2003	5 488	11 760
2004	6 900	14 785
2005	7 483	16 035
2006	9 491	20 338
2007	11 405	24 439
2008	10 534	22 573

Year	Weighted Urea Consumption [t N/yr]	Urea used in agriculture [t UREA/yr]
2009	13 984	29 966
2010	12 450	26 679
2011	11 683	25 036
2012	13 800	29 571
2013	13 685	29 326

RWA: Raiffeisen Ware Austria, sales company

5.7.3 Source specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.7.4 Recalculations

There have not been carried out any recalculations as this source category is reported for the first time.

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.

Table 204 presents emissions and removals from this sector by sub categories.

Table 204: Emissions and removals (+/-) from Sector 4 LULUCF by sub-categories[1)] in Gg CO_2 equivalents.

Year	Greenhouse gas emissions/removals [Gg CO_2 equivalent]							
	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	-13 042	-10 929	-54	324	42	385	444	-3 253
1991	-17 684	-16 659	-54	319	42	388	454	-2 174
1992	-12 721	-11 896	-48	314	42	391	463	-1 988
1993	-13 071	-12 368	-41	309	42	395	473	-1 880
1994	-12 986	-11 304	-26	309	42	392	473	-2 872
1995	-14 119	-12 284	-4	142	36	337	375	-2 721
1996	-11 562	-9 265	17	144	36	333	371	-3 198
1997	-19 927	-18 016	38	145	36	328	368	-2 826
1998	-18 047	-16 200	62	147	36	323	364	-2 778
1999	-20 167	-19 118	72	147	36	321	365	-1 990
2000	-16 888	-16 028	78	147	36	319	366	-1 805
2001	-19 610	-17 980	92	146	36	317	367	-2 588
2002	-14 760	-12 284	117	354	47	401	334	-3 728
2003	-5 331	-2 292	117	352	47	405	335	-4 296
2004	-9 674	-7 373	110	352	47	401	327	-3 539
2005	-11 142	-8 825	104	353	37	398	319	-3 529
2006	-5 806	-3 010	111	354	39	376	311	-3 987
2007	-5 942	-1 982	124	357	51	410	303	-5 205
2008	-4 747	-1 088	159	348	49	443	295	-4 953
2009	-4 688	-4 524	145	49	69	282	211	-920
2010	-6 167	-4 490	132	46	73	261	203	-2 392
2011	-6 439	-4 455	129	49	70	269	196	-2 697
2012	-6 016	-4 421	137	45	75	135	188	-2 175
2013	-4 978	-4 386	150	50	78	215	181	-1 266
1990-2013	***-61.8***	***-59.9***	***-376.3***	***-84.5***	***85.4***	***-44.1***	***-59.3***	***-61.1***

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 204 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 of the subcategory „forest land remaining forest land (*4.A.1*) with related impacts on the totals of the LULUCF sector.

The most important sub category is forest land, in particular its subcategory forest land remaining forest land which is a net sink for CO_2. For the second commitment period (2013-2020), harvested wood products are reported as well. This sub category is the second largest sink for CO_2, whereas the other sub categories are sources of GHG emissions. Total emissions arising from the other sub categories amount to 5–119% of removals from forest land. In the years 2007 and 2008 also the subcategory forest land remaining forest land represents a net emission source.

6.1.1 Emission Trends

In 2013, net removals from sector 4 amount to 4 978 kt CO_2 equivalents which corresponds 6.3% of total GHG in Austria (without LULUCF), compared to 16.6% in 1990. The removals of the LULUCF sector decreased by 61.8% from 1990 to 2013.

The most important sub-category is forest land (*4.A*) with net removals of 4 386 kt CO_2 in 2013, followed by harvested wood products (*4.G*) with net removals of 1 266 kt CO_2. The total emissions from the other sub-categories amount to 654 kt CO_2 in 2013.

The net carbon stock changes in forest biomass (category *4.A.1*) have a major impact on the overall results in sector 4. These changes vary considerable between single years and outliers exist. The reason is that the figures for annual growth and for annual harvest of forest biomass differ significantly year by year due to annual 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). These 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 averages of the last NFI (2007/09) for the forest biomass gains and losses for the estimates of the years 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 of NFI 2000/02. 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 followed and reported in the conversion status for 20 years. After these 20 years they are accounted in the remaining categories.

6.1.2 Key Categories

The key category analysis (based on CRF Table 7) is presented in Chapter 1.5. Key sources within this category are shown in Table 205.

Table 205: Key Categories of LULUCF (KCA CRF Table 7).

IPCC Category	Source Categories	Key Sources	
		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.C.2	Land converted to grassland	CO_2	TA
4.E.2	Land converted to settlements	CO_2	TA
4.F.1	Other land remaining other land	CO_2	TA
4.F.2	Land converted to other land	CO_2	TA
4.G	Harvested wood products	CO2	LA; TA

LA = Level Assessment 2013

TA = Trend Assessment 1990–2013

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 6.7. Following the methodology of the actual emission/removal calculations, all land use changes from forest land (which are sub categories of *4.B – 4.F*) are included in the methodological description of land converted to forest land. The next two chapters give a brief overview on the used methods.

6.1.3.1 Activity data

For a complete time series from 1990 to 2013 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 of 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 sub-category „Other land")
- Consistency within and across years in sub-categories
- 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 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 of the National Forest Inventories. For each mean year of an inventory period data on the total forest area are provided, thus the annual data between two consecutive inventories were calculated by linear interpolation. The land use changes from and to forests are based on information from the NFIs. As announced in NIR 2013 a detailed assessment of the ARD activities under Article 3.3 of the Kyoto Protocol was carried out in the years 2011–2013. On the basis of these assessments, also the areas of land use changes to and from forests, the emission factors for those sites and the related estimates of the emissions/removals were revised for the whole time series. For area consistency reasons this led also to an update of activity data (area) in some other LUC subcategories.

Data for the total cropland area are available annually from STATISTIK AUSTRIA (STATISTIK AUSTRIA 1990–2013). Based on the Austrian farm structure surveys (e.g. 1993, 1995, 1999, 2010) STATISTIK AUSTRIA also provides data for the total grassland area. For the years between these surveys data were calculated by linear interpolation. For 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 are protected areas in most Austrian provinces thus these areas are constant since 1990. The changes in the annual water body area were derived from data of the Real Estate Database. Between 1990 and 2004 a mean average increase was calculated, since then annual data are reported.

Based on the regional information of the Real Estate Database, also data for the settlement area are provided annually. As the database is updated by occasion a mean annual increase of the settlement area was calculated for certain time periods (see 6.6). The increases of settlement area derive mainly from grassland and cropland sites.

The area of other land is reported in accordance to the IPCC-GPG. So, other land is understood to be the difference of the area of all other categories and the whole area of Austria in order to avoid double accounting or omission of an area. The LUC areas from forest land to other land are based on the NFIs. The remaining increases in other land across the time series are assumed to origin from grassland.

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 206). 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 annually 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 a quite accuratee picture of the areas of the Austrian land use.

Table 206 presents land use data and data for land use changes for the year 1990 and 2013 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 206: Land use and LUC data for Austria for the years 1990 and 2013.

Area in ha	1990	2013	Diff 1990-2013
5.A Forest land – total area	**3 891 333**	**4 018 500**	**127 167**
1 Forest land remaining forest land – total area	3 631 514	3 861 084	229 570
1.1.a Forest land remaining forest land: coniferous	2 468 466	2 397 858	-70 608
1.1.b Forest land remaining forest land: deciduous	748 475	923 275	174 800
1.1.c Forest land remaining forest land: forest not in yield	414 573	539 950	125 377

Area in ha	1990	2013	Diff 1990-2013
2. Land converted to forest land	259 819	157 416	-102 403
2.1 Cropland converted to forest land	30 962	13 501	-17 462
2.2 Grassland converted to forest land	144 197	82 022	-62 175
2.3 Wetland converted to forest land	12 534	9 808	-2 726
2.4 Settlement converted to forest land	17 122	8 244	-8 878
2.5 Other Land converted to forest land	55 004	43 842	-11 162
5.B Cropland – total area	**1 498 005**	**1 431 444**	**-66 561**
1. Cropland remaining cropland	1 459 067	1 378 725	-80 342
1.a Annual remaining annual and perennial remaining perennial	1 428 952	1 350 239	-78 712
1.b Annual converted to perennial	16 654	15 739	-915
1.c Perennial converted to annual	13 461	12 746	-715
2. Land converted to cropland	38 938	52 719	13 781
2.1 Forest Land converted to cropland	4 125	3 326	-799
2.2 Grassland Land converted to cropland	34 813	49 393	14 580
2.2.a Grassland converted to perennial cropland	1 411	2 001	591
2.2.b Grassland converted to annual cropland	33 402	47 392	13 989
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
5.C. Grassland – total area	**1 714 917**	**1 463 133**	**-251 784**
1. Grassland remaining grassland	1 666 375	1 406 349	-260 026
2. Land converted to grassland	48 542	56 784	8 242
2.1 Forest land converted to grassland	32 467	29 578	-2 889
2.2 Cropland converted to grassland	16 074	27 206	11 132
2.2.a annual cropland converted to grassland	15 901	26 924	11 024
2.2.b perennial cropland converted to grassland	174	282	108
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
5 D Wetlands – total area	**133 068**	**149 360**	**16 292**
1. Wetlands remaining wetlands	127 557	124 614	-2 943
2. Land converted to wetlands	5 511	24 746	19 235

Area in ha	1990	2013	Diff 1990-2013
2.1 Forest land converted to wetlands	1 706	2 279	573
2.2 Cropland converted to wetlands	NO	NO	NO
2.3 Grassland converted to wetlands	3 804	22 467	18 662
2.4 Settlement converted to wetlands	NO	NO	NO
2.5 Other land converted to wetlands	NO	NO	NO
5 E Settlements – total area	**386 858**	**543 587**	**156 729**
1. Settlements remaining settlements	237 093	399 024	161 931
2. Land converted to settlements	149 765	144 563	-5 203
2.1 Forest land converted to settlements	9 792	9 122	-670
2.2 Cropland converted to settlements	53 149	63 538	10 390
2.3 Grassland converted to settlements	86 824	71 902	-14 922
2.4 Wetlands converted to settlements	NO	NO	NO
2.5 Other land converted to settlements	NO	NO	NO
5 F Other land – total area	**762 819**	**780 976**	**18 157**
1. Other land remaining other land	744 684	770 126	25 442
2. Land converted to other land	18 134	10 850	-7 285
2.1 Forest land converted to other land	18 134	10 850	-7 285
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 207: 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.

Pools		Description
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 soils.
Soils	Soil organic matter	All organic matter in mineral and organic soils (including peat) to a soil depth of 50 cm (forests, LUC from and to forests) or to a soil depth of 30 cm (all other land uses and LUC).

6.1.3.3 Emission factors

The calculations of the emissions follow to a very large extent the methods described in the IPCC GPG. Wherever possible, higher tiers are used and the emission factors are derived from national data. Austria is consistently closing gaps of national input data for relevant sub-categories 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 and the results of the country-wide soil surveys. Furthermore, specific national studies are available to come up with emission factors for the categories „settlement" 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 1.6).

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 calculations 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:

<u>1) Bottom-up check</u>

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

Step3: 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 of the consistence of the total 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 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 inplausible differences. Documentation of this further check.

6.1.5 Uncertainty Assessment (for LULUCF without HWPs)

For submission 2012 a complete uncertainty analysis for the whole LULUCF sector and time series was carried out by using Monte-Carlo-simulations with the @Risk-Software. For that purpose, the uncertainties of all activity data, emission factors and input parameters for the emission factors were defined. Previously estimated uncertainties on such parameters (as included in previous submissions) were undertaken a critical reassessment and partly revised using related information in the used statistics/literature, in the IPCC GPG and by consultations of experts. For each subcategory a bottom-up analysis of the uncertainties of the estimated emission/removal figures for the subcategory were 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 will 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. Each simulation was run with 10 000 to 100 000 iteration steps.

All single uncertainties of the LULUCF subcategories estimates were merged then to the uncertainty of the total LULUCF sector emissions/removals by Monte-Carlo-simulations.

Uncertainty values in the LULUCF chapter represent (cover) always the range of the 95% confidence interval (the distance of twice the standard deviation from the mean) which is in line with the IPCC GPG.

The uncertainty of the total LULUCF sector emissions/removals is approx. ±19 000 Gg CO_2. This represents on average ±152% 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 (several hundred % up to several thousand %).

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 sub category, 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 following average uncertainties for the single years of the total LULUCF emissions/removals remain: approx. ±5 600 Gg CO_2 (with higher absolute uncertainties in the 90ies due to more uncertain input data in previous years). This represents on average ±53% of the total LULUCF emissions/removals in the years 1990 to 2002. In the years after 2002 with very low net LULUCF emissions/removals the relative uncertainty of the total LULUCF emissions/removals lies accordingly higher, between ±60% and ±2 139%.

So, the inclusion of the litter/soil C pool of *4.A.1* with its high uncertainty impairs significantly the quality of the estimated totals 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). So, no improvement of these estimates can be achieved in the short run; however, significant improvements are very likely after decades, when repeated soil inventories allow a significant 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 sub-category *4.A.1* (which represents emissions of about 2 600 Gg CO_2 per year) constitutes a significant share in the total LULUCF emissions/removals of Austria.

The biomass of *4.A.1* has in most years 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%) has also 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 %) of their total emissions/removals (e.g. grasslands, settlements and other land).

6.1.6 Recalculations

The annual cropland area statistics of „Statistik Austria" are used as activity data for Cropland. They have been recalculated for this submission and are based on a combination of FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System) data. In the years where Farm Structure Surveys were conducted these data were taken: For the years 1990, 1995, 1999 and 2010 (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013) a full Farm Structure Survey (FSS) was conducted and in between there were random sample Farm Structure Surveys undertaken, that is for the years 1993, 1997, 2003, 2005, 2007 and 2013 (ÖSTAT 1994, 1998, STATISTIK AUSTRIA 2005, 2006, 2008, 2014). Since joining the EU in 1995 Austria is committed to run the IACS data base. It covers detailed information on cropland areas (see explanation below).

For the total annual cropland area the data from the FSS differ from the IACS data, in most cases the area in the FSS database is larger, because of the greater number of farms included in FSS compared to IACS. This relationship has been represented by calculating a factor

FSS area for total annual cropland/IACS area for total annual cropland,

which was calculated for the years where FSS has been conducted. For the years between two Farm Structure Surveys the annual cropland area of the IACS database has been adjusted to the FSS area by multiplying it with the factor from the year in which the next FSS has been conducted.

Furthermore for Christmas trees and Energy crops data on roots biomass have been added. By using the root/shoot ration of 0.3 for energy crops (wood), which was derived from the AR-results, also the belowground biomass could be estimated (implementation of planned improvements 4 and 5 of the NIR 2014 (UMWELTBUNDESAMT 2014a).

For Grassland: In the current submission an improvement of areas of alpine pastures was carried out: In the year 2010 new entry conditions for receiving subsidies for alpine pastures were applied in the framework of the Rural Development Programme in Austria. Subsequently improved topographical surveying in the alpine regions was undertaken, allowing better distinction of areas unfit for agricultural use from the actual alpine pasture areas. Due to the new delineation the areas of alpine pasture comprise solely areas of rough grazing (fodder areas) excluding stony patches and unproductive areas covered with shrubs or trees. Subsequently the estimation led to different, reduced areas of alpine pastures. The area dedicated to rough grazing dropped from 470 800 hectares to 362 562 hectares in 2013 (STATISTIK AUSTRIA 2014). The main part of the stony and unproductive areas was relocated to the category "other land" thus reflecting more precisely the real situation. The new determination was finalized in 2013 and the data were published in the Farm Structure Survey 2013 (STATISTIK AUSTRIA 2014). The methodological refinement required a complete recalculation of the historic alpine grassland area to receive a consistent time series: Based on the alpine grassland data of the FSS 2013 a reduction factor was estimated considering the share of areas that shifted to other land and forest land respectively. Subsequently the conversion factor was applied in the years of the FSS 1960, 1970, 1980, 1990, 1999, 2010. Thus the estimated reduced areas reflect the actual area trend over time. The areas of the years between the full Farm Structure Survey were interpolated (implementation of planned improvement 3 of the NIR 2014 (UMWELTBUNDESAMT 2014a).

6.1.7 Completeness

Table 208: IPCC categories according to the IPCC 2006 Guidelines. 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 sub-categories. A „✓" indicates that emissions/removals from this sub-category have been estimated; for LULUCF CO_2 emissions/removals are estimated.

Table 208: IPCC categories according to the IPCC 2006 Guidelines.

IPCC categories[68]/ 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	✓	
	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	✓	
	Carbon stock change in soils	✓	
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	✓	

[68] IPCC categories – applied according to the 2006 IPCC 2006 Guidelines for National Greenhouse Gas Inventories

IPCC categories[68]/ Sub division for calculation	Description	Status for CO_2	Other GHG
	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	✓	
4.C.2	Land converted to grassland	✓	
4.C.2.1	Forest land converted to grassland	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in soils	✓	
4.C.2.2	Cropland converted to grassland	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.C.2.3	Wetland converted to grassland	NO	
4.C.2.4	Settlements converted to grassland	NO	
4.C.2.5	Other land converted to grassland	NO	
4.D	Wetlands	✓	
4.D.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.2.1	Forest land converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.E.2.2	Cropland converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.E.2.3	Grassland converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
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.2.1	Forest land converted to other land	✓	

IPCC categories[68]/ Sub division for calculation	Description	Status for CO_2	Other GHG
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.F.2.2	Cropland converted to other land	NO	
4.F.2.3	Grassland converted to other land	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
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	✓	
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		
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	NO
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

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 2013.

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

There is a steady re-evaluation and substitution of the used input parameters and the applied methods.

The following issues will be considered for future submissions:

- Improvement of estimates for C-stock changes in forests not in yield as recommended by the ERT during the ICR 2013. A new NFI is planned starting in 2016. In this new NFI estimates for forest not in yield will become available.
- Improvement of the values for biomass C-stocks in viticulture and orchards is still on top of the agenda to improve the inventory for this subsector. The default carbon accumulation factor of 2.1 tons C/ha/yr for the derivation of biomass increase, which leads to biomass carbon stock at harvest of 63 t C /ha after a rotation period of 30 years (IPCC 2006, Vol.4, Ch. 5.2.1.2, Table 5.1), is probably too high for Austrian conditions and will be improved with country- and species-specific values when they become available.
- For soil organic carbon in cropland and grassland estimates in a refined time resolution will be prepared.
- The LUCs from cropland and grassland to settlement in year 2012 represent unrealistic outliers. The settlement area data series will be checked and corrected for these outliers in submission 2016.

6.2 Forest land (Category 4.A)

6.2.1 Category description

4.02 Mio ha (47.9%) of Austria are forest land (BFW 2014). There was a steady increase of the standing C stocks in the Austrian forests in the last decades (since the first NFI 1961-70). The sustaining of the Austrian forests in the past helped to restore 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 2000).

Emission/Removal trends of forest land

In Austria, the area of forest land has been constantly increasing in the past (Figure 32). The land converted to forest land categories show a decreasing trend with exception of other land to forest land which is stagnating.

The annual net CO_2 removals under sector 4.A of the reported period 1990–2013[69] range from 1 088 Gg CO_2 to 19 118 Gg CO_2 (mean: 9 633 Gg CO_2). The most important sub-category 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.

2008 is the media year of the last national forest inventory period, which was carried out between 2007 and 2009. For the years since 2008 the means 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 annu-

[69] For the years since 2009 the means for the last period (2007 to 2009) of the National Forest Inventory (NFI) have been reported.

al net carbon sink amounted to 11 081 Gg CO_2 (from 4 324 Gg CO_2 to 16 385 Gg CO_2). Between 1990 and 2013 the net carbon sink of this category ranges between 4% and 23% 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 2013 the total annual net CO_2 removals (biomass and soil) from land use changes to forest range from about 1 825 Gg CO_2 to 3 412 Gg CO_2. The total annual emissions (biomass and soil) from land use changes from forests vary between 539 Gg CO_2 and 1 203 Gg CO_2.

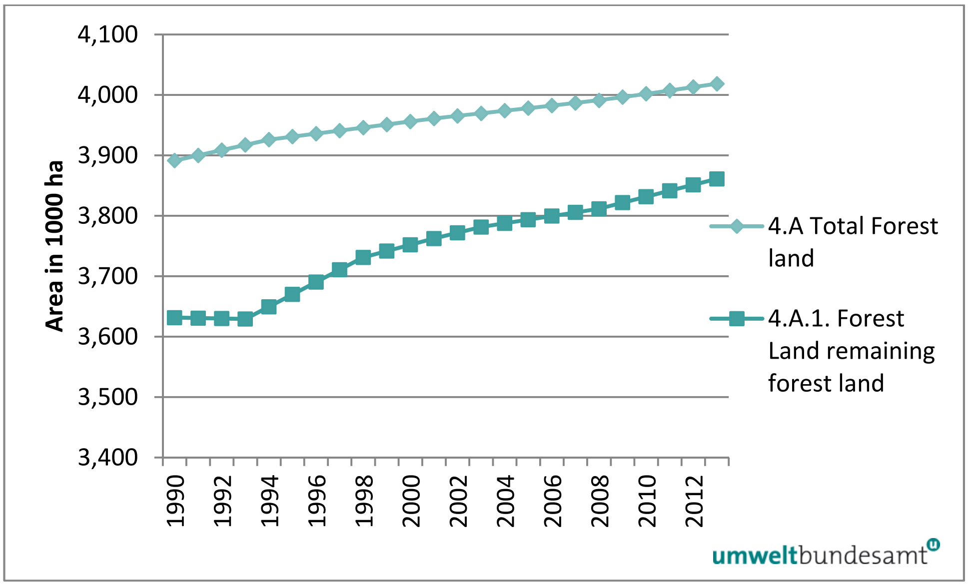


Figure 31: Trend of Total forest land and Forest land remaining forest land

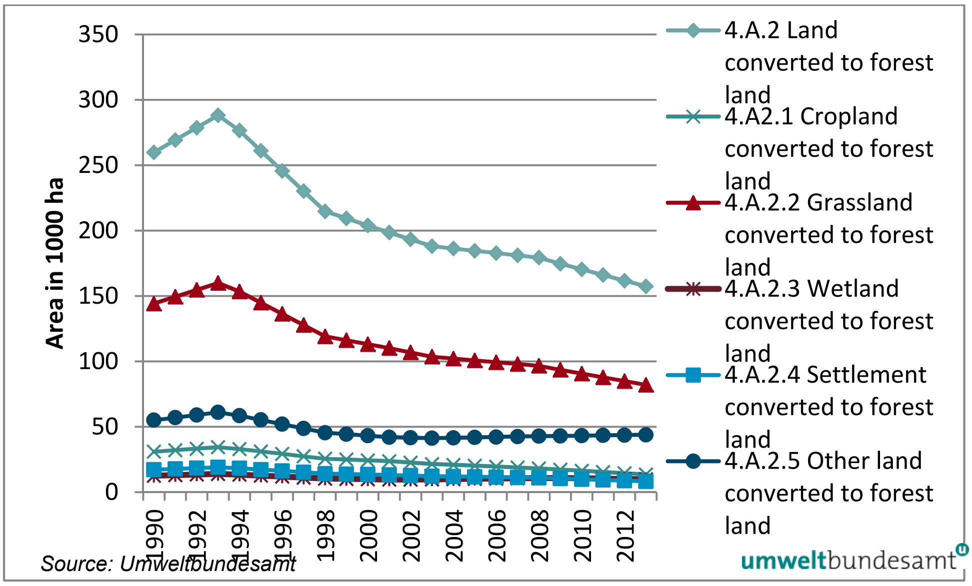


Figure 32: Trend of LUC to forest land (below) covering a conversion period of 20 years from 1990 to 2013 in 1 000 ha (Total forest land includes also forest out of yield).

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 total sector 4). 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 averages 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 209: CO_2 removals/emissions (+/-) from IPCC Category 4.A Forest Land from 1990–2013 (Gg CO_2 resp. Gg CO_2 equiv.).

	4 A Total Forest land	4.A.1. Forest land remaining Forest land	4.A.2. Land converted to Forest land	4.A.2.1 Cropland converted to Forest land	4.A.2.2 Grassland converted to Forest land	4.A.2.3 Wetlands converted to Forest land	4.A.2.4 Settlements converted to Forest land	4.A.2.5 Other Land converted to Forest land	4.A.1_BiomassBurn_wild_CO2	4.A.1_BiomassBurn_wild_CH4	4.A.1_BiomassBurn_wild_N2O	4 Forestland Conv
1990	-10 930	-7 849	-3 081	-422	-1 033	-93	-368	-1 165	IE	0.465	0.307	1 170
1991	-16 660	-13 472	-3 187	-437	-1 068	-96	-381	-1 206	IE	0.123	0.081	1 181
1992	-11 896	-8 602	-3 294	-451	-1 102	-99	-394	-1 247	IE	0.307	0.203	1 192
1993	-12 369	-8 957	-3 412	-468	-1 143	-103	-408	-1 291	IE	0.261	0.172	1 203
1994	-11 304	-8 035	-3 269	-448	-1 094	-98	-391	-1 238	IE	0.135	0.089	1 203
1995	-12 284	-9 218	-3 066	-421	-1 022	-92	-368	-1 164	IE	0.074	0.049	855
1996	-9 265	-6 369	-2 895	-397	-967	-87	-347	-1 098	IE	0.067	0.044	850
1997	-18 016	-15 291	-2 725	-373	-913	-82	-326	-1 031	IE	0.047	0.031	845
1998	-16 200	-13 647	-2 554	-350	-858	-77	-305	-964	IE	0.216	0.143	840
1999	-19 118	-16 631	-2 487	-341	-835	-75	-297	-940	IE	0.019	0.012	841
2000	-16 028	-13 607	-2 421	-332	-812	-73	-289	-915	IE	0.098	0.064	843
2001	-17 980	-15 625	-2 355	-323	-790	-71	-281	-890	IE	0.056	0.037	844
2002	-12 285	-9 997	-2 288	-305	-759	-73	-271	-880	IE	0.447	0.295	1 130
2003	-2 292	-73	-2 219	-292	-731	-72	-261	-863	IE	0.426	0.281	1 131
2004	-7 373	-5 180	-2 193	-284	-718	-72	-257	-863	IE	0.040	0.026	1 122
2005	-8 825	-6 658	-2 167	-277	-704	-72	-253	-862	IE	0.072	0.048	1 113
2006	-3 010	-869	-2 142	-267	-689	-74	-248	-864	IE	0.172	0.114	1 103
2007	-1 982	134	-2 116	-257	-674	-76	-243	-867	IE	0.086	0.057	1 093
2008	-1 088	1 003	-2 091	-247	-659	-77	-238	-870	IE	0.116	0.077	1 083
2009	-4 524	-2 495	-2 030	-234	-628	-74	-224	-870	IE	0.130	0.086	579
2010	-4 490	-2 511	-1 979	-222	-602	-74	-212	-869	IE	0.114	0.075	569
2011	-4 456	-2 526	-1 929	-210	-576	-74	-201	-868	IE	0.102	0.068	559
2012	-4 421	-2 542	-1 879	-198	-551	-74	-189	-867	IE	0.128	0.084	548
2013	-4 387	-2 561	-1 825	-185	-523	-73	-177	-867	IE	0.210	0.139	539

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 2011; 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[70]). Each grid point 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).

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 (as sum of 20 years LUC transition period).
2) LUC to forests not in yield takes also place and is assessed by the NFIs – after 20 years of transition period those areas are considered as FL remaining FL and added to the result of step 1. (The sum of step 1 plus step 2 for 1990: 3 217 kha. This is the sum of the figures of 1.1a and 1.1b in Table 206: Land use and LUC data for Austria for the years 1990 and 2013.
3)).

[70] http://www.bfw.ac.at/rz/bfwcms.web?dok=2384

4) The result of step 2 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 206 and CRF table).
5) Remaining forests not in yield under forest land remaining forest land is calculated from the total forest area based on the NFI results (e.g. 3 891 kha) minus the sum area of step 1 + 2 (e.g. 3 217 kha) minus LUC to forests (e.g. 260 kha). For 1990: 407 kha (see 1.1c in Table 206: Land use and LUC data for Austria for the years 1990 and 2013.
6)).
7) Total forest land remaining forest land in CRF table is the sum of step 3 and 4 = 3 631kha.

The result of step 5 and the LUC to forest 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 assumption for the exclusion of carbon stock changes in non-productive forests is the following: There is a balance between C-losses due to decay and C-gains due to biomass increment. There is no extraction of biomass due to the missing access to these forests, but the opposite, planting measures are carried out (for maintaining the essential protective function of these forests). Therefore, we assume that this assumption is conservative. The NFI 2007/09 carried out for the first time an assessment of the standing stocks in the non-productive forests. So, 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.

6.2.2.2 Estimation of the annual LUC from and to FL, and their splitting into the different subcategories

LUC areas to and from forests are available from the individual NFIs and for the whole time series to be reported. A division of these areas by the NFI assessment period leads to data for the annual LUCs.

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). 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 summed up according to the IPCC 2006 Guidelines LU categories (Table 210).

In the years 2011 to 2013 a reduced NFI was carried out only at all NFI plots which had according to previous NFIs 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 measurement 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 basis of the results of these thorough inspections of each ARD plot, the ARD areas of previous submissions were reduced by these misclassified ARD areas. The LUC areas to/from forests were reduced accordingly.

Table 210: LU-classification systems (IPCC 2006 Guidelines and NFI 2000/02, 2007/09 and ARD NFI 2011/13).

Land use categories in the IPCC GPG	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 (inkl. 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 211: Land use changes to forest (%, 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 GPG 2003	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 [1000 ha]	LUC to forest land (%)	LUC to forest land [1000 ha]	LUC to forest land (%)	LUC to forest land [1000 ha]	LUC to forest land (%)	LUC to forest land [1000 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 212: Land use changes from forest (%, 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 GPG 2003	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 211 and Table 212 the land use changes to and from forests mainly appear from/to grassland sites (49–56 % or 49–57 %, respectively). The land use changes from or to other categories are far below this value.

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 other land use categories according to NFI 2000/02 could be applied directly to split the total LUC areas from/to FL according to the NFIs 1986/90 and 1992/96 to individual past/previous 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. 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, was adjusted accordingly.

Figure 33 gives an overview of the LUCs to and from forests from 1970 and 1990 on, respectively. 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 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 lead to wrong results. 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 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 211 and Table 212. The specific carbon stocks for litter and soil for each forest growth region are shown in Table 223.

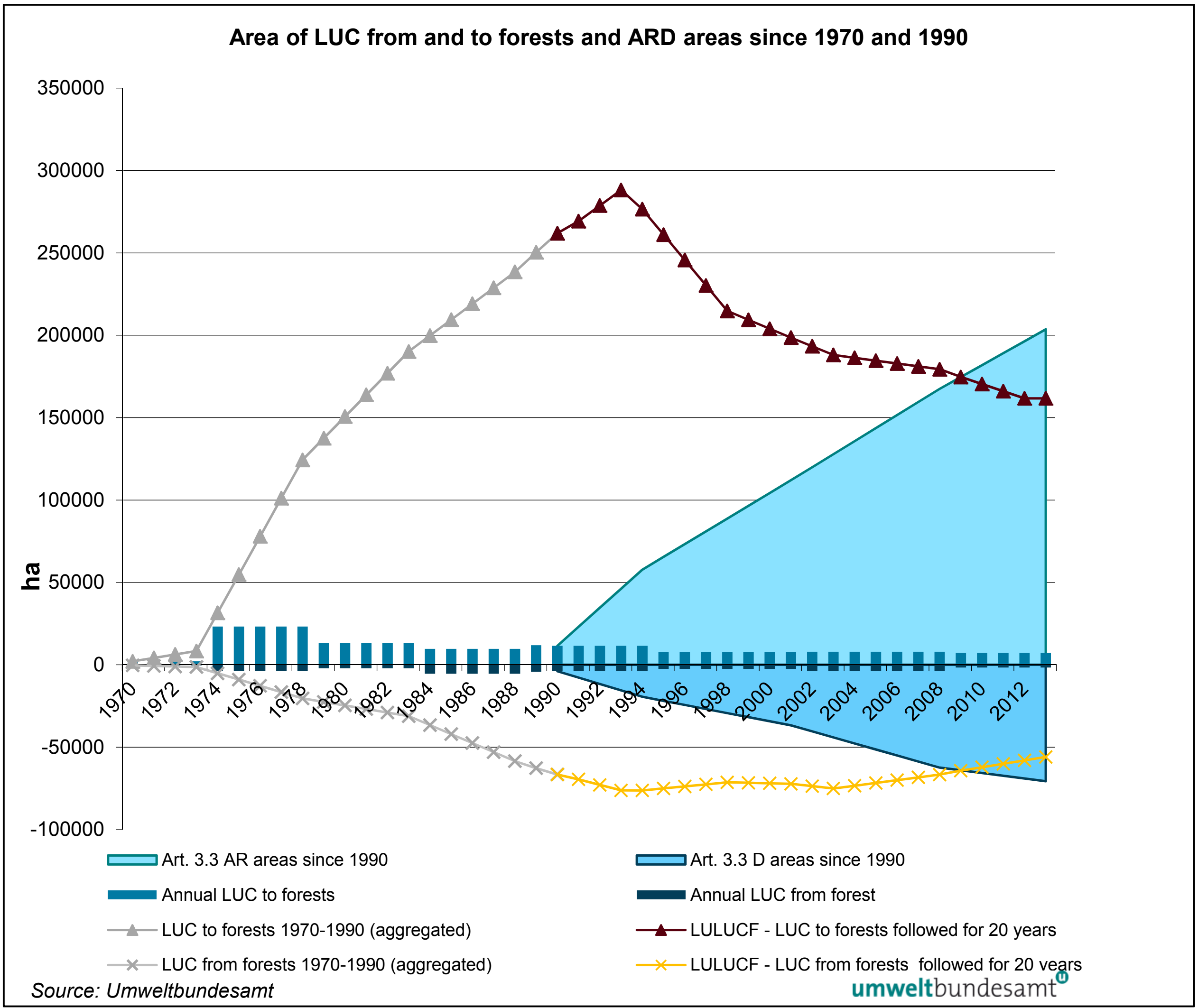


Figure 33: Areas of LUC from and to forests and ARD areas since 1970 and 1990, respectively.

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 reason 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 more than 10 m.

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 do not account as forests but represent cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.

6.2.4 Methodological Issues

6.2.4.1 Forest Land remaining Forest Land (4.A.1)

6.2.4.1.1 Biomass

A national method is applied which 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 the 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 2011; 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.

In addition to the NFI drain data, which are based on measurements in the forests, further harvest statistics exist: the annually reported records of timber harvest and the Austrian wood balance (BITTERMANN & GERHOLD 1995, BMLFUW 1964–2011). These statistics are not based on measured data. Therefore, it is assumed that the NFI provides more accurate figures on the stemwood drain and for this reason the estimates are based on NFI drain figures. However, the results of the other statistics are used to derive „relative harvest indices for individual years“ (see below). Table 213 gives an overview of the different harvest statistics in Austria.

Table 213: 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

Statistics	Characteristics/methodological approach	Units of drain or harvested wood
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

Further comments for a better understanding of the NFI increment and drain data

The NFI increment and drain data include all possible reasons for biomass increments and losses in the forests. This means that biomass increments due to land use changes and re-growth by forests or biomass losses due to e.g. traditional (non-commercial) fuel wood consumption, forest land conversion, mortality, forest fires (wild-fires) and other damages are already considered in the NFI data.

In order to fulfil the requirements of the reporting format and to report on the category *4.A.1 Forest land remaining forest land*, estimates of emissions and removals from biomass with a DBH ≥ 5cm due to annual land use changes from and to forests are subtracted from the totals based on the total increment and drain of biomass with a DBH ≥ 5cm according to NFI results. The approaches on calculating CO_2 emissions and removals related to land use changes are described in more detail in chapter 6.2.4.2.

The NFI provides mean values for annual increment and drain for the individual NFI observation periods. The measured annual means of increment and harvest provided by the NFI have been attached to the year in the middle of an observation period and not to the year in the middle of an inventory period. This methodological approach reflects the fact that the mean annual increment and drain which are detected in a certain NFI period are the results of the respective changes in the observation period (which is the time span between a NFI period and the NFI period before, and which is not the NFI assessment period).

The single year values are estimated then from these average annual NFI results for the single NFI observation periods with the help of related annual indices. In a next step, these NFI means are converted with relative indices[71] to obtain annual data of increment and drain (instead of using the means or interpolated values for single years). For drain these relative indices are derived from further national statistics on harvest which are the annually reported records of timber harvest (BMLFUW 1964–2011) and the wood balance (BITTERMANN & GERHOLD 1995). For increment, representative Austrian sets of tree ring cores (HASENAUER et al. 1999a, b; BFW 2011a, pers. comm.) are used to calculate the relative indices. These indices are available until 2010. This method allows accurate estimates for individual years for the category *4.A.1*. The figures for annual growth and for annual drain may differ significantly year by year thus the net carbon stock changes between single years vary considerable 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 or wind throws. Such reasons for different growth and different drain in individual years explain the high annual variations in the CO_2 net removals by the Austrian forests. Table 214 shows the results of these estimates of annual values for increment and drain on basis of the average annual in-

[71] Values for the relative variation in the individual years of the time series

crement and drain according to NFIs and the relative indices.

Table 214: Increment and drain in the Austrian forests on basis of NFIs and interpolated on basis of relative indices[72]. 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*

Wood densities

Shrinkage values, wood densities (absolute dry) and C contents for all tree species in Austria are used to convert the increment and drain of m³ stemwood over bark (o.b.) which is measured by the NFI into t carbon increment and t carbon drain of the stemwood o.b. The mean wood densities according to Table 215 represent aggregated values on basis of the species composition of increment and drain in Austria (see example in Table 216 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

[72] 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.

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 2000).

Table 215: Conversion factors for the stemwood o.b. of the Austrian forests; mean of several NFIs (UMWELTBUNDESAMT 2000, 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 216: Share of tree species in total stemwood increment and drain of the NFIs 2007/09 and 2000/02. (BFW 2011).

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
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 217) 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 217 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 carried out at the Austrian Federal Research Centre for Forests.

Table 217: Used biomass functions.

Tree species	Tree parts	Input parameter	Literature
Norway spruce (Douglas fir and other coniferous species than listed below)	Branches, needles	Dbh, height, crown ratio	(ECKMÜLLNER 2006)
Fir	Branches, needles	Dbh, crown ratio	(LEDERMANN & NEUMANN 2006)
Pine	Branches, needles	Dbh, height, crown ratio	(ECKMÜLLNER 2006)
Larch	Branches	Dbh, height, crown ratio	(RUBATSCHER et al. 2006)
Beech	Branches	Dbh, crown ratio	(LEDERMANN& NEUMANN 2006)
Oak	Branches	Dbh, crown ratio	(LEDERMANN& NEUMANN 2006)
Oak (coppice)	Branches	Dbh, crown ratio	(HOCHBICHLER et al. 2006)
Hornbeam	Branches	Dbh, crown ratio	(LEDERMANN& NEUMANN 2006)
Ash	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Other hardwood deciduous species	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Poplar	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Other weed tree species	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
All	Roots	Dbh, age	(WIRTH et al. 2004), (OFFENTHALER & HOCHBICHLER 2006)

On basis of the results of these biomass functions the average biomass expansion ratios according to Table 218 for total tree biomass/stemwood biomass were derived. The aggregated expansion factors in Table 218 are not used for the estimates but are provided as additional information for transparency reasons and to allow comparisons. The estimates of increment and drain of the other tree compartments are based on the biomass functions shown in Table 217.

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 due to an extreme rise of the shape of the curve 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 explaining parameter 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 218 (old vs. new i.e. „submissions before 2012" vs. „since submission 2012").

Table 218: 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 for stemwood (see above).

The biomass increment and drain as estimated on basis of the NFI results for all Austrian forests includes also biomass increment and drain of LUC areas to/from forests. Therefore, to avoid any double accounting the biomass increment and drain of the LUC areas to/from forests needs to be subtracted from the estimates on basis of the NFI results to get the biomass increment and drain of subcategory 4.A.1. In 2014 a revision of the activity data and emission factors for the LUC categories to/from forests was carried out on basis of the finalised ARD NFI 2011/13 (see chapters 6.2.2.2 and 6.2.4.2). The time series of measured values for individual years ends with the year 2009. For the years since 2008 the mean values of biomass increment and biomass drain for the last inventory period (2007/09) are reported. This procedure is carried out for the following reasons:

The extrapolation of trends for increment and drain from the inventory period 1986/90 to the 90ies led to figures, which had to be strongly revised downwards after the inventory period 1992/96. One of the main reasons was that increment did not increase as in the years before. The use of mean values for increment and for drain, which are based on the last NFI results, for years after the last NFI provides more likely figures than an extrapolation of trends that is rather uncertain. This is particularly true for increment that strongly depends on weather conditions, but also for drain, when e.g. storm fellings are taken into account.

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. So, 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 inclusion of lying dead wood would cause a double accounting with the estimates of the litter/soil C stock changes, because any falling dead tree (part) is accounted as C flux to litter/soil in the modelling 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 changes areas from and to forests for the first time (see chapter 6.2.4.2 – Dead wood). In order to fulfil 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 215 were used. These conversion factors do not include any estimates for roots and branches of the dead trees. The rationale in behind 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 obviously show an increase of dead wood in Austria. However, the annual net C-stock changes range between 221 Gg CO_2 and 844 Gg CO_2, which is only a minor part of the total C-balance of sector 4.

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 the data for its parameterization are available in countries conducting national forest inventories (NFI).

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 influx 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 decomposition model of soil organic material. It is based on field measurements in a wide range of climatic conditions and has been applied to site conditions 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 influx 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 tools 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. So, 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 verified on basis of information 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. So, the simulations are based on the annual variation of input data. 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. All estimates were carried out at the Austrian Federal Research Centre for Forests.

The output of Yasso is a time series of the total litter/soil C pool and its changes, which is divided into carbon woody matter, non-woody matter and the acid-, water-, ethanol- and insoluble fractions. Yasso does not allow to distinguish between the C stock changes in the single litter and soil horizons and provides totals for the litter layer plus the soil C pool. Therefore, the C stock changes of litter of the subcategory "FL remaining FL "are reported under the mineral soil C pool changes in the CRFs. The simulation results for the NFI plots were extrapolated for the areas of forests in yield of the subcategory *4.A.1* in the single years of the time series.

In addition to the Yasso simulations for the soils of forests in yield, the C losses in those soils of category *4.A.1* were estimated that were converted from stocked forest to non-stocked forest land for forest management operations (particularly forest roads). These areas account as forest land according to the Austrian and FAO forest definition (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 and for those with vegetation 60 t C per ha was assumed as equilibrium soil C stock (0–50 cm). The estimate method for the annual soil C losses at such forest land follows completely the method as provided by the IPCC GPG for soil C losses in land use change lands with a discounting of the soil C stock differences of the previous land use and the final land use across 20 years (see for instance chapter 6.2.4.2).

According to the Yasso model results plus the estimates of the soil C losses due to the increase in forest roads, the litter plus soil of category *4.A.1* was an emission source in the whole time series since 1990 with an annual average C stock loss of 0.2 t C per ha and year and, in total, of 2 600 Gg 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 2013 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 IPCC 2006 Guidelines.

However, the amounts of N_2O and CH_4 emissions caused by biomass burning due to wildfires are negligible, as they range between 0.012 and 0.47 Gg CO_2 equivalents. This is due to the small area concerned.

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 LUC areas since 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 (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 219 and Table 220.

Table 219: 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 220: 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 219 and Table 220.

Conversion factors (BF, BEF, 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 221: C-conversion factors for forest biomass land use changes areas from and to forest land.

Conversion factors	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 areas with LUC to forests the calculations lead on average for 1990 to 2013 to the following result of annual net C stock change in living biomass (DBH>0cm) per ha and year:

$\Delta C_{BM} = 1.204$ 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 2013:

$\Delta C_{BM} = -1.682$ 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:

$\Delta C_{BM\ drain} = -42.6$ t C ha^{-1} a^{-1}

An overview of the emissions/removals from land use changes from and to forests is given in Table 209.

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 summarised in Table 222.

Table 222: 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 sub-categories 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). The calculations for the regionalised land use specific agricultural soil C stocks are based on the Austrian soil inventories. 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 other land use categories than forest, cropland and grassland national estimates were applied. Table 223 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 LUC categories with wetlands were revised. In previous submissions wetlands (flooded land) were assumed to have a 0 soil C stock. Using the IPCC GPG 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 for submission 2015 no C-stock changes in mineral soil are assumed at LUC between forest land and wetland. The changes WL to FL are higher than those of FL to WL and FL can be expected to have higher C stocks in soil. Therefore, this approach used for submission 2015 represents a conservative estimate.

Table 223: 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, 2009
Forest – mineral soil	Forest	88	91	109	77	117	BFW, 2009
Cropland	Cropland	56	90	80	65	90	Umweltbundesamt – see[1] below
	Vineyards	58	58	58	58	58	Gerzabek et al. 2005
	Orchards/garden land	78	78	78	78	78	Gerzabek et al. 2005
Grassland	grassland intensive use	75	95	100	79	94	Umweltbundesamt– see[1] below
	grassland extensive use	132	130	120	139	139	Umweltbundesamt– see[1] below
Wetlands	Bogs	500	500	500	500	500	expert judgement
	Surface waters and reed beds:	0	0	0	0	0	expert judgement
Settlements	Settlements and traffic area	60	60	60	60	60	expert judgement
	Industrial and mining areas, dumps	0	0	0	0	0	expert judgement
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

[1]The values for forests, cropland and grassland represent regional averages which are based on Austrian soil inventories for forests (BFW 2009) and for agricultural land (AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 1988–1996, AMT DER TIROLER LANDESREGIERUNG 1988, AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG 1993, AMT DER SALZBURGER LANDESREGIERUNG 1993, AMT DER NIEDERÖSTERREICHISCHEN LANDEREGIERUNG 1994, AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG 1996, AMT DER KÄRNTNER LANDESREGIERUNG 1999, compiled in the Austrian Soil Information System BORIS). The data have been stratified according to the Austrian forest growth regions.

The estimate of C stocks in bogs (0–50 cm) is 500 t C ha^{-1}, based on extensive literature studies and soil data of the Austrian Soil Information System BORIS. However, in Austria only minor LUC between bogs and forests were observed during the last two NFIs (annual changes between 9 and 50 ha). These land use changes always occur along forest boundaries. For these LUC areas no evidence is given, that the soil carbon stocks change significantly over a time period of 20 years. Therefore no emissions or removals from these LUC are reported.

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 (One third of these areas are assumed to be sealed and two thirds unsealed; unsealed areas have the same soil C stock as intensively used grassland), but the higher value for the LUCs with forests takes the higher soil depth of 0–50 cm into account which is used for these estimates. 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 223). Consequently, for each 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 200/02, NFI 2000/02 to 2007/09 and NFI 2007/09 to ARD NFI 2011/13). The area weighted mean values of C-stocks used to estimate emissions and removals from soil and litter at LUC areas from and to forest are shown in Table 224, Table 225 and Table 226.

Table 224: 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	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	60	25	60	27	10	60	44	60	19	60
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 225: 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	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	-	19	60	9	39	60	46	41	27	12
Other land	46	49	49	30	39	53	41	22	13	-

[1] - no LUC from/to forest could be observed in these regions

Table 226: 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	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	20	60	60	-	-	60	-	60	20	60
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 of land use change areas from and to forests were split into litter (humus layer, see Table 223) and mineral soil (see Table 224, Table 225 and Table 226) 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. For these estimates, the LUC areas to and from forests 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 LUC areas from and to forest land

$$\Delta\ SOC = A^{*}(SOC_{O} - SOC\ _{O\text{-}T})/20$$

Δ SOC = average annual carbon stock change in soils (t C a^{-1}) over the LUC transition period of 20 years

A = 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 225)

$SOC_{O\text{-}T}$ = 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 225).

Annual carbon stock changes in litter at LUC areas from and to forest land:

$$\Delta\ C_{LT} = A^{*}\ (C_{LTo} - C_{LTo\text{-}t})/T$$

$\Delta\ C_{LT}$ = average annual carbon stock change in litter (t C a^{-1})

A = annual 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 225)

$C_{LTo\text{-}t}$ = 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)

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 6.3.4.2, 6.4.4.2, 6.5.4.2, 6.6.4.1, 6.7.4.1).

6.2.5 Uncertainty Assessment

The Austrian Federal Research Centre for Forests carried out a re-assessment of the uncertainty of the C stock changes of the biomass of the Austrian Forests (BFW 2010, internal report). This in-depth analysis leads to an almost complete picture for the uncertainty of the biomass changes in the Austrian forests. It was estimated to be ±40% for the average annual net change[73] of the C biomass stock in the NFI period 2000/02.

It is important to note that due to the design of the NFI these changes in biomass stock also include the biomass changes due to 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 sub-categories 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 ±0.7 t C ha^{-1} a^{-1}. The average emission out of the forest soils is 0.2 t C ha^{-1} a^{-1}. So, just the standard deviation is more than 3 times the simulated C stock change, but the double standard deviation is the uncertainty to be considered according to IPCC GPG. 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 of 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}.

According to these accuracy 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 227 shows the uncertainties for the areas of the subcategories with LUC to and from forests:

[73] 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 227: 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 is the outcome of 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, the 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 of the uncertainties of single subcategories reflect the different size of the LUC areas of these subcategories and, as a consequence, the different accuracy with which they can be detected by the NFI system (larger LUC areas with a higher accuracy than smaller areas).

For the litter/soil C stocks of all LUC areas the uncertainties according to Table 228 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 223 (other land) or on expert judgment based on information from related studies.

Table 228: Uncertainties of the litter/soil C stocks in the forest growth regions according to Table 223: Specific C-stocks (t C ha-1) for litter and soil (0–50 cm) stratified according to five forest growth regions in Austria.

(all distributions were truncated at the assessed minimum and maximum)

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}					

IPCC LU categories	National LU categories	Forest growth regions					Austria
		Bohe-mian Massif	Inner alps	Calcareous alps	Foot-hills	Alpine Ridge	
		%					
Settlements	Settlements and traffic area	Triangle distribution 10–60–75 t C ha^{-1}					
	Industrial and mining areas, dumps	Uniform distribution 0–20 t C ha^{-1}					
Other land	Alpine shrub lands	Triangle distribution 15–119–567 t C ha^{-1}					
	Rocks and stone slopes:	Uniform distribution 0–13 t C ha^{-1}					
	Other land uses	Uniform distribution 0–70 t C ha^{-1}					

The Monte-Carlo-simulation with all these single uncertainties gave the following uncertainty of the total emissions/removals of the complete forest land category: ±18 712 Gg CO_2. This represents on average ±138% in the years 1990 to 2002 with significant annual net sinks in category *4.A* and between 215 and 1 756% after 2002 when the net removals/emissions were very low (with highest relative uncertainties in the years of lowest net removals/emissions). If the significant uncertainty of litter/soil C stock changes of sub-category *4.A.1* (see above) is neglected during the simulations, the total uncertainty of category *4.A* is on average ±4 764 Gg CO_2 with higher absolute uncertainty values in the 90ies and lower uncertainty values in the recent years due to more accurate input data in recent years. On average the relative uncertainties are ±44% in the years 1990 to 2002 with significant annual net sinks and in the range of 44 to 152% after 2002 with much lower annual net emissions/removals than in the years before.

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 this 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 the right location of the grid and sample points, guarantees the repeated measurement of the right trees (permanent marked grid) and indicates at once implausible figures for individual parameters during the measurements on site and any missing trees compared to the period before (further details are given in HAUK & SCHADAUER (2009) and SCHIELER & HAUK (2001)).

The calculation of the data for category *4.A* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see chapter 6.1.4).

6.2.7 Recalculations

No recalculations were conducted for the submission 2015

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* the estimate of emissions from cropland remaining cropland and land converted to cropland is carried out. The calculations were made for the individual years from 1990 to 2013. Some management practices (e.g. slash and burn etc.) and some sub categories (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, and dead wood and litter is assumed to occur not at cropland areas.

Emissions/Removals were estimated for the sub categories and related sources/sinks as shown in Table 229.

Table 229: 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 „annual cropland remaining annual 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 due to LUC from forest land to cropland
- carbon stock change in SOM due to LUC from forest land to cropland
- N_2O emissions from soils due to LUC from forest land to cropland
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

In 2013 1.43 Mio ha of Austria were cropland including annual and perennial crops (STATISTIK AUSTRIA 2014). There is a decrease in cropland along the time series.

The total emissions of cropland range between -69 and 130 Gg CO_2 with removals in the 90ies and a tendency of higher emissions in the last years (Table 230). Main reasons for the emissions and trend are the emissions due to the conversion from forest land and grassland to cropland (particularly from the soil pool) and decreases of perennial cropland biomass. For some perennial cropland types IPCC default emission factors for biomass are used, which seem to be too high for Austrian conditions. The planned improvement to country specific emission factors may significantly change the result for category 4.B in the future.

For consistency and transparency reasons also the biomass C stock changes at LUC areas to perennial cropland are reported in these LUC categories for a transition period of 20 years (see chapter 6.3.4.1.2)

In 2013 the land use change area to cropland was 52 719 ha. The annual emissions of land converted to cropland from 1990–2013 range from 165 Gg CO_2 equivalents to 194 Gg CO_2 equivalents (Table 231).

Table 230: Total areas and land-use change areas of cropland (1990–2013) 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. annual cropland converted to perennial cropland	c.Perennial cropland converted to annual cropland	4.B. 2. Land converted to cropland	2.1 Forest Land converted to cropland	2.2 Grassland Land converted to cropland - total	a. Grassland converted to annual cropland	b. Grassland converted to perennial cropland	2.3 Wetland converted to Cropland	2.4 Settlement converted to cropland	2.5 Other Land converted to cropland
1990	1 498 005	1 459 067	1 428 952	16 654	13 461	38 938	4 125	34 813	33 402	1 411	NO	NO	NO
1991	1 516 184	1 477 258	1 447 081	16 624	13 554	38 926	4 346	34 580	33 178	1 401	NO	NO	NO
1992	1 506 236	1 467 300	1 437 107	16 556	13 637	38 936	4 567	34 370	32 977	1 393	NO	NO	NO
1993	1 488 708	1 449 738	1 419 546	16 483	13 710	38 970	4 787	34 183	32 798	1 385	NO	NO	NO
1994	1 491 175	1 452 363	1 422 146	16 444	13 773	38 812	4 792	34 019	32 641	1 378	NO	NO	NO
1995	1 490 916	1 452 361	1 422 131	16 407	13 823	38 555	4 710	33 845	32 473	1 371	NO	NO	NO
1996	1 487 684	1 449 386	1 419 154	16 373	13 859	38 298	4 628	33 671	32 306	1 364	NO	NO	NO
1997	1 480 423	1 442 354	1 412 148	16 334	13 872	38 069	4 546	33 523	32 165	1 358	NO	NO	NO
1998	1 476 458	1 438 593	1 408 443	16 287	13 863	37 866	4 463	33 402	32 049	1 353	NO	NO	NO
1999	1 473 838	1 436 063	1 406 004	16 223	13 836	37 775	4 483	33 291	31 942	1 349	NO	NO	NO
2000	1 455 332	1 417 638	1 387 668	16 178	13 793	37 693	4 504	33 190	31 845	1 345	NO	NO	NO
2001	1 452 131	1 414 496	1 384 627	16 137	13 732	37 635	4 524	33 111	31 770	1 342	NO	NO	NO
2002	1 449 996	1 412 340	1 382 599	16 080	13 661	37 655	4 612	33 044	31 705	1 339	NO	NO	NO
2003	1 449 723	1 411 951	1 382 326	15 907	13 718	37 772	4 699	33 072	31 732	1 340	NO	NO	NO
2004	1 477 974	1 440 823	1 411 607	15 707	13 509	37 151	4 581	32 570	31 250	1 320	NO	NO	NO
2005	1 479 688	1 442 371	1 413 621	15 434	13 316	37 317	4 463	32 854	31 523	1 331	NO	NO	NO
2006	1 464 050	1 424 591	1 396 009	15 408	13 174	39 460	4 345	35 115	33 692	1 423	NO	NO	NO
2007	1 461 718	1 418 460	1 389 619	15 744	13 097	43 258	4 226	39 031	37 450	1 582	NO	NO	NO
2008	1 447 255	1 400 090	1 371 572	15 748	12 769	47 164	4 108	43 057	41 312	1 745	NO	NO	NO
2009	1 442 815	1 394 890	1 366 484	15 713	12 693	47 926	3 934	43 991	42 209	1 783	NO	NO	NO
2010	1 439 802	1 391 393	1 362 634	15 821	12 937	48 409	3 782	44 627	42 818	1 808	NO	NO	NO
2011	1 437 181	1 388 041	1 359 245	15 848	12 948	49 141	3 630	45 511	43 667	1 844	NO	NO	NO
2012	1 432 648	1 381 794	1 352 907	15 941	12 946	50 854	3 478	47 376	45 456	1 920	NO	NO	NO
2013	1 431 444	1 378 725	1 350 239	15 739	12 746	52 719	3 326	49 393	47 392	2 001	NO	NO	NO

Table 231: Emissions /removals (+/-) from cropland (1990–2013) in Gg CO_2; other land use changes are not occurring.

	4 B Total Cropland	4 B 1 Cropland remaining Cropland - total	a. Annual remaining annual and perennial remaining perennial	b. Annual cropland converted to perennial cropland	c. Perennial cropland converted to annual cropland	4 B 2 Land converted to cropland	2.1 Forest land converted to cropland	2.2 Grassland converted to cropland - total	2.2.a Grassland converted to annual cropland	2.2.b Grassland converted to perennial cropland	N_2O (in CO_2 equiv)
1990	-68.89	-260.69	-293.42	-129.58	162.31	191.80	81.09	110.71	116.82	-6.11	14.72
1991	-68.47	-260.46	-295.89	-129.80	165.23	191.99	82.02	109.97	116.03	-6.06	14.70
1992	-62.33	-254.53	-290.32	-128.91	164.69	192.20	82.94	109.26	115.27	-6.01	14.69
1993	-55.22	-247.74	-283.51	-128.37	164.14	192.52	83.90	108.62	114.59	-5.97	14.69
1994	-40.49	-232.47	-267.77	-128.27	163.57	191.98	83.92	108.07	113.99	-5.93	14.63
1995	-18.24	-186.67	-220.94	-127.89	162.17	168.43	60.87	107.56	113.47	-5.91	14.54
1996	2.21	-165.28	-198.48	-127.55	160.75	167.50	60.47	107.03	112.91	-5.89	14.44
1997	23.49	-143.10	-173.33	-127.22	157.46	166.59	60.07	106.51	112.36	-5.85	14.36
1998	47.36	-118.40	-145.67	-126.88	154.14	165.76	59.68	106.09	111.90	-5.81	14.29
1999	57.61	-107.89	-133.41	-126.46	151.98	165.50	59.77	105.74	111.53	-5.79	14.25
2000	64.09	-101.18	-125.05	-125.93	149.80	165.27	59.85	105.42	111.20	-5.78	14.22
2001	77.50	-87.59	-109.39	-125.74	147.55	165.09	59.94	105.14	110.90	-5.75	14.19
2002	102.44	-74.00	-94.03	-125.26	145.29	176.44	71.54	104.90	110.64	-5.73	14.17
2003	102.78	-73.48	-118.47	-126.44	171.43	176.26	71.50	104.76	110.42	-5.66	14.17
2004	96.32	-78.72	-68.67	-126.23	116.18	175.03	70.55	104.48	110.49	-6.01	13.91
2005	89.92	-83.08	-77.37	-125.47	119.76	173.00	69.60	103.40	108.81	-5.41	13.95
2006	96.62	-77.78	-89.13	-119.15	130.50	174.40	68.63	105.77	109.99	-4.23	14.75
2007	108.29	-73.79	-104.87	-113.50	144.58	182.09	67.65	114.43	118.11	-3.67	16.19
2008	141.73	-52.43	-23.47	-121.61	92.66	194.15	66.68	127.47	131.93	-4.46	17.67
2009	127.31	-46.36	-69.36	-122.00	145.00	173.67	35.09	138.58	145.86	-7.28	17.96
2010	113.39	-62.26	-154.89	-119.43	212.06	175.65	34.17	141.48	149.16	-7.68	18.14
2011	111.08	-65.96	-110.46	-122.18	166.68	177.03	33.25	143.79	151.46	-7.67	18.42
2012	118.41	-61.31	-103.65	-121.09	163.43	179.72	32.33	147.39	154.63	-7.24	19.08
2013	129.88	-55.23	-50.18	-126.63	121.57	185.11	31.46	153.64	161.18	-7.54	19.79

6.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The data of the total cropland areas were taken from STATISTIK AUSTRIA (STATISTIK AUSTRIA 1960–2014). 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" used as activity data are based on a combination of FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System) data. In the years where Farm Structure Surveys were conducted these data were taken: For the years 1990, 1995, 1999 and 2010 (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013) a full Farm Structure Survey (FSS) was conducted and in between there were random sample Farm Structure Surveys undertaken, that is for the years 1993, 1997, 2003, 2005, 2007 and 2013 (ÖSTAT 1994, 1998, STATISTIK AUSTRIA 2005, 2006, 2008, 2014). Since joining the

EU in 1995 Austria is committed to run the IACS data base. It covers detailed information on cropland areas (see explanation below). For some crops which are not fully covered by the IACS (vegetable, flowers and floriculture) the data are revised and in addition estimated by expert judgement (e.g. experts of the chambers of agriculture estimate the area of these crops).

For the total annual cropland area the data from the FSS differ from the IACS data, in most cases the area in the FSS database is larger, because of the greater number of farms included in FSS compared to IACS. This relationship has been represented by calculating a factor

FSS area for total annual cropland/IACS area for total annual cropland,

which was calculated for the years where FSS has been conducted. For the years between two Farm Structure Surveys the annual cropland area out of the IACS database has been adjusted to the FSS area by multiplying it with the factor from the year in which the next FSS has been conducted.

Data for perennial cropland area (viticulture, orchards, house gardens, Christmas trees and perennial energy crops) were taken from FSS, for the years in between two Farm Structure Surveys the area was interpolated.

For orchards two inter-annual cracks which led to serious area changes occur in the activity data:

- from 1968 to 1969 there was a huge increase of areas, probably due to included extensive orchards area (Streuobst orchards).
- from 1982 to 1983 there was a considerable area reduction probably due to changed limits of included areas: the limit was raised from 0.5 to 1 ha and in addition to that municipalities were not obliged any more since 1983 to report on small areas and unproductive agricultural areas, which have been reported before likely in the orchards category.

For time series consistency, the area for orchards was extrapolated backwards until 1960.

For house gardens two inter-annual cracks which led to serious area reduction occur in the activity data:

- from 1982 to 1983: this is probably due to changed limits of included areas: the limit was raised from 0.5 to 1 ha and in addition to that municipalities were not obliged any more since 1983 to report on small areas and unproductive agricultural areas, which have been reported before likely in the house gardens category.
- from 1994 to 1995 : this is probably due to joining the EU: Because the areas of house gardens are not supported under the CAP regime, they were likely reported either as grassland or annual cropland.

For time series consistency, the area for house gardens was interpolated across these two time periods.

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 to farmers established by the Member States in application of the Common Agricultural Policy (CAP). Thus it provides among others a unique identification system for farmers and an identification system covering all agricultural areas called 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 86% of the agricultural areas.LPIS is one 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 information on land uses and land use changes of cropland (annual, perennial) and grassland between 2002 and 2013 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, which were again converted the other direction after few years ("short time oscillating changes"), are not taken into account. Only permanent conversions are calculated. The subsample of IACS data for the examination of permanent land use conversions between grassland to cropland in Austria has to comply to the following:

a) continuity
b) constancy of area
c) initial homogeneity of the land unit: units had to be entirely grass- 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 retained about one third of the grassland units available in IACS for further analysis (=subsample).

For submission 2014 and 2015 the assessment period was enlarged for the years 2002–2013 (instead of 2002–2010 for previous submissions).

Each unit's composition was calculated for all of the years 2002–2013. 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.

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 estimated on basis of 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.

The LUC area from grassland to cropland derived by this method is in the order of 3.5 % of the total cropland area (across a LUC transition period of 20 years) and on average 0.2 % of the total cropland area each year. In relation to the total grassland area the LUC area is 3.4 % of the total grassland area (across a LUC transition period of 20 years) and on average 0.25 % of the total grassland area each year.

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. In addition, wetland, settlement and other land areas are not suited (anymore) for a land use as cropland: 1) Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas. 2) Settlement areas and soils – once converted – are usually not more usable for cropland management. 3) There is also a higher economic factor for land dedicated to settlements area than agricultural land which makes a reconversion very unlikely. 4) „Other lands" are the highest located areas of Austria or very steep areas, all in all, areas of very unfavorable ecological conditions that do not allow any cropland use.

6.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The STATISTIK AUSTRIA (2001) 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);
- Perennial cropland (viticulture, orchards, tree nurseries, Christmas trees, perennial 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:

4.B.1 cropland remaining cropland total

a) annual remaining annual and perennial remaining perennial cropland

b) annual cropland converted to perennial cropland

c) perennial cropland converted to annual cropland

For the estimates of the relevant areas annual crops and woody perennial species like orchards, vineyards, house gardens and plantations for Christmas trees and energy crops are considered according to 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 estimated to be zero. For annual crops in the subcategory „annual cropland remaining annual cropland" 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 sub-category „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 land use change areas have to be considered (IPCC 2006, Vol. 4, Ch. 5.3). So, these emissions/removals were estimated for areas of LUC 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 in the LUC calculation subsequently (see chapters 6.3.4.1.2 and 6.3.4.1.3).

The biomass stocks of Christmas tree cultures, energy crops and annual crops 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 AR-results (Tier 2 for below-ground biomass-accumulation according to the IPCC 2006 GL). In this way, the planned improvements 4 and 5 of the NIR 2014 (UMWELTBUNDESAMT 2014a, p. 350, 351) were implemented. The above-ground biomass carbon stock of orchards, vineyards and house gardens were estimated applying the default values of IPCC 2006 GL (Table 5.1) and an IPCC Tier 1 methodology. However, these default values seem to be very high for Austrian conditions, so the below-ground biomass was not considered, which is in line with Tier 1 method of the 2006 IPCC GL (Vol. 4, Ch. 5.2.1.2, p.5.10). It is planned to assess and report national data for viticulture and orchards.

Dead organic matter (DOM) with the two pools dead wood and litter is considered as not present in cropland or to be at equilibrium as in agroforestry systems and orchards (reported as NO). 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 total annual removals of *4.B.1* range between 260.7 Gg CO_2 and 46.4 Gg CO_2.

Annual fluctuations of the emissions are higher in the period after 2002 because the use of the IACS system (see chapter 6.3.2) since then allows a more accurate assessment of the land-use changes within cropland and from cropland to grassland and vice-versa. This has also an impact on the emissions. For instance, a higher conversion of perennial cropland to annual cropland or to grassland goes hand in hand with less biomass harvest in the category perennial cropland remaining cropland and vice-versa. Harvest of perennial cropland biomass causes significant emissions in this category. Therefore, the annual variations of such land-use changes are a main reason for the annual variations in the emissions of this subcategory.

In the following sub chapters the methodologies and used emission factors for the estimates are explained.

6.3.4.1.1 Changes of 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 energy crops and a share (50%) of house gardens, which is assumed to be perennial.

According to Tier 1 2006 IPCC GL, Table.5.1 (IPCC 2006) for perennial cultures as viticulture, orchards and house gardens a steady state of biomass increase during the 30 years of rotation period was assumed. 3.33 % of these cultures are removed and replanted annually and cause emissions.

The observation period started in 1960 and based entirely on the activity data from Statistik Austria based on Farm Structure Surveys and yearly agricultural statistics (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014 and STATISTIK AUSTRIA, 1960–2013). 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 across these inconsistent periods.

A vineyard survey was undertaken in 2009. It led to a figure of 45 533 ha of planted vineyards (STATISTIK AUSTRIA 2010) which is taken for the years 2009 and 2010. All together the Austrian total vine area comprises 46 653 ha (STATISTIK AUSTRIA 2013: FSS 2010) but 1 102 ha of this total vine area is out of production and thus planted with annual crops to increase soil fertility, before it is replanted with vine again. This deviation area (1 102 ha) is added to the category annual cropland remaining annual for the years 2009 and 2010 accordingly. For the years 2011 and 2012 an interpolated value between 2010 and 2013 (STATISTIK AUSTRIA 2013 and 2014) has been calculated.

Table 232: Estimated total area of perennial crops from 1990–2013 in ha (including areas of LUC to perennial cropland).

	Viticulture	Horticul-ture	Garden	Energy crops	Christmas trees	Total area
1990	58 364	19 581	13 205	1 254	1 347	93 751
1991	57 981	19 293	12 319	1 528	1 392	92 512
1992	57 599	19 005	11 432	1 801	1 436	91 274
1993	57 216	18 717	10 546	2 075	1 481	90 035
1994	56 422	18 883	9 660	1 769	1 618	88 352
1995	55 628	19 049	8 774	1 463	1 754	86 668
1996	54 061	18 673	8 776	1 564	1 793	84 867
1997	52 494	18 297	8 778	1 665	1 832	83 066
1998	51 854	17 845	7 685	1 481	1 950	80 815
1999	51 214	17 392	6 593	1 297	2 068	78 564
2000	50 304	17 120	6 609	1 403	1 962	77 398
2001	49 393	16 849	6 625	1 510	1 856	76 232
2002	48 483	16 577	6 641	1 616	1 750	75 066
2003	47 572	16 305	6 657	1 722	1 644	73 900
2004	48 846	15 851	5 924	1 711	1 846	74 177
2005	50 119	15 396	5 191	1 700	2 048	74 454
2006	49 981	14 952	4 817	1 935	2 449	74 133
2007	49 842	14 507	4 444	2 170	2 849	73 812
2008	49 704	14 633	3 821	2 669	2 567	73 394
2009	45 533	14 758	3 199	3 169	2 284	68 943
2010	45 533	14 884	2 576	3 668	2 002	68 663
2011	45 462	14 988	2 393	3 593	2 204	68 640
2012	45 391	15 093	2 209	3 517	2 406	68 616
2013	45 320	15 197	2 026	3 442	2 608	68 593

Figure 34 indicates the decrease of the total perennial cropland area from 1960 to 2013. This trend was mainly caused by the continuous decline of the fruit growing area and the house garden area. According to 2006 IPCC GL (Tier 1 method, Table 5.1) 3.33% of perennial crops are removed and replanted after the rotation period of 30 years. Hence the decrease of orchard and house garden area causes emissions. 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. 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 in the 10 years and 6 years, respectively, of rotation period was assumed. The energy crop cultivation was assumed to start in 1990 (according to Statistik Austria). So, from 1996 on the energy crops cause also emissions.

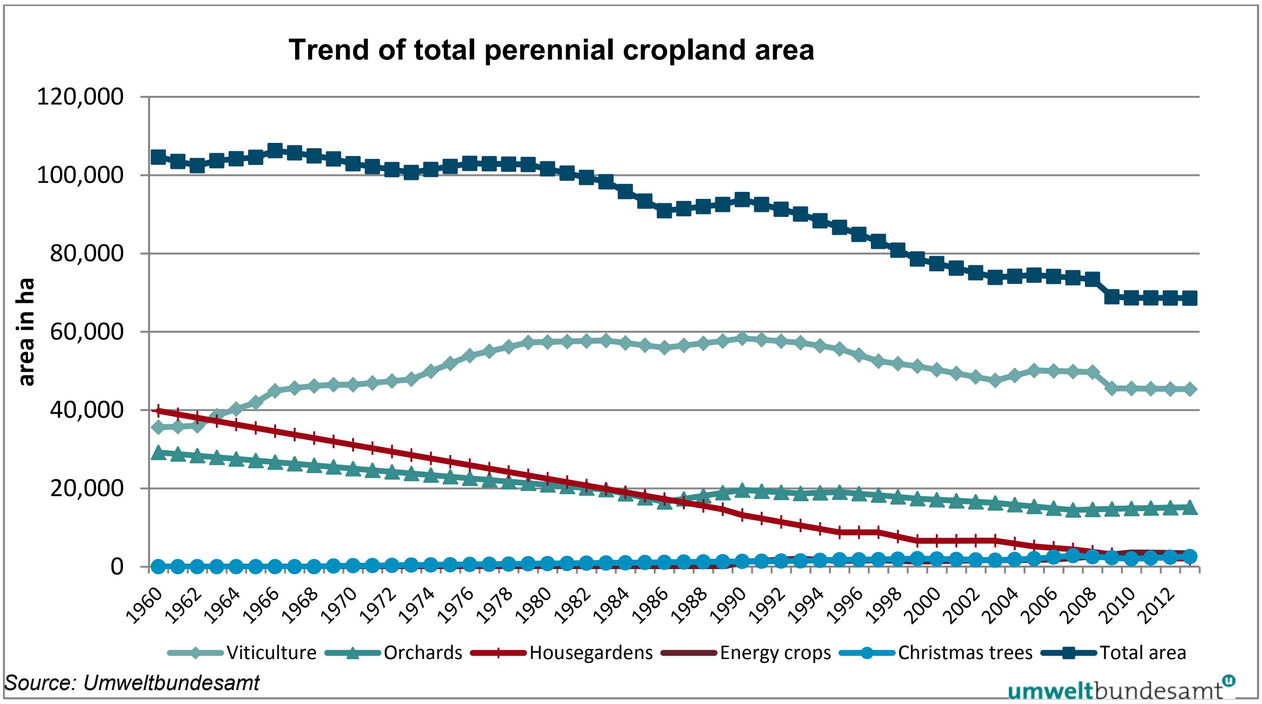


Figure 34: Trend of total perennial cropland area (ha) from 1960–2013 (including LUC areas to perennial cropland).

The reason for the inter-annual changes of emissions/removals within this category lies mainly within the area decrease and changes of the subcategory „perennial cropland remaining perennial cropland": The high variability of the emissions of this subcategory is mainly caused by the emissions from biomass. Whereas the emissions from soil are rather stable over the years the emissions from biomass (particularly from vineyard and orchards) vary significantly.

The area of vineyards increased until the 90ies but decreased thereafter, the areas of orchards and house gardens continuously decreased since 1960. 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". This causes the changes of the emissions of living biomass within the time series. The variability from year to year is also caused by the LUCs from perennial cropland to other agricultural land uses. Such changes are for economic reasons usually carried out at the end of the rotation period. High areas of such land-use changes in some years go hand in hand with less harvest in the "remaining" perennial cropland subcategory and vice-versa. For instance, the higher biomass losses in "perennial CL remaining perennial CL" in 2008 (Figure 35) are negatively correlated with less conversion perennial CL to annual CL and related less emissions in this subcategory in 2008 (Table 231). In the year 2010 it was the other way round (see Table 231 and Figure 35). The IACS system (see chapter 6.3.2) provides more detailed information of such land-use changes for the years after 2002 which is the reason for the higher variation in this period as before.

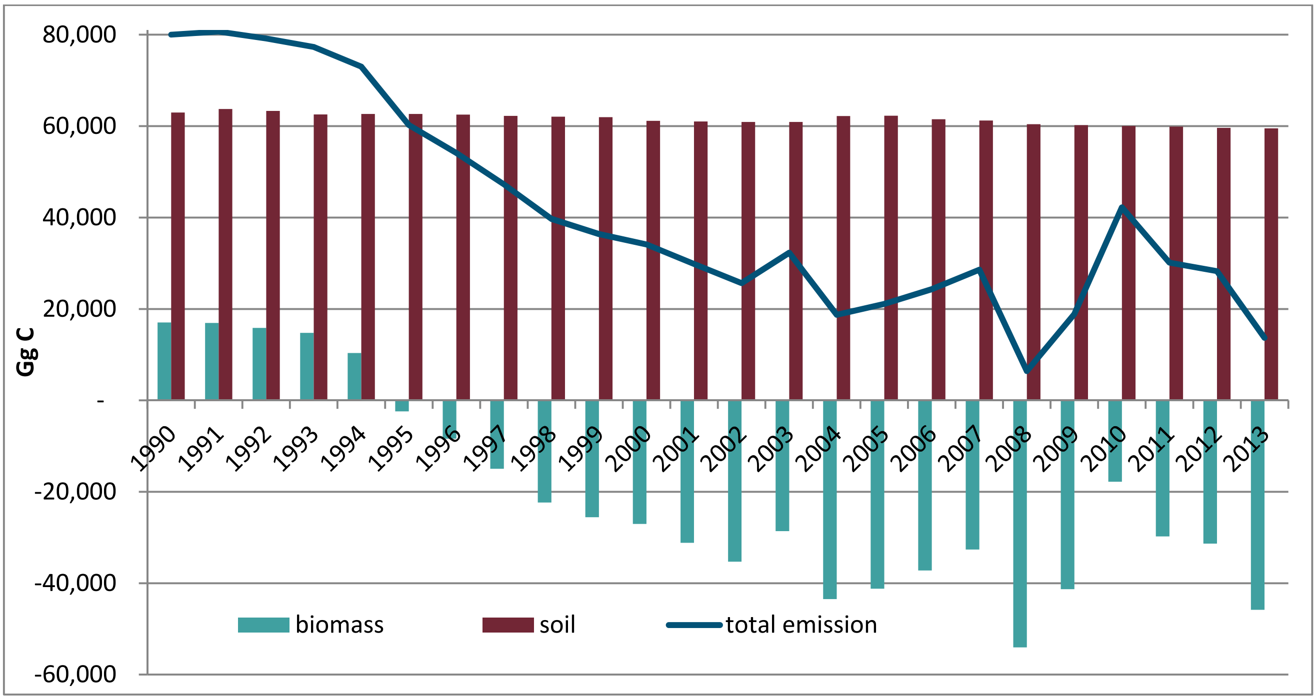


Figure 35: Carbon stock changes from soil and biomass of the subcategory annual cropland remaining annual cropland and perennial cropland remaining perennial cropland

For calculating the carbon stock change of living biomass of viticulture, orchards and house gardens the following Tier 1 equation based on the 2006 IPCC GL (IPCC 2006, Vol.4, Ch. 2.3.1.1, Equation 2.7, 2.9. and 2.10) was applied:

> *Annual change in biomass = (area of perennial cropland remaining perennial cropland*[a] ** Carbon accumulation rate) – (area of perennial cropland before 30 years*[a.b] ** 0.033 * biomass carbon stock at harvest)*
>
> [a]*excluding areas of Christmas tree cultures and energy crops (which are estimated according to the approaches below)*
>
> [b]*excluding perennial cropland areas lost by LUCs*

For the annual "carbon accumulation rate" in perennial cropland[a] the 2006 IPCC GL (IPCC 2006, Vol.4, Ch. 5.2.1.2, Table 5.1) default value of 2.1 t C $ha^{-1}a^{-1}$ was used.

For the aboveground „biomass carbon stock at harvest" the 2006 IPCC GL default value of 63 t C ha^{-1} was used for house gardens, viticulture and orchards (IPCC 2006, Vol.4, Ch. 5.2.1.2, Table 5.1).

However, these default values seem to be very high for Austrian conditions, so the belowground biomass was not considered, which is in line with Tier 1 method of the 2006 IPCC GL (Vol. 4, Ch. 5.2.1.2, p.5.10). It is planned to assess and report national data for viticulture and orchards.

For some perennial cropland types (Christmas trees, 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 trees the following equation was applied using country specific data:

> *Annual change in biomass = (area of Christmas tree cultures remaining Christmas tree cul-*

*tures * Carbon accumulation rate) – (area of Christmas trees before 10 years * 0.1 * biomass carbon stock at harvest)*

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 starting point of the calculations. 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 ration of 0.3 for Christmas trees, which was derived from the AR-results, also the belowground biomass could be estimated. Including the root biomass 4.68 t C/ha*year accumulation rate and a carbon stock of 46.8 t C ha^{-1} at harvest was computed and applied for Christmas trees biomass (above-ground and below-ground) for all years.

For energy 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 crops is six years. This leads to a carbon accumulation rate in above ground biomass of 5 t C ha^{-1} a^{-1} for energy crops. By using the root/shoot ration of 0.3 for energy crops (wood), which was derived from the AR-results, also the belowground biomass could be estimated. Including the root biomass a new factor of 6.5 t C/ha*year accumulation rate and a carbon stock of 39 t C ha^{-1} at harvest was computed and applied for energy crops biomass (above-ground and below-ground) for all years.

For calculating the carbon stock change of living biomass on energy crops the following equation was applied:

*Annual change in biomass of energy crops = (area of energy crops remaining energy crops * Carbon accumulation rate) – (area of energy crops before 6 years * 0.166 * biomass carbon stock at harvest)*

Figures for the area of energy crops are available since 1990 (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014).

Table 233: Annual carbon accumulation rate of the biomass stock of perennial cropland..

Perennial crop	Annual increase in carbon stock biomass (t C ha^{-1})	Rotation period (year)	Method
Vine, orchards, house gardens	2.1	30	Tier 1 2006 IPCC GL, Table 5.1
Christmas trees	4.68	10	Tier 2. country specific values
Energy crops	6.5	6	Tier 2. country specific values

6.3.4.1.2 Changes of carbon stocks in biomass of annual cropland converted to perennial cropland (4.B.1.b)

The total land use change area from annual cropland converted to perennial cropland was 15 739 ha in 2013.

The applied method follows entirely 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 LUCs within the cropland category. However, annual cropland and perennial cropland have completely different C stocks and C accumulation rates in both, biomass and soil. Therefore our approach to account for the C stock changes due to LUC between annual cropland and perennial cropland gives a more accurate picture on the emissions/removals of the sub-category „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. 6.3.4.1.5 and 6.3.4.1.6), because the estimates of the soil C stock changes in these sub-categories 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 LUC between these two cropland subcategories occur. The used activity data for estimating these emissions/removals do also strictly represent the areas of these „cropland remaining cropland" subcategories. So, there is 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 an annual growth according to the 2006 IPCC GL (2.1 t C $ha^{-1}a^{-1}$, IPCC 2006, Vol.4, Ch. 5.2.1.2, Table 5.1) was assumed for each year of 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

C_{after}	*= carbon stock immediately after conversion is 0*
ΔC_{growth}	*= IPCC default value for perennial crops carbon accumulation rate is 2.1 t C $ha^{-1}a^{-1}$ (annual growth rate in each year of the whole LUC 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 LUC)*

For the annual cropland biomass losses in the year of LUC from annual to perennial cropland the country specific average biomass stock in annual cropland was used. The average carbon stock of living biomass in annual cropland was calculated by using country specific data from Statistic Austria (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" has 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 should allow good estimates (IPCC GPG default values for root/shoot ratios of crops are not available). 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 belowground 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 of carbon stocks in biomass of perennial cropland converted to annual cropland (4.B.1.c)

The total land use change area from perennial cropland converted to annual cropland was 12 746 ha in 2013.

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).

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} = *IPCC default value for carbon stock of perennial cropland biomass before conversion is 63 t C ha^{-1}(accounted only for the year of LUC)*

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 the soil inventories in Austria organic soils are not occurring in cropland in Austria.

Emissions/removals of the 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 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 factors 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 the study of AGES (Austrian Agency for Health and Food Safety) and UMWELTBUNDESAMT (2010b) the IPCC default factors have been assessed against results from national long-term field experiments of AGES. Consistency between default and national factors for cropland was found for management induced soil carbon stock changes (reduced tillage, no-till), removal of crop residues and green manuring (input factor: low-medium residue return). A weaker correlation was found for the application of organic fertilisers (e.g. manure) and land use. Table 234: Relative stock change factors for cropland according to IPCC default values and one national study (UMWELTBUNDESAMT 2010b).

shows the national factors used since the submission 2011 compared to the (previously used) IPCC default values.

Starting point of the estimates are the applied national management factors according to Table 234.

Table 234: Relative stock change factors for cropland according to IPCC default values and one national study (UMWELTBUNDESAMT 2010b).

Factor value type		Level	IPCC default GPG 2003	IPCC default 2006 IPCC GL	Applied national factors (UMWELTBUNDESAMT 2010b)
Land use (F_{LU})	F_{LU}	Long-term cultivated	0.82	0.80	0.93
Tillage (F_{MG})	F_{MG1}	Full	1.00	1.00	1.00
	F_{MG2}	Reduced	1.03	1.09	1.03
	F_{MG3}	No-Till	1.10	1.10	1.10
Input (F_I)	F_{I1}	Low	0.92	0.95	0.92
	F_{I2}	Medium	1.00	1.00	1.00
	F_{I3}	High – without manure	1.07	1.04	1.07
	F_{I4}	High – with manure	1.34	1.37	1.11

These management factors are in a next step multiplied with the areas of related management in Austria for two years, first for 1990 (as indicated in the NIR being representative for the management in the period up to 1990) and in a next step for 2011 (being representative for the recent management). The result of these individual multiplications is added to sums for each management factor value type ($F_{LU,}$ F_{MG} and F_I) and for each year (1990, 2011). In a next step these sums for each management factor value type and year are divided by the total areas to result in specific average F_{LU}, F_{MG} and F_I for 1990 („$(F_{LU} \times F_{MG} \times F_I)_{1990}$") and for 2011 („$(F_{LU} \times F_{MG} \times F_I)_{2011}$"). These average ($(F_{LU} \times F_{MG} \times F_I)_{1990}$) and ($(F_{LU} \times F_{MG} \times F_I)_{2011}$) are used then to calculate the average soil C stock change for 21 years. The following equations shall demonstrate the approach:

$$(F_{LU} \times F_{MG} \times F_I)_{1990} = ((F_{LU} \times CL_{1990FLU})/CL_{tot}) \times ((F_{MG1} \times CL_{1990FMG1} + \ldots + F_{MG3} \times CL_{1990FMG3})/CL_{tot}) \times ((F_{I1} \times CL_{1990FI1} + \ldots + Fi_4 \times CL_{1990FI4})/CL_{tot}) \quad (1)$$

$$(F_{LU} \times F_{MG} \times F_I)_{2011} = ((F_{LU} \times CL_{2011FLU})/CL_{tot}) \times ((F_{MG1} \times CL_{2011FMG1} + \ldots + F_{MG3} \times CL_{2011FMG3})/CL_{tot}) \times ((F_{I1} \times CL_{2011FI1} + \ldots + Fi_4 \times CL_{2011FI4})/CL_{tot}) \quad (2)$$

$$SOC_{1990+21} = (SOC_{1990}/(F_{LU} \times F_{MG} \times F_I)_{1990}) \times (F_{LU} \times F_{MG} \times F_I)_{2011} \quad (3)$$

$$\Delta SOC_{21} = (SOC_{1990+21} - SOC_{1990})/21 = 0.044\ t\ C\ ha^{-1}\ a^{-1} \quad (4)$$

$(F_{LU} \times F_{MG} \times F_I)_{1990}$ *average Management factor for Austria for 1990*

$(F_{LU} \times F_{MG} \times F_I)_{2011}$ *average Management factor for Austria for 2011*

CL.... areas of cropland where "tot" represents related total CL area; CL with indices of managemnent factors and years represent CL areas with indicated management type in the indicated year according to the Austrian agricultural statistics

note for understanding: $CL_{FlU} = CL_{tot}$

$CL_{FMG1} + \ldots + CL_{FMG3} = CL_{tot}$

$CL_{FI1} + \ldots + CL_{1990FI4} = CL_{tot}$

SOC_{1990}50 t C ha^{-1}. Austrian specific soil carbon content per ha 0–30 cm for cropland in 1990 (GERZABEK et al. 2003)

$SOC_{1990+21}$av. soil carbon stock per ha after 21 years based on different land management factors (calculated value 50.92 t C ha^{-1})

Δ SOC_{21}average annual carbon stock change in Austrian cropland soils (t C ha^{-1} a^{-1}) over a period of 21 years

*Annual change in carbon stock of mineral soils in annual cropland remaining annual cropland = Δ SOC_{21} * area of annual cropland remaining annual cropland.*

This estimation method is based exactly on the approach of the example at p. 5.22 in the IPCC 2006 GL (IPCC 2006) with the only difference that the C stock at the start of the inventory period (SOC_{1990}) in Austria is 50 t C/ha. Its division by the average management factors representing the period to 1990 $(F_{LU}$ x F_{MG} x $F_I)_{1990}$ in the equation above is therefore only a back-calculation to the reference C stock (SOC_{REF} according to the IPCC 2006 GL example) on basis of which the C stock 1990 + 21 years ($SOC_{1990+21}$) can be calculated with the recent average management factors $(Flu$ x Fmg x $Fi)_{2011}$.The approach of the IPCC 2006 GL was used to divide *($SOC_{1990+21}$ - SOC_{1990})* by the length of the inventory period.

The estimates result in an average annual increase of soil organic carbon of 44 kg ha^{-1} a^{-1} since 1990. This increase is mainly caused by changes in agricultural management (e.g. increase of biological agriculture), tillage (e.g. crop residues remain on the fields) and crop rotation (increase of legumes and greening of cropland areas) since 1985.

For the sub-category „perennial cropland remaining perennial cropland" the same soil C stock changes as for „annual cropland remaining annual cropland" are assumed.

6.3.4.1.5 Changes of carbon stock in soils of annual cropland converted to perennial cropland (4.B.1.b)

The LUC area from annual cropland to perennial cropland (in conversion status for a time period of 20 years) changed from 16 654 ha to 15 739 ha from 1990 to 2013.

The rationale for estimating the soil C stock changes of this LUC has been given in chapter 6.3.4.1.2.

Emissions/removals were calculated by country specific values for carbon stocks in mineral soils of 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 =

*Δ SOC_{20} * conversion area for a transition period of 20 years*

$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 0.35$ t C ha^{-1} a^{-1}

Δ SOC_{20}...average annual carbon stock change in soils of annual cropland converted to perennial cropland (t C ha^{-1} a^{-1}) over a LUC 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 status from perennial cropland to annual cropland for a time period of 20 years is rather stable and ranges from 13 461 ha to 12 746 ha from 1990 to 2013.

The rationale for estimating the soil C stock changes of this LUC has been given in chapter 6.3.4.1.2.

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 =

*Δ SOC * 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 LUC transition period of 20 years

6.3.4.1.7 Liming

From this submission on liming is reported in the agricultural sector (chapter 5.6).

6.3.4.1.8 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 chapters 6.2.2 and 6.2.4.2. The area in conversion status from forest land to cropland (for a time period of 20 years) ranges from 3 478 ha to 4 792 ha between 1990 and 2012 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 32.3 Gg CO_2 to 83.9 Gg 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 231). An interpolation across these steps would lead to wrong results and is therefore not carried out.

N_2O emissions from soils of forest land converted to cropland

The area of land use conversions (forest land to cropland) was taken from Table 230. The annual release of N_2O was calculated with IPCC default values ((TIER 1, see table 11.1 in IPCC 2006) using equation 11.2 (IPCC 2006)). On basis of the results of the Austrian forest soil survey the C/N ratio in soil organic matter was assumed to be 19 for forest soils (BFW 1992).

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:

4.B.2.2 grassland converted to cropland total

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. In addition, in the extrapolation factor from the assessed subsample to all Austria was improved (see chapter 6.3.2).

The average annual land use change area from grassland to annual cropland from 1990–2013 is 2 238 ha. The area in conversion status for a time period of 20 years ranges from 31 250 ha to 47 392 ha for the period 1990 to 2013. Considering the area of the 20 year time period this leads to emissions between 108.8 and 161.2 Gg CO_2.

The average annual land use change area from grassland to perennial cropland from 1990–2013 is 95 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 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. After five years of grassland use these lands must not be converted to cropland anymore. This regulation came into force in 2002 – therefore, 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 see Table 230. Emissions were estimated applying a country specific methodology (Tier 2) for both 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).

*Annual change in biomass = 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 an annual growth according to the IPCC 2006 GL (2.1 t C $ha^{-1}a^{-1}$) 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} = IPCC default value for annual carbon accumulation rate in perennial crops is 2.1 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 as recommended by the ERT.

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 were 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 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 (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 GPG (2003) 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 = Δ SOC * conversion area for a transition period of 20 years*

Δ SOC = 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 annual land use change area from grassland to perennial cropland ranges from 1 320 ha to 2 001 ha for the period 1990–2013 considering the area to be 20 years in the conversion category.

Emissions/removals were calculated by country specific 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 land were used (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.

For consistency and transparency reasons the biomass C stock changes at these LUC areas to perennial cropland are reported in these LUC categories for a transition period of 20 years.

$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -0.65\ t\ C\ ha^{-1}\ a^{-1}$

*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. Separately, as recommended by the ERT.

N_2O emissions from soils of grassland converted to cropland

The N_2O emissions due to the conversion of grassland to cropland were calculated with IPCC default values (TIER 1, see table 11.1) using equation 11.2 (IPCC 2006). The area of land use conversions (grassland to annual and perennial cropland) was taken from Table 230.

The C/N ratio in soil organic matter was assumed to be 12 for grassland soils (based on Austrian soil inventory data, BORIS).

6.3.5 Uncertainty assessment

For the Monte-Carlo-simulations the following uncertainties of the input parameters were used:

Table 235: 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 227	see Chapter 6.2.5. Table 227
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] *Distribution was truncated at 0, because 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 236: 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 228	
N_2O emission factor for soil at LUC to CL		±150%
C/N ratio grassland soils	±55%	
C/N ratio forest soils	±58%	
Liming		±50%

These uncertainties origin from:

- 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
- Liming: expert judgement from two agricultural experts

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 Gg CO_2 with higher uncertainties in the 90ies[74]. This reflects the fact that the activity data of previous years have a higher uncertainty (see Table 227). The relative uncertainties in the single years are in the range from ±356 to ±1 849%. Again, the higher relative uncertainties were assessed for the 90ies. Here, the fact that the net emissions in these years were clearly lower than in the 2000s plays an additional and significant role for this result.

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.

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

For Cropland the annual cropland area statistics of „Statistik Austria" used as activity data since 1990 have been recalculated and are with this submission based on a combination of FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System) data. In the years where Farm Structure Surveys were conducted these data were taken: For the years 1990, 1995, 1999 and 2010 (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013) a full Farm Structure Survey (FSS) was conducted and in between there were random sample Farm Struc-

[74] 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.

ture Surveys undertaken, that is for the years 1993, 1997, 2003, 2005, 2007 and 2013 (ÖSTAT 1994, 1998, STATISTIK AUSTRIA 2005, 2006, 2008, 2014). Since joining the EU in 1995 Austria is committed to run the IACS data base. It covers detailed information on cropland areas (see explanation below).

For the total annual cropland area the data from the FSS differ from the IACS data, in most cases the area in the FSS database is larger, because of the greater number of farms included in FSS compared to IACS. This relationship has been represented by calculating a factor

FSS area for total annual cropland/IACS area for total annual cropland,

which was estimated for the years where FSS has been conducted. For the years between two Farm Structure Surveys the annual cropland area out of the IACS database has been adjusted to the FSS area by multiplying it with the factor from the year in which the next FSS has been conducted.

Furthermore for Christmas trees and Energy crops data on roots biomass have been added. By using the root/shoot ration of 0.3 for energy crops (wood), which was derived from the AR-results, also the belowground biomass could be estimated (implementation of planned improvements 4 and 5 of the NIR 2014 (UMWELTBUNDESAMT 2014a).

The LUCs between perennial and annual CL and the LUCs between CL and GL of the most recent years were updated on basis of an assessment of the most recent statistics.

6.3.8 Planned improvements

Improvement of the values for biomass C-stocks in viticulture and orchards is still on top of the agenda to improve the inventory for this sector. The default carbon accumulation factor of 2.1 tons C/ha/yr for the biomass increase, which leads to biomass carbon stock at harvest of 63 t C /ha after a rotation period of 30 years (IPCC 2006, Vol.4, Ch. 5.2.1.2, Table 5.1), is probably too high for Austrian conditions and will be improved with country- and species-specific values within the next years.

For soil organic carbon in cropland and grassland estimates a refined time resolution will be carried out.

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 2013 1.46 Mio ha of Austria were grassland (STATISTIK AUSTRIA 2014). There was a decrease in grassland along the time series. Total grassland includes one cut meadows, two cut meadows and three and more cut meadows, permanent pastures, litter meadows, rough pastures, alpine meadows and pastures, grassland where grassland management was stopped and GLÖZ G (grassland in good agricultural and ecological condition no longer used for production).

The annual emission of grassland in Austria amounted to 324 Gg CO_2 in 1990 and 50 Gg CO_2 in 2013. The main driver of the emissions is the LUC from forest land to grassland.

In the current submission a recalculation of the areas of alpine pasture was undertaken. The new delineation led to a decrease of the total grassland area from 1990 to 2013 (ha). 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 sub categories (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 237: 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 238: Total areas and land-use change areas of grassland 1990–2013 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	1 666 375	48 542	32 467	16 074	15 901	174	NO	NO	NO
1991	1 713 391	1 663 137	50 254	34 203	16 051	15 878	174	NO	NO	NO
1992	1 711 865	1 659 934	51 932	35 939	15 993	15 820	173	NO	NO	NO
1993	1 710 340	1 656 736	53 603	37 675	15 929	15 756	172	NO	NO	NO
1994	1 686 023	1 632 411	53 613	37 716	15 897	15 725	172	NO	NO	NO
1995	1 668 997	1 616 063	52 934	37 069	15 866	15 694	172	NO	NO	NO
1996	1 670 182	1 617 924	52 258	36 421	15 837	15 666	171	NO	NO	NO
1997	1 671 366	1 619 791	51 575	35 773	15 802	15 631	171	NO	NO	NO
1998	1 661 034	1 610 151	50 884	35 125	15 758	15 588	170	NO	NO	NO
1999	1 650 702	1 599 715	50 987	35 284	15 703	15 533	170	NO	NO	NO
2000	1 652 301	1 601 200	51 102	35 442	15 659	15 490	169	NO	NO	NO
2001	1 653 900	1 602 683	51 217	35 601	15 616	15 447	169	NO	NO	NO
2002	1 655 499	1 603 321	52 178	36 621	15 557	15 389	168	NO	NO	NO
2003	1 657 097	1 604 150	52 948	37 640	15 307	15 132	176	NO	NO	NO
2004	1 628 997	1 576 838	52 159	37 037	15 122	14 947	175	NO	NO	NO
2005	1 608 648	1 556 760	51 887	36 433	15 454	15 278	176	NO	NO	NO
2006	1 581 383	1 529 775	51 608	35 830	15 778	15 597	181	NO	NO	NO
2007	1 554 118	1 501 283	52 834	35 227	17 608	17 403	204	NO	NO	NO
2008	1 539 169	1 481 804	57 365	34 623	22 742	22 525	217	NO	NO	NO
2009	1 524 220	1 466 641	57 579	33 477	24 102	23 879	223	NO	NO	NO
2010	1 509 271	1 451 593	57 679	32 502	25 177	24 945	231	NO	NO	NO
2011	1 493 892	1 436 230	57 662	31 527	26 134	25 874	261	NO	NO	NO
2012	1 478 512	1 421 252	57 260	30 553	26 708	26 432	276	NO	NO	NO
2013	1 463 133	1 406 349	56 784	29 578	27 206	26 924	282	NO	NO	NO

Table 239: Emissions/removals (+/-) from grassland in Gg CO_2 (1990–2013)

	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
1990	324.19	2.05	322.13	376.24	-54.11	-55.50	1.39	NO	NO	NO
1991	318.89	2.07	316.82	370.95	-54.13	-55.48	1.35	NO	NO	NO
1992	313.84	2.09	311.75	365.61	-53.86	-55.23	1.37	NO	NO	NO
1993	308.97	2.11	306.85	360.51	-53.65	-55.01	1.36	NO	NO	NO
1994	309.03	2.25	306.77	360.36	-53.59	-54.93	1.34	NO	NO	NO
1995	141.97	2.35	139.62	193.08	-53.46	-54.81	1.35	NO	NO	NO
1996	143.64	2.34	141.30	194.66	-53.36	-54.70	1.35	NO	NO	NO
1997	145.32	2.33	142.99	196.23	-53.24	-54.58	1.35	NO	NO	NO
1998	147.11	2.39	144.72	197.82	-53.10	-54.44	1.34	NO	NO	NO
1999	146.90	2.45	144.45	197.36	-52.91	-54.24	1.34	NO	NO	NO
2000	146.59	2.44	144.15	196.90	-52.75	-54.09	1.34	NO	NO	NO
2001	146.23	2.43	143.80	196.45	-52.65	-53.96	1.31	NO	NO	NO
2002	354.06	2.43	351.63	404.07	-52.45	-53.76	1.31	NO	NO	NO
2003	351.92	2.42	349.50	400.01	-50.51	-53.51	3.00	NO	NO	NO
2004	351.80	2.59	349.22	400.63	-51.41	-52.70	1.29	NO	NO	NO
2005	353.32	2.70	350.62	401.25	-50.63	-52.06	1.42	NO	NO	NO
2006	353.54	2.86	350.67	401.52	-50.84	-53.26	2.42	NO	NO	NO
2007	356.50	3.03	353.47	401.79	-48.32	-54.59	6.27	NO	NO	NO
2008	347.65	3.15	344.50	402.06	-57.56	-61.51	3.94	NO	NO	NO
2009	48.75	3.24	45.51	122.83	-77.32	-79.91	2.59	NO	NO	NO
2010	46.25	3.33	42.92	124.85	-81.93	-84.85	2.92	NO	NO	NO
2011	48.79	3.42	45.37	126.87	-81.50	-88.81	7.31	NO	NO	NO
2012	44.51	3.51	41.00	128.88	-87.88	-92.14	4.26	NO	NO	NO
2013	50.14	3.60	46.54	131.36	-84.82	-93.09	8.27	NO	NO	NO

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 1960–2014). The surveys are based on the responses to questionnaires sent to all farms and forest enterprises and cover 90 % of Austria. 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 2013 (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014). For the years between the surveys the data have been interpolated. The data of the random sample farm structure survey 2013 (Statistik Austria 2014) are considered in this submission.

In the current submission an improvement of areas of alpine pastures was carried out:

In the year 2010 new entry conditions for receiving support for alpine pastures were applied in the framework of the Rural Development Programme in Austria. Subsequently improved topographical surveying in the alpine regions was undertaken, allowing better distinction of areas unfit for agricultural use from the actual alpine pasture areas. Due to the new delineation the areas of alpine pasture comprise solely areas of rough grazing (fodder areas) excluding stony patches and unproductive areas covered with shrubs or trees. Subsequently the estimation led to different, reduced areas of alpine pastures since about 1999 compared to previous surveys. The area dedicated to rough grazing dropped by 470 800 hectares to 362 562 hectares in 2013 (STATISTIK AUSTRIA 2014). The main part of the stony and unproductive areas was relocated to the category "other land" thus reflecting more precisely the real situation. Figure 36 shows clearly the shift of unproductive rough grazing areas to "other land".

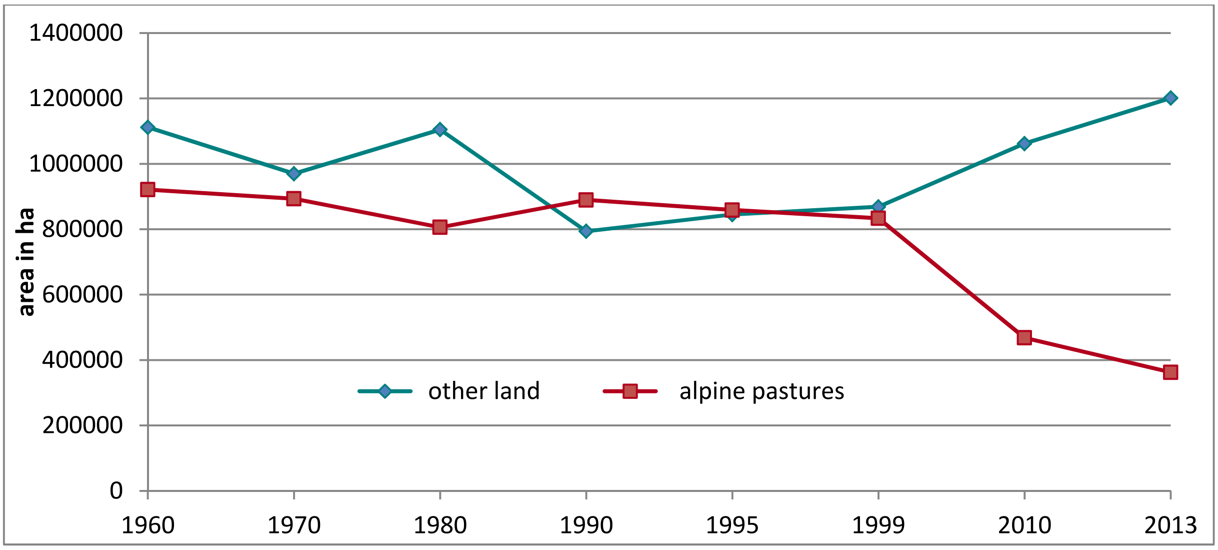


Figure 36: Area shift of alpine meadows to other land (ha) according to the reclassification of alpine meadows

The new determination was finalized in 2013 and the data were published in the Farm Structure Survey 2013 (STATISTIK AUSTRIA 2014).

The methodological refinement required a recalculation of the alpine grassland area to receive consistent time series: Based on the alpine grassland data of the FSS 2013 reduction factors were estimated considering the share of areas that shifted to other land and forest land respectively and the relative trend before 1999 (start of the re-assessment was kept). Subsequently the conversion factors were applied in the years of the FSS 1960, 1970, 1980, 1990, 1999, 2010. Thus the estimated reduced areas reflect the area trend over the time without inclusion of areas of other land uses (forest land, other land) under alpine pastures. The areas of the years between the full Farm Structure Survey were interpolated.

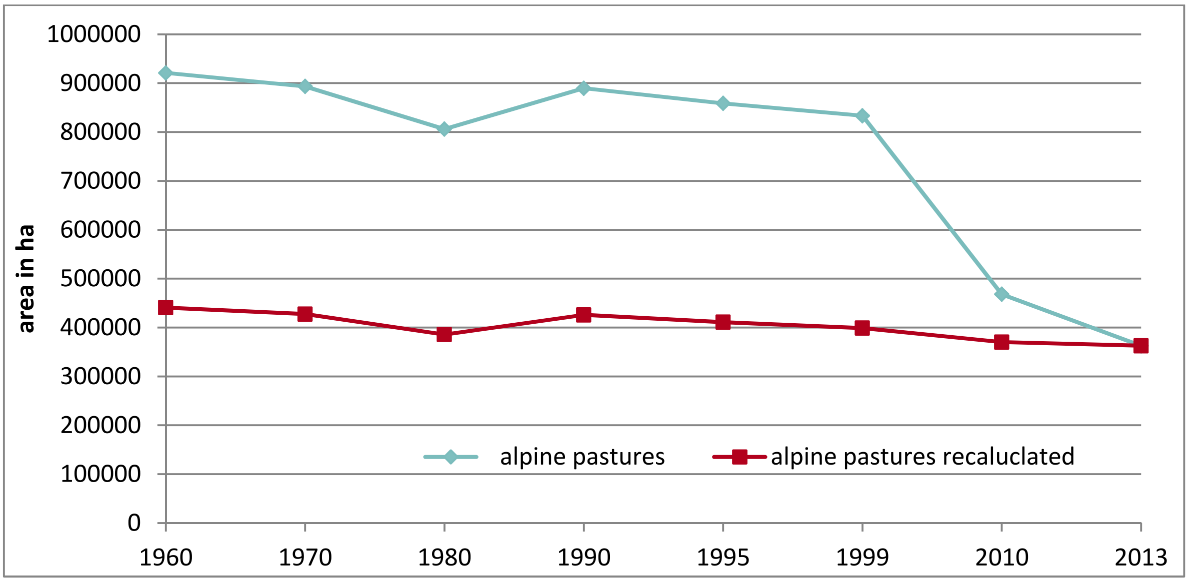


Figure 37: Time series of alpine pastures - recalculated (ha)

A consultation of the results of the recalculation with experts of the administrative agricultural authorities of the AMA, Statistics Austria and the Ministry of Agriculture was carried out and confirmed the correctness of the recalculation.

Due to the recalculated areas of alpine pastures the area of total grassland dropped significantly compared with the previous submissions.

Data for land use changes between cropland and grassland were estimated on basis of IACS. The time series of these lands was changed according to an update of these LUC areas for the last years on basis of the most recent statistics (for a detailed description see Chapter 6.3.2).

The LUC area from cropland to grassland is in the order of 1.9 % of the total grassland area (across a LUC transition period of 20 years) and on average 0.08 % of the total grassland area each year.

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 praxis 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 – are usually not more usable as grassland.
4) There is also a higher economic factor for land dedicated to settlements area than agricultural land which makes a reconversion very unlikely.
5) „Other lands" are the highest located areas of Austria or very steep areas, all in all, areas of very unfavorable ecological conditions that do not allow any agricultural use.

6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The STATISTIK AUSTRIA (2014) classification for grassland was used for land use definitions:

- One cut meadows,
- Two cut meadows,
- Three and more cut meadows,
- Litter meadows,
- Permanent Pastures,
- Rough Pastures,
- Alpine meadows and pastures,
- Grassland where grassland management was stopped,
- GLÖZ G: grassland in good agricultural and ecological condition no longer used for production.

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 2013 was 1.41 Mio ha.

The annual emissions from grassland remaining grassland between 1990 and 2013 range from 2.05 Gg CO_2 to 3.60 Gg 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 equations used for calculating the change in carbon stocks of grassland soils and the method are exactly the same as for cropland described in detail in Chapter 6.3.4.1.4 with the difference of using the soil C stock (SOC_{1990}) for grassland with 70 t C/ha, the management factors for grassland according to the guidelines IPCC (2006) table 6.2 and the areas of related grassland management in Austria.

These default factors were applied to the Austrian situation of grassland management in the years 1990 and 2011 on basis of national statistics for the grassland (STATISTIK AUSTRIA 1985–2003; BMLFUW 1985–2011). Management improvements (e.g. increase of biological agriculture) were considered since 1985. On basis of these grassland management data and changes and on the IPCC (2006) default management factors an annual increase of soil organic carbon of 0.00162 t C ha^{-1} across a period of 21 years is calculated.

The carbon stock changes of grassland soil (70 t C ha^{-1}) from 1990–2013 were calculated then on basis of this annual soil C stock increase.

*Annual change in carbon stock of mineral soils in grassland remaining grassland = Δ SOC_{21} * area of grassland remaining grassland*

$\Delta SOC_{21} = (SOC_{1990+21} – SOC_{1990})/21 = 0.00162 t C ha^{-1} a^{-1}$

The approach of the IPCC 2006 Guidelines was used to divide *($SOC_{1990+21}$ - SOC_{1990})* by the length of the inventory period.

6.4.4.1.3 Liming

From this submission on liming is reported in the agricultural sector (chapter 5.6).

6.4.4.1.4 Changes in carbon stocks of organic soils of grassland remaining grassland

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.

The emissions from organic soils were estimated according to the IPCC 2006 Guidelines with the EF for boreal/cold temperate regime ($EF_{boreal/cold}$ =0.25 t C/ha; see table 6.3)

The calculated emission from organic grassland soils was 11.87 Gg CO_2.

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 status from forest land to grassland for a time period of 20 year ranges from 37 716 ha to 29 578 ha between the years 1990 and 2013. The main part of conversion takes place from forests to pasture causing annual emissions due to the loss of biomass and C stock changes in soil and litter between 122.8 Gg CO_2 and 404.1 Gg CO_2.

For the calculation of the annual change of carbon stocks 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 239). An interpolation across these steps would lead to wrong results 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 1990–2013 is 1 264 ha. The average annual land use change area (1990–2013) from perennial cropland to grassland is 14 ha. The total area in conversion status for a time period of 20 years amounts to 16 074 ha in 1990 and 27 206 ha in 2013. Considering the area of the 20 years time period this leads to annual removals from 54.11Gg CO_2 in 1990 and 84,82 Gg CO_2 in 2013.

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. After 2008 a higher conversion rate from cropland to GL could be observed with a peak in 2008. 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 for a time period of 10 years (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein – HBLFA).

The mean of the grassland yield of the categories one cut meadows, two cut meadows, litter meadows, rough pastures and cultivated pastures was calculated by considering the total area of these different grassland categories. The calculation led to an average biomass yield per year of 6.2 t dm ha^{-1} for grassland under the Austrian situation, these are 3.1 t C per ha and year.

To calculate the weighted mean a „weighting factor" is used. This factor is estimated on basis of the area share of a specific grassland type (e.g. two and more cut meadows have a share of 78% of the total grassland area in the 10 years average (1996–2005). thus the weight factor is 0.78). These weighting factors are multiplied then by the related yields and summed up to get the weighted grassland yields.

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 240: 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

	area in ha (avg 10 year)	**weighting factor**	**yield in t** (avg 10 year)	**contribution to weighted mean** ($t\ dm\ ha^{-1}$)
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 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 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 2013 is 14 ha. The used equation and methodological approach is described before (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 represents the IPCC (2006) default value for perennial cropland (table 5.1):

C_{before}= IPCC default value of biomass carbon stock of perennial crops before conversion is 63 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 sub-categories.

Changes of carbon stock in mineral soil of annual cropland converted to grassland

The area in conversion status from annual cropland converted to grassland for a time period of 20 years amounts to 15 901 ha and 26 924 ha in the years 1990 and 2013, respectively.

The IPCC method with a four step approach was applied. The calculation steps for determining SOC_0. $SOC_{(0-T)}$ and net soil change per ha of area are as follows:

- Step 1: Selecting Austrian specific values for annual cropland before conversion →SOC_{0-T}
- Step 2: Selecting Austrian specific values for grassland 20 years after conversion → SOC_0
- Step 3: Calculation of average annual carbon stock change for the LUC period of 20 a.
- Step 4: Multiply the annual carbon stock change by the conversion area for a transition period of 20 years.

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 (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 174 ha and 282 ha in the years 1990 and 2013:

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 (GERZABEK et al. 2003, STREBL et al. 2003).

$$\Delta\ SOC = (SOC_0 - SOC_{0-T})/20 = 0.65\ t\ C\ ha^{-1}\ a^{-1}$$

*annual change in carbon stock of mineral soils converted from grassland to perennial cropland = Δ SOC * conversion area for a transition period of 20 years*

SOC_0…… carbon stock in soils 20 years after conversion from perennial cropland to grassland →70 t C ha^{-1}

SOC_{0-T}…… carbon stock in Austrian perennial cropland soils before conversion →57 t C ha^{-1}

The results in the CRF table are split into the soil carbon stock changes of annual cropland converted to grassland and perennial cropland converted to grassland and the sum of these subcategories.

6.4.5 Uncertainty assessment

Table 241: 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 227	see Chapter 6.2.5 Table 227
Annual LUC area pCL to GL	±300%[1]	±260%[1]
Annual LUC area aCL to GL	±200%[1]	±150%[1]

[1] Distribution was truncated at 0, because negative areas are not possible

These uncertainties origin from:

- 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% and those for the emission factor of organic soils which are ±90% according to the IPCC GPG.

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: ±538 to ±831 Gg CO_2 with higher uncertainties in the 90ies[75]. Like in the cropland subcategory, this difference is caused by the activity data of previous years which have a higher uncertainty (see Table 241). The relative uncertainties in the single years are in the range from ±154 to ±1 392%. Very high relative uncertainties occur in the first years of the 90ies, but also in the most recent years when the net emissions/removals were clearly lower than in the intermediate 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 sub-categories 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.

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

In the current submission an improvement of areas of alpine pastures was carried out: In the year 2010 new entry conditions for receiving support for alpine pastures were applied in the framework of the Rural Development Programme in Austria. Subsequently improved topographical surveying in the alpine regions was undertaken, allowing better distinction of areas unfit for agricultural use from the actual alpine pasture areas. Due to the new delineation the areas of alpine pasture comprise solely areas of rough grazing (fodder areas) excluding stony patches and unproductive areas covered with shrubs or trees. Subsequently the estimation led to different, reduced areas of alpine pastures. The area dedicated to rough grazing dropped by 470 800 hectares to 362 562 hectares in 2013 (STATISTIK AUSTRIA 2014). The main part of the stony and

[75] 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.

unproductive areas was relocated to the category "other land" thus reflecting more precisely the real situation. Only a small part went to forest land. The new determination started in the 2000s and was finalized in 2013 and the data were published in the Farm Structure Survey 2013 (STATISTIK AUSTRIA 2014). The methodological refinement required a recalculation of the alpine grassland area to achieve a consistent time series: Based on the alpine grassland data of the FSS 2013 reduction factors were estimated considering the share of areas that shifted to other land and forest land respectively, and the relative trend information for the assessment before 1999 were used. Subsequently the conversion factors and the relative trend before 1999 were applied in the years of the FSS 1960, 1970, 1980, 1990, 1999, 2010 to correct the time series into a consistent one. Thus the estimated reduced areas reflect the real area trend over the time of alpine pastures without any inclusion of land of other land categories. The areas of the years between the full Farm Structure Survey were interpolated. Due to the recalculated areas of alpine pastures the area of total grassland dropped significantly compared with the previous submissions (implementation of planned improvement 3 of the NIR 2014 (UMWELTBUNDESAMT 2014a).

The areas of CL and GL of the most recent years were updated on basis of an assessment of the most recent statistics. In addition, the extrapolation factor from the assessed subsample to all Austria used in previous submissions was improved.

6.4.8 Planned improvements

For soil organic carbon in cropland and grassland estimates in a refined time resolution will be prepared.

6.5 Wetlands (Category 4.D)

6.5.1 Category description

In this category emissions/removals from the sub-categories "Wetland remaining wetland" and "Land converted to wetland" are considered.

The wetland area ranges from 133 068 ha to 149 360 ha in the years 1990–2013. Along the time series a steady increase in wetland could be observed with slightly higher increases in the last years.

The shares of the different previous land use types before conversion to wetland vary between the years. Since 2005 the wetland area was taken in annual resolution while interpolations were carried out for the years before. As a consequence, the LUC areas to WL and the emissions show higher variations in the years after 2005. The slightly higher LUCs to WL in the last years are the reason for the slightly higher emissions of this subcategory in the last years.

Table 242:Total areas and land-use change areas of wetland 1990–2013 in ha.

and Table 242:Total areas and land-use change areas of wetland 1990–2013 in ha.

show the land use change and removals/emissions from LUC to wetland from 1990–2013.

Table 242: Total areas and land-use change areas of wetland 1990–2013 in ha.

	4 D Total wet-land	1. Wetland remaining wet-land	2. Land conver-ted 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	133 068	127 557	5 511	1 706	NO	3 804	NO	NO
1991	133 519	127 009	6 510	1 798	NO	4 713	NO	NO
1992	133 970	126 460	7 510	1 889	NO	5 621	NO	NO
1993	134 422	125 912	8 509	1 980	NO	6 529	NO	NO
1994	134 873	125 453	9 420	1 982	NO	7 438	NO	NO
1995	135 587	125 177	10 410	1 948	NO	8 462	NO	NO
1996	136 302	124 901	11 401	1 914	NO	9 487	NO	NO
1997	137 016	124 625	12 392	1 880	NO	10 512	NO	NO
1998	137 731	124 349	13 382	1 846	NO	11 536	NO	NO
1999	138 445	124 030	14 415	1 854	NO	12 561	NO	NO
2000	139 160	123 712	15 448	1 863	NO	13 585	NO	NO
2001	139 874	123 393	16 481	1 871	NO	14 610	NO	NO
2002	140 589	122 757	17 832	1 898	NO	15 935	NO	NO
2003	141 303	122 120	19 183	1 924	NO	17 259	NO	NO
2004	142 018	121 569	20 449	1 865	NO	18 583	NO	NO
2005	142 245	121 018	21 227	1 806	NO	19 421	NO	NO
2006	142 575	120 893	21 682	1 747	NO	19 935	NO	NO
2007	143 477	121 118	22 359	1 688	NO	20 670	NO	NO
2008	144 265	121 344	22 921	1 630	NO	21 291	NO	NO
2009	145 084	122 012	23 071	1 752	NO	21 319	NO	NO
2010	146 123	122 663	23 461	1 884	NO	21 576	NO	NO
2011	146 989	123 313	23 676	2 016	NO	21 660	NO	NO
2012	148 096	123 964	24 133	2 148	NO	21 985	NO	NO
2013	149 360	124 614	24 746	2 279	NO	22 467	NO	NO

Table 243: Emissions/removals (+/-) of wetland 1990–2013 in Gg CO_2.

	4.D Total wetland	1. Wetland remaining wet-land	2. Land conver-ted to wetland	2.1 Forest land converted to wet-land	2.2 Cropland converted to Wetland	2.3 Grassland converted to wet-land	2.4 Settlements converted to wet-land	2.5 Other land converted to wet-land
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	41.98	NO	41.98	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	35.81	NO	35.81	14.41	NO	21.40	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	37.17	NO	37.17	19.68	NO	17.49	NO	NO
2006	39.32	NO	39.32	19.70	NO	19.62	NO	NO

	4.D Total wetland	1. Wetland remaining wetland	2. Land converted to wetland	2.1 Forest land converted to wetland	2.2 Cropland converted to Wetland	2.3 Grassland converted to wetland	2.4 Settlements converted to wetland	2.5 Other land converted to wetland
2007	51.30	NO	51.30	19.72	NO	31.58	NO	NO
2008	48.93	NO	48.93	19.75	NO	29.18	NO	NO
2009	68.78	NO	68.78	49.05	NO	19.73	NO	NO
2010	73.40	NO	73.40	49.06	NO	24.34	NO	NO
2011	69.77	NO	69.77	49.07	NO	20.70	NO	NO
2012	74.84	NO	74.84	49.07	NO	25.77	NO	NO
2013	78.04	NO	78.04	49.02	NO	29.02	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 2014). 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 occasionally. The change in the annual water body area was calculated from mean average increase (714 ha) of water bodies from the period 1990–2004. According to methodological changes in the inventory of the regional information derived from the Real Estate Database the real annual reported wetland area was taken since 2005 and interpolations were carried out for the years before. As a consequence, the LUC areas to WL and the emissions show higher variations in the years after 2005.

Due to the fact that the 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 courses of rivers. 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. For area consistency reasons and due to the updated LUC areas FL to WL, also the LUC areas GL to WL were changed for submission 2014 and are slightly different to those of previous submissions.

The area in conversion status of land converted to wetland for a time period of 20 years ranges from 5 511 ha to 24 746 ha for the period 1990 to 2013.

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 area in Austria amounts to 22 239 ha. As bogs 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 area is reported under the sub-category other wetlands. Emissions are not occurring because bogs 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, all areas of flooded lands remaining flooded are included (IE) in sub-category other wetlands remaining other wetlands.

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 sub-category 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 status from forest land to wetland for a time period of 20 years ranges from 1630 ha to 2 279 ha between the years 1990 and 2013 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 14.4 Gg CO_2 to 49.1 Gg 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 these steps would lead to wrong results 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 conversion areas are mainly 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 $(tonne\ d.m.)^{-1}$

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 literature for submission 2015 no C-stock changes in mineral soil are assumed at LUC 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 227; 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 sub-categories and their uncertainties.

The uncertainties of the emission factors are given in Chapter 6.2.5. Table 228 and Chapter 6.3.5. Table 236. Since only the sub-categories 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 Gg CO_2 with a steady increase across the time series or between 419 and 1 605% 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 recalculations

6.5.8 Planned improvements

See Chapter 6.1.8.

6.6 Settlements (Category 4.E)

6.6.1 Category description

In this category only emissions/removals from the sub-categories Land converted to settlements are considered. Dead wood and litter is assumed not to occur at settlement areas. About 0.54 million ha of Austria's surface can be allocated to the IPCC land use category settlements (BEV 2014). Along the time series a steady increase in settlement areas could be observed.

The shares of the different previous land use types before conversion to settlements vary between the years. Since 2005 the settlement area was taken in annual resolution while interpolations were carried out for the years before. As a consequence, the LUC areas to SL and the emissions show higher 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 144 563 ha to 153 161 ha between the years 1990 and 2013 causing annual emission rates due to C stock changes of biomass, dead organic matter and soils from 135 Gg CO_2 to 443 Gg CO_2. The LUCs from forest land and grassland to settlement are the reason for the emissions in this subcategory.

Annual LUCs to settlement occur from the sub-categories Forest Land, Cropland and Grassland. The portions of these categories vary between the years and cause variations of CO_2 emissions and IEF for the sum of net C stock changes in living biomass and soils in the category LUC to settlements. Consequently, the trend of total emissions in this category is partly different to the trend of the total settlement area because:

- the increase of living biomass of perennial species (trees and shrubs) as well as the discounting of soil carbon stock changes refer to LUC transition areas for a time period of 20 years. whereas;
- the increase of ground vegetation (annual plants) is accounted only at the LUC areas with current LUC (in the year of LUC) in the categories.

Table 244 and Table 245 show the land use changes and removals/emissions from LUC to settlements for the period 1990 to 2013.

Table 244: Total areas and land use change areas for the subcategory settlements 4.E for the period 1990 to 2013 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	386 858	237 093	149 765	9 792	53 149	86 824	NO	NO

1991	393 661	242 931	150 730	10 315	53 972	86 443	NO	NO
1992	400 465	248 769	151 696	10 839	54 796	86 061	NO	NO
1993	407 268	254 607	152 661	11 362	55 619	85 679	NO	NO
1994	414 071	261 836	152 235	11 375	56 113	84 747	NO	NO
1995	420 874	269 315	151 560	11 180	56 587	83 793	NO	NO
1996	427 678	276 794	150 884	10 984	57 061	82 839	NO	NO
1997	434 481	284 273	150 208	10 789	57 534	81 885	NO	NO
1998	441 284	291 752	149 533	10 593	58 008	80 931	NO	NO
1999	448 088	298 569	149 519	10 641	58 639	80 239	NO	NO
2000	454 891	305 385	149 505	10 689	59 270	79 546	NO	NO
2001	461 694	312 545	149 149	10 737	59 772	78 640	NO	NO
2002	468 497	319 815	148 682	11 151	60 051	77 480	NO	NO
2003	475 395	327 086	148 309	11 565	60 373	76 370	NO	NO
2004	482 293	334 127	148 165	11 490	60 966	75 710	NO	NO
2005	489 190	341 168	148 022	11 414	61 558	75 050	NO	NO
2006	494 950	348 209	146 741	11 339	61 617	73 786	NO	NO
2007	502 903	355 250	147 653	11 263	62 704	73 686	NO	NO
2008	513 017	362 291	150 726	11 188	64 805	74 733	NO	NO
2009	521 598	369 657	151 941	10 733	66 244	74 964	NO	NO
2010	529 188	376 999	152 189	10 330	66 549	75 309	NO	NO
2011	537 502	384 341	153 161	9 928	67 194	76 039	NO	NO
2012	538 107	391 682	146 425	9 525	64 223	72 677	NO	NO
2013	543 587	399 024	144 563	9 122	63 538	71 902	NO	NO

Table 245: Emissions/removals (+/-) from land use changes to settlement for the period 1990 to 2013 in Gg CO_2.

	4.E.2. Land converted to Settlement	4.E.2.1 Forest land converted to settlement	4.E.2.2 Cropland converted to settlement	4.E.2.3 Grassland converted to settlement	4.E.2.4 Wetland converted to settlement	4.E.2.5 Other Land converted to settlement
1990	385	246	-51	190	NO	NO
1991	388	252	-53	189	NO	NO
1992	391	257	-55	189	NO	NO
1993	395	263	-57	188	NO	NO
1994	392	263	-58	187	NO	NO
1995	337	211	-59	185	NO	NO
1996	333	209	-60	184	NO	NO
1997	328	207	-61	182	NO	NO
1998	323	205	-62	181	NO	NO
1999	321	205	-63	180	NO	NO
2000	319	206	-65	178	NO	NO
2001	317	206	-66	177	NO	NO
2002	401	300	-71	171	NO	NO

2003	405	305	-71	170	NO	NO
2004	401	304	-72	169	NO	NO
2005	398	303	-73	168	NO	NO
2006	376	302	-83	157	NO	NO
2007	410	301	-66	175	NO	NO
2008	443	300	-51	194	NO	NO
2009	282	161	-65	185	NO	NO
2010	261	158	-74	178	NO	NO
2011	269	154	-69	185	NO	NO
2012	135	150	-131	117	NO	NO
2013	215	146	-87	155	NO	NO

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 2014). 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 occasionally. For the years before 1980 data were extrapolated following a mean annual increase/decrease between the years 1980–1990.

The real estate database is updated in case of occasion; therefore a mean annual increase of the settlement area was calculated for the years 1970–1980 with 6 610 $ha.a^{-1}$, for the years 1981–2002 with 7 036 $ha.a^{-1}$, for the years 2003–2005 with 6 898 $ha.a^{-1}$. For the following years, so since 2006 the yearly reported data from the regional information are taken into consideration.

Obviously the annual increase of settlement area results in a decrease of other land use categories. Therefore. the following criteria were set up to allocate to the categories of land use changes to settlement:

- land use changes from forests are based on the statistical results of the NFI.
- further increases of the settlement area were considered to come from cropland and grassland with changing shares according to „availability" out of area consistency in these two categories and the need of areas to fully cover the assessed year-to-year increase of the total settlement area.

In compliance with this method the land use changes to settlement area as shown in Table 244 were derived for the period 1990 to 2013.

For the 2015 submission revised data on alpine grassland area became available (Statistik Austria 2014). 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 (see Table 246). For detailed information on the revision see chapter 6.4.2. In addition, for submission 2015 the LUC areas CL and GL to SL were adjusted so that all LUCs with SL area fully match the assessed year-to-year increase of the total settlement area.

Table 246: Changes in areas of grassland converted to settlements and cropland to settlements due to the revision of alpine grassland areas and due to consistency adjustments with the trend of the total settlement area

ha	4.E.2.2 Cropland converted to Settlement (2015 submission)	5.E.2.2 Cropland converted to Settlement (2014 submission)	Difference	4.E.2.3 Grassland converted to Settlement (2015 submission)	5.E.2.3 Grassland converted to Settlement (2014 submission)	Difference
1990	53 149	142 266	-89 117	86 824	55 717	31 108
1991	53 972	142 856	-88 884	86 443	55 292	31 151
1992	54 796	143 447	-88 651	86 061	54 867	31 194
1993	55 619	144 037	-88 418	85 679	54 442	31 237
1994	56 113	144 628	-88 515	84 747	54 017	30 730
1995	56 587	145 467	-88 880	83 793	53 593	30 201
1996	57 061	146 306	-89 245	82 839	53 168	29 671
1997	57 534	147 145	-89 611	81 885	52 743	29 142
1998	58 008	147 984	-89 976	80 931	52 318	28 613
1999	58 639	148 823	-90 184	80 239	51 893	28 345
2000	59 270	143 682	-84 413	79 546	52 088	27 458
2001	59 772	138 542	-78 769	78 640	52 283	26 357
2002	60 051	133 401	-73 350	77 480	52 478	25 002
2003	60 373	128 260	-67 887	76 370	52 673	23 698
2004	60 966	123 119	-62 153	75 710	52 867	22 843
2005	61 558	119 137	-57 579	75 050	50 764	24 285
2006	61 617	115 154	-53 537	73 786	48 661	25 124
2007	62 704	111 172	-48 468	73 686	46 558	27 127
2008	64 805	107 189	-42 384	74 733	44 456	30 277
2009	66 244	103 207	-36 963	74 964	42 353	32 611
2010	66 549	101 869	-35 320	75 309	40 055	35 255
2011	67 194	100 531	-33 337	76 039	37 757	38 282
2012	64 223	99 193	-34 970	72 677	35 459	37 218
2013	63 538			71 902		

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
- road, railway, track and excavation area.
- 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 about 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 the reporting to 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 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 yearly C-pool.

The following stocks (t C ha^{-1}) and average annual increments (t C ha^{-1}a^{-1}) of biomass were calculated:

Table 247: Stocks and average annual increments of biomass

t C ha^{-1}	t C ha^{-1} a^{-1}						
trees	**shrubs**	**ground veg.**	**total**	**trees**	**shrubs**	**ground veg.**	**total**
31.4	1.2	1.5	34.1	0.52	0.06	1.5	2.08

The increase of living biomass of perennial species (trees and shrubs) at LUC areas to settlement is calculated with 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 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. Litter stocks area assumed to be emitted 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. Based on calculations of the regional information derived from the real estate database two thirds of the national settlement area is unsealed. That results in a carbon stock in soil for settlement area of 50 t ha^{-1} (= 2/3 * 70 t ha^{-1}) on average (0–30 cm soil depth). For the other IPCC land use 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 9 122 ha to 11 565 ha between the years 1990 and 2013 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 146 Gg CO_2 to 305 Gg CO_2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to SL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). Any interpolation across these steps would lead to wrong results and is therefore not carried out.

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 Gg CO_2 in the years 1990 to 2013.

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 Gg CO_2 in the years 1990 to 2013.

The annual emission rates due to C stock changes in soil range from 107 to 132 Gg CO_2 in the years 1990–2013.

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 53 149 to 67194 ha in the years 1990–2013. The update of the areas (see chapter 6.4.2 and Table 246) has substantially changed the time series, and as a consequence the related emissions/removals as well.

Since 2005 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. The year 2012 represents an unrealistic outlier. The settlement area data series will be checked and corrected for this outlier in submission 2016.

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 cropland and settlements as described in 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 to 2013 the annual removal rates range from 51 to 131 Gg CO_2 due to increase of biomass on settlement areas.

Changes in carbon stocks in soil of cropland converted to settlement

The estimates for soil carbon stocks in cropland are as high as in settlement areas (50 t ha^{-1}. see Chapter 6.3.4.1.4)

Consequently, no emissions or removals result from carbon stock changes in soils due to land use conversion from cropland to settlement.

6.6.4.1.5 Grassland converted to Settlement (4.E.2.3)

The area in conversion status from grassland to settlement for a time period of 20 years ranges from 71 902 to 86 824 ha in the years 1990–2013 resulting in annual emission rates due to C stock changes of biomass and soils from 117 Gg CO_2 to 194 Gg CO_2. The update of the areas (see chapter 6.4.2 and Table 246) has substantially changed the time series, and as a consequence the related emissions/removals as well.

Since 2005 the settlement area was taken in 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 2005. The year 2012 represents an unrealistic outlier. The settlement area data series will be checked and corrected for this outlier in submission 2016.

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 1990–2013 the annual removal rates (net change) range from 80 to 150 Gg 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 PCC Tier 2 approach is used. The method is the same as described in Chapters 6.3.4.2.2 and 6.4.4.2.2 with country specific soil C stocks for grassland and settlement areas (see Chapter 6.6.4.1.2).

The annual emission rate due to loss of soil carbon in soils ranges from 264 to 318 Gg CO_2 in the years 1990–2013.

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 1990–2013.

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 1990–2013.

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 227. 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 228) and Chapter 6.3.5. (Table 236). For the settlement biomass growth rates ±75% on basis of an 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 Gg CO_2 to 2 108 Gg CO_2[76]. Higher values were found for the 90ies were 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 776 and 2 348% depending on the amount of net emissions in the single years.

6.6.6 QA/QC and Verification

The calculation of the data for category *5.E* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.6.7 Recalculations

A recalculation of the LUC areas from GL and CL to SL has been carried out due to the improvement of the GL area and due to the improvement of the area consistency. As a consequence, the related emissions/removals of these LUC subcategories had to be revised.

6.6.8 Planned improvements

See Chapter 6.1.8.

[76] 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.

6.7 Other Land (Category 4.F)

6.7.1 Category description

The emissions/removals of the LUC categories to OL had to be revised for the whole time series. Due to the update of the whole 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).

Table 248: Total areas and land-use change areas for the subcategory Other Land 4.F for the period 1990 to 2013 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	762 819	744 684	18 134	18 134	NO	NO	NO	NO
1991	730 245	711 141	19 104	19 104	NO	NO	NO	NO
1992	725 797	705 723	20 073	20 073	NO	NO	NO	NO
1993	728 929	707 886	21 043	21 043	NO	NO	NO	NO
1994	734 857	713 791	21 066	21 066	NO	NO	NO	NO
1995	739 625	718 921	20 704	20 704	NO	NO	NO	NO
1996	729 155	708 812	20 343	20 343	NO	NO	NO	NO
1997	722 713	702 732	19 981	19 981	NO	NO	NO	NO
1998	724 492	704 873	19 619	19 619	NO	NO	NO	NO
1999	724 927	705 219	19 708	19 708	NO	NO	NO	NO
2000	729 316	709 520	19 796	19 796	NO	NO	NO	NO
2001	718 401	698 516	19 885	19 885	NO	NO	NO	NO
2002	707 134	687 290	19 844	19 844	NO	NO	NO	NO
2003	693 910	674 106	19 804	19 804	NO	NO	NO	NO
2004	681 862	663 005	18 857	18 857	NO	NO	NO	NO
2005	689 086	671 176	17 910	17 910	NO	NO	NO	NO
2006	721 613	704 650	16 963	16 963	NO	NO	NO	NO
2007	738 070	722 054	16 016	16 016	NO	NO	NO	NO
2008	752 295	737 226	15 069	15 069	NO	NO	NO	NO
2009	756 783	742 635	14 148	14 148	NO	NO	NO	NO
2010	760 616	747 292	13 324	13 324	NO	NO	NO	NO
2011	763 936	751 437	12 499	12 499	NO	NO	NO	NO
2012	776 635	764 961	11 675	11 675	NO	NO	NO	NO
2013	780 976	770 126	10 850	10 850	NO	NO	NO	NO

Table 249: Emissions/removals (+/-) from land use changes to Other Land for the period 1990 to 2013 in Gg 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
1990	444	444	NO	NO	NO	NO
1991	454	454	NO	NO	NO	NO
1992	463	463	NO	NO	NO	NO
1993	473	473	NO	NO	NO	NO
1994	473	473	NO	NO	NO	NO
1995	375	375	NO	NO	NO	NO
1996	371	371	NO	NO	NO	NO
1997	368	368	NO	NO	NO	NO
1998	364	364	NO	NO	NO	NO
1999	365	365	NO	NO	NO	NO
2000	366	366	NO	NO	NO	NO
2001	367	367	NO	NO	NO	NO
2002	334	334	NO	NO	NO	NO
2003	335	335	NO	NO	NO	NO
2004	327	327	NO	NO	NO	NO
2005	319	319	NO	NO	NO	NO
2006	311	311	NO	NO	NO	NO
2007	303	303	NO	NO	NO	NO
2008	295	295	NO	NO	NO	NO
2009	211	211	NO	NO	NO	NO
2010	203	203	NO	NO	NO	NO
2011	196	196	NO	NO	NO	NO
2012	188	188	NO	NO	NO	NO
2013	181	181	NO	NO	NO	NO

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 IPCC 2006 Guidelines. So, other land is understood to be the difference of the area of all other categories and the whole area of Austria in order to avoid double accounting or omission of an area.

The digital cadastral data base of Austria (see for instance in Chapter 6.6.2) 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 a rather good picture of the areas of the Austrian land use.

For the 2015 submission revised data on alpine grassland area became available (Statistik Austria 2014). 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 geographically or from logic reasons 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 sub-categories 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 6.2.2 and 6.2.4.2. The area in conversion status from forest land to other land for a time period of 20 years ranges from 10 850 ha to 21 066 ha in the years 1990 to 2013 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 181 Gg CO_2 to 473 Gg CO_2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation period to NFI observation period while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to OL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). Any interpolation across these steps would lead to wrong results 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 emission rates due to the loss of biomass on areas of land use change from forest land to other land range from 33 to 158 Gg CO_2 in the years 1990–2013.

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 Gg CO_2 in the years 1990–2013.

The annual emission rates due to C stock changes in mineral soils range from 127 to 220 Gg CO_2 in the years 1990–2013.

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.

6.7.5 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 227.

The uncertainties of the emission factors were given in the Chapter 6.2.5, Table 228 and Chapter 6.3.5, Table 236.

The uncertainty of the totals of the emissions/removals of the other land category across the time series ranges from 1 044 Gg CO_2 to 1 659 Gg CO_2[77]. Higher values were found for the 90ies where the input data had a lower accuracy. Expressed in % of the total emissions of the other land category, the uncertainty lies between 346 and 537%. The amount of net emissions was in the most recent years lower. As a consequence, the relative uncertainty of the estimates was higher in these years.

6.7.6 QA/QC and Verification

The calculation of the data for category 5.E is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.7.7 Recalculations

An update of the areas of alpine grassland (see chapter 6.4.2) led to the omission of the category LUC GL to OL and it is therefore reported as NO since the 2015 submission.

[77] 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.

6.7.8 Planned improvements

See Chapter 6.1.8.

6.8 Harvested Wood Products (Category 4.G)

6.8.1 Category description

The category Harvested wood products (HWP) is the second largest sink in Austria. In 2013 this category contributed to net emission removals of 1 266 Gg CO_2. The largest contribution results from the product category sawn wood, followed by wood panels and paper/paper products. HWPs produced and exported are included in 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 in the following years in all product categories. Until now pre-2008 production levels have not yet been achieved again.

Table 250: Emissions/removals from Harvested wood products for the period 1990 to 2013 in Gg CO_2

	Harvested wood prod-ucts (pro-duced and consumed domestically)	**Sawn wood**	**Panels**	**Paper an paper board**	**Harvested wood products (produced and ex-ported)**	**HWP in SWDS**
1990	-3 253	-1 877	-852	-524	IE	NO
1991	-2 174	-1 186	-801	-186	IE	NO
1992	-1 988	-1 009	-714	-265	IE	NO
1993	-1 880	-904	-706	-271	IE	NO
1994	-2 872	-1 477	-800	-596	IE	NO
1995	-2 721	-1 537	-799	-385	IE	NO
1996	-3 198	-1 908	-832	-458	IE	NO
1997	-2 826	-1 736	-805	-285	IE	NO
1998	-2 778	-1 760	-715	-304	IE	NO
1999	-1 990	-1 583	-527	121	IE	NO
2000	-1 805	-1 448	-579	222	IE	NO
2001	-2 588	-1 626	-1 021	59	IE	NO
2002	-3 728	-2 008	-1 396	-324	IE	NO
2003	-4 296	-2 279	-1 455	-562	IE	NO
2004	-3 539	-2 058	-1 213	-268	IE	NO
2005	-3 529	-2 020	-1 214	-295	IE	NO
2006	-3 987	-1 900	-1 518	-570	IE	NO
2007	-5 205	-2 904	-1 613	-689	IE	NO
2008	-4 953	-2 643	-1 617	-694	IE	NO
2009	-920	-630	-892	602	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
2010	-2 392	-1 311	-1 049	-33	IE	NO
2011	-2 697	-1 491	-1 109	-97	IE	NO
2012	-2 175	-1 052	-1 021	-102	IE	NO
2013	-1 266	-739	-839	313	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 2013. Table 251: Production of harvested wood products in Austria for the period 1990 to 2013 in cubic metres or tonnes according to FAO Statistics

shows the domestic production of sawn wood, wood panels and paper/paper board based on data from the FAO Stat database as it has been used for the calculation of the HWP carbon stocks and stock changes.

Table 251: Production of harvested wood products in Austria for the period 1990 to 2013 in cubic metres or tonnes according to FAO Statistics

	Sawn wood [m³]	wood panels [m³]	Paper and paper board [t]
1990	5 615 705	1 322 913	2 192 764
1991	4 826 955	1 298 208	2 060 436
1992	4 655 112	1 237 318	2 156 471
1993	4 555 523	1 248 573	2 216 001
1994	5 266 318	1 356 849	2 505 883
1995	5 377 673	1 368 467	2 480 042
1996	5 866 057	1 421 374	2 613 257
1997	5 724 410	1 414 437	2 585 130
1998	5 793 968	1 347 461	2 658 581
1999	5 620 759	1 186 501	2 418 071
2000	5 496 399	1 247 614	2 320 231
2001	5 751 680	1 694 459	2 390 206
2002	6 251 856	2 049 276	2 652 612
2003	6 632 695	2 161 437	2 891 077
2004	6 420 993	1 968 401	2 798 384
2005	6 430 551	2 001 577	2 874 411
2006	6 315 069	2 242 399	3 133 193
2007	7 586 538	2 446 945	3 338 051
2008	7 331 267	2 496 473	3 486 418
2009	4 963 695	1 839 892	2 702 826
2010	5 811 867	2 024 516	3 031 476
2011	6 064 727	2 104 537	3 084 706

	Sawn wood [m³]	wood panels [m³]	Paper and paper board [t]
2012	5 561 243	2 008 427	3 108 536
2013	5 207 824	1 863 989	2 832 459

As the 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, m³

$IRW_{p,i}$ = Industrial roundwood production (wood in the rough) for year i, m³

$IRW_{ex,\,i}$ = Industrial roundwood – export quantity for year i, m³

$IRW_{im,\,i}$ = Industrial roundwood – import quantity for year i, m³

This share is then applied to the product categories to determine the HWPs from domestic harvest as shown in Table 251. However, the production approach requires a time series starting with year 1900 in order to reflect current emissions from HWPs which were in use many decades ago. For this reason it is required that the production variables shown in Table 251 are extrapolated backwards by applying equation 12.6 of Vol 4, chapter 12 of the IPCC 2006 Guidelines:

$$V_t = V_{1961} * e^{[U*(t-1961)]}$$

Where

V_t = annual production, imports or exports for a solid wood or paper product for year t, Gg C yr^{-1}

t = year

V_{1961} = annual production, imports or exports for a solid wood or paper product for the year 1961, Gg 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

Variable V_t is used in the following equation as $inflow_i$ for the time period 1900 to 1961. The changes in the carbon stock of products in use are estimated by using equation 12.1 of Vol 4, chapter 12 of the IPCC 2006 Guidelines:

$$C_{i+1} = e^{-k} * C_i + \left[\frac{(1-e^{-k})}{k}\right] * inflow_i$$

Where:

i = year

C_i = the carbon stock of the HWP pool in the beginning of year I, Gg 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.

$Inflow_i$ = the inflow to the HWP pool during year i, Gg C yr^{-1}

ΔC_i = carbon stock change of the HWP pool during year I, Gg C yr^{-1}

With $C_{(1900)}$ = 0.0

Tier 2 half-lives are used for sawn wood, wood panels and paper according to table 2.8.2 of the KP supplement.

Finally, the carbon stock change is calculated as the difference of C_{i+1} and C_i.

6.8.3 Uncertainty assessment

No uncertainty estimate was carried out so far for HWPs

6.8.4 Recalculations

Submission 2015 includes for the first time estimates for HWPs

6.8.5 Planned Improvements

The uncertainties of emissions/removals of HWPs will be estimated for submission 2016.

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 2013 amounted to 1 684 kt CO_2 equivalent (1990: 4 226 kt CO_2 equivalent). These are about 2.1% of total greenhouse gas emissions in Austria in 2013 and 5.4% in 1990. In 2013, greenhouse gas emissions from the waste sector were 60% below the level of 1990.

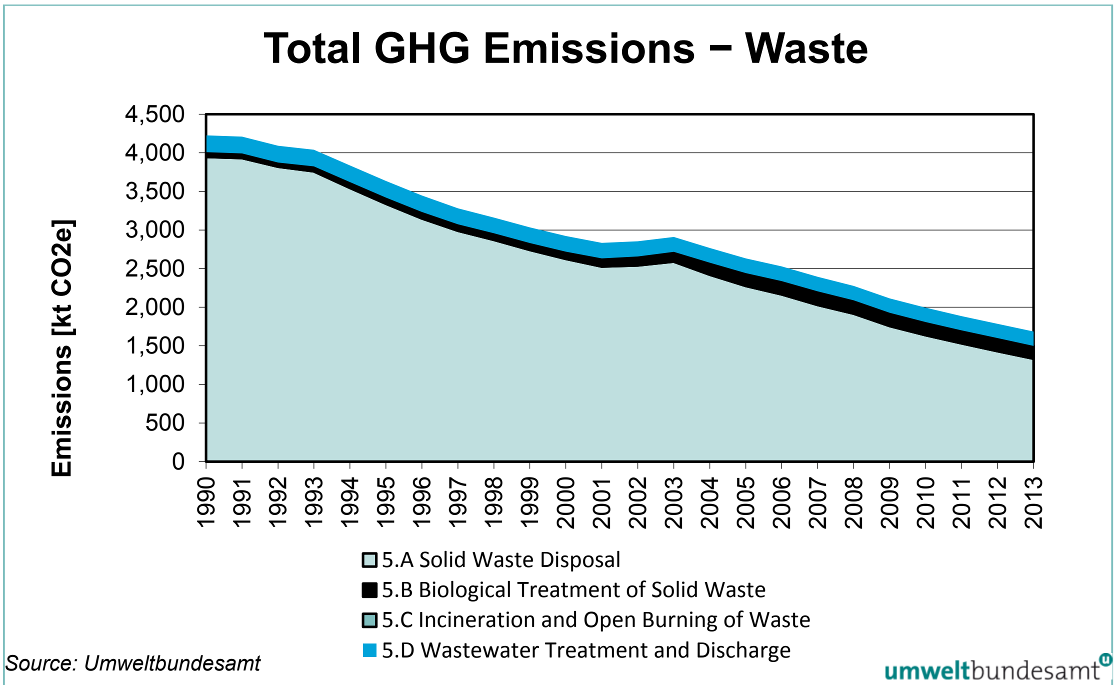


Figure 38: GHG emissions from CRF 5 Waste.

Table 252 presents the emission trend by gas. The major greenhouse gas emitted from this sector is CH_4, which represents 84.3% of all emissions from this sector in 2013, followed by N_2O (15.5%) and CO_2 (0.1%).

CH_4 emissions

CH_4 emissions from sector Waste amounted to 1 421 kt CO_2 equivalent in 2013; that is 65.2% 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 93.8% 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 these 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 261.8 kt CO_2 equivalent in 2013. Emissions increased by 120% since 1990.

61.1% of N_2O emissions originate from *5.D. Wastewater Treatment and Discharge*, 38.9% 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 2.03 kt CO_2 equivalent in 2013 and decreased by 92.4% 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 252: Greenhouse gas emissions from sector Waste by gas.

	CO_2	CH_4	N_2O	Total
	[kt]		[kt CO_2e]	
1990	26.89	4 079.90	118.93	4 225.72
1991	23.40	4 065.52	121.13	4 210.05
1992	10.86	3 953.30	127.02	4 091.19
1993	10.60	3 893.14	135.02	4 038.75
1994	10.65	3 679.21	146.43	3 836.29
1995	10.97	3 471.49	153.85	3 636.31
1996	11.30	3 273.48	161.24	3 446.02
1997	11.62	3 105.07	164.39	3 281.07
1998	11.94	2 978.93	170.10	3 160.97
1999	12.26	2 844.66	176.59	3 033.51
2000	12.26	2 724.28	185.18	2 921.72
2001	12.26	2 623.13	198.08	2 833.47
2002	12.26	2 635.01	206.36	2 853.63

	CO_2	CH_4	N_2O	Total
	[kt]		[kt CO_2e]	
2003	12.26	2 682.54	214.26	2 909.06
2004	12.26	2 519.90	234.14	2 766.30
2005	12.26	2 374.42	245.16	2 631.84
2006	10.15	2 263.82	254.18	2 528.15
2007	8.12	2 126.90	258.63	2 393.65
2008	6.09	2 011.41	258.79	2 276.29
2009	4.06	1 849.40	261.04	2 114.50
2010	2.03	1 728.88	262.54	1 993.45
2011	2.03	1 620.36	261.94	1 884.33
2012	2.03	1 519.01	263.82	1 784.87
2013	2.03	1 420.60	261.76	1 684.39
Trend 1990-2013	***−92.4%***	***−65.2%***	***+120.1%***	***−60.1%***

Table 253 presents the greenhouse gas emissions by sub-category. As can be seen, the dominant sub-category is *5.A Solid Waste Disposal*, contributing 79.1% to greenhouse gas emissions from sector Waste.

Table 253: Greenhouse gas emissions from sector waste by subcategories.

Year	5.A	5.B	5.C	5.D	Total
			[kt CO_2e]		
1990	3 945.56	35.74	27.09	217.32	4 225.72
1991	3 930.85	37.47	23.59	218.14	4 210.05
1992	3 819.30	44.43	10.91	216.55	4 091.19
1993	3 758.72	55.09	10.64	214.30	4 038.75
1994	3 545.08	65.39	10.69	215.14	3 836.29
1995	3 340.34	69.09	11.01	215.87	3 636.31
1996	3 149.45	72.49	11.33	212.74	3 446.02
1997	2 989.90	71.32	11.66	208.20	3 281.07
1998	2 871.27	73.90	11.98	203.82	3 160.97
1999	2 741.90	77.72	12.30	201.59	3 033.51
2000	2 626.25	81.73	12.30	201.44	2 921.72
2001	2 527.09	92.68	12.30	201.41	2 833.47
2002	2 541.03	103.54	12.30	196.76	2 853.63
2003	2 590.41	113.86	12.30	192.50	2 909.06
2004	2 421.00	142.82	12.30	190.17	2 766.30
2005	2 275.06	154.75	12.30	189.73	2 631.84
2006	2 165.65	162.13	10.18	190.18	2 528.15
2007	2 029.09	167.43	8.15	188.99	2 393.65
2008	1 916.36	166.02	6.11	187.79	2 276.29
2009	1 756.11	167.32	4.07	187.00	2 114.50
2010	1 638.05	167.16	2.04	186.21	1 993.45
2011	1 531.18	165.98	2.04	185.13	1 884.33
2012	1 429.87	168.71	2.04	184.25	1 784.87
2013	1 332.85	164.27	2.04	185.23	1 684.39
Trend 1990–2013	***−66.2%***	***+359.6%***	***−92.5%***	***−14.8%***	***−60.1%***

7.1.2 Key Categories

The key category analysis (based on CRF Table 7) is presented in Chapter 1.5. CH_4 from solid waste disposal has been identified as the only key source in this sector.

Table 254: Key sources of Waste

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
5.A	Solid Waste Disposal	CH_4	LA; TA

LA = Level Assessment (2013)

TA = Trend Assessment 1990–2013

7.1.3 Completeness

Table 255 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 255 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**)	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 only reported as an information item in the Energy sector; CH_4: no unintentional leakage expected. N_2O: negligible according to IPCC 2006.*

****) 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. However, as good quality country-specific data on current and historical waste deposited at Solid Waste Disposal Sites (SWDS) are available, the method used has been classified as Tier 2 method.

For *CRF 5.B Biological Treatment of Solid Waste* the method from the 2006 IPCC GL is applied (Tier 1), multiplying waste quantities by emission factors taken from national studies. Calculations are done separately for composted waste and mechanical-biologically treated waste.

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, based on the 2006 IPCC Guidelines. Main differences to the default methodology are described in Chapter 7.5.2.

7.1.5 Quality Assurance and Quality Control (QA/QC)

In addition to the general QC activities described in Chapter 1.3.3, the following QA/QC activities are done on a regular basis:

- To ensure, that most up-to-date data and parameters (e.g. landfill gas recovery, connection rate, etc.) are considered, waste experts at different departments within the Umweltbundesamt are contacted annually. 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)

7.2.1 Source Category Description

Emissions: CH_4

Key Source: Yes

In the year 2013 emissions from solid waste disposal contributed 79 % to greenhouse gas emissions from sector Waste and 1.7 % to total greenhouse gas emissions in Austria. From 1990 to 2013 greenhouse gas emissions from this source decreased by 66.2% (see Table 259)

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[78] 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[79]), 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.

'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 260). 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 256 presents a summary of all considered waste types and the corresponding identification numbers (list of waste).

[78] 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).

[79] 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

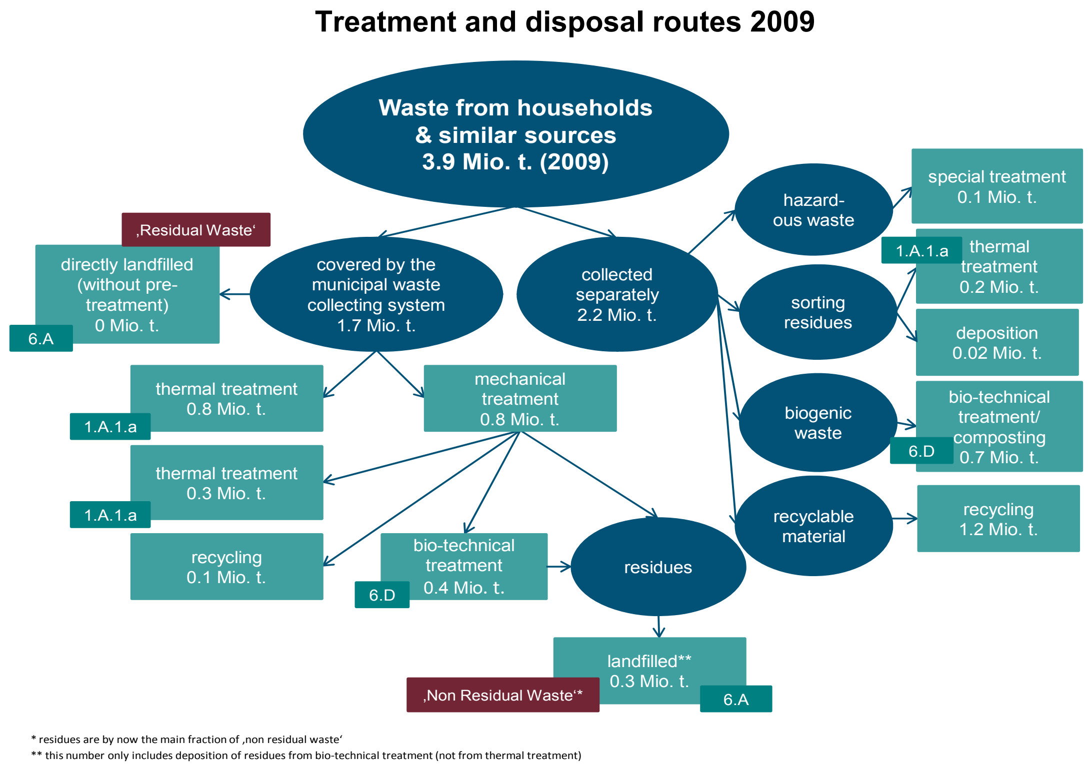
Table 256: Considered types of waste (list of waste[80] pursuant to Article 1 (a) of Directive 75/442/EEC on waste).

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
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		

The following picture 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[81]) and to demonstrate that all relevant activity data are taken into account in the inventory.

[80] 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

[81] In fact non-residual waste also comprises waste from other (industrial) sources.



Source: BMLFUW (2011a), Umweltbundesamt

Figure 39: Waste from households and similar sources – treatment and disposal routes 2009.

Almost 100% of waste from households and similar sources is incinerated, recycled or treated mechanical-biologically. In 2012 only sorting residues from potentially recyclable material collected separately (<0.1% of total waste from households and similar sources) were directly deposited.

Table 257: 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)]
bio-technical treatment	16.7%[2)]	6.3%	11.2%	17.9%	8.8%	10.4%	8.5%	11.0%	10.9%
thermal treatment (incineration)	5.9%	14.7%	28.3%	23.7%	34.7%	36.4%	40.2%	38.2%	38.8%
treatment in plants for hazardous waste	0.4%	0.8%	1.2%	1.8%	2.3%	2.4%	2.5%	2.4%	2.1%
recycling	12.9%	34.3%	35.6%	34.8%	32.3%	31.7%	30.7%	26.8%	27.2%
bio-technical treatment/composting	1.0%	15.4%	16.0%	17.9%	18.2%	18.7%	17.7%	21.6%	20.9%
direct deposition at landfills	63.1%	28.5%	7.7%	3.8%	3.7%	0.4%[*)]	0.4%[*)]	<0.1%[*)]	0.1%

[1)] *Federal Waste Management Plan (BMLFUW 2001)*
[2)] *This value also includes plants used in the past to reduce odour emissions.*
[3)] *Federal Waste Management Plan (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 (BMLFUW 2011a)*
[7)] *Annual update (2012) of the Federal Waste Management Plan (BMLFUW 2011a)*
[8)] *Annual update (2013) of the Federal Waste Management Plan (BMLFUW 2011a)*
[9)] *Annual update (2014) of the Federal Waste Management Plan (BMLFUW 2011a) (BMLFUW 2015a)*

[*)] *solely sorting residues from potentially recyclable material collected separately.*

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.

Table 258: Number and type of landfill sites

Landfill type	2002	2003	2004	2005	2006	2007	2008	2010	2013
Mass waste landfills	61	62	58	50	54	53	46	34	31
Residual waste landfills*)	18	23	30	27	29	31	40	42	45
Construction and demolition waste landfills	64	63	124	74	84	87	90	82	83
Excavated soil material landfills	108	211	454	340	376	377	475 **)	n.a. ***)	n.a. ***)

*) *Landfills for residual waste do not contain the fraction 'residual waste' as defined in the inventory and do not cover relevant organic material as they have to comply with stronger limits with regard to organic material (TOC). „Residual waste" has to be disposed of on mass waste landfills.*

**) *In this number inert waste landfills are included*

***) *data on the number of excavated soil material landfills is not available as has not to be collected/reported any more from 2009 on pursuant to EU Waste Statistics Regulation (No. 2150/2002)*

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[82] 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 40: Waste ('residual waste' and 'non-residual waste') with a relevant share of degradable organic carbon (deposited on mass waste landfills), period 1950–2013.

[82] Law on the Remediation of Contaminated Sites (1989), Federal Law Gazette No 299/1989 as amended

In 1990 waste management was for the first time regulated by law (Austrian Waste Management Law[83]). 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[84], which – apart from some exemptions[85] – prohibits the disposal of untreated waste in Austria from 2004 on and therefore leads to reduced waste volumes as well as decreased carbon content in deposited waste.

Since beginning of 2009 no waste is allowed to be deposited any more without being pre-treated (Landfill Ordinance).

7.2.2 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.

7.2.2.1 Activity data

The quantities of 'residual waste' have been taken from the following sources:

- Data for 2008–2013 have been taken from the EDM[86], 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.

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[83] Waste Management Act of 2002, Federal Law Gazette I No 102/2002 as amended by Federal Law Gazette I No 9/2011

[84] 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

[85] 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.

[86] Electronic Data Management

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[87] (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 2008–2013 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 259 presents activity data and CH_4 emissions from managed waste disposal on land for the period 1990–2013.

Table 259: Activity data for 'residual waste' and 'non residual waste', greenhouse gas emissions and implied emission factors 1990–2013.

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		157 822		0.06
1991	661 676	1 799 718	2 461 394	-6.9%	157 234	-0.4%	0.07
1992	674 909	1 995 747	2 644 448	-7.0%	152 772	-2.8%	0.07
1993	688 407	1 799 718	2 461 394	1.9%	150 349	-1.6%	0.07
1994	702 175	1 614 157	2 289 067	-21.0%	141 803	-5.7%	0.08
1995	716 219	1 644 718	2 333 126	-4.2%	133 614	-5.8%	0.08
1996	730 543	1 142 067	1 844 242	5.0%	125 978	-5.7%	0.08
1997	745 154	1 049 709	1 765 928	-1.5%	119 596	-5.1%	0.08
1998	760 057	1 124 169	1 854 713	0.7%	114 851	-4.0%	0.07
1999	822 179	1 082 634	1 827 788	3.6%	109 676	-4.5%	0.07
2000	826 874	1 081 114	1 841 171	-1.5%	105 050	-4.2%	0.07
2001	772 786	1 084 625	1 906 804	-2.2%	101 083	-3.8%	0.07
2002	792 753	1 052 061	1 878 935	7.0%	101 641	0.6%	0.06
2003	890 640	1 065 592	1 838 378	15.7%	103 616	1.9%	0.05
2004	344 747	1 174 543	1 967 296	-72.4%	96 840	-6.5%	0.18
2005	389 660	1 385 944	2 276 584	0.6%	91 002	-6.0%	0.17
2006	425 091	282 656	627 403	8.5%	86 626	-4.8%	0.15

[87] Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

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]*
2007	464 109	241 733	631 393	-9.7%	81 163	-6.3%	0.15
2008	319 927	260 068	685 159	-27.4%	76 655	-5.6%	0.19
2009	256 340	154 517	618 626	-42.9%	70 244	-8.4%	0.32
2010	244 786	129 324	449 251	-4.5%	65 522	-6.7%	0.31
2011	273 313	0	256 340	11.7%	61 247	-6.5%	0.25
2012	166 263	0	244 786	-39.2%	57 195	-6.6%	0.39
2013	185 156	0	273 313	11.4%	53 314	-6.8%	0.32

* *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. 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 2013 only 185 kt were landfilled resulting in an IEF of 0.3 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 260: 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

	residual waste	non residual waste							
	Mixed MSW	wood	paper	sludges	sorting residues	bio-waste	textiles	construction waste	fats
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	0.00	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	0.03	0.00

7.2.2.2 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 261: Parameters for calculating CH_4 emissions from SWDS.

Waste category/ Parameters	**residual waste**	**wood**	**paper**	**sludges**	**Sorting residues/output MBT[88]/bulky waste**	**Bio-waste**	**textiles**	**Construction 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
	IPCC default taking into account national waste expertises.								
DOC (Gg C/Gg Waste)	See Table 264	0.45	0.3	0.11	0.16	0.16	0.5	0.09	0.2
	(HACKL & MAUSCHITZ 1999) (UMWELTBUNDESAMT 2003) (BMLFUW 2006a)	(BAUMELER et al. 1998)							
Half life period	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)
Number of considered years[2)]	41	64	64	41	64	50	64	64	41
Fraction of CH_4 in Landfill Gas	0.55 Mean value cited in the literature, also within the IPCC range.								
Methane Oxidation in the upper layer	10% IPCC default								
Landfill gas recovery	see Figure 42 (UMWELTBUNDESAMT 2004d, 2008c, 2014)								

[2)] *In general historical data since 1950 are taken into account in the calculation. The number of considered years for the different waste fractions however depends on their half-lives. According to the IPCC 2006 GL it is necessary to include data on solid waste disposal for 3-5 half-lives to achieve accurate emission estimates. In the Austrian Inventory in general at least 5 half-lives are considered, at minimum 41 years - to be in line with the calculation for 1990 emissions considering waste amounts for 1950–1990 for time series consistency reason.*

No delay time and no average residence time of waste in the SWDS are currently considered in the Austrian inventory. Reaction start in the 1st month after deposition (M=1). According to the IPCC 2006 Guidelines this is within the default range of between zero and six months.

[88] **M**echanical-**b**iological **t**reatment

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 261. These are clearly defined (wood, paper, sludge, etc.) and quite 'homogenous'.

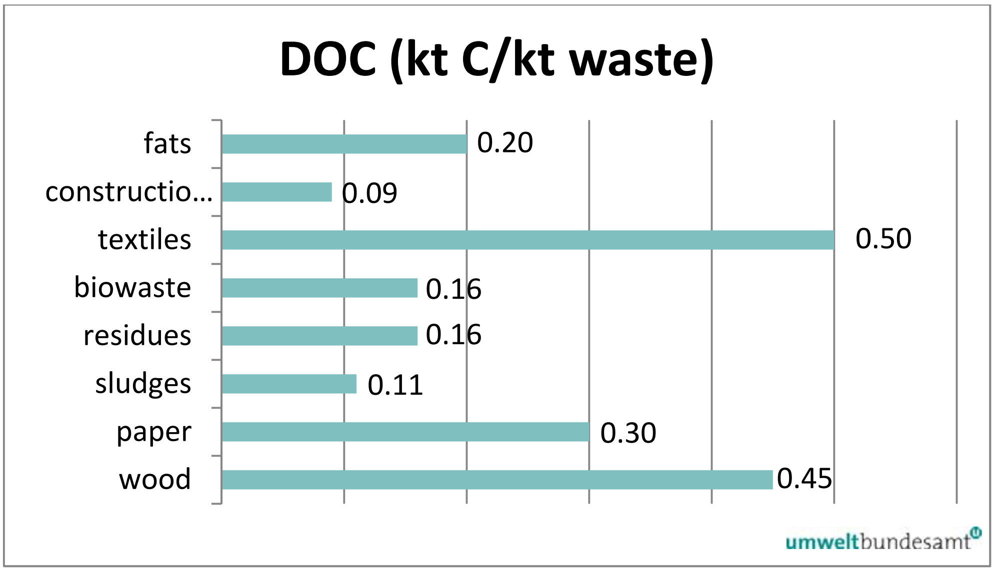

Figure 41: DOC of non-residual waste fractions

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 262: Time series of bio-degradable organic carbon content of residual waste (mixed MSW, directly deposited)

Year	Gg C/Gg Residual Waste	Year	Gg C/Gg Residual Waste
1950–1959	0.24 [1)]	1998	0.13 [2)]
1960–1969	0.23 [1)]	1999	0.12 [2)]
1970–1979	0.22 [1)]	2000	0.13 [*)]
1980–1989	0.21 [1)]	2001	0.14 [*)]
1990	0.20 [2)]	2002	0.15 [*)]
1991	0.19 [2)]	2003	0.16 [*)]
1992	0.18 [2)]	2004	0.17 [3)]
1993	0.17 [2)]	2005	0.17 [*)]
1994	0.16 [2)]	2006	0.17 [*)]
1995	0.15 [2)]	2007	0.17 [*)]
1996	0.14 [2)]	2008	0.17 [4)]
1997	0.13 [2)]	2009–2013	n.r.**)

1) (HACKL & MAUSCHITZ 1999)
2) (UMWELTBUNDESAMT 2003)
3) calculated according to waste composition 2001 (BMLFUW 2006a)
4) calculated according to waste composition 2009 (Status Report to 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 263).

Table 263: 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)

Landfill gas recovery

In 2004, the Umweltbundesamt investigated the amount of annually collected landfill gas by questionnaires sent to landfill operators (UMWELTBUNDESAMT 2004d) showing that in 2001 the amount of collected landfill gas was more than 5 times higher than in 1990. In 1990 only 9 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 2008c, 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 the:

- reduced carbon content of deposited waste and consequently reduced landfill gas production
- slightly decreasing methane concentration in recovered landfill gas[89] – 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 63% by 2013.

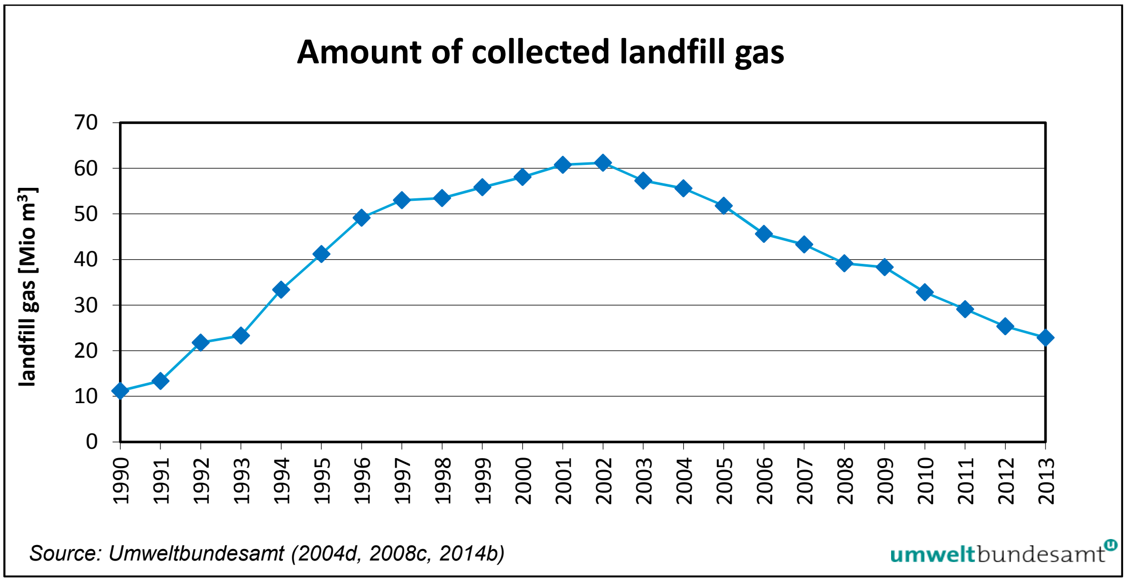

Figure 42: Amount of collected landfill gas 1990 to 2013.

7.2.3 Uncertainties and time series consistency

The Uncertainty Assessment is originally based on a national study (WINIWARTER & RYPDAL 2000) 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;

[89] a methane concentration of 55 % (default) is used for the estimation of the landfill gas **produced** ('F') over the whole time-series.

- Availability of data on landfill recovered on a regular basis.

Table 264: Uncertainty assessment for managed waste disposal on land

	(WINIWARTER & RYPDAL 2000)	Expert judgement 2005 (WINIWARTER 2007)
Activity data	25%	12%
Emission factor	35%	25%

7.2.4 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[90] 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). The 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

[90] According to § 41 (1) Landfill Ordinance

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.

7.2.5 Category-specific recalculations

No methodological changes were considered necessary for this category. Austria already applies the first-order decay method (FOD) to model the rate of CH_4 generation over time. Moreover industrial waste is already covered and mainly country specific values (waste disposed for different waste types, methane recovery, etc.) are used.

7.2.6 Category-specific planned improvements

Austria has chosen a delay time of zero months (which is within the range provided by the IPCC 2006 GL as good practice), but has not considered the average residence time of waste in the calculation (M=0). It is considered to set the process start in deposition year to M=7 as according to the IPCC GL zero delay is equivalent to an average decomposition start at beginning of month 7. This will lead to a slight shift of emissions.

7.3 Biological Treatment of Solid Waste (Category 5.B)

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 (MB) treatment and composting.

- waste treated in Mechanical-Biological Treatment (MBT) plants, covering waste from households and similar sources covered by the municipal waste collecting system, but also waste from industrial sources (e.g. residues from processing of recovered paper) are included (UMWELTBUNDESAMT 2008d).
- biogenic waste composted, covering centralised composting facilities and home composting

Biogenic waste treated in anaerobic treatment plants (anaerobic digestion) is not considered as an emissions source under this sub-category. CO_2 emissions are of biogenic origin and thus reported as an information item in the Energy sector. CH_4 emissions due to unintentional leakages during process disturbances or other unexpected events are not reported as technical standards (safety regulations) for biogas plants (BMWFJ 2013) ensure that unintentional CH_4 emissions are flared.

Emissions increased over time as the result of the increasing amount of composted as well as mechanical-biologically treated waste.

7.3.2 Methodological issues

Emissions were 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)*

7.3.2.1 Activity data

Historical activity data were taken from several publications on national and regional level. For years where no data were available inter- or extrapolation was done.

Since 2006, data is available from a national publication referred to as 'Federal Waste Management Plan' ('BAWP': BMLFUW 2011), which is (in part) updated annually ('Status Reports'). Data on amounts of waste composted and treated mechanical-biologically are originally based on surveys and own estimates, whereas since 2011 the Electronic Data Management (EDM) is the primary data basis[91]. The EDM is an information network operated by the Environment Agency Austria. 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.

For most recent years, mechanical-biologically treated waste is taken directly from the EDM. The EDM is also the data source of biogenic waste treated in composting plants. However, an expert judgement made by Umweltbundesamt (2015) indicates higher amounts of waste being composted due to some minor exemptions in the reporting requirements and in some cases missing reports. Currently about 400 kt biogenic waste has to be considered additionally for the years 2012 and 2013; this assumption is based on former surveys conducted for the Federal Waste Management Plan' (BMLFUW 2011).

Amounts composted domestically are not included in the EDM and are taken from the Federal Waste Management Plan.

[91] In subcategory *5.A Solid Waste Disposal* waste amounts have been taken from EDM reports already since 2008.

Table 265: Activity data and sources for 5.B ‚Biological Treatment of Solid Waste'

	Total waste	Mechanical-Biological Treatment (MBT)		Composted Waste					
				Bio waste collected separately		Gardening waste		Home composting	
	[kt]	[t]	source	[t]	source	[t]	source	[t]	source
1990	**763**	345 000	BAUMELER et al. 1998	10 436	sum of data reported by the Austrian Federal Provinces, (AMLINGER 2003)	37 370	sum of data reported by the Austrian Federal Provinces, (AMLINGER 2003)	370 000	AMLINGER 2003
1991	**798**	345 000		27 372		50 995		375 000	
1992	**942**	345 000		88 243		48 464		460 000	
1993	**1 161**	345 000		156 936		149 470		510 000	
1994	**1 373**	345 000		246 375		197 130		584 985	
1995	**1 446**	294 739	ANGERER 1997	301 809		249 264		600 000	
1996	**1 515**	281 378	expert judgement	334 371		283 127		616 000	
1997	**1 488**	243 780	LAHL 1998	351 862		229 643		662 571	
1998	**1 541**	239 671	LAHL 2000	362 572		241 835		696 487	
1999	**1 621**	265 672	UMWELT-BUNDESAMT 2001e	378 796		244 587		732 273	
2000	**1 703**	253 660	interpolated	374 271		303 239	interpolated	771 773	
2001	**1 928**	241 648		399 090		361 890		944 412	Inter-polated
2002	**2 150**	229 636		422 126		420 542		1 117 051	
2003	**2 362**	217 625	UMWELT-BUNDESAMT 2008d	433 911		479 194		1 289 691	
2004	**2 979**	487 623		491 670	BAWP (BMLFUW 2006a)	537 845		1 462 330	calculated on basis of Status Report 2008**
2005	**3 236**	623 393		543 420	inter-polated	596 497		1 472 325	
2006	**3 391**	660 231		595 170	Status Re-port* 2007	655 148		1 479 963	
2007	**3 502**	684 322		618 570	Status Re-port* 2008	713 800	Status Report* 2008	1 484 839	Status Report* 2008
2008	**3 467**	619 495	interpolated	650 700	Status Re-port* 2009	699 400	Status Report* 2009	1 497 877	calculated on basis of Status Report 2008**
2009	**3 489**	554 668	BAWP (BMLFUW 2011a)	752 100	BAWP (BMLFUW 2011a)	677 400	BAWP (BMLFUW 2011a)	1 505 000	BAWP (BMLFUW 2011a)

	Total waste	**Mechanical-Biological Treatment (MBT)**		**Composted Waste**					
				Bio waste collected separately		**Gardening waste**		**Home composting**	
2010	**3 486**	550 613	Status Report 2012	752 496	calculated based on BAWP (BMLFUW 2011a)	677 400	same as 2009	1 504 992	calculated on basis of BAWP (BMLFUW 2011a)**
2011	**3 459**	519 080	based on EDM reports***)	1 429 896			same as 2010	1 509 936	
2012	**3 510**	453 392	Status Report 2013, based on EDM reports	1 539 939			based on EDM reports, supplemented by expert judgement****)	1 516 736	
2013	**3 413**	378 643	Status Report 2014, based on EDM reports	1 508 284			based on EDM reports, supplemented by expert judgement ****)	1 525 901	

*) *Status Reports are the annual updates (2007, 2008, 2009) of the Federal Waste Management Plan 2006 ('BAWP', BMLFUW 2006a)*

**) *In the BAWP 2011 (BMLFUW 2011a) a per-capita value for the amount of home composted waste is given (180 kg/person/a). This was used to calculate activities for the years 2004–2006 and 2010–2013 too.*

***) *interim evaluation of activity data (input MBT) reported via EDM; conducted for Status Report 2013*

****) *Values are based on activity data reported by treatment plants via EDM complemented by estimates on additional waste volumes not covered by the reporting obligation (based on BAWP 2011)*

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 266: Emission factors used for 'Biological Treatment of Solid Waste'

	CH_4 [kg/t FS]	**N_2O [kg/t FS]**	**References**
Mechanical-biologically treated waste	0.6	0.1	(UBA BERLIN 1999) (AMLINGER et al. 2003, 2005) (ANGERER & FRÖHLICH 2002) (DOEDENS et al. 1999)
Composted waste (bio-waste, loppings, home composting)	0.75	0.1	(AMLINGER et al. 2003, 2005)

7.3.3 Uncertainties and time-series consistency

The following uncertainties are considered in the Uncertainty Analysis:

Table 267: 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

Methodology and emission factors remain unchanged compared to previous submissions. Activity data for composted waste had to be slightly revised downwards for 2011 and 2012 as in the previous submission also biogenic waste were included, which had not been treated in composting plants.

Table 268: Recalculation with respect to previous submission in category 5.B

	CH_4	N_2O
	[t]	[t]
2011	−8.0	−1.1
2012	−28.2	−3.8

7.3.5 Category-specific QA/QC and verification

See 7.1.5.

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.

For the years 2012 and 2013 activity data (composted amounts) reported via Electronic Data Management have to be supplemented by estimated amounts based on expert judgement by the department Waste & Material Flow Management in the framework of the compilation of the Federal Waste Management Plan (BAWP). As according to current knowledge the EDM reporting obligation does not cover all potential composting plants in Austria, some not via EDM reported biogenic waste (410 kt) have to be considered additionally to achieve time-series consistency.

7.3.6 Category-specific planned improvements

A study on municipal green waste in Austria is currently ongoing. It is planned to use the results for future estimates, i.e. for complementing EDM data (as described under 7.3.5). These newly assessed amounts would then replace the 400 kt assumption. Preliminary results show lower biogenic waste amounts than estimated in the frame of the Federal Waste Management Plan and currently used.

7.4 Incineration and Open Burning of Waste (Category 5.C)

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 0.6% for the year 1990 and 0.1% for the year 2013.

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 incineration regulation[92] came into force, introducing strong limits (from 2005 on[93]) 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 269: Greenhouse gas emissions from Category 5.C.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	26.89	0.0032	0.0004	27.09
1991	23.40	0.0031	0.0004	23.59
1992	10.86	0.0006	0.0001	10.91
1993	10.60	0.0005	0.0001	10.64
1994	10.65	0.0003	0.0001	10.69
1995	10.97	0.0003	0.0001	11.01
1996	11.30	0.0003	0.0001	11.33
1997	11.62	0.0003	0.0001	11.66
1998	11.94	0.0003	0.0001	11.98
1999	12.26	0.0003	0.0001	12.30
2000	12.26	0.0003	0.0001	12.30
2001	12.26	0.0003	0.0001	12.30
2002	12.26	0.0003	0.0001	12.30
2003	12.26	0.0003	0.0001	12.30
2004	12.26	0.0003	0.0001	12.30
2005	12.26	0.0003	0.0001	12.30

[92] 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.

[93] Old facilities had to conform to the new regulation 2005 at the latest.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2006	10.15	0.0003	0.0001	10.18
2007	8.12	0.0002	0.0001	8.15
2008	6.09	0.0002	0.0001	6.11
2009	4.06	0.0001	0.0000	4.07
2010	2.03	0.0001	0.0000	2.04
2011	2.03	0.0001	0.0000	2.04
2012	2.03	0.0001	0.0000	2.04
2013	2.03	0.0001	0.0000	2.04
Trend 1990-2013	***−92%***	***−98%***	***−96%***	***−92%***

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 waste oil, the same CO_2 emission factor as for *1.A.1.a* heavy oil (CO_2: 80 [t/TJ]) is used and a heating value of 40.3 GJ/Mg waste oil (source: Energy balance-residual fuel oil) is used to convert the emission factors from [kg/TJ] to [kg/Mg].

For municipal solid waste and clinical waste the CO_2 emission factor is calculated by means of default assumptions from (IPCC-GPG 2000) as presented in Table 270.

Table 270: Emission factors and parameters of IPCC Category 5.C Waste Incineration.

Waste Type	Carbon content	Share in fossil carbon	Combustion efficiency	CO_2 [kg/Mg]	CH_4 [g/Mg]	N_2O [g/Mg]
Municipal Waste	40%	40%	95%	557.70	104.40	12.18
Clinical Waste	60%	40%	95%	836.00	100.00	12.00
Waste Oil	–	–	–	3 224.00	NA	24.18

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 strong 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 271: 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	0	6 050	1 800
1993	0	4 575	2 100
1994	0	3 100	2 500
1995	0	3 100	2 600
1996	0	3 100	2 700
1997	0	3 100	2 800
1998	0	3 100	2 900
1999–2005	0	3 100	3 000
2006	0	2 500	2 500
2007	0	2 000	2 000
2008	0	1 500	1 500
2009	0	1 000	1 000
2010	0	500	500
2011	0	500	500
2012	0	500	500
2013	0	500	500

The following table shows activity data of waste incineration with energy recovery.

Table 272: 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 [Mg]	hazardous waste [Mg] [4]	sewage sludge [Mg]	Industrial waste [Mg]	of which waste oil [Mg]	Ind. Waste [TJ]
1990	299 256	80 000	55 000	59 422	11 716	3 220
1991	341 001	80 000	55 000	66 552	22 069	4 556
1992	403 307	80 000	55 000	78 803	24 141	5 271
1993	421 907	72 500	64 500	78 568	21 273	4 179
1994	442 479	75 000	61 600	82 658	25 047	4 726
1995	441 502	71 337	60 672	86 998	28 675	5 270
1996	438 549	75 812	61 372	100 036	25 719	6 349
1997	446 471	95 334	64 778	101 063	22 781	5 693
1998	608 505	86 098	68 316	121 719	28 279	5 891
1999	526 928	70 513	80 406	135 065	26 607	5 388
2000	528 365	70 513	80 406	169 888	27 794	6 250
2001	498 590	70 513	75 117	218 048	26 437	8 278
2002	498 590	70 513	64 225	238 959	30 017	9 385
2003	561 801	70 513	62 970	253 874	30 057	10 898
2004	923 830	90 771	59 460	257 360	28 370	13 952
2005	944 948	103 058	58 979	338 491	27 028	9 885
2006	1 180 898	113 695	60 216	436 596	21 697	11 064
2007	1 124 139	109 724	62 376	514 071	23 996	11 440
2008	1 146 547	95 548	60 082	359 879	22 206	14 426
2009	1 348 681	96 505	54 243	336 691	14 881	16 849
2010	1 418 176	109 772	57 002	359 589	21 911	14 568
2011	1 456 520	108 220	164 636	393 857	19 597	15 580
2012	1 438 921	98 227	176 809	388 235	12 662	14 113
2013	1 516 986	143 848	173 637	433 857	10 365	11 541

[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 have been made since last years' submission.

7.5 Wastewater Treatment and Discharge (Category 5.D)

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 2013, greenhouse gas emissions from *5.D Wastewater Treatment and Discharge* contributed 11.0 % to greenhouse gas emissions from sector Waste and 0.2% to total greenhouse gas emissions in Austria. From 1990 to 2013, greenhouse gas emissions from this category decreased by 14.8%. 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)[94] to 72% (2013).

Table 273: Greenhouse gas emissions from domestic and commercial wastewater treatment (5.D.1) 1990–2013.

	CH_4		**N_2O**				**GHG**
Source	**septic systems**		**N_2O indirect effluent plants**	**N_2O indirect effluent population**	**N_2O direct plants**	**total**	**total**
	[t CH_4]	**[t CO_2 e]**	**[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	36.98	105 471	**215 140**
1995	4 205	105 137	215.45	78.53	77.63	110 738	**215 874**
1996	3 867	96 680	197.64	71.31	120.52	116 062	**212 741**
1997	3 527	88 181	187.53	64.07	151.14	120 016	**208 196**
1998	3 186	79 659	176.33	56.80	183.51	124 158	**203 818**
1999	2 934	73 350	162.68	51.85	215.80	128 237	**201 588**
2000	2 682	67 047	137.55	46.89	266.55	134 396	**201 443**
2001	2 432	60 799	110.02	41.98	319.84	140 607	**201 406**

[94] 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**		**N_2O direct**	**total**	**total**
			effluent plants	**effluent population**	**plants**		
	[t CH_4]	**[t CO_2 e]**	**[t N_2O]**	**[t N_2O]**	**[t N_2O]**	**[t CO_2e]**	**[t CO_2e]**
2002	2 181	54 516	112.68	37.82	326.84	142 245	**196 761**
2003	1 946	48 660	115.33	33.60	333.74	143 837	**192 497**
2004	1 794	44 854	117.99	33.81	335.85	145 318	**190 172**
2005	1 641	41 019	100.60	34.04	364.38	148 709	**189 728**
2006	1 483	37 069	83.22	25.59	405.00	153 114	**190 183**
2007	1 389	34 721	78.83	23.97	414.87	154 267	**188 988**
2008	1 294	32 354	74.44	22.34	424.84	155 440	**187 793**
2009	1 198	29 954	74.85	20.68	431.48	157 049	**187 003**
2010	1 102	27 541	75.26	19.01	438.17	158 669	**186 210**
2011	1 051	26 273	73.93	18.14	441.02	158 859	**185 132**
2012	1 001	25 026	72.60	17.28	444.41	159 219	**184 245**
2013	1 007	25 177	72.60	17.38	447.10	160 051	**185 228**
1990-2013	*−79%*		*−65%*	*−85%*	*-*	*+67%*	***−15%***
2012-2013	*+0.6%*		*0.0%*	*+0.6%*	*+0.6%*	*+0.5%*	***+0.5%***

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 2013 the connection rate to wastewater treatment plants increased from 59 % to 95%.

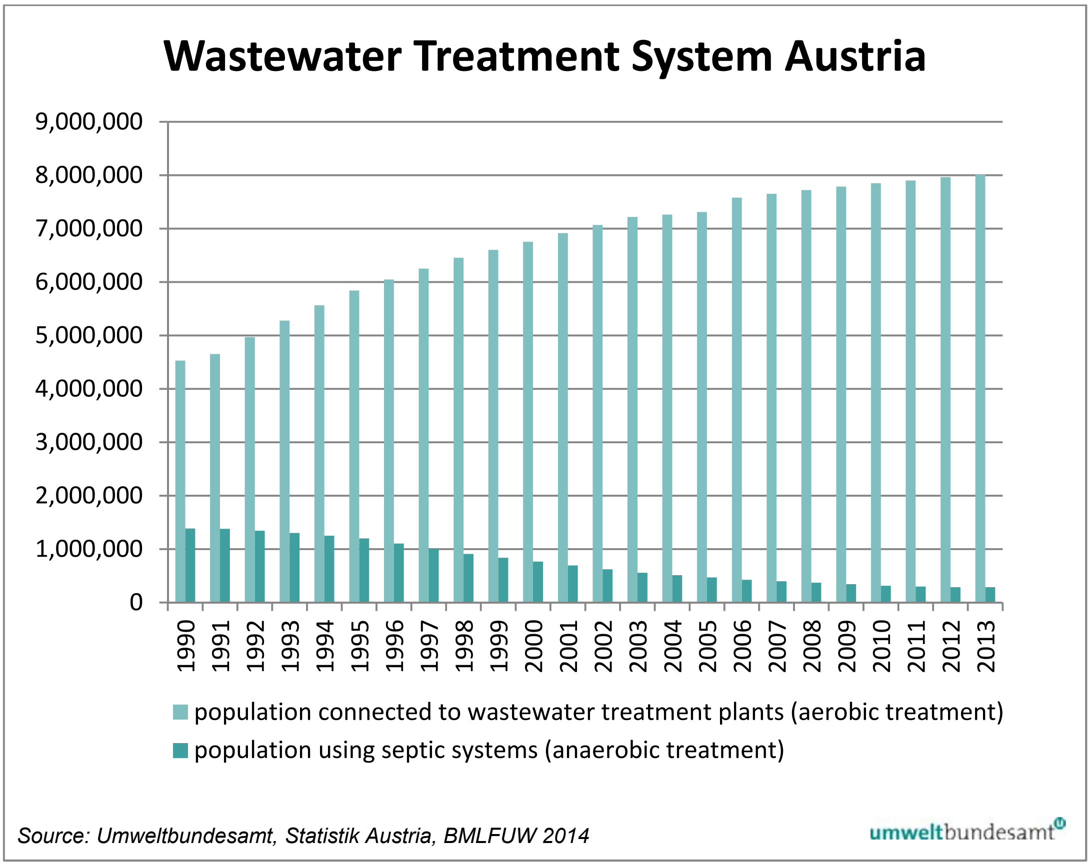

Figure 43: Domestic Wastewater Treatment in Austria/Connection rates.

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.

$$CH_4 \text{ (domestic wastewater)} = P * T_{[septic\ tanks]} * BOD * 365 * EF$$

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 274: Share of population using septic tanks (1991–2012)

1991	2001	2003	2006	2008	2010	2012
17.8%	8.6%	6.8%	5.1%	4.4%	3.8%	3.4%

In the year 2012[95] 94.5% of the Austrian population is connected to municipal wastewater treatment plants. The remaining wastewater is treated either in septic tanks (3.4%), domestic wastewater handling systems (1.9%), or disposed otherwise ('unspecified disposal routes': 0.2%).

Data on wastewater disposal routes and connection rates to the sewage system were 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 2008, BMLFUW 2010, BMLFUW 2012, BMLFUW 2014). Data are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010 and 2012. The missing data was interpolated.

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 country specific method. Emissions are calculated separately for N_2O from effluent (indirect

[95] the latest year for which data on connection rate is currently available

emissions) and N_2O from advanced centralized wastewater treatment plants, hereinafter referred to as 'plants', (direct emissions), and are then summed up.

$$N_2O\ \text{emissions} = N_2O_{PLANTS} + N_2O_{EFFLUENT}$$

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 44: Wastewater treatment systems and discharge pathways
- 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.

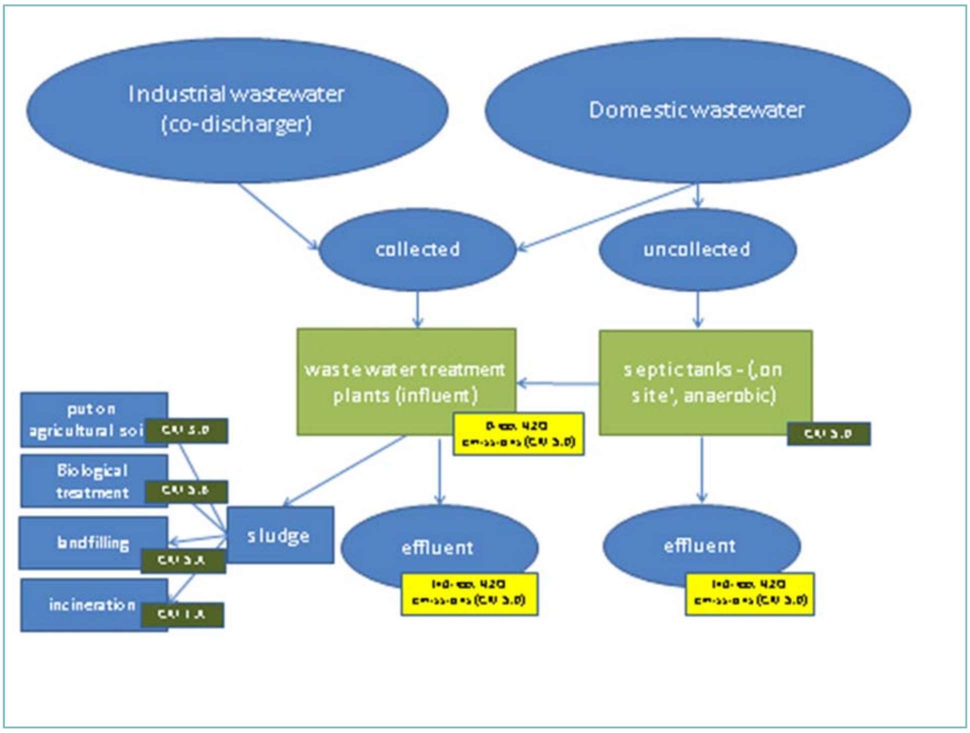

Figure 44: Wastewater treatment systems and discharge pathways (schematic illustration)

Direct N_2O emissions from plants (N_2O_{PLANTS})

N_2O emissions from wastewater treatment plants are calculated, basically applying Equation 6.9

of the IPCC 2006 GL:

$$N_2O_{PLANTS} = P * T_{CND\text{-}PLANTS} * F_{IND\text{-}COM} * EF_{PLANT}$$

N_2O_{PLANTS}= N_2O emissions from modern wastewater treatment plants

P= Austrian population

$T_{CND\text{-}PLANTS}$ = connection rate to modern, centralized wastewater treatment plants (CS)

$F_{IND–COM}$= fraction of industrial and commercial co-discharge (CS)

EF_{PLANT} = emission factor for Austrian wastewater treatment plants (CS)

Activity data

Data on the Austrian population (P) is taken from national statistics provided by Statistik Austria. 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 2008, BMLFUW 2010, BMLFUW 2010, BMLFUW 2012, BMLFUW 2014). Data are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010 and 2012; missing data was interpolated. In the year 2012 – the latest year for which data on connection rate is currently available – 94.5% 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%). 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 made by Umweltbundesamt (2015)). The $T_{CND\text{-}PLANTS}$ was calculated on basis of connection rates to the public sewage system (national statistics) and the assessed share of CND-plants in Austria.

Table 275: Activity data for calculation of direct N_2O emissions (plants)

	population	$T_{CND\text{-}PLANTS}$		Denitrification rate
		Connection rate plants	Share CND-plants	
	no.	[%]	[%]	[%]
1990	7 677 850	59%	0%	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

	population	$T_{CND-PLANTS}$		Denitrification rate
		Connection rate plants	Share CND-plants	
	no.	[%]	[%]	[%]
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%	80

As $F_{IND-COM}$ it is assumed that 30% of total nitrogen influent to wastewater treatment plants are 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 2015b). 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 2012 this value has increased to 80% (BMLFUW 2014).

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"[96]), an elec-

[96] 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

tronic 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 and 2012. Data for the years in between had to be interpolated. For the years before 2001 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.

Table 276: Activity data for calculation of N_2O from wastewater effluent

	$N_{EFFLUENT\ PLANTS}$	$N_{EFFLUENT\ POPULATION}$	$N_{EFFLUENT\ total}$
	[t N/yr]	[t N/yr]	[t N/yr]
1990	26 094	14.937	41 031
1991	26 803	14.719	41 522
1992	28 624	13.626	42 250
1993	30 398	12.473	42 871
1994	29 090	11.250	40 340
1995	27 420	9.994	37 415
1996	25 154	9.076	34 230
1997	23 867	8.154	32 021
1998	22 442	7.229	29 671
1999	20 704	6.599	27 303
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	11 439
2013	9.240	2.212	11 452

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.

Emissionen von Stoffen aus Punktquellen (EmRegV-OW)

7.5.3 Uncertainties and time-series consistency

The Uncertainty was originally based on ORTHOFER et al, and then slightly adapted by WAPPEL (Expert judgement 2005). Despite methodological improvements and the use of good quality country-specific data, the uncertainty for N_2O AD was not reduced, the N_2O EF has even increased. This is due to the relatively low uncertainty assessment of previous submissions and the wide dispersion of the individual measurement results influencing the EF for wastewater treatment plants (Expert judgement 2015) as well as the very large uncertainty associated with the default EF for N_2O from effluent (IPCC 2006 GL).

Uncertainties for CH_4 remain unchanged compared to previous estimations.

Table 277: 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[97]. 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 an 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)[98] and provided the scientific basis for the PhD Thesis of Mrs. Tanya Valkova,

[97] A MCF value of 0.22 was calculated using the mean methane emission value measured for the septic tanks from this project,

[98] Parravicini V.; Svardal K. (2015). Klimarelevante Emissionen aus der Abwasserreinigung. ÖWAV-TU-Seminar 2015,

which will be completed at the Vienna University of Technology (Vienna) by the end of this year.

7.5.5 Category-specific Recalculations

Revisions of N_2O emissions in this years' submission are due to methodological refinements to comply with the 2006 IPCC Guidelines and the use of country-specific activity and EF data. The reason for the revised CH_4 emissions are updated connection rates of the Austrian population, also changing the percentage of the population disposing their wastewater to septic systems.

The revision of N_2O emission values also affects the overall emission trend of this category, changing from + 37% (submission 2014) to –15% (submission 2015) between 1990 and 2012.

Table 278: Recalculation with respect to previous submission in category 5.D

	CH_4	N_2O	GHG
	[kt CH_4]	[kt N_2O]	[t CO_2e]
1990	-	-0.03	+5.97
1991	-	-0.02	+7,95
1992	-	0.00	+14.67
1993	-	0.02	+20.54
1994	-	0.00	+12.57
1995	-	-0.03	+2.97
1996	-	-0.06	-9.11
1997	-	-0.08	-16.51
1998	-	-0.11	-27.11
1999	-	-0.15	-39.42
2000	-	-0.21	-59.56
2001	-	-0.27	-78.29
2002	-	-0.26	-78.36
2003	-	-0.25	-75.54
2004	-	-0.24	-73.32
2005	-	-0.27	-82.31
2006	-	-0.30	-92.87
2007	-	-0.31	-95.95
2008	-	-0.32	-99.04
2009	-	-0.32	-100.02
2010	-	-0.32	-101.00
2011	-0.05	-0.32	-103.02
2012	-0.11	-0.32	-105.21

Summary methodological change N_2O compared to previous submissions:

Until submission 2014 the calculation was based on the protein intake of the population (FAO statistics) as described in the 1996 IPCC Guidelines, resulting in a steady growth of N_2O emis-

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.

sions in line with the rising population connected. The current inventory is based on measured nitrogen flows taken from the Electronic Emission Register of Surface Water Bodies[99] (indirect emissions) and measured emissions from advanced wastewater treatment plants in Austria (direct emissions). For the calculation of direct emissions from wastewater treatment plants, the newly available equation for N_2O emissions from centralized wastewater treatment processes from the IPCC 2006 Guidelines (Box 6.1) is applied, using a country specific emission factor derived from a measurement program conducted 2012–2014. For the calculation of indirect emissions measured N flows provided by plant operators in fulfillment of the EmRegV-OW were used.

The country specific approach is thus maintained and expanded respectively. Some adaptations to better comply with the IPCC 2006 GL were necessary, above all full consideration of indirect emissions (effluent from plants). This methodological change has led to a revision of N_2O emissions downwards, but increases accuracy due to use of national data.

7.5.6 Category-specific planned improvements

No further improvements are currently planned for this category.

[99] EmRegV-OW; Federal Law Gazette II 29/2009 …notification obligation of plant operators

8 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 six greenhouse gases compared to the previous submission. Recalculations are quantified for total GHG gas emissions for all years and by gas for 1990 and 2012.

8.1 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 because 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.

8.1.1.1 Energy (Sector 1)

Combustion Activities (1.A)

Stationary sources

Updates of activity data and of NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority Statistik Austria.

Revision of the Energy Balance

Main revisions affect the years 2009 to 2012 which results between +6.1 and −3.7 PJ of total gross inland consumption. Minor revisions affect the year 2005 (−0.5 PJ of total gross inland coal consumption).

Natural gas

2009: +3.4 PJ gross inland consumption (revision of imports).

2009–2011: Shift of natural gas from Total Other sectors to chemicals industry (between 1.4 and 1.9 PJ).

2010 and 2012: Shift from Transformation Sector (Industrial auto producers) to final energy consumption of Manufacturing Industries which is 3 PJ in 2012. This shift does not affect total consumption of Manuf. Industries.

Liquid fuels

Petrol coke 2011: +1.5 PJ of Manufacturing Industries final consumption.

Solid fuels

Coke oven coke 2005: Revision of final energy consumption of non metallic mineral industries by −0.5 PJ.

Other fuels

Industrial waste: Revision of final energy consumption of manufacturing industries by +2.5 PJ in 2009 and by +1.0 PJ in 2012. Revision of industrial autoproducers 2009–2012 with a maximum of +0.8 PJ in 2010 and +0.2 PJ in 2012.

Biomass

Fuel wood 2011–2012: Revision of final energy consumption of other sectors (+0.8 PJ in 2011 and +0.2 PJ in 2012).

Other solid biomass 2005: Revision of transformation input into public power plants by −3.2 PJ. This revision is due to the change from national energy balance data to IEA data use.

Mobile sources

Update/Improvement of activity data

For road transport the transition from the previously used emission calculation model GLOBEMI to the new model NEMO has resulted in revised emission data for the whole time series.

1.A.3.b Road Transport

Energy use and emissions for domestic traffic are calculated more accurately by the new model NEMO than before.[100] The methodological changes concerning domestic transport lead to an altered distribution of energy consumption between domestic and fuel export. The annually sold quantities of fuel in Austria however were not changed compared to the previous inventory (i.e. no impact on total emission data for this sub-category).

In the national energy balance the levels for liquid gas (LPG) were changed retrospectively for the years 2009-2012. Levels for natural gas (CNG) were only changed for the year 2012. In total, activity data for LPG and CNG show a slightly increased fuel use compared to last year's inventory.

1.A.3.c Rail Transport

Revisions of energy consumption data (diesel and coal) for the years 2009-2012 in the national energy balance resulted in minor adjustments. Overall revisions of the sector rail transport show

[100] Hausberger, S. et al. (2014): Road transport emissions and emissions from other mobile sources in Austria 1990–2013 (OLI2014), compiled on behalf of the Umweltbundesamt GmbH, Graz, 2014.

a slight decrease of GHG emissions (−3.1 kt CO_2e in 2012).

1.A.3.d Domestic Navigation

Revisions of energy consumption data due to an updated fleet consumption model for Danube navigation resulted in minor adjustments. Overall revisions of the sector domestic navigation show an increase of GHG emissions (+0.8 kt CO_2e in 2012).

1.A.2.f, 1.A.4.a,b,c Mobile Sources (Off-Road)

The mobile sources of off-road transport have still been calculated with the model GEORG[101] as in the years before.

Revisions of the national energy balance resulted in minor adjustments of sectorial diesel consumption data applied in the national off-road model.

Update of methodology and emission factors

1.A.3.b Road Transport

The transition to the new emissions calculation model NEMO for road transport has not changed the method itself, but is characterised by some essential improvements, which are integrated over individual partial modules in NEMO as follows:

1) Updated fleet model

Change in the assumptions for age- and size-dependent vehicle failure probabilities used for the extrapolation of the vehicle fleet depending on the year of first registration, engine type and other distinguishing characteristics (engine capacity or gross vehicle weight) of the fleet stock structure has led to a change in age distribution. Furthermore, through the possibility of the implementation of electric vehicles as a single-car model category and through a methodical shift in the new registration of gasoline and diesel car units in the fleet stock changes for each drive and emission category arise. However, the total fleet stock for each vehicle category agrees except for rounding differences with the previous inventory.

2) Updated consumption and emission factors

The application of the new emission factors from the manual "Emission Factors Road Transport (HBEFA)" Version V3.2 leads to changes in specific fuel consumption and emissions per vehicle kilometer for all vehicle categories.

3) Updated HDV (heavy duty vehicles) size classes

Weight size classes of the vehicle category HDV were adjusted to the HBEFA logic and the associated emission factors.

This restructuring affects HDV > 3.5 t maximum gross weight and all HDV <> 18 t maximum gross weight instead of the current structure in GLOBEMI <> 14 t maximum gross weight. In addition, the HDV class "buses" has been divided exactly into two vehicle categories "coaches" and "service buses" with associated specific emission factors from HBEFA V3.2.

4) Updated vehicle driving distance distribution according to road categories

Changed fleet shares mentioned under 1) result in a different driving distance distribution between vehicle and road categories.

[101]Hausberger, S. et al. (2014): Road transport emissions and emissions from other mobile sources in Austria 1990-2013 (OLI2014), compiled on behalf of the Umweltbundesamt GmbH, Graz, 2014, p.29.

In the present inventory emission factors of the manual "Emission Factors Road Transport (HBEFA)", Version V3.2 has been used. This version was finally released by INFRAS (Bern) in July 2014 and shows changes to those emission factors that were used in the previous year in the inventory model GLOBEMI. Mistakenly, the description of the previous year's inventory was pointing out that HBEFA Version 3.2 had been integrated, but in fact this was an update of Version 3.1.

The use of updated EFs in road transport changed the emissions for the whole time series. For passenger cars the update resulted in significantly higher CO_2 emissions per vehicle kilometer from 2001 onwards. For light duty vehicles the update led to decreased CO_2 emissions per vehicle kilometer, whereas CO_2 emissions per vehicle kilometer from heavy duty vehicles increased.

Overall revisions of the sector road transport show a slight decrease of GHG emissions (-0.3% for 2012).

Fugitive emissions (1.B)

1.B.1. Coal Mining

Historical emissions from mining activities (1.B.1.a) were revised due to a refined methodology, calculating surface and underground mining separately (2006: +0.001 kt CH_4). Solid fuel transformation is now included in 1.A, leading to lower emissions under 1.B.1.b (–0.04 kt CH_4).

1.B.2 Oil and natural gas

Reporting of oil and natural gas production is now under 1.B.2.b.2 (previously reported under 1.B.2.a.2) due to the fact, that gas emissions hold >80% of total emissions. Under 1.B.2.a.3 emissions from crude oil transport are reported for the first time, increasing emissions 2012 by 1.25 kt CO_2e.

8.1.1.2 Industrial Processes and Other Product Use (Sector 2)

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

Update of activity data

2.A.4.b Soda ash use

The amount of total soda ash used in 2012 was revised, resulting in lower CO_2 emissions (–1.7 kt).

2.F.1 Refrigeration and air conditioning equipment

Updated activity data for Transport refrigeration for the past years led to a new trend for activity data.

2.F.3. Fire Protection

Due to a remark during the last ESD review, previously reported use of R227ea in the years 1991 and 1996 was moved to 1998. The use of this agent earlier than 1998 seemed unlikely (even though reported by the company), so data was moved in line with the German market.

2.F.4.b *Aerosols*

Same as for 2.F.3: first use of 134a for aerosols was changed to 1995, in line with the German market.

2.F.5 Solvents

Same as for 2.F.3: first use of HFC-43-10-mee was changed to 2000.

2.G.1 Electrical Equipment

Changes in the timeline are due to a recalculation of stock data of the association of energy suppliers and industrial facilities (where all data is gathered).

2.D.4 Solvents-other: Use of N_2O for anesthesia – N_2O emissions

Updated information for the usage of N_2O for medical purpose leads to a reduction of N_2O emissions, as quantities for export were also included (−0.02 kt N_2O in 2012).

Improvements of methodologies and emission factors

2.B.1 Ammonia production

In line with the 2006 IPCC Guidelines, CO_2 emissions from urea use are subtracted from ammonia production. Only those emissions are subtracted which are reported elsewhere in the inventory, i.e. urea use in the transport sector (2.G.4) and urea application in agriculture (3.H).
As CH_4 emissions reported under fertilizer production originate from one single carbon input to the integrated ammonia/fertilizer plant, these emissions are subtracted from the emissions reported under ammonia production, in order to avoid double counting (−40 kt in 2012).

2.B.8.b Petrochemical and Carbon Black production – Ethylene

In line with the 2006 IPCC Guidelines, CH_4 emissions from ethylene production were estimated using the default emission factor. This resulted in higher CH_4 emissions for the whole time series (+1.5 kt in 2012)

2.B.10 Other

New source categories were introduced (production of formaldehyde, maleic anhydride and phthalic anhydride), which resulted in higher CO_2 emissions (+142 kt in 2012).

2.C.1 Iron and Steel Production

In line with the 2006 IPCC guidelines, CO_2 emissions were estimated based on a carbon balance. All emissions except those related to the coke oven and on-site power plants were taken into account. Consequently, parts of the emissions that had previously been reported under sector 1 are now included in sector 2. This resulted in revised emissions for the whole time series. The increase in 2012 was 4 404 kt CO_2.

According to the 2006 IPCC Guidelines, VOC emissions in electric steel production consist of NMVOC only. Likewise, in rolling mills, emissions are restricted to NMVOC (i.e. no methane emissions). Hence, CH_4 emissions of electric steel production and rolling mills were revised to "NA" for the whole time series and higher NMVOC emissions were reported instead.

2.C.3 Aluminium Production

The default CO_2 emission factor for primary aluminium production was updated in line with the 2006 IPCC Guidelines and secondary aluminium production was introduced as a new category, resulting in revised emissions for the whole time series (lower emissions 1990-1992, higher emissions 1992-2012, +4.11 kt in 2012).

2.F.1 Refrigeration and air conditioning equipment

A transcription error in the calculation of R134a stock in mobile air conditioning for passenger cars was corrected. This resulted in lower stocks and lower emissions in the years 2006-2012 (−12.2 t of R134a emitted in 2012).

8.1.1.3 Agriculture (Sector 3)

Based on a new study (AMON & HÖRTENHUBER 2014[102]) the Austrian inventory model for sector agriculture was revised according to the 2006 IPCC GL and the EMEP/EEA GB 2013.

Due to the applied model of the nitrogen balance along the reactions throughout the N-flow the recalculations resulted in higher emissions of NH_3 and lower ones of N_2O.

Update of activity data

3.A Enteric Fermentation

Annual livestock data

The two previous categories "chicken" and "other poultry" were divided into "layers" and "broilers" and "turkeys" and "other poultry" (i.e. the rest including ducks, geese, etc.).

3.B Manure Management

Annual livestock data

See *3.A Enteric Fermentation*

3.D Agricultural Soils

Other organic fertilizers applied to soils (CRF 3.D.a.2.c)

In addition to N from digested manure, which has been already accounted for in previous submissions, this revision implements additional N inputs from energy crops that are digested in biogas plants, and applied to soils as fertilizer after the digestion process (biogas slurry). This update resulted in additional N_2O emissions of 107 tonnes in 2013.

Crop Residues (CRF 3.D.a.4)

Direct N_2O emissions from plant residues left on the fields and mineralized (after incorporation). In contrast to the 1996 IPCC Guidelines, the new 2006 IPCC Guidelines account for the nitrogen of both, above and below ground biomass.

The estimation of N from crop residues is now covering the following sources:

(a) residues from harvest crops which have already been considered in the previous National

[102] Amon & Hörtenhuber: Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft, Wien 2014

Inventory, and additionally

(b) N from legume crops in rotations on cropland

(c) N from meadows ploughed every few years

(d) N from crop residues of cover crops

The source category 'N-fixing crops' has been removed as a direct source of N_2O. Anyhow, the N in crop residues of N-fixing crops has to be accounted for under 'crop residues'.

Improvements of methodologies and emission factors

3.A Enteric Fermentation

In Austria no country specific methane conversion rate is available. The 2006 IPCC default value has been used, which was 6.0% according to the 1996 IPCC GL and is 6.5% according to the 2006 IPCC GL. Therefore CH_4 emissions increased by about 8% within this source category.

3.B CH_4 emissions from Manure Management

As used in previous submissions, the country specific MCFs for liquid systems of cattle and swine have been applied. For the other systems the 2006 IPCC default values have been used. The default MCF for cattle/swine – solid storage UNTREATED increased from 0.01 to 0.02. Furthermore there were several changes of the IPCC default Tier 1 methane EF, which are applied in the Austrian inventory. These changes, especially the higher MCF for solid storage, lead to an increase of CH_4 emissions within this source category (+0.5 kt in 2012).

3.B Direct N_2O emissions from manure management

The IPCC default values have been used for the Austrian inventory. Almost all of the updated EFs in the 2006 IPCC GL were revised downwards. N_2O emissions of this source category decreased significantly compared to previous inventories, mainly due to lower N_2O EF for solid systems (decreased from 0.02 to 0.005 kg N_2O-N /kg N_{ex}) compared to the 1996 IPCC GL.

3.B.5 Indirect N_2O emissions from manure management

The 2006 IPCC Guidelines introduce the estimation of indirect N_2O emissions from the N volatilization from manure management systems. According to the 1996 IPCC Guidelines all indirect N_2O emissions caused by atmospheric deposition of nitrogen and nitrogen leaching from soils were reported under CRF category *4.D.3 Indirect soil emissions*.

The 2006 IPCC Guidelines require a split of indirect N_2O emissions into:

- Sector Manure Management including nitrogen losses through both, deposition (i.e. gaseous NH_3-N and NO_X-N losses) and leached NO_3-N.
- Sector Agricultural Soils including deposition and leaching/run-off. The following N inputs are considered: application of organic and mineral fertilizers, N in crop residues (above- and below-ground), urine and dung N deposited on pasture, range and paddock by grazing animals.

3.D.a Agricultural Soils (direct soil emissions – N_2O)

According to the 1996 IPCC Guidelines all N_2O emissions were calculated from N applied to soils after subtraction of volatile losses through NH_3-N and NO_x-N during and after application. 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 a consequence, the emission factor was reduced to 0.01 kg N_2O-N per kg N applied to soils. The new methodology leads to a decrease in N_2O emissions (–0.9 kt in 2012).

3.D.b Agricultural Soils (indirect soil emissions – 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. In the new 2006 IPCC Guidelines the overall value for the emission factor for leached N has been changed from 0.025 to 0.0075 kg N_2O–N/kg N leached. Furthermore, Austria introduced a national value for $Frac_{Leach}$ (0.15) based on a national study (Eder, A.; et al 2014)[103], substituting the previously used default factor of 0.30.

Due to the already explained revisions and the reallocation of nitrogen volatilized at housings, which is accounted under sector manure management according to the 2006 IPCC GL, indirect N_2O emissions from agricultural soils decreased (–2.7 kt in 2012).

New emission sources

3.G Liming

Up to now, Liming was reported under CRF category 5.B.1 *Cropland remaining Cropland* in sector LULUCF and is now reported under subcategory 3.G *Liming*. Liming is a source of CO_2 emissions.

3.H Urea Application

Emissions from urea application are reported in accordance with the 2006 IPCC GL for the first time in sector Agriculture. Emissions from urea use are reallocated according to the sectors where the urea is used. Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. In the previous inventory CO_2 emissions were reported in the Industrial Processes and Product Use Sector (IPPU Sector).

8.1.1.4 LULUCF (Sector 4)

Revisions of the data series for LULUCF are due to the following changes:

5.A Forest land

no revisions of the time series

5.B Cropland

The whole time series of cropland areas and consequently the time series of LUC areas to cropland were updated on basis of the most up-to-date figures from the statistics and assessment system.

Liming is no more reported under Cropland but in the Agriculture sector.

So, the emission estimates for this subcategory and for the whole time series changed on basis of these modifications.

5.C Grassland

The whole time series of grassland areas and consequently the time series of LUC areas to grassland were updated on basis of the most up-to-date figures from the statistics and assessment system. Major changes (reductions) occurred in the grassland areas in Alpine

[103] Eder, A.; Blöschl, G.; Feichtinger, F.; Herndl, M.; Klammler, G.; Hösch, J.; Erhart, E. & Strauss, P (2014). Indirect nitrogen losses of managed soils contributing to greenhouse emissions of agricultural areas in Austria: results from lysimeter studies. Article in Nutr Cycl Agroecosyst. DOI 10.1007/s10705-015-9682-9. 2015

ranges. In the last years a process was started in the grassland assessment system to correct for wrongly assessed grassland areas which in fact represent other land uses (forests, other land). This correction process was finalised in the year 2014 and as a consequence the whole time series of grassland areas was corrected. So, the emission estimates for this subcategory and for the whole time series changed on basis of these corrected activity data.

5.D Wetlands

No revisions of the time series.

5.E Settlements

The areas of the LUC subcategories CL to SL and GL to SL were changed on basis of the area improvements in the CL and GL subcategories and the related consequences on areas from these land-uses changing to SL. The annual areas of the LUC subcategories CL to SL and GL to SL were also corrected to better meet the annual increase in total SL area. So, the emission estimates for this subcategory and for the whole time series changed on basis of these adjusted activity data.

5.F Other lands

Due to the significant correction of the time series of grassland areas in Alpine ranges the total Other Land areas also changed and there was no more LUC from GL to OL due to area consistency reasons. This had consequences on the emissions and removals on this subcategory.

HWPs

Emissions and removals from HWPs were estimated for the first time.

LULUCF KP estimates

The Af-/reforestation and deforestation time series were not revised.

Emissions/removals from Forest Management including HWPs were estimated for the first time, because Austria did not elect Forest Management for the first commitment period. The methods follow the approaches as for Forest Land remaining Forest Land, but with slightly different activity data and consequently emissions/removals due to the rules for accounting under ARD.

8.1.1.5 Waste (Sector 5)

Update of activity data

5.B Biological Treatment of Solid Waste

Activity data for composted waste had to be slightly revised downwards for 2011 and 2012 as in previous submissions also anaerobically treated (digested) biogenic waste was considered under composting (which is actually an aerobic process).

5.D Wastewater Treatment and Discharge

CH_4 emissions 2011 and 2012 were revised due to the availability of updated connection rates of the Austrian population.

Improvements of methodologies and emission factors

5.D Wastewater Treatment and Discharge

Until submission 2014 the calculation was largely based on the protein intake of the population as described in the 1996 IPCC Guidelines, resulting in a steady growth of N_2O emissions in line with the rising population connected. For submission 2015 some adaptations to better comply with the IPCC 2006 GL were necessary: Indirect emissions from the effluent from wastewater treatment plants are considered for the first time. Furthermore, the current inventory is based on measured nitrogen flows and a country specific EF for advanced wastewater treatment plants is applied. This methodological change has led to a revision of N_2O emissions downwards for the entire time-series (−0.32 kt N_2O in 2012).

8.2 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 2012 which are submitted this year differ slightly from data reported previously.

The following table presents the recalculation difference with respect to last years' submission for each gas (positive values indicate that this years' estimate is higher). CO_2, CH_4 emissions and emissions of fluorinated compounds have been revised upwards, whereas N_2O emissions were revised downwards due to methodological changes. This is in part also due to the revised Global Warming Potentials (IPCC 2007).

Table 279: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission.

	1990	**2012**
	Recalculation Difference [%]	
Total	**0.76%**	**-0.33%**
CO_2	0.32%	0.16%
CH_4	27.39%	25.03%
N_2O	-32.29%	-37.01%
HFC, PFC, SF_6, (NF_3)	7.62%	12.70%

without emissions from LULUCF

National total emissions (excluding LULUCF) for the year **1990** have been slightly revised upwards since last years' submission (+597 kt CO_2e), mainly due to the higher GWP of CH_4. In 1990 the share of CH_4 in total GHG emissions was 13.5% compared to 8.2% in 2013.

Revised total emissions for **2012** are 266 kt CO_2 equivalents lower than the value submitted last year, mainly because of methodological revisions in the sector *Agriculture*.

A description of all recalculations by each sector is given in Chapter 8.1 as well as the relevant sectoral chapters. Table 281 in Chapter 8.4 shows all improvements made in response to the UNFCCC review process.

Table 280 presents the recalculation differences of national total GHG emissions for all years.

Table 280: Recalculation Difference of National Total GHG Emissions.

Year	National Total GHG emissions without LULUCF		
	Submission 2015 [kt CO_2e]	Submission 2014 [kt CO_2e]	Recalculation Difference [%]
1990	78 683	78 086	0.76%
1991	82 395	82 135	0.32%
1992	75 622	75 411	0.28%
1993	75 704	75 484	0.29%
1994	76 131	76 345	-0.28%
1995	79 456	79 744	-0.36%
1996	82 647	82 755	-0.13%
1997	82 124	82 278	-0.19%
1998	81 416	81 653	-0.29%
1999	79 746	79 966	-0.27%
2000	80 124	80 277	-0.19%
2001	84 107	84 275	-0.20%
2002	85 921	85 976	-0.06%
2003	91 899	91 985	-0.09%
2004	91 523	91 569	-0.05%
2005	92 496	92 581	-0.09%
2006	89 713	89 711	0.00%
2007	86 933	86 967	-0.04%
2008	86 757	86 882	-0.14%
2009	80 032	80 148	-0.14%
2010	84 788	84 808	-0.02%
2011	82 583	82 761	-0.22%
2012	79 793	80 059	-0.33%

8.3 Implications for Emission Trends, including time series consistency

As can be seen in Figure 45, Austria's GHG emission reported this year (OLI 2014) in sum differs only slightly to the data submitted last year (OLI 2013[104]), given the multitude of changes. The national total (excl. LULUCF) for 1990 is 0.76% higher, the national total (excl. LULUCF) for 2012 is 0.33% lower compared to the values submitted last year. The trend reported in this submission is thus flatter (+1.4%) than in the previous submission (+2.5%).

[104]Status Data: 10.3.2014 (CRF v1.4)

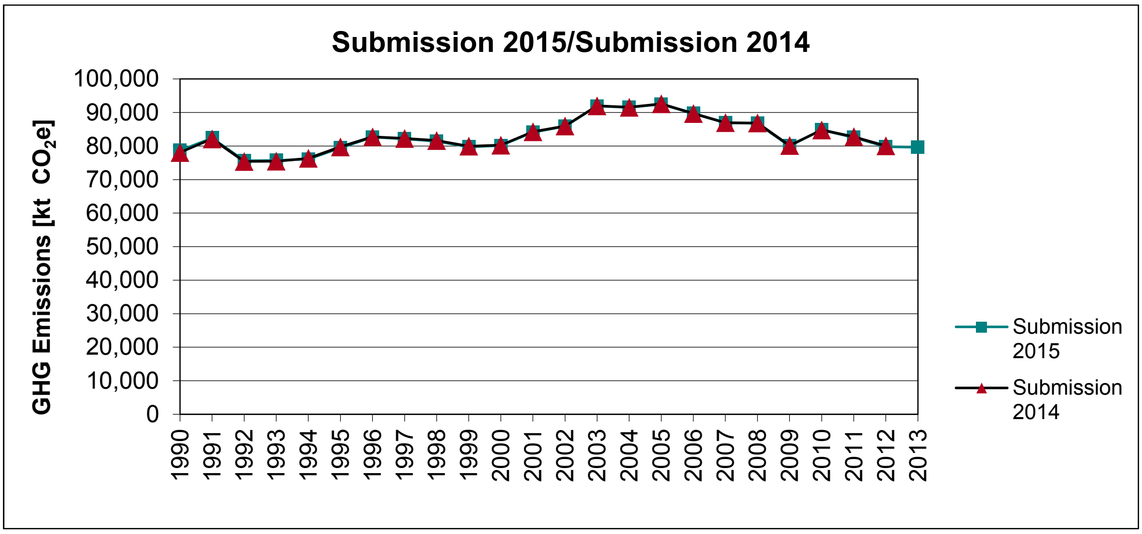

Figure 45: Comparison submission 2015 with submission 2014.

8.4 Planned improvements, including in response to the review process, and planned improvements to the inventory

Improvements made in response to the review process

Improvements made in response to the issues raised in the UNFCCC review process are summarized in Table 281.

Planned improvements

Source specific planned improvements are presented in the respective subchapters of Chapters 3–7.

Goals

The overall goal is to produce emission inventories which are fully consistent with the UNFCCC reporting guidelines and the IPCC Guidelines. An improvement programme has been established to help meet this goal and to avoid any adjustments under the Kyoto Protocol.

Linkages

The improvement programme is driven by the results of the various review processes, as e.g. the internal Austrian review, review under the European Union Monitoring Mechanism, and review under the UNFCCC and/or under the Kyoto Protocol. Improvement is triggered by the improvement programme that plans improvements sector by sector and also identifies actions outside the Umweltbundesamt.

The improvement programme is supported by the QA/QC programme based on the international standard EN ISO/IEC 17020:2012.

Updating

The improvement programme is updated every year after the results from the UNFCCC review process become available.

Responsibilities

The Umweltbundesamt is responsible for the management of the improvement programme.

Table 281: Improvements made in response to the UNFCCC Review.

Finding	Reference	Improvement made	Chapter
Energy			
Comparison of the reference approach with the sectoral approach and international statistics: It was recommended that AT continue efforts to harmonize fuel consumption data of domestic aviation and navigation betwween the CRF tables, which use a bottomup approach, and the International Energy Agency (IEA) reports, which rely on a top-down approach, and report the results in the NIR.	ARR 2014 para 24	A regular adoption of inventory data in the national statistics was agreed between Umweltbundesamt and Statistik Austria. As part of regular QA/QC, annual inventory data – energy split between national and international aviation and navigation – is provided to Statistics Austria for IEA statistics and checked by inventory agency for actual adoption.	Chapter 3.2.12.1 Chapter 3.2.12.4
Road transportation: liquid fuels – CH_4 and N_2O: Report N_2O and CH_4 emissions from biomass separately Reference and sectoral approach:	ARR 2014 para 30	N_2O and CH_4 associated with LPG and CNG are already reported separately. Concerning biomass use in road transportation, Austria continues to not plan to separate emissions because most of the fuels are used in blended diesel and gasoline and a separation of N_2O and CH_4 from these fuels would be "artificial" and not contribute to more transparency.	Chapter 3.2.12.2, CRF Table 9
Navigation: liquid fuels – CO_2, CH_4 and N_2O: Include supporting material and explanations in the NIR, whenever inconsistencies in trends of emissions or implied emission factors occur	ARR 2014 para 31	An explanation is included in the NIR 2015	Chapter 3.2.12.4
Other (energy): Investigate further the production of charcoal and improve the related estimates of CH_4 fugitive emissions for the years 1990-2004 in order to increase the accuracy of reporting	ARR 2014 para 33	ongoing	–
Fugitive Emissions			
No recommendations during Centralized Review 2014			
Industrial Processes and Other Product Use			
Lime production – CO_2: The ERT recommends to include a mass balance with data on lime produced, the CO_2 produced by calcination, the coke consumed and the mass of $CaCO_3$ produced. A description of the use of the total amount of calcium carbonate ($CaCO_3$) obtained is to be included in the NIR.	ARR 2014 para 36	A mass balance has been included	Chapter 4.2.2.2; Table 108

2.F Consumption of Halocarbons and SF_6 – HFCs and PFCs: The ERT recommends to include a more detailed and transparent description as to where emissions of HFC-23 are included.	ARR 2014 para 37	A more detailed description has been included in the NIR.	Chapter 4.7.2.1
2.F Consumption of Halocarbons and SF_6 – HFCs and PFCs: The ERT recommends that Austria corrects the description of data sources used for domestic refrigeration in its summary table in the NIR.	ARR 2014 para 38	The description of data sources used for domestic refrigeration was extended and the table corrected accordingly.	Chapter 4.7.2, Table 128
2.F Consumption of Halocarbons and SF_6 – HFCs and PFCs: The ERT noted that Austria did not provide data on the assumptions made during the estimation of emissions of fluorinated gases, such as the initial charges and the lifespan of different types of equipment. It was encouraged to provide general aggregated information on that.	ARR 2014 para 39	Information is included in the NIR.	Chapter 4.7.1; Chapter 4.7.2.2
Agriculture			
Direct and indirect soil emissions – N_2O: The ERT recommends to report on the results of specific research activities to establish a country-specific value for FracLEACH (fraction of nitrogen input to soils that is lost through leaching and run-off).	ARR 2014 para 51	A country-specificFracLEACH has been applied for submission 2015	Chapter 5.4.2
LULUCF			
Use results of Uncertainty analysis for priorisation of improvements and refinements	ARR 2014 para 55	ongoing; results of the uncertainty analysis are used for that purpose, but are not the only criteria for improvements and refinements - sometimes sophistic methods at highest tier are already used, but still lead to very uncertain values (e.g. for forest litter/soil)	–
Forest land remaining forest land CO_2: The ERT recommends that Austria provides estimates of the carbon stock changes for "forests not in yield" when the new NFI data become available and use the correct notation key.	ARR 2014 para 57	The notation key was corrected; estimates will be possible with the next NFI (at the end of 2nd CP)	CRF Table 4.A
Forest land remaining forest land CO_2: The ERT recommends that Austria provides estimates of the carbon stock changes in mineral soils for "forests not in yield" using the best available data. Alternatively, the Party should use the appropriate notation key	ARR 2014 para 58	The notation key was corrected; estimates will be possible with the next NFI (at the end of 2nd CP)	CRF Table 4.A

Forest land remaining forest land CO_2: The ERT recommends that Austria enhances the description of the method used to report litter and dead wood separately in the dead organic matter and soil pools in the annual submission	ARR 2014 para 59	Issue addressed in the NIR 2015 as well as documentation box in the CRF.	Chapter 6.2.4.1.3
Waste			
No recommendations during Centralized Review 2014			

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

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

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)

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 [IPCC GPG, 2000]

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 5

NACE....................Nomenclature des activites economiques de la Communaute Europeenne

NAPFUE ....Nomenclature for Air Pollution Fuels

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

OECD ....Organisation for Economic Co-operation and Development

OLI ....Österreichische Luftschadstoff Inventur / Austrian Air Emission Inventory

OMV......................Österreichische Mineralölverwaltung / Austrian Mineraloil Company

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 includ-ed 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 Gg
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}

REFERENCES

ABFALLWIRTSCHAFT (2003): Artikel „Situation der Monoverbrenner, E.H.Reil, Fernwärme Wien“ aus „Abfallwirtschaft und Klimaschutz, Umweltbundesamt, Oktober 2003, Wien“.

AMLINGER (2003): information from Dipl.Ing. Florian Amlinger – Compost Consulting & Development, Hochbergstrasse A-2380 Perchtoldsdorf.

AMLINGER, F.; PEYR, S.; HILDEBRANDT, U.; MÜSKEN, J.; CUHLS, C. & CLEMENS, J. (2005): Stand der Technik der Kompostierung. Grundlagenstudie. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. **http://www.umweltnet.at/article/articleview/30919/1/6954**

AMON, B. & HÖRTENHUBER, S. (2008): Revision der österreichischen Luftschadstoff-Inventur (OLI) für NH_3, NMVOC und NO_x; Sektor 4, Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien. (unpublished)

AMON, B. & HÖRTENHUBER, S. (2010): Revision of Austria's National Greenhouse Gas Inventory, Sector Agriculture. Final Report. Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU), study on behalf of Umweltbundesamt GmbH. Wien. (unpublished)

AMON, B. & HÖRTENHUBER, S. (2014): Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien 2014 (unveröffentlicht).

AMON, B.; FRÖHLICH, M.; WEIßENSTEINER, R; ZABLATNIK, B. & AMON, T. (2007): Tierhaltung und Wirtschaftsdüngermanagement in Österreich. Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft, Wien.

AMON, B.; HOPFNER- SIXT, K. & AMON, T. (2002): Emission Inventory for the Agricultural Sector in Austria – Manure Management, Institute of Agricultural, Environmental and Energy Engineering (BOKU – University of Agriculture, Vienna), July 2002.

AMON, B.; KRYVORUCHKO, V. & AMON, T. (2006): Influence of different levels of covering on greenhouse gas and ammonia emissions from slurry stores. International Congress Series (ICS) No 1293 “2nd International Conference on Greenhouse Gases and Animal Agriculture.

AMON, B.; KRYVORUCHKO, V.; FRÖHLICH, M.; AMON, T.; PÖLLINGER, A.; MÖSENBACHER, I. & HAUSLEITNER, A. (2007a). Ammonia and greenhouse gas emissions from a straw flow system for fattening pigs: Housing and manure storage. Livestock Science 112, 199–207.

AMON, B.; MOITZI, G.; SCHIMPL, M.; KRYVORUCHKO, V. & WAGNER-ALT, C. (2002a): Methane, Nitrous Oxide and Ammonia Emissions from Management of Liquid Manures. Final Report November 2002. Research project no. 1107, BMLF GZ 24.002/24-IIA1a/98 and extension GZ 24.002/33-IIA1a/00. On behalf of Federal Ministry of Agriculture, Forestry, Environment and Water Management, and Federal Ministry for Education, Science and Culture. Vienna.

AMON, B. (2010): expert judgement, personal communication. Vienna.

AMON, T. (2011): expert judgement, personal communication. Vienna.

AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG 1996: Bodenzustandsinventur Burgenland. Amt der Burgenländischen Landesregierung, Eisenstadt.

AMT DER KÄRNTNER LANDESREGIERUNG 1999: Kärntner Bodenzustandsinventur. Amt der Kärntner Landesregierung, Klagenfurt.

AMT DER NIEDERÖSTERREICHISCHEN LANDESREGIERUNG 1994: Bodenzustandsinventur Niederösterreich. Amt der Niederösterreichischen Landesregierung, St. Pölten.

AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG 1993: Oberösterreichischer Bodenkataster – Bodenzustandsinventur 1993. Amt der Oberösterreichischen Landesregierung, Linz.

AMT DER SALZBURGER LANDESREGIERUNG 1993: Salzburger Bodenzustandsinventur. Amt der Salzburger Landesregierung, Salzburg.

AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 1988–1996: Steiermärkische Bodenschutzberichte 1988–1996. Amt der Steiermärkischen Landesregierung, Graz.

AMT DER TIROLER LANDESREGIERUNG 1988: Bericht über den Zustand der Tiroler Böden. Amt der Tiroler Landesregierung, Innsbruck.

ANGERER, T. & FRÖHLICH, M. (2002): Thermisch Regenerative Oxidation als Verfahren der Abluftreinigung bei mechanisch-biologischen Anlagen zur Behandlung von Abfällen. Schriftenreihe des BMLFUW. Study is not published but can be made available to the ERT upon request.

ANGERER, T. (1997): Stand der Mechanisch-Biologischen Restabfallbehandlung vor der Deponierung (MBRVD) in Österreich – November 1997 – MUL Leoben.

AUSTRIAN CHAMBER OF AGRICULTURE (2012): Statistical data of burning straw. Mag. Längauer (email), November 2012.

AUSTRIAN STANDARD ÖNORM B 3012 (2003): Holzarten – Kennwerte zu den Benennungen und Kurzzeichen der ÖNORM EN 13556 (Wood species – Characteristic values to terms and symbols of ÖNORM EN 13556). Austrian Standard, Wien.

AUSTRO CONTROL (2007, 2008, 2009, 2010, 2011, 2012): Flight movements Austria – nonstandard analysis (not published). Austro Control.

BARBER, M.A.; (1996): (Alcan International Limited) Alcans's P-FKW Emission Reduction Program. A Case Study, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

BARNERT, H. (1998): Österreichisches Lackinstitut: Möglichkeiten und Grenzen umweltverträglicher Beschichtung (Lacke, Klebstoffe, Bautenschutzmittel, Holzschutzmittel), Wien.

BAUMELER, A.; BRUNNER, P. H.; FEHRINGER, R.; KISLIAKOVA, A. & SCHACHERMAYER, E. (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft (CH_4). Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs. Wien.

BEV - BUNDESAMT FÜR EICH- UND VERMESSUNGSWESEN (2012): Regional Information derived from the Austrian real estate database BEV – Austrian Federal Office of Metrology and Surveying, Wien.

BFW (1992): Österreichische Waldbodenzustandsinventur. Mitteilungen der Forstlichen Bundesversuchsanstalt Wien, Vol. 168/I, Vol. 168/II, Federal Office and Research Centre for Forests, Wien.

BFW (2005): Erhebungsnetz der österreichischen Waldinventur. **http://www.bfw.ac.at/rz/bfwcms.web?dok=2384**

BFW (2009): BioSoil - das europäische Waldboden-Monitoring. In: BFW-Praxisinformation Nr. 20 p. 13-15. Federal Office and Research Centre for Forests, Wien.

BFW (2011): Waldinventurergebnisse der Perioden 1992/96, 2000/02, 2007/09. Federal Office and Research Centre for Forests, Wien. **http://bfw.ac.at/rz/wi.home**

BFW (2011a pers. comm.): Annual growth indices. Personal communication, Federal Office and Research Centre for Forests, Wien.

BGBL. Nr. 440/1975: Forest Act of the Republic of Austria. Federal Ministry of Agriculture, Forestry, Environment and Water Management – Vienna/Austria.

BITTERMANN, W. & GERHOLD, S. (1995): Wirtschaftliche Aspekte und Holzbilanz. In: Östereichisches Statistisches Zentralamt, Forstliche Bundesversuchsanstalt (eds.): Ökobilanz Wald. Statistik Austria, Wien, 99–110.

BIERMAYR, P. et al. (2013): Innovative Energietechnologien in Österreich. Marktentwicklung 2012. Bundesministerium für Verkehr, Wirtschaft und Technologie, Wien.

BMLFUW - Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2000): Empfehlungen für die sachgerechte Düngung von Christbaumkulturen. Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2001): Bundesabfallbericht 2001, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2002): Gewässerschutzbericht gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006a): Bundes-Abfallwirtschaftsplan 2006 (BAWP 2006), Wien. Latest annual update (specific chapters): Statusbericht 2009. **www.bundesabfallwirtschaftsplan.at**

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006b): Kommunale Abwasserrichtlinie der EU – 91/271 EWG, Österreichischer Bericht 2006. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006c): Richtlinien für die Sachgerechte Düngung. 6. Auflage. Fachbeirat für Bodenfruchtbarkeit und Bodenschutz, Wien.

BMLFUW (2007): Sonderrichtlinie des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW) für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft. Anlage I, Anhänge zum Agrarumweltprogramm und zur Tierschutzmaßnahme (ÖPUL 2007). **http://www.ama.at/Portal.Node/ama/public?gentics.rm=PCP&gentics.pm=gti_full&p.contentid=10008.47092&SRL_O4_20071126.pdf**

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1993, 1996, 1999, 2002): Gewässerschutzberichte gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2008. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2009): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2009 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2010. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011a): Bundes-Abfallwirtschaftsplan 2011 (BAWP 2011). Wien. **http://www.bundesabfallwirtschaftsplan.at/**

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2011 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien **http://www.lebensministerium.at/publikationen/wasser/abwasser/05012011.html**

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2012): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2012. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1964–2011): Österreichische Waldberichte; Jahresberichte über die Forstwirtschaft. Edited annually by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW (1985–2011): Grüner Bericht. Bericht über die Lage der österreichischen Land- und Forstwirtschaft. Wien. Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2000–2014): Grüner Bericht 1999, 2000, 2002, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Grüner Bericht gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. **www.gruenerbericht.at**

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015a): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2014. Wien, Februar 2015. **http://www.bundesabfallwirtschaftsplan.at/dms/bawp/Statusbericht_2018/Statusbericht_2014.pdf**

BMLFUW – Federal Ministry of Agriculture and Forestry, Environment and Water Management (2015b): Parravicini, V.; Valkova, T.; Haslinger, J.; Saracevic, E.; Winkelbauer, A.; Tauber, J.; Svardal, K.; Hohenblum, P.; Clara, M.; Windhofer, G.; Pazdernik, K. & Lampert, C.: ReLaKO – Reduktionspotential bei den Lachgasemissionen aus Kläranlagen durch Optimierung des Betriebes. Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der TU Wien & Umweltbundesamt GmbH. Wien. **http://www.bmlfuw.gv.at/publikationen/wasser/abwasser/Lachgasemissionen---Kl-ranlagen.html**

BMUJF – Federal Ministry of Environment,Youth and Family Affairs (1995): Bundesabfallbericht 1995. Bundesministerium für Umwelt, Jugend und Familie, Wien.

BMUJF (1994): N_2O-Emissionen in Österreich. Endbericht zum Forschungsauftrag des BMUJF GZ 01 2943/2-I/7/94 vom 18.Mai 1994. Bundesministerium für Umwelt, Jugend und Familie, Wien.

BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung 1990. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung 1996. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (2003): Energiebericht der Österreichischen Bundesregierung 2003. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2008): Die österreichischen Bergbauproduktion 2008, Wien 2008.

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2010): Österreichisches Montan-Handbuch 2010. Bergbau - Rohstoffe - Grundstoffe – Energie, Wien 2010.

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2011): Österreichisches Montan-Handbuch 2011. Bergbau - Rohstoffe - Grundstoffe – Energie, Wien 2011.

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2012): Österreichisches Montan-Handbuch 2012. Bergbau - Rohstoffe - Grundstoffe – Energie, Wien 2012.

BMWFJ –.BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2013): Österreichisches Montan-Handbuch 2013. Bergbau - Rohstoffe - Grundstoffe – Energie, Wien 2013.

BORIS – Bodeninformationssystem des Umweltbundesamtes: **http://www.borisdaten.at**

BRITISH GEOLOGICAL SURVEY (2001): World Mineral Statistics 1995–1999. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2005): World mineral production 1999–2003. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2006): World mineral production 2000–2004. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2007): World mineral production 2001–2005. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2008): World mineral production 2002–2006. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2009): World mineral production 2003–2007. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2010): World mineral production 2004–2008. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2011): World mineral production 2005–2009. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2012): World mineral production 2006–2010. Keyworth, Nottingham: British Geological Survey. **http://www.bgs.ac.uk/mineralsuk/statistics/worldStatistics.html**

BUNDESANSTALT FÜR AGRARWIRTSCHAFT (2013): Federal Institute of Agricultural Economics. Download from data pool. **http://www.awi.bmlfuw.gv.at**

CHARLES, D., JONES, B.M.R., SALWAY, A.G., EGGLESTON, H.S., MILNE, R., 1998: Treatment of uncertainties for national estimates of greenhouse gas emissions. AEAT-2688-1, AEA Technology, Culham, UK.

DETZEL, A; VOGT, R; FEHRENBACH, H. et al. (2003): Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationalen Richtlinien. Institut für angewandte Ökologie (IFEU). Institute for Applied Ecology.

DLG (DEUTSCHE LANDWIRTSCHAFTS-GESELLSCHAFT) (1997): DLG-Futterwerttabelle für Wiederkäuer. 7. erweiterte und überarbeitete Auflage. DLG-Verlag, Frankfurt/Main, Germany.

DOEDENS, H.; CUHLS, C.; MÖNKEBERG, F.; LEVSEN, K.; KRUPPA, J.; SÄNGER, U. & KOCK, H. (1999): Bilanzierung von Umweltchemikalien bei der biologischen Vorbehandlung von Restabfällen, Phase 2: Emissionen, Schadstoffbilanzen und Abluftbehandlung. BMB+F Verbundvorhaben: Mechanisch-biologische Vorbehandlung von zu deponierenden Abfällen.

DOMENIG, M. (2004): information from Mag. Manfred Domenig, expert for waste management at the Umweltbundesamt Klagenfurt.

DÖRFLINGER, A.; HIETZ, P.; MAIER, R.; PUNZ, W.; FUSSENEGGER, K. (1995): Ökosystem Großstadt Wien – Quantifizierung ökologischer Parameter unter besonderer Berücksichtigung der Vegetation; Bundesministerium für Wissenschaft und Forschung und MA 22.

ECKMÜLLNER, O. (2006): Allometric relations to estimate needle and branch mass of Norway spruce and Scots pine in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions. 123. Jg., Heft 1/2, 7-16.

ECOFYS, FRAUNHOFER INSTITUTE FOR SYSTEMS AND INNOVATION RESEARCH, ÖKO-INSTITUT (Eds.) (2009): Methodology for the free allocation of emission allowances in the EU ETS post 2012 - Sector report for the chemical industry. By order of the European Commission. Study Contract: 07.0307/2008/515770/ETU/C2. Ecofys project Number: PECSNL082164. **http://www.ecofys.com/files/files/091102_chemicals.pdf**

E-CONTROL (2008): Ökostrombericht 2008. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Oktober 2008. Wien.

E-CONTROL (2010): Ökostrombericht 2010. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Juli 2009. Wien.

E-CONTROL (2011): Ökostrombericht 2011. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2011. Wien.

E-CONTROL (2013): Ökostrombericht 2013. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2013. Wien.

E-CONTROL (2013): Rohstoffbilanzen für 2011. Personal communication by DI Michael Sorger, 18.09.2013.

E-CONTROL (2014): **http://www.e-control.at/portal/page/portal/medienbibliothek/publikationen/dokumente/pdfs/Oekostrombericht2014_final.**pdf accessed October 2014

EDER, A., FEICHTINGER, F., STRAUSS, P. & BLÖSCHL G. (2013): Calculation of nitrogen leaching values for the annual greenhouse gas inventory of Austria – Evaluation of long term lysimeter time series. Federal Agency for Water Management, Institute for Land and Water Management Research, Petzen-kirchen,and Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria.

EDER, A., BLÖSCHL G., FEICHTINGER, F.; HERNDL, M., KLAMMLER, G.; HÖSCH, J., ERHART, E. & STRAUSS, P. (2014): Indirect nitrogen losses of managed soils contributing to greenhouse emissions of agricultural areas in Austria: results from lysimeter studies. Article in Nutr Cycl Agroecosyst. DOI 10.1007/s10705-015-9682-9. 2015.

EEA – European Environment Agency (1999): EMEP/CORINAIR Emission Inventory Guidebook – Second Edition, Prepared by the EMEP Task Force on Emission Inventories, Edited by Stephen Richardson Task Force Secretary. Technical Report No. 30. Copenhagen 1999.

EEA – European Environment Agency (2007): EMEP/CORINAIR Emission Inventory Guidebook – 2007, Technical report No 16/2007. Copenhagen.

EEA – European Environment Agency (2009): EMEP/EEA air pollutant emission inventory guidebook – 2009. Technical report No 6/2009. Copenhagen. **http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009**

EEA – European Environment Agency (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013. EEA Technical report No. 12/2013. **http://www.eea.europa.eu/publications/emep-eea-guidebook-2013**

EAGER – European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

ENTEC UK LIMITED (2006): European Commission, Support for the Development and Adoption of Monitoring and Reporting Guidelines as Harmonized Benchmarks for N2O activities for unilateral inclusion in the EU ETS for 2008-12, final report.

ENVIRONMENTAL SCIENCE & TECHNOLOGY (2011): Diaz-Valbuena, L.; Leverenz, H.L.; Cappa, C.D.; Tchobanoglous, G.; Horwath, W.R., and Darby, J.L.; Methane, carbon dioxide, and nitrous oxide emissions from septic tank systems. Department of Civil and Environmental Engineering, Department of Land, Air, and Water Resources, University of California

EUROPEAN COMMISSION (2007): Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers. BAT Reference Document LVIC-AAF August 2007. Brussels. **http://eippcb.jrc.es/reference/BREF/lvic_aaf.pdf**

EUROSTAT (2008): Structural business statistics (NACE Rev.1.1) – online statistics. Luxembourg. **http://epp.eurostat.ec.europa.eu**

FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V. (FNR, 2010): Leitfaden Biogas. Von der Gewinnung zur Nutzung. Herausgegeben von der Fachagentur Nachwachsende Rohstoffe mit Förderung des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz aufgrund eines Beschlusses des Deutschen Bundestages 5., vollständig überarbeitete Auflage, Gülzow, 2010.

FAO AGR. STATISTICAL SYSTEM (2001): FAO Agricultural Statistical System. **http://faostat.fao.org/site/339/default.aspx**

FINNISH ENVIRONMENT INSTITUTE (2011): Soil Carbon Model Yasso. Finnish Environment Institute, Helsinki, **http://www.ymparisto.fi/default.asp?contentid=250208&lan=en&clan=en**

FNR (FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V.; 2006): Handreichung - Biogasgewinnung und – nutzung. 3. überarbeitete Auflage. Gülzow, Germany

FRANKHAUSER, J. (2007): Personal Communication, Austrian Chamber of Agriculture, May. Vienna.

FREIBAUER, A. & KALTSCHMITT, M. (2001): Biogenic greenhouse gas emissions from agriculture in Europe. European Summary Report (Project Report Task 3) of the EU-Concerted Action FAIR3-CT96-1877 "Biogenic Emissions of Greenhouse Gases Caused by Arable and Animal Agriculture".

FVGW – FACHVERBAND DER GAS- UND WÄRMEVERSORGUNGSUNTERNEHMUNGEN (2012): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2012 - Auswertung Rohrleitungsnetz GAS in Österreich für die Jahre 2002 bis 2011 (personal communication).

FVGW – FACHVERBAND DER GAS- UND WÄRMEVERSORGUNGSUNTERNEHMUNGEN (2013): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2013 - Auswertung Rohrleitungsnetz GAS in Österreich für die Jahre 2002 bis 2012 (personal communication; Email 21.10.2013).

FVMI – FACHVERBAND DER MINERALÖLINDUSTRIE (1999-2012): Jahresberichte des Fachverbandes der Mineralölindustrie Österreichs. Jeweilige Jahresberichte für die Jahre 1999 bis 2012. Wien. **https://www.wko.at/Content.Node/branchen/oe/Mineraloelindustrie/Jahresberichte.html**

FVMI – FACHVERBAND DER MINERALÖLINDUSTRIE (2013): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2013 – Emissionen der Mineralölkette (personal communication; Email 26.11.2013).

GEBETSROITHER, E.; STREBL, F. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; Report ARC-S-0175, ARC Seibersdorf research, July 2002.

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2003). Quantification of carbon pools in agriculturally used soils of Austria by use of a soil information system as basis for the Austrian carbon balance model. OECD Expert Meeting: Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analyses., C. A. S. Smith (ed., 14–18 October 2002, Ottawa, Canada, Agriculture and Agri-Food Canada, Ottawa, CA & Organisation of Economic Co-operation and Development, Paris, FR.

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2005). Quantification of organic carbon pools for Austria's agricultural soils using a soil information system. Can. J. Soil Sci. 85: 491–498.

GIBBS, M. (ICF Inc.) & JACOBS, C. (US EPA) (1996): Reducing P-FKW Emissions from Primary Aluminium Production in the USA, from: Light Metal Age, February 1996.

GILBERG, U. et al. (2005): Waste management in Europe and the Landfill Directive, Background paper from the ETC/RWM to the ETC/ACC workshop „Inventories and Projections of Greenhouse Gas Emissions from Waste"; European Environment Agency.

GOOD PRACTICE GUIDANCE FOR CLRTAP EMISSION INVENTORIES – Draft chapter for the UNECE Corinair Guidebook on Emissions inventories, Tino Pulles, Jon van Aardenne, European Topic centre on air and climate change (ETC/ACC), November 2001.

GRABNER, R.; KLATZER, R.; MEIER, W.; STEINWIDDER, A.; STÖGER, E. & TOIFL, G. (2004): Mutterkuh- und Ochsenhaltung 2003. Ergebnisse und Konsequenzen der Betriebszweigauswertung aus den Arbeitskreisen Mutterkuh und Ochsenhaltung [Husbandry of mother cows and bullocks 2003]. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien.

GRUBER, L. & STEINWIDDER, A. (1996): Einfluß der Fütterung auf die Stickstoff- und Phosphorausscheidung landwirtschaftlicher Nutztiere – Modellkalkulationen auf Basis einer Literaturübersicht in: Die Bodenkultur – Austrian Journal of Agricultural Research, 47. Band/Heft 4/Dezember 1996/ISBN 0006-5471, WUV-Universitätsverlag, Wien.

GRUBER, L.; PÖTSCH, E. M. (2006): Calculation of nitrogen excretion of dairy cows in Austria. Die Bodenkultur, 2006, Vol. 57, Heft 1–4, Vienna.

GSCHWANTNER, TH. & SCHADAUER, K. (2006): Branch biomass functions for broadleaved tree species in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions, 123 Jg.; Heft 1/2, 17–34.

GSCHWANTNER, TH., GABLER, K., SCHADAUER, K. & WEISS, P. (2010): National Forest Inventory Reports, Chapter 1: Austria. In: TOMPPO, E.; GSCHWANTNER, TH.; LAWRENCE, M. & MCROBERTS, R.E. (Eds.): National Forest Inventories: pathways for common reporting. Springer, Heidelberg, Dordrecht, London, New York, 57–71.

HACKL, A. & MAUSCHITZ, G. (1995, 1997, 2001, 2003, 2007): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

HACKL, A. & MAUSCHITZ, G. (1996): Methangas und Kohlendioxid aus der Bereitstellung in Österreich genutzter Energieträger, TU-Wien, Wien, 1996.

HACKL, A. & MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.

HADORN, R. & WENK, C. (1996): Effect of different sources of dietary fibre on nutrient and energy utilization in broilers. 2. Energy and N-balance as well as whole body composition. Archiv für Geflügelkunde.

HARNISCH, J. & SCHWARZ, W. (2003): Final Report on the Costs and the impact on emissions of potential regulatory framework for reducing emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. European Commission (DG ENV).

HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K. & RUNNING, S.W. (1999a): Forest growth response to changing climate between 1961 and 1990. Forest Ecology and Management 122: 209–219.

HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K. & RUNNING, S.W. (1999b): Climate variations and tree growth between 1961 and 1995 in Austria. In: Karjalainen, T.; Spiecker, H. & Laroussini, O. (eds.): Causes and consequences of accelerating tree growth in Europe. European Forest Institute Joensuu, Proceedings No. 27: 75–86.

HAUK, E. & SCHADAUER, K. (2009): Instruktionen für die Feldarbeit der Österreichischen Waldinventur 2007–2009. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at:, **http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf**

HAUK, E. & SCHADAUER, K. (2009): Instruktionen für die Feldarbeit der Österreichischen Waldinventur 2007–2009. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at:, **http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf**

HAUSBERGER, S. (1997): GLOBEMI – Globale Modellbildung für Emissions- und Verbrauchsszenarien im Verkehrssektor; Institute for Internal Combustion and Thermodynamics. University of Technology Graz; Volume 71; Graz.

HAUSBERGER, S. & KELLER, M. et al. (1998): Handbuch der Emissionsfaktoren des Straßenverkehrs in Österreich. Im Auftrag des Umweltbundesamtes; BMLFUW und BMVIT. Wien.

HAUSBERGER, S. & SCHWINGSHACKL, M. (2012): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2011. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2012.

HAUSBERGER, S. (1998): GLOBEMI – Globale Modellbildung für Emissions- und Verbrauchsszenarien im Verkehrssektor; Institute for Internal Combustion and Thermodynamics. University of Technology Graz; Volume 71; Graz.

HAUSBERGER, S. 2005: Scenarios for the Transport Sector in Austria 1990 to 2020. Report No. FVT-68/05/ Haus Em 24/04-6790. Forschungsinstitut für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz.

HAUSBERGER, S. (2005): Scenarios for the Transport Sector in Austria 1990 to 2020. Report No. FVT-68/05/ Haus Em 24/04-6790. Forschungsinstitut für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz.

HAUSBERGER, S. / SCHWINGSHACKL, M. / REXEIS, M. (2014): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2012. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2014.

HAUSBERGER, S. / SCHWINGSHACKL, M. / REXEIS, M. (2015a): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2013. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

HAUSBERGER, S. / SCHWINGSHACKL, M. / REXEIS, M. (2015b): NEMO Methodenbericht im Rahmen des Projekts NEMO4U. Erstellt im Auftrag der Umweltbundesamt mbH. Graz 2015. Not yet published.

HÄUSLER, J. (2009): Das Leistungspotenzial von Fleckviehmutterkühen – Versuchsergebnisse des LFZ Raumberg-Gumpenstein. Fachtag „Erfolgreiche Mutterkuhhaltung“ Fachschule Warth.

HEIM, P. (2005): Fütterung von Kuh und Kalb. [Feeding of mother cow and calve]. Article in UFA-Revue 3/05, an agricultural journal of Switzerland.

HIEBLER, M.; GAMSJÄGER, H. & GOD, C.: Vergleich von metallurgisch und thermisch bedingten CO_2 Emissionen. Montanuniversität Leoben.

HOCHBICHLER, E.; BELLOS, P. & LICK, E. (2006): Biomass functions and expansion factors for spruce, pine, beech and oak in Austria. Austrian Journal on Forest Science, Special Issue on Austrian biomassfunctions. 123. Jg., Heft 1/2, 35–46.

IEA - INTERNATIONAL ENERGY AGENCY (2014): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2014). Submission 2014. Statistik Austria, Wien.

INTERNATIONAL ASSOCIATION OF OIL & GAS PRODUCERS (2011): Petroleum industry guidelines for reporting greenhouse gas emissions, 2nd Edition, OGP Report Number 446, International Association of Oil & Gas Producers.

INTERNATIONAL IRON AND STEEL INSTITUTE (IISI)(2004): Steel statistical yearbook 2004. Brussels.

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 1: Reporting Instructions, Vol. 2: Workbook, Vol. 3: Reference Manual. Intergovernmental Panel on Climate Change, Edited by J.T. Houghton, L.G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander, Genf.

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2000): Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Report). Japan. [also referenced as „IPCC GPG" in the NIR]

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry. Edited by J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner.

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and anabe K. (eds). Published: IGES, Japan. **http://www.ipcc-nggip.iges.or.jp/public/2006gl/**

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007): Climate Change 2007 – Impacts, Adaptation and Vulnerability. 4th Assessment Report. **http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml**

JÄGER, F.(2003): Forstrecht. 3rd Edition, Verlag Österreich, Wien.

KALIVODA, M. et al (2002): Air Traffic Emission Calculation for Austria 1990–2000, study commissioned by Umweltbundesamt, Vienna. Study has not been published, but can be made available upon request.

KAUSEL, A. (1998): Ein halbes Jahrhundert des Erfolges, Der ökonomische Aufstieg Österreichs im OECD-Raum seit 1950. Österreichische Nationalbank, Wien.

KIRNER, L. & SCHNEEBERGER, W. (1999): Strukturanalyse der Betriebe mit der ÖPUL-Maßnahme "Verzicht auf bestimmte ertragssteigernde Betriebsmittel (Betrieb)". Der Förderungsdienst 47(6).

KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht, WUV Universitätsverlag, Wien.

KÖRNER, C.; SCHILCHER, B. & PELAEZ-RIEDL, S. (1993): Bestandsaufsaufnahme anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – Mögliche Maßnahmen. Dokumentation, Kapitel 6.1. Österreichische Akademie der Wissenschaften. Wien.

KORTELAINEN, P.; PAJUNEN, H.; RANTAKARI, M. & SAARNISTO, M. (2004): A large carbon pool and small sink in boreal Holocene lake sediments. Global Change Biology 10/10, 1648–1653.

KTBL (KURATORIUM FÜR TECHNIK UND BAUWESEN IN DER LANDWIRTSCHAFT; GERMAN ASSOCIATION FOR TECHNOLOGY AND STRUCTURES IN AGRICULTURE; 2005): Gasausbeute in Landwirtschaftlichen Biogasanlagen. KTBL-Heft 50. Darmstadt, Germany

LAHL, U.; ZESCHMAR-LAHL, B. & ANGERER, T. (2000): Entwicklungspotentiale der mechanisch-biologischen Abfallbehandlung. Eine ökologische Analyse. Wien.

LAHL, U.; ZESCHMAR-LAHL, B. & SCHEIDL, K. (1998): Abluftemissionen aus der mechanisch-biologischen Abfallbehandlung in Österreich. Klagenfurt.

LANDESBETRIEB LANDWIRTSCHAFT HESSEN (2013): Nährstoffgehalte pflanzlicher Produkte zum Nährstoffvergleich.**http://www.llh-hessen.de/pflanzenproduktion/duengung-boden/n-duengung/155-landwirtschaft/pflanzenproduktion/duengung-boden/567-naehrstoffgehalte-pflanzlicher-produkte-zum-naehrstoffvergleich.html** (accessed 4.6.2014)

LEBENSMINISTERIUM (2012): CO_2 Monitoring 2011. Zusammenfassung der Daten der Neuzulassungen von Pkw der Republik Österreich gemäß Entscheidung Nr. 1753/2000/EG für das Berichtsjahr 2011. Wien, 2012.

LEDERMANN, T. & NEUMANN, M. (2006): Biomass equations from data of old long-term experimental plots. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 47–64.

LEISEWITZ, A. & SCHWARZ, W. (2010): Assessment of the Consumption and the Real Emissions of Fluorinated Greenhouse Gases in Austria 2000-2008. Ökorecherche, Frankfurt am Main.

LEISEWITZ, A. (2012): Überprüfung von Vereinfachungsmöglichkeiten bei der Datenerhebung und -berechnung für die österreichische F-Gas-Berichterstattung im Bereich der stationären Kälte und Klimatisierung im Anschluss an den Bericht von Ökorecherche 2010. Ökorecherche, Frankfurt am Main.

LÖHR, L. (1990): Faustzahlen für den Landwirt.

MAUSCHITZ, G. (2004, 2009, 2010, 2011, 2012): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien. Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften. Wien.

MAUSCHITZ, G. (2008): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2009): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien. **http://www.zement.at/downloads/emissionen_2004_2009.pdf**

MAUSCHITZ, G. (2010): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2009. TU Wien. **http://www.zement.at/downloads/emissionen_2010.pdf**

MAUSCHITZ, G. (2011): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2010. TU Wien. **http://www.zement.at/downloads/emissionen_2010.pdf**

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2011. TU Wien. **http://www.zement.at/downloads/emissionen_2011.pdf**

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2012. TU Wien. **http://www.zement.at/downloads/emissionen_2012.pdf**

MCPFE LIAISON UNIT and UNECE/FAO (2007): "State of Europe's Forest 2007". Ministerial Conference on the Protection of Forests in Europe, Liaison Unit Warsaw, ISBN 10-83-922396-8-7.

MEET (1999): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium.

MENZI, H.; RUETTIMANN, L. & REIDY, B. (2003): DYNAMO: A new calculation model for dynamic emission inventories for ammonia. Proc. International Symposium 'Gaseous and odour emissions from animal production facilities', Horsens, Denmark, June 1–4.

MOLITOR, R., S. HAUSBERGER, G. BENKE et al. (2004) Abschätzung der Auswirkungen des Tanktourismus auf den Kraftstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich, Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Trafico, Wien 2004.

MOLITOR, R., S. SCHÖNFELDER, S. HAUSBERGER, G. BENKE et al. (2009) Abschätzung der Auswirkungen des Kraftstoffexports im Tank auf den Kraftstoffabsatz und die Entwicklung der CO_2- und Luftschadstoffemissionen in Österreich - Aktualisierung 2007 und Prognose 2030. Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und Bundesministerium für Verkehr, Innovation und Technologie. Wien 2009.

MONNI, S. AND S. SYRI, 2003: Uncertainties in the Finnish 2001 Greenhouse Gas Emission Inventory. VTT RESEARCH NOTES 2209, Espoo.

NESTROY, O.; DANNEBERG, O. H. & ENGLISCH, M. (2000): Systematische Gliederung der Böden Österreichs (Österreichische Bodensystematik 2000). Mitt. d. Österr. Bodenkundl. Ges., H. 60, Wien 2000.

OBERNOSTERER, R.; SMUTNY, R. & JÄGER, E. (2004): HFKW Gase in Dämmschäumen des Bauwesens. Umweltbundesamt, Internal Report. Study has not been published, but can be made available upon request.

OFFENTHALER, I. & HOCHBICHLER, E. (2006): Estimation of root biomass for Austrian forest tree species. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 65–86.

ÖIGV – Österreichischer Industriegaseverband (2013): N_2O use in medical and industrial field (personal communication), Schwechat.

ÖKOINSTITUT (2002): Öko Institut e.V., Institut für angewandte Ökologie, April 2002, Freiburg, Darmstadt, Berlin.

ORTHOFER, R., 1991: Abschätzung der Methan-Emissionen in Österreich, OEFZS-4586, Seibersdorf, Austria.

ORTHOFER, R., H.M. KNOFLACHER, J. ZÜGER (1995): N_2O-Emissionen in Österreich. Seibersdorf Research Report OEFZS-A-3256, Seibersdorf.

PHILIPPITSCH, R.; GRATH, J.; SCHIMON, W.; GMEINER, C.; DEUTSCH, K.; GRUBER, D.; TOMEK, H.; BONANI, M. & LASSNIG, M. (2001): Wassergüte in Österreich. Jahresbericht 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBl. Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.

PISCHINGER, R. (2000): Emissionen des Off-Road-Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz. Unveröffentlicht.

PÖLLINGER, A. (2008): national expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution 1990-2008 carried out in June 2008. Vienna.

PÖTSCH, E.M.; GRUBER, L. & STEINWIDDER, A. (2005): Answers and comments on the additional questions, following the meeting in Bruxelles. Internal statement, HBLFA Raumberg-Gumpenstein.

RAMIREZ RAMIREZ, A., C. DE KEIZER, J. P. VAN DER SLUIJS, 2006: Monte Carlo Analysis of Uncertainties in the Netherlands Greenhouse Gas Emission Inventory for 1990 – 2004. Report NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht.

REIDY, B. & MENZI, H. (2005): Ammoniakemissionen in der Schweiz: Neues Emissionsinventar 1990 bis 2000 mit Hochrechungen bis 2003 Technischer Schlussbericht Schweizerische Hochschule für Zollikofen.

REIDY, B.; DÄMMGEN, U.; DÖHLER, H.; EURICH-MENDEN, B.; EVERT, F. K. VAN; HUTCHINGS, N. J.; LUESINK, H. H.; MENZI, H.; MISSELBROOK, T. H.; MONTENY, G.J. & WEBB, J. (2008): Comparison of models used for national agricultural ammonia emission inventories in Europe : liquid manure systems. Atmospheric environment, Band 42, Heft 14, Seite 3452-3464, englisch. ISSN: 0004-6981.

REIDY, B.; RIHM, B. & MENZI, H. (2007): A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations, Reference: AEA7495, IN Journal: Atmospheric Environment.

REIDY et al. (2008, 2009): Comparisons of models used for national agricultural ammonia emission inventories in Europe. Atmospheric Environment, Band 42 and Band 43.

REIDY, B.; WEBB, J.; MISSELBROOK, T.H.; MENZI, H.; LUESINK, H.H.; HUTCHINGS, N.J.; EURICH-MENDEN, B.; DÖHLER, H. & DÄMMGEN, U. (2009): Comparison of models used for national agricultural ammonia emission inventories in Europe: Litter-based manure systems. Atmospheric environment, Band 43, Heft 9, Seite 1632–1640, englisch. ISSN: 0004-6981

RESCH, R., GUGGENBERGER, T., WIEDNER, G., KASAL, A., WURM, K., GRUBER, L., RINGDORFER, F. & BUCHGRABER, K. (2006): Futterwerttabellen im Jahr 2006 für das Grundfutter im Alpenraum. Available from Website **http://www.gumpenstein.at**

RUBATSCHER, D.; MUNK, K.; STÖHR, D.; BAHN, M.; MADER-OBERHAMMER, M. & CERNUSCA, A. (2006): Biomass expansion functions for Larix decidua: a contribution to the estimation of forest carbon stocks. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 86–101.

RUSS, W. (2004): Mehr Wald – ein positiver Trend? BFW Praxis Information 3/2004, pp. 4-7, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at: **http://bfw.ac.at/700/pdf/BFW_praxis2004_kl.pdf**

RWA (2006–2013): Expert judgements based on annual sales data of urea. Personal communication, Raiffeisen Ware Austria AG, Wien.

RYPDAL K., W. WINIWARTER, 2001: Uncertainties in Greenhouse Gas Inventories – Evaluation, comparability and implications. Environmental Science.

SBV – SWISS FARMERS UNION (2007): Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2006. Swiss Farmers Union, Brugg.

SCHÄFER, R. (2002): Neues Konzept zum Düngemitteleinsatz. In: VKS News 65. Ausgabe 08/2002.

SCHECHTNER (1991): Wirtschaftsdünger – Richtige Gewinnung und Anwendung, Sonderausgabe des Förderungsdienst 1991, BMLF, Wien.

SCHIELER, K. & HAUK, E. (2001): Instruktion für die Feldarbeit – Österreichische Waldinventur 2000/2002, Fassung 2001. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna. Download at: **http://bfw.ac.at/700/pdf/da_ges_neu.pdf**

SCHIELER, K.; BÜCHSENMEISTER, R. & SCHADAUER, K. (1995): Österreichische Forstinventur – Ergebnisse 1986/90. Bericht 92, Federal Office and Research Centre for Forests, Wien.

SCHMIDT, A.; VITOVEC, W.; PUXBAUM, H. & KNIERIDER, R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien.

SCHWARZ, W. & GSCHREY, B. (2009): Service contract to assess the feasibility of options to reduce emissions of SF6 from the EU non-ferrous metal industry and analyse their potential impacts. Prepared for European Commission, DG Environment. Final Report, Frankfurt am Main

SCHWARZ, W. (2004): Emissionen, Aktivitätsraten und Emissionsfaktoren von fluorierten Treibhausgasen (F-Gasen) in Deutschland für die Jahre 1995-2002. Anpassung an die Erfordernisse der internationalen Berichterstattung und Implementierung der Daten in das Zentrale System Emissionen (ZES), Umweltbundesamt, Dessau.

SJARDIN, M. (2003): CO_2 emission factors for non-energy use in the non-ferrous metal, ferroalloys and inorganics industry. Copernicus Institute, Department of Science, Technology and Society, University of Utrecht.

SPLECHTNA, B. & GLATZEL, G. (2005): Optionen der Bereitstellung von Biomasse aus Wäldern und Energieholzplantagen für die energetische Nutzung. Berlin-Brandenburgische Akademie der Wissenschaften, Berlin, Materialien Nr. 1.

STANZEL, G., J. JUNGMEIER, J. SPITZER, 1995: Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research, Graz.

STATISTIK AUSTRIA (1960–2012): Statistik der Landwirtschaft. Statistik Austria, Wien.

STATISTIK AUSTRIA (2001): Agrarstrukturerhebung 1999. Wien.

STATISTIK AUSTRIA (2008, 2009, 2010, 2011, 2012): Flight movements per aircraft type and airport (national and international) – nonstandard analysis (not published). Statistik Austria. Wien.

STATISTIK AUSTRIA (2010): Weingartengrunderhebung 2009. Schnellbericht 1.19. Wien.

STATISTIK AUSTRIA (2012): Agrarstrukturerhebung 2010. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2012): Allgemeine Viehzählung am 1. Dezember 2012. National livestock counting December 2012. Wien.

STATISTIK AUSTRIA (2013): Austrian Transport Statistics. Statistik Austria 2013. Wien. **http://www.statistik.at/web_de/dynamic/services/publikationen/14/publdetail?id=14&listid=14&detail=643**

STATISTIK AUSTRIA: National statistics. Wien.
- Statistisches Jahrbuch Österreich 1992–2012;
- Industrie und Gewerbestatistik (1. Teil) 1990–1995, 2000–2007;
- Konjunkturerhebung im Produzierenden Bereich (Band 3) 1997–2012;.
- Konjunkturerhebung im Produzierenden Bereich (Band 2 bzw. 3) 1997–2011;
- Der Außenhandel Österreichs 1. bis 4. Vierteljahr 1980–2011, Spezialhandel nach Waren und Ländern. Statistik Austria, Wien.

STATSTIK AUSTRIA (2012): Binnenschifffahrtsstatistik. Wien. (erstellt am 14.04.2012) **http://www.statistik.at/web_de/statistiken/verkehr/binnenschifffahrt/index.html**.

Statistik Austria (2013): Statistik des Bevölkerungsstandes; revidierte Ergebnisse von 2007 bis 2011. Erstellt am 15.07.2013. **http://www.statistik.at/web_de/statistiken/bevoelkerung/bevoelkerungsstand_und_veraenderung/bevoelkerung_im_jahresdurchschnitt/index.html**

STATSTIK AUSTRIA (1990-2014): Agrarstrukturerhebungen 1990-2013. Schnellbericht. Statistik Austria. Wien 2014 **http://www.statistik.at/web_de/services/publikationen/8/index.html**

STEINER, G., M. & REITER, K. (1992): Österreichischer Moorschutzkatalog-Datenbank. Styria Medien Service. Wien.

STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J. & WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemissionen. Report des Joanneum Research: Institut für Umweltgeologie und Ökosystemforschung.

STEINWENDER, R. & GOLD, H. (1989): Produktionstechnik und Gebrauchskreuzungen in der Mutterkuhhaltung. Versuchsbericht. Agricultural Research Center for Alpine Regions, Gumpenstein.

STEINWIDDER, A. & GUGGENBERGER, T. (2003): Erhebungen zur Futteraufnahme und Nährstoffversorgung von Milchkühen sowie Nährstoffbilanzierung auf Grünlandbetrieben in Österreich. Die Bodenkultur 54 (1), 49–66.

STEINWIDDER, A; HÄUSLER, J.; SCHAUER, A.; MAIERHOFER, G.; GRUBER, L.; GASTEINER, J. & PODSTATZKY, L. (2006): Einfluss des Absetztermins auf die Milchleistung und Körpermasse von Mutterkühen sowie die Zuwachsleistung von Mutterkuh-Jungrindern. Versuchsbericht. Extensively managed beef cows – Effects on animal health, reproductive success, performance of calves and economics. Experiment 2004 to 2008. Interim report. Agricultural Research and Education Centre, HBLFA Raumberg-Gumpenstein.

Stork, C.; Windhofer, G. & Zieritz, I.: Kommunales Abwasser: Österreichischer Bericht 2014. Kombinierter Bericht gemäß Artikel 15 und Artikel 16 der Richtlinie 91/271/EWG für den Zeitraum 2011 – 2012. Hrsg. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW). Wien, Juni 2014. **http://www.bmlfuw.gv.at/wasser/wasserqualitaet/abwasserreinigung/Lagebericht2014.html**.

STREBL, F.; GEBETSROITHER, E. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Agricultural Soils in Austria; ARC Seibersdorf research, revised version, February 2003.

TABERAUX, A. (1996): Relationship between Operating Parameters and Emissions, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

THE OIL INDUSTRY INTERNATIONAL EXPLORATION AND PRODUCTION FORUM (1994): Methods for estimating atmospheric emissions from E&P operations, Report No. 2.59/197, London 1994. **http://www.ogp.org.uk/pubs/197.pdf**

UBA BERLIN (1999): MBA Bericht: Ökologische Vertretbarkeit mechanisch-biologischer Vorbehandlung von Restabfällen.

UMWELTBUNDESAMT (1995): Boos, R.; Neubacher, F.; Reiter, B.; Schindlbauer, H. & Twrdik, F.: Zusammensetzung und Behandlung von Altölen in Österreich. Monographien, Bd. M-054. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1997): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlammes in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998a): Götz, B.: Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Berichte, Bd. BE-087a, Umweltbundesamt, Wien, July 1998.

UMWELTBUNDESAMT (2000): Weiss, P.; Schieler, K.; Schadauer, K.; Radunsky, K. & Englisch, M.: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Monographien, Bd. M-106, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999. Interner Bericht, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001b): Bichler, B.; Werenskiold, W. & Unterberger, S.: Abschätzung der tatsächlichen und potentiellen treibhauswirksamen Emissionen von H-FKW, P-FKW und SF_6 für Österreich. Internal Report. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2001c): Häusler, G.: Emissionen aus Abfalldeponien 1980–1998, Interner Bericht, Bd. IB-623. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001d): Perz, K.: Materialien zum Bundesabfallwirtschaftsplan 2001, Monographien, Bd. M-138, Umweltbundesamt, Klagenfurt.

UMWELTBUNDESAMT (2001e): Grech, H. & Rolland, C.: Stand der Abfallbehandlung in Österreich im Hinblick auf das Jahr 2004. Berichte, Bd. BE-182. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001f): WIESENBERGER, W.: State-of-the-art for the Production of Nitric Acid with Regard to the IPPC Directive. Monographien, Band 150. Wien. **http://www.umweltbundesamt.at/fileadmin/site/publikationen/M150.pdf**

UMWELTBUNDESAMT (2002): Erdgas-mix in Österreich, Elementaranalyse. Auszug aus der GEMIS-Datenbank des Umweltbundesamt.

UMWELTBUNDESAMT (2003): Rolland, C. & Scheibengraf, M.: Biologisch abbaubarer Kohlenstoff im Restmüll. Berichte, Bd. BE-236. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004): SCHINDLER I., KUTSCHERA U., WIESENBERGER H.: Medienübergreifende Umweltkontrolle in ausgewählten Gebieten. Wien.

UMWELTBUNDESAMT (2004a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 2003. Berichte, Bd. BE-254. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004b): Pilot study on statistics on waste management in agriculture, forestry and fishing – Agriwaste. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004c): Rolland, C. & Oliva, J.: Erfassung von Deponiegas – Statusbericht von österreichischen Deponien. Berichte, Bd. BE-238. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2005): Schachermayer, E.: Vergleich und Evaluierung verschiedener Modelle zur Berechnung der Methanemissionen aus Deponien. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2006a): Neubauer, C. & Öhlinger, A.: Ist-Stand der mechanisch biologischen Abfallbehandlung (MBA) in Österreich, Zustandsbericht 2006. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2006b): Salchenegger, S.: Biokraftstoffe im Verkehrssektor in Österreich 2006, Zusammenfassung der Daten der Republik Österreich gemäß Art. 4, Abs. 1 der Richtlinie 2003/30/EG für das Berichtsjahr 2005. Reports, Bd. REP-0068. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007b): Dampfkesseldatenbank, Stand Oktober 2007. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007c): Lenz, K. & Kampel, E.: Nitrous Oxide emissions from industrial wastewater, Interne Studie, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008b): Query of data from the National Austrian Waste Water Database. Vienna.

UMWELTBUNDESAMT (2008c): Schachermayer, E. & Lampert, C.: Erfasste Deponiegasmengen auf Österreichischen Deponien – Zeitreihe für die Jahre 2002 bis 2007. Reports, Bd. REP-0100. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008d): Neubauer, C. & Walter, B.: Behandlung von gemischten Siedlungs- und Gewerbeabfällen in Österreich – Betrachtungszeitraum 2003–2008. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010a): Anderl, M.; Freudenschuß, A.; Friedrich, A.; Köther, T.; Kriech, M.; Kuschel, V.; Muik, B.; Pazdernik, K.; Poupa, S.; Schodl, B.; Stranner, G.; Schwaiger, E.; Seuss, K.; Weiss, P.; Wieser, M. & Zethner, G.: Austria's National Inventory Report 2010. Reports, Bd. REP-0265. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010b): Freudenschuß, A.; Sedy, K.; Spiegel, H. et al.: Arbeiten zur Evaluierung von ÖPUL-Maßnahmen hinsichtlich ihrer Klimawirksamkeit. REP-290. Umweltbundeamt, Wien. **http://www.umweltbundesamt.at/aktuell/publikationen/publikationssuche/publikationsdetail/?&pub_id=1875**

UMWELTBUNDESAMT (2011b): Query of data from the National Austrian Waste Water Database. Vienna 2011.

UMWELTBUNDESAMT (2012a): Winter, R.; Biokraftstoffe im Verkehrssektor 2011 – Zusammenfassung der Daten der Republik Österreich gemäß Art.4, Abs.1 der Richtlinie 2003/30/EG für das Berichtsjahr 2011, im Auftrag des BMFLUW, Wien 2012.

UMWELTBUNDESAMT (2012b): Poetscher, F.: CO_2-Monitoring 2011. Zusammenfassung der Daten der Neuzulassungen von Pkw der Republik Österreich gemäß Entscheidung Nr. 1753/2000/EG für das Berichtsjahr 2011. Umweltbundesamt, Wien 2012.

UMWELTBUNDESAMT (2013a): Data on sewage sludge application provided by the provincial governments. Vienna 2013.

UMWELTBUNDESAMT (2014a): Anderl, M.; Freudenschuß, A.; Haider, S.; Jobstmann, H.; Kohlbach, M.; Köther, T.; Kriech, M.; Lampert, Ch.; Moosmann, L.; Pazdernik, K.; Pinterits, M.; Poupa, S.; Schmid, C.; Stranner, G.; Schwaiger, E.; Schwarzl, B.; Weiss, P.; Zechmeister, A.: Austria's National Inventory Report 2014 – Submission under the United Nations Framework Convention of Climate Change and the Kyoto Protocol. Report REP-475; Umweltbundesamt, Vienna

UMWELTBUNDESAMT (2014b): Lampert, C.: Stand der temporären Abdeckung von Deponien und Deponiegaserfassung. Report. REP-0484. Umweltbundesamt, Wien

UMWELTBUNDESAMT (2014c): Stakeholder Workshop on the revision of the agricultural model according to the IPCC 2006 GL.16th September 2014. Vienna

UMWELTBUNDESAMT (2015a): Haider, S.; Anderl, M.; Lampert, C.; Moosmann, L.; Pazdernik, K.; Perl, D.; Pinterits, M.; Poupa, S.; Purzner, M.; Schodl, B.; Stranner, G.; Wieser, M. & Zechmeister, A.: Austria's Informative Inventory Report 2015. Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Reports, Bd. REP-0505 Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2015b): Emissionshandelsregister Österreich. „Stand der Einhaltung" für LFZB für die Jahre 2013 und 2014 im österreichischen Teil des Unionsregisters. 4.5.2015. **http://www.emissionshandelsregister.at/ms/emissionshandelsregister/de/ehr_anlagen/ehr_stand_der_einhaltung**

UN-FCCC (2011): Report of the technical assessment of the forest management reference level submission of Austria submitted in 2011. **http://unfccc.int/resource/docs/2011/tar/aut01.pdf**

UN-FCCC (2012): Decision 2/CMP.7 Land use, land use change and forestry, The seventh session of the Conference of the Parties serving as the meeting of the Parities to the Kyoto Protocol, 2011 in Durban, South Africa. **http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf**

UNTERARBEITSGRUPPE N-ADHOC (2004): Überprüfung und Überarbeitung der N-Anfallswerte für einzelne Tierkategorien. Unterlagen ausgearbeitet vom Fachbeirat für Bodenfruchtbarkeit und Bodenschutz des BMLFUW.

VITOVEC, W., 1991: N2O-Emissionen anthropogener Quellen in Österreich. Dissertation, TU Vienna, Austria.

WARTHA, C. (2005): Life Cycle Inventory Austria 2000 - Review, Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2005.

WARTHA, C. (2011): Life Cycle Inventory „Erdgasbereitstellung Austria – Update 2010", Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2011.

WASNER, J. (2009): Einfluss einer Carbokalkdüngung bei kalkhältigen Böden auf das Ertragsverhalten sowie auf ausgewählte bodenchemische und -physikalische Parameter. PhD Thesis, Universität für Bodenkultur, Wien.

WERF – WATER ENVIRONMENT RESEARCH FOUNDATION (2010): Leverenz, H.L.; Tchobanoglous, G.; Darby, J.L.: Evaluation of Greenhouse Gas Emissions from septic systems. University of California.

WEST, T.O. (2008): Country-level estimates for Carbon distribution in U.S. croplands, 1990–2005. Environmental Science Division, Oak Ridge National Laboratory. **http://cdiac.ornl.gov/carbonmanagement/cropcarbon/**

WINDSPERGER, A. & HINTERMEIER, G. (2002): Entschwefelungstechnologien – Die Situation in Österreich. Eine Studie im Auftrag des Umweltbundesamt.

WINDSPERGER, A. & TURI, K. (1997): Emissionserhebung der Industrie für 1993 und 1994. Technische Universität Wien, Forschungsinstitut für Chemie und Umwelt, Wien.

WINDSPERGER, S. & SCHMIDT-STEJSKAL, H. (2008): Austria's Emission Inventroy from solvent use 2009. Institut für Industrielle Ökologie (IIÖ). Studie im Auftrag des Umweltbundesamt. Wien. Study has not been published, but can be made available upon request.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt. Wien.

WINIWARTER, W. & ORTHOFER, R. (2000): Unsicherheit der Emissionsinventur für Treibhausgase in Österreich, Seibersdorf Research Report, OEFZS--S-0072, Seibersdorf.

WINIWARTER, W. & RYPDAL, K. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria. Atmospheric Environment 35: 5 425–5 440.

WINIWARTER, W. (2007): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, ARC (Austrian Research Centers) Seibersdorf. Research Report ARC-sys-0154. Final report contracted by Umweltbundesamt.

WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports – Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5–74.

WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports – Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5–74.

WINKLER, N. (2003): Walderschließung Österreichs im Detail. Federal Office and Research Centre for Forests, Wien, **http://bfw.ac.at/700/2109.html**

WIRTH, C.; SCHUMACHER, J. & SCHULZE, E.D. (2004): Generic biomass functions for Norway spruce in Central Europe – a meta-analysis approach toward prediction and uncertainty estimation. Tree Physiology 24, 121–139.

WKO - WIRTSCHAFTSKAMMER ÖSTERREICH (2005): Bergbau-Stahl Jahresbericht, Fachverband der Bergwerke und Eisen erzeugenden Industrie, Wien 2005.

WKO - WIRTSCHAFTSKAMMER ÖSTERREICH (2006): Bergbau-Stahl Jahresbericht, Fachverband Bergbau-Stahl, Wien 2006.

WKO - WIRTSCHAFTSKAMMER ÖSTERREICH (2007): Bergbau-Stahl Jahresbericht, Fachverband Bergbau-Stahl, Wien 2007.

ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Jahrbuch 2004. Data query 2007. **http://www.zamg.ac.at/fix/klima/jb2004/Web/index.html**

ZENTRALE ARBEITSGEMEINSCHAFT ÖSTERREICHISCHER RINDERZÜCHTER (2004): Cattle Breeding in Austria, 148 pp.

ZESSNER, M. (1999): Bedeutung und Steuerung von Nährstoff- und Schwermetallflüssen des Abwassers. Wiener Mitteilung Band 157. Wien, 1999.

ZESSNER, M. & LINDTNER, S. (2005): Estimations of municipal point source pollution in the context of river basin management. Institute for Water Quality and Waste Management, Vienna University of Technology Published in Water Science & Technology. Vol. 52, No 9 pp 175-182. IWA Publishing 2005

DATA SOURCES BY SECTOR

All Sectors

EEA – EUROPEAN ENVIRONMENT AGENCY (1999): EMEP/CORINAIR Emission Inventory Guidebook – Second Edition, Prepared by the EMEP Task Force on Emission Inventories, Edited by Stephen Richardson Task Force Secretary. Technical Report No. 30. Copenhagen 1999.

EEA – European Environment Agency (2006): EMEP/CORINAIR Emission Inventory Guidebook – 2006, Technical report No 11/2006. Copenhagen. http://www.eea.europa.eu//publications/EMEPCORINAIR4

EEA – European Environment Agency (2007): EMEP/CORINAIR Emission Inventory Guidebook – 2007, Technical report No 16/2007. Copenhagen.

EEA – European Environment Agency (2009): EMEP/EEA air pollutant emission inventory guidebook – 2009. Technical report No 6/2009. Copenhagen. http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

EEA – European Environment Agency (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013. EEA Technical report No. 12/2013. http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and anabe K. (eds). Published: IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/

IPCC – INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007): Climate Change 2007 – Impacts, Adaptation and Vulnerability. 4th Assessment Report. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

UMWELTBUNDESAMT (2015): Haider, S.; Anderl, M.; Lampert, C.; Moosmann, L.; Pazdernik, K.; Perl, D.; Pinterits, M.; Poupa, S.; Purzner, M.; Schodl, B.; Stranner, G.; Wieser, M. & Zechmeister, A.: Austria's Informative Inventory Report 2015. Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Reports, Bd. REP-0505 Umweltbundesamt, Wien.

Uncertainties

CHARLES, D., JONES, B.M.R., SALWAY, A.G., EGGLESTON, H.S., MILNE, R. (1998): Treatment of uncertainties for national estimates of greenhouse gas emissions. AEAT-2688-1, AEA Technology, Culham, UK.

GEBETSROITHER E., STREBL F., ORTHOFER R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; Seibersdorf research report ARC--S-0175, Seibersdorf.

HAUSBERGER, S. 2005: Scenarios for the Transport Sector in Austria 1990 to 2020. Report No. FVT-68/05/ Haus Em 24/04-6790. Forschungsinstitut für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz.

MONNI, S. AND S. SYRI (2003): Uncertainties in the Finnish 2001 Greenhouse Gas Emission Inventory. VTT RESEARCH NOTES 2209, Espoo.

ORTHOFER, R. (1991): Abschätzung der Methan-Emissionen in Österreich, OEFZS-4586, Seibersdorf, Austria.

ORTHOFER, R., H.M. KNOFLACHER, J. ZÜGER (1995): N_2O-Emissionen in Österreich. Seibersdorf Research Report OEFZS-A-3256, Seibersdorf.

RAMIREZ RAMIREZ, A., C. DE KEIZER, J. P. VAN DER SLUIJS (2006): Monte Carlo Analysis of Uncertainties in the Netherlands Greenhouse Gas Emission Inventory for 1990 – 2004. Report NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht.

RYPDAL K., W. WINIWARTER (2001): Uncertainties in Greenhouse Gas Inventories – Evaluation, comparability and implications. Environmental Science.

STANZEL, G., J. JUNGMEIER, J. SPITZER (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research, Graz.

VITOVEC, W. (1991): N_2O-Emissionen anthropogener Quellen in Österreich. Dissertation, TU Vienna, Austria.

WINIWARTER, W. & ORTHOFER, R. (2000): Unsicherheit der Emissionsinventur für Treibhausgase in Österreich, Seibersdorf Research Report, OEFZS--S-0072, Seibersdorf.

WINIWARTER, W. & RYPDAL, K. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria. Atmospheric Environment 35: 5 425–5 440.

WINIWARTER, W. (2007): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, ARC (Austrian Research Centers) Seibersdorf. Research Report ARC-sys-0154. Final report contracted by Umweltbundesamt.

Energy

ABFALLWIRTSCHAFT (2003): Artikel „Situation der Monoverbrenner, E.H.Reil, Fernwärme Wien" aus „Abfallwirtschaft und Klimaschutz, Umweltbundesamt, Oktober 2003, Wien".

BMUJF (1994): N_2O-Emissionen in Österreich. Endbericht zum Forschungsauftrag des BMUJF GZ 01 2943/2-I/7/94 vom 18.Mai 1994. Bundesministerium für Umwelt, Jugend und Familie, Wien.

BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung 1990. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung 1996. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

BMWA–EB (2003): Energiebericht der Österreichischen Bundesregierung 2003. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.

HACKL, A. & MAUSCHITZ, G. (1996): Methangas und Kohlendioxid aus der Bereitstellung in Österreich genutzter Energieträger, TU-Wien, Wien, 1996.

IEA - INTERNATIONAL ENERGY AGENCY (2014): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2014). Submission 2014. Statistik Austria, Wien.

MAUSCHITZ, G. (2004, 2009, 2010, 2011, 2012): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien. Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften. Wien.

ÖKOINSTITUT (2002): Öko Institut e.V., Institut für angewandte Ökologie, April 2002, Freiburg, Darmstadt, Berlin.

STANZEL, G.; JUNGMEIER, J. & SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research Graz.

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999. Interner Bericht, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2002): Erdgas-mix in Österreich, Elementaranalyse. Auszug aus der GEMIS-Datenbank des Umweltbundesamt.

UMWELTBUNDESAMT (2004a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 2003. Berichte, Bd. BE-254. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007b): Dampfkesseldatenbank, Stand Oktober 2007. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2015b): Emissionshandelsregister Österreich. „Stand der Einhaltung" für LFZB für die Jahre 2013 und 2014 im österreichischen Teil des Unionsregisters. 4.5.2015. http://www.emissionshandelsregister.at/ms/emissionshandelsregister/de/ehr_anlagen/ehr_stand_der_einhaltung

Transport

ASFINAG (2012): Analysis of mileage on Austrian highways for the years 2011 - 2013 - nonstandard analysis (not published). ASFINAG data edited by Austrian Federal Ministry of Transport (bmvit), Katharina Raub. Wien, 2014.

AUSTRO CONTROL (2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014): Flight movements Austria – nonstandard analysis (not published). Austro Control.

BMLFUW (2014a): Winter, R.; Biokraftstoffe im Verkehrssektor 2014 – Daten zu Biokraftstoffen in Österreich für das Berichtsjahr 2013, BMFLUW, Wien 2014. http://www.lebensministerium.at/umwelt/luft-laerm-verkehr/biokraftstoffbericht.html

BMLFUW (2014b): Pötscher, F./Lichtblau, G.; CO_2-Monitoring Pkw 2014. Zusammenfassung der Daten der Neuzulassungen von Pkw der Republik Österreich gemäß Entscheidung Nr. 1753/2000/EG für das Berichtsjahr 2013. Wien, 2014. http://www.bmlfuw.gv.at/publikationen/umwelt/laerm_verkehr_mobilitaet/CO2Monitoring2014.html

DIPPOLD, M. / REXEIS, M. / HAUSBERGER, S. (2012): NEMO – A Universal and Flexible Model for Assessment of Emissions on Road Networks. 19th International Conference „Transport and Air Pollution“, 26. – 27.11.2012, Thessaloniki.

HAUSBERGER, S. & KELLER, M. et al. (1998): Handbuch der Emissionsfaktoren des Straßenverkehrs in Österreich. Im Auftrag des Umweltbundesamtes; BMLFUW und BMVIT. Wien.

HAUSBERGER, S. (1997): GLOBEMI – Globale Modellbildung für Emissions- und Verbrauchsszenarien im Verkehrssektor; Institute for Internal Combustion and Thermodynamics. University of Technology Graz; Volume 71; Graz.

HAUSBERGER, S. (2005): Scenarios for the Transport Sector in Austria 1990 to 2020. Report No. FVT-68/05/ Haus Em 24/04-6790. Forschungsinstitut für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz.

HAUSBERGER, S. / SCHWINGSHACKL, M. / REXEIS, M. (2014): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2012. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2014.

HAUSBERGER, S. / SCHWINGSHACKL, M. / REXEIS, M. (2015a): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2013. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

HAUSBERGER, S. / SCHWINGSHACKL, M. / REXEIS, M. (2015b): NEMO Methodenbericht im Rahmen des Projekts NEMO4U. Erstellt im Auftrag der Umweltbundesamt mbH. Graz 2015. Not yet published.

IEA - INTERNATIONAL ENERGY AGENCY (2012): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2012). Submission 2012. Statistik Austria, Wien.

KALIVODA, M./KUDRNA, M. (2002): Air Traffic Emission Calculation for Austria 1990–2000, study commissioned by Umweltbundesamt GmbH, Perchtoldsdorf, 2002. Study has not been published, but can be made available upon request.

KALIVODA, M./KUDRNA, M (1997): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium, Perchtoldsdorf/Vienna, 1997.

MOLITOR, R., S. HAUSBERGER, G. BENKE et al. (2004) Abschätzung der Auswirkungen des Tanktourismus auf den Kraftstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich, Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Trafico, Wien 2004.

MOLITOR, R., S. SCHÖNFELDER, S. HAUSBERGER, G. BENKE et al. (2009) Abschätzung der Auswirkungen des Kraftstoffexports im Tank auf den Kraftstoffabsatz und die Entwicklung der CO_2- und Luftschadstoffemissionen in Österreich - Aktualisierung 2007 und Prognose 2030. Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und Bundesministerium für Verkehr, Innovation und Technologie. Wien 2009. Study has not been published, but can be made available upon request.

PISCHINGER, R. (2000): Emissionen des Off-Road-Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz. Unveröffentlicht.

REXEIS, M. ET AL. (2013): Emissionen aus Kalt- und Kühlstarts sowie aus AdBlue-Verwendung in SCR-Katalysatoren von Lkw, LNF, 2-Rädern sowie von mobilen Maschinen. Erstellt im Auftrag des Umweltbundesamtes GmbH. Graz, 2013.

STATISTIK AUSTRIA (2008, 2009, 2010, 2011, 2012, 2013, 2014): Flight movements per aircraft type and airport (national and international) - nonstandard analysis (not published). Statistik Austria. Wien.

STATISTIK AUSTRIA (2014a): Austrian Transport Statistics 2013. Statistik Austria 2014. Wien. http://www.statistik.at/web_de/dynamic/services/publikationen/14/publdetail?id=14&listid=14&detail=695

STATSTIK AUSTRIA (2014b): Binnenschifffahrtsstatistik. Wien. http://www.statistik.at/web_de/statistiken/verkehr/binnenschifffahrt/index.html.

UMWELTBUNDESAMT (2006b): Salchenegger, S.: Biokraftstoffe im Verkehrssektor in Österreich 2006, Zusammenfassung der Daten der Republik Österreich gemäß Art. 4, Abs. 1 der Richtlinie 2003/30/EG für das Berichtsjahr 2005. Reports, Bd. REP-0068. Umweltbundesamt, Wien.

Fugitives

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2008): Die österreichischen Bergbauproduktion 2008, Wien 2008.

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2010): Österreichisches Montan-Handbuch 2010. Bergbau - Rohstoffe – Grundstoffe – Energie, Wien 2010.

BMWFJ –BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2011): Österreichisches Montan-Handbuch 2011. Bergbau - Rohstoffe – Grundstoffe – Energie, Wien 2011.

BMWFJ –.BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2012): Österreichisches Montan-Handbuch 2012. Bergbau - Rohstoffe – Grundstoffe – Energie, Wien 2012.

BMWFJ –.BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ARBEIT (2013): Österreichisches Montan-Handbuch 2013. Bergbau - Rohstoffe – Grundstoffe – Energie, Wien 2013.

E-CONTROL (2013): **http://www.e-control.at/de/statistik/gas/marktstatistik** . accessed October 2013

FVGW – FACHVERBAND DER GAS- UND WÄRMEVERSORGUNGSUNTERNEHMUNGEN (2013): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2013 – Auswertung Rohrleitungsnetz GAS in Österreich für die Jahre 2002 bis 2012 (personal communication; Email 21.10.2013).

FVMI – FACHVERBAND DER MINERALÖLINDUSTRIE (2013): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2013 – Emissionen der Mineralölkette (personal communication; Email 26.11.2013).

FVMI – FACHVERBAND DER MINERALÖLINDUSTRIE (1999-2012): Jahresberichte des Fachverbandes der Mineralölindustrie Österreichs. Jeweilige Jahresberichte für die Jahre 1999 bis 2012. Wien. **https://www.wko.at/Content.Node/branchen/oe/Mineraloelindustrie/Jahresberichte.html**

INTERNATIONAL ASSOCIATION OF OIL & GAS PRODUCERS (2011): Petroleum industry guidelines for reporting greenhouse gas emissions, 2nd Edition, OGP Report Number 446, International Association of Oil & Gas Producers.

THE OIL INDUSTRY INTERNATIONAL EXPLORATION AND PRODUCTION FORUM (1994): Methods for estimating atmospheric emissions from E&P operations, Report No. 2.59/197, London 1994. **http://www.ogp.org.uk/pubs/197.pdf**

WARTHA, C. (2005): Life Cycle Inventory Austria 2000 - Review, Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2005.

WARTHA, C. (2011): Life Cycle Inventory „Erdgasbereitstellung Austria – Update 2010", Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2011.

WKO - WIRTSCHAFTSKAMMER ÖSTERREICH (2005): Bergbau-Stahl Jahresbericht, Fachverband der Bergwerke und Eisen erzeugenden Industrie, Wien 2005.

WKO - WIRTSCHAFTSKAMMER ÖSTERREICH (2006): Bergbau-Stahl Jahresbericht, Fachverband Bergbau-Stahl, Wien 2006.

WKO - WIRTSCHAFTSKAMMER ÖSTERREICH (2007): Bergbau-Stahl Jahresbericht, Fachverband Bergbau-Stahl, Wien 2007

Industry

BARBER, M.A.; (1996): (Alcan International Limited) Alcans's P-FKW Emission Reduction Program. A Case Study, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

BIERMAYR, P. et al. (2013): Innovative Energietechnologien in Österreich. Marktentwicklung 2012. Bundesministerium für Verkehr, Wirtschaft und Technologie, Wien.

BRITISH GEOLOGICAL SURVEY (2001): World Mineral Statistics 1995–1999. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2005): World mineral production 1999–2003. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2006): World mineral production 2000–2004. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2007): World mineral production 2001–2005. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2008): World mineral production 2002–2006. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2009): World mineral production 2003–2007. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2010): World mineral production 2004–2008. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2011): World mineral production 2005–2009. Keyworth, Nottingham: British Geological Survey.

BRITISH GEOLOGICAL SURVEY (2012): World mineral production 2006–2010. Keyworth, Nottingham: British Geological Survey. **http://www.bgs.ac.uk/mineralsuk/statistics/worldStatistics.html**

ECOFYS, FRAUNHOFER INSTITUTE FOR SYSTEMS AND INNOVATION RESEARCH, ÖKO-INSTITUT (Eds.) (2009): Methodology for the free allocation of emission allowances in the EU ETS post 2012 - Sector report for the chemical industry. By order of the European Commission. Study Contract: 07.0307/2008/515770/ETU/C2. Ecofys project Number: PECSNL082164. **http://www.ecofys.com/files/files/091102_chemicals.pdf**

ENTEC UK LIMITED (2006): European Commission, Support for the Development and Adoption of Monitoring and Reporting Guidelines as Harmonized Benchmarks for N2O activities for unilateral inclusion in the EU ETS for 2008-12, final report.

EUROPEAN COMMISSION (2007): Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers. BAT Reference Document LVIC-AAF August 2007. Brussels. **http://eippcb.jrc.es/reference/BREF/lvic_aaf.pdf**

GIBBS, M. (ICF Inc.) & JACOBS, C. (US EPA) (1996): Reducing P-FKW Emissions from Primary Aluminium Production in the USA, from: Light Metal Age, February 1996.

HACKL, A. & MAUSCHITZ, G. (1995, 1997, 2001, 2003, 2007): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

HARNISCH, J. & SCHWARZ, W. (2003): Final Report on the Costs and the impact on emissions of potential regulatory framework for reducing emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. European Commission (DG ENV).

HIEBLER, M.; GAMSJÄGER, H. & GOD, C.: Vergleich von metallurgisch und thermisch bedingten CO_2 Emissionen. Montanuniversität Leoben.

INTERNATIONAL IRON AND STEEL INSTITUTE (IISI)(2004): Steel statistical yearbook 2004. Brussels.

LEISEWITZ, A. & SCHWARZ, W. (2010): Assessment of the Consumption and the Real Emissions of Fluorinated Greenhouse Gases in Austria 2000-2008. Ökorecherche, Frankfurt am Main.

LEISEWITZ, A. (2012): Überprüfung von Vereinfachungsmöglichkeiten bei der Datenerhebung und - berechnung für die österreichische F-Gas-Berichterstattung im Bereich der stationären Kälte und Klimatisierung im Anschluss an den Bericht von Ökorecherche 2010. Ökorecherche, Frankfurt am Main.

MAUSCHITZ, G. (2004): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2008): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2009): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien. http://www.zement.at/downloads/emissionen_2004_2009.pdf

MAUSCHITZ, G. (2010): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2009. TU Wien. http://www.zement.at/downloads/emissionen_2010.pdf

MAUSCHITZ, G. (2011): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2010. TU Wien. http://www.zement.at/downloads/emissionen_2010.pdf

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2011. TU Wien. http://www.zement.at/downloads/emissionen_2011.pdf

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2012. TU Wien. http://www.zement.at/downloads/emissionen_2012.pdf

OBERNOSTERER, R.; SMUTNY, R. & JÄGER, E. (2004): HFKW Gase in Dämmschäumen des Bauwesens. Umweltbundesamt, Internal Report. Study has not been published, but can be made available upon request.

SCHWARZ, W. & GSCHREY, B. (2009): Service contract to assess the feasibility of options to reduce emissions of SF6 from the EU non-ferrous metal industry and analyse their potential impacts. Prepared for European Commission, DG Environment. Final Report, Frankfurt am Main

SCHWARZ, W. (2004): Emissionen, Aktivitätsraten und Emissionsfaktoren von fluorierten Treibhausgasen (F-Gasen) in Deutschland für die Jahre 1995-2002. Anpassung an die Erfordernisse der internationalen Berichterstattung und Implementierung der Daten in das Zentrale System Emissionen (ZES), Umweltbundesamt, Dessau.

SJARDIN, M. (2003): CO_2 emission factors for non-energy use in the non-ferrous metal, ferroalloys and inorganics industry. Copernicus Institute, Department of Science, Technology and Society, University of Utrecht.

STATISTIK AUSTRIA: National statistics. Wien.
- Statistisches Jahrbuch Österreich 1992–2012;
- Industrie und Gewerbestatistik (1. Teil) 1990–1995;
- Konjunkturerhebung im Produzierenden Bereich (Band 3) 1997–2012;
- Außenhandelsstatistik 1996–2012.

TABERAUX, A. (1996): Relationship between Operating Parameters and Emissions, Lecture at the U.S. EPA Workshop on P-FKW's, Washington DC, May 8th–9th 1996.

UMWELTBUNDESAMT (2001b): Bichler, B.; Werenskiold, W. & Unterberger, S.: Abschätzung der tatsächlichen und potentiellen treibhauswirksamen Emissionen von H-FKW, P-FKW und SF_6 für Österreich. Internal Report. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2001f): WIESENBERGER, W.: State-of-the-art for the Production of Nitric Acid with Regard to the IPPC Directive. Monographien, Band 150. Wien. http://www.umweltbundesamt.at/fileadmin/site/publikationen/M150.pdf

WASNER, J. (2009): Einfluss einer Carbokalkdüngung bei kalkhältigen Böden auf das Ertragsverhalten sowie auf ausgewählte bodenchemische und -physikalische Parameter. PhD Thesis, Universität für Bodenkultur, Wien.

WINDSPERGER, A. & HINTERMEIER, G. (2002): Entschwefelungstechnologien – Die Situation in Österreich. Eine Studie im Auftrag des Umweltbundesamt.

WINDSPERGER, A. & TURI, K. (1997): Emissionserhebung der Industrie für 1993 und 1994. Technische Universität Wien, Forschungsinstitut für Chemie und Umwelt, Wien.

Other Product Use

BARNERT, H. (1998): Österreichisches Lackinstitut: Möglichkeiten und Grenzen umweltverträglicher Beschichtung (Lacke, Klebstoffe, Bautenschutzmittel, Holzschutzmittel), Wien.

EUROSTAT (2008): Structural business statistics (NACE Rev.1.1) – online statistics. Luxembourg. **http://epp.eurostat.ec.europa.eu**

GOOD PRACTICE GUIDANCE FOR CLRTAP EMISSION INVENTORIES – Draft chapter for the UNECE Corinair Guidebook on Emissions inventories, Tino Pulles, Jon van Aardenne, European Topic centre on air and climate change (ETC/ACC), November 2001.

ÖIGV – Österreichischer Industriegaseverband (2013): N_2O use in medical and industrial field (personal communication), Schwechat.

RAMIREZ, A.; DE KEIZER, C.; & VAN DER SLUIJS, J. P. (2006): Monte Carlo Analysis of Uncertainties in the Netherlands Greenhouse Gas Emission Inventory for 1990–2004. Report NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht.

SCHMIDT, A.; VITOVEC, W.; PUXBAUM, H. & KNIERIDER, R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien.

STATISTIK AUSTRIA: Statistisches Jahrbuch Österreich 1992–2011;
- Industrie und Gewerbestatistik (1. Teil) 1990–1995; 2000 - 2007
- Konjunkturerhebung im Produzierenden Bereich (Band 2 bzw. 3) 1997–2011;
- Der Außenhandel Österreichs 1. bis 4. Vierteljahr 1980–2011, Spezialhandel nach Waren und Ländern. Statistik Austria, Wien.

WINDSPERGER, S. & SCHMIDT-STEJSKAL, H. (2008): Austria's Emission Inventroy from solvent use 2009. Institut für Industrielle Ökologie (IIÖ). Studie im Auftrag des Umweltbundesamt. Wien. Study has not been published, but can be made available upon request.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt. Wien.

Agriculture

Emission estimation for *4.A*, *4.B* and *4.D* were carried out by scientific institutes, results were provided as in the following studies:

AMON, B.; HOPFNER- SIXT, K. & AMON, T. (2002): Emission Inventory for the Agricultural Sector in Austria – Manure Management, Institute of Agricultural, Environmental and Energy Engineering (BOKU – University of Agriculture, Vienna), July 2002.

AMON, B. & HÖRTENHUBER, S. (2010): Revision of Austria's National Greenhouse Gas Inventory, Sector Agriculture. Final Report. Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU), study on behalf of Umweltbundesamt GmbH. Wien. (unpublished)

AMON, B. & HÖRTENHUBER, S. (2014): Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien 2014 (unveröffentlicht).

GEBETSROITHER, E.; STREBL, F. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; Report ARC-S-0175, ARC Seibersdorf research, July 2002.

STREBL, F.; GEBETSROITHER, E. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Agricultural Soils in Austria; ARC Seibersdorf research, revised version, February 2003.

As these studies are not published, a detailed description of the applied methods is given in the NIR. In the following data sources used in the studies mentioned above are summarized.

AMON, B. & HÖRTENHUBER, S. (2008): Revision der österreichischen Luftschadstoff-Inventur (OLI) für NH_3, NMVOC und NO_x; Sektor 4, Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien. (unpublished)

AMON, B.; FRÖHLICH, M.; WEIßENSTEINER, R; ZABLATNIK, B. & AMON, T. (2007): Tierhaltung und Wirtschaftsdüngermanagement in Österreich. Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft, Wien.

AMON, B.; KRYVORUCHKO, V. & AMON, T. (2006): Influence of different levels of covering on greenhouse gas and ammonia emissions from slurry stores. International Congress Series (ICS) No 1293 "2nd International Conference on Greenhouse Gases and Animal Agriculture.

AMON, B.; KRYVORUCHKO, V.; FRÖHLICH, M.; AMON, T.; PÖLLINGER, A.; MÖSENBACHER, I. & HAUSLEITNER, A. (2007a). Ammonia and greenhouse gas emissions from a straw flow system for fattening pigs: Housing and manure storage. Livestock Science 112, 199–207.

AMON, B.; MOITZI, G.; SCHIMPL, M.; KRYVORUCHKO, V. & WAGNER-ALT, C. (2002a): Methane, Nitrous Oxide and Ammonia Emissions from Management of Liquid Manures. Final Report November 2002. Research project no. 1107, BMLF GZ 24.002/24-IIA1a/98 and extension GZ 24.002/33-IIA1a/00. On behalf of Federal Ministry of Agriculture, Forestry, Environment and Water Management, and Federal Ministry for Education, Science and Culture. Vienna.

AMON, B. et al. (2002, 2008 & 2010): not published final reports on the revision of Austria's Air Emissions Inventory, Sector Agriculture. Vienna.

AMON, B. (2010): expert judgement, personal communication. Vienna.

AMON, T. (2011): expert judgement, personal communication. Vienna.AUSTRIAN CHAMBER OF AGRICULTURE (2012): Statistical data of burning straw. Mag. Längauer (email), November 2012.

BMLFUW (2000–2013): Grüne Berichte 1999 bis 2013. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Grüner Bericht gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. **www.gruenerbericht.at**

BMLFUW (2002): Gewässerschutzbericht gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW (2007): Sonderrichtlinie des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW) für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft. Anlage I, Anhänge zum Agrarumweltprogramm und zur Tierschutzmaßnahme (ÖPUL 2007). **http://www.ama.at/Portal.Node/ama/public?gentics.rm=PCP&gentics.pm=gti_full&p.contentid=10008.47092&SRL_O4_20071126.pdf**

BMLFUW Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2000–2014): Grüner Bericht 1999, 2000, 2002, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Grüner Bericht gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. **www.gruenerbericht.at** .

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006): Richtlinien für die Sachgerechte Düngung. 6. Auflage. Fachbeirat für Bodenfruchtbarkeit und Bodenschutz, Wien.

BUNDESANSTALT FÜR AGRARWIRTSCHAFT (2013): Federal Institute of Agricultural Economics. Download from data pool. **http://www.awi.bmlfuw.gv.at**

DETZEL, A; VOGT, R; FEHRENBACH, H. et al. (2003): Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationalen Richtlinien. Institut für angewandte Ökologie (IFEU). Institute for Applied Ecology.

DLG (DEUTSCHE LANDWIRTSCHAFTS-GESELLSCHAFT) (1997): DLG-Futterwerttabelle für Wiederkäuer. 7. erweiterte und überarbeitete Auflage. DLG-Verlag, Frankfurt/Main, Germany.

E-CONTROL (2008): Ökostrombericht 2008. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Oktober 2008. Wien.

E-CONTROL (2010): Ökostrombericht 2010. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Juli 2009. Wien.

E-CONTROL (2011): Ökostrombericht 2011. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2011. Wien.

E-CONTROL (2013): Ökostrombericht 2013. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2013. Wien.

E-CONTROL (2013): Rohstoffbilanzen für 2011. Personal communication by DI Michael Sorger, 18.09.2013.

E-CONTROL (2014): **http://www.e-control.at/portal/page/portal/medienbibliothek/publikationen/dokumente/pdfs/Oekostrombericht2014_final.**pdf accessed October 2014

EDER, A., FEICHTINGER, F., STRAUSS, P. & BLÖSCHL G. (2013): Calculation of nitrogen leaching values for the annual greenhouse gas inventory of Austria – Evaluation of long term lysimeter time series. Federal Agency for Water Management, Institute for Land and Water Management Research, Petzen-kirchen,and Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria.

EDER, A., BLÖSCHL G., FEICHTINGER, F.; HERNDL, M., KLAMMLER, G.; HÖSCH, J., ERHART, E. & STRAUSS, P. (2014): Indirect nitrogen losses of managed soils contributing to greenhouse emissions of agricultural areas in Austria: results from lysimeter studies. Article in Nutr Cycl Agroecosyst. DOI 10.1007/s10705-015-9682-9. 2015.

EEA – European Environment Agency (1999): EMEP/CORINAIR Emission Inventory Guidebook – Second Edition, Prepared by the EMEP Task Force on Emission Inventories, Edited by Stephen Richardson Task Force Secretary. Technical Report No. 30. Copenhagen 1999.

EEA – European Environment Agency (2007): EMEP/CORINAIR Emission Inventory Guidebook – 2007, Technical report No 16/2007. Copenhagen.

EEA – European Environment Agency (2009): EMEP/EEA air pollutant emission inventory guidebook — 2009. Technical report No 6/2009. Copenhagen.

EAGER – European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V. (FNR, 2010): Leitfaden Biogas. Von der Gewinnung zur Nutzung. Herausgegeben von der Fachagentur Nachwachsende Rohstoffe mit Förderung des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz aufgrund eines Beschlusses des Deutschen Bundestages 5., vollständig überarbeitete Auflage, Gülzow, 2010.

FAO AGR. STATISTICAL SYSTEM (2001): FAO Agricultural Statistical System. **http://faostat.fao.org/site/339/default.aspx**

FNR (FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V.; 2006): Handreichung - Biogasgewinnung und –nutzung. 3. überarbeitete Auflage. Gülzow, Germany.

FRANKHAUSER, J. (2007): Personal Communication, Austrian Chamber of Agriculture, May. Vienna.

FREIBAUER, A. & KALTSCHMITT, M. (2001): Biogenic greenhouse gas emissions from agriculture in Europe. European Summary Report (Project Report Task 3) of the EU-Concerted Action FAIR3-CT96-1877 "Biogenic Emissions of Greenhouse Gases Caused by Arable and Animal Agriculture".

GRABNER, R.; KLATZER, R.; MEIER, W.; STEINWIDDER, A.; STÖGER, E. & TOIFL, G. (2004): Mutterkuh- und Ochsenhaltung 2003. Ergebnisse und Konsequenzen der Betriebszweigauswertung aus den Arbeitskreisen Mutterkuh und Ochsenhaltung [Husbandry of mother cows and bullocks 2003]. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien.

GRUBER, L. & STEINWIDDER, A. (1996): Einfluß der Fütterung auf die Stickstoff- und Phosphorausscheidung landwirtschaftlicher Nutztiere – Modellkalkulationen auf Basis einer Literaturübersicht in: Die Bodenkultur – Austrian Journal of Agricultural Research, 47. Band/Heft 4/Dezember 1996/ISBN 0006-5471, WUV-Universitätsverlag, Wien.

GRUBER, L.; PÖTSCH, E. M. (2006): Calculation of nitrogen excretion of dairy cows in Austria. Die Bodenkultur, 2006, Vol. 57, Heft 1–4, Vienna.

HADORN, R. & WENK, C. (1996): Effect of different sources of dietary fibre on nutrient and energy utilization in broilers. 2. Energy and N-balance as well as whole body composition. Archiv für Geflügelkunde.

HÄUSLER, J. (2009): Das Leistungspotenzial von Fleckviehmutterkühen – Versuchsergebnisse des LFZ Raumberg-Gumpenstein. Fachtag „Erfolgreiche Mutterkuhhaltung" Fachschule Warth.

HEIM, P. (2005): Fütterung von Kuh und Kalb. [Feeding of mother cow and calve]. Article in UFA-Revue 3/05, an agricultural journal of Switzerland.

KIRNER, L. & SCHNEEBERGER, W. (1999): Strukturanalyse der Betriebe mit der ÖPUL-Maßnahme "Verzicht auf bestimmte ertragssteigernde Betriebsmittel (Betrieb)". Der Förderungsdienst 47(6).

KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht, WUV Universitätsverlag, Wien.

KTBL (KURATORIUM FÜR TECHNIK UND BAUWESEN IN DER LANDWIRTSCHAFT; GERMAN ASSOCIATION FOR TECHNOLOGY AND STRUCTURES IN AGRICULTURE; 2005): Gasausbeute in Landwirtschaftlichen Biogasanlagen. KTBL-Heft 50. Darmstadt, Germany

LANDESBETRIEB LANDWIRTSCHAFT HESSEN (2013): Nährstoffgehalte pflanzlicher Produkte zum Nährstoffvergleich.**http://www.llh-hessen.de/pflanzenproduktion/duengung-boden/n-duengung/155-landwirtschaft/pflanzenproduktion/duengung-boden/567-naehrstoffgehalte-pflanzlicher-produkte-zum-naehrstoffvergleich.html** (accessed 4.6.2014)

LÖHR, L. (1990): Faustzahlen für den Landwirt.

MENZI, H.; RUETTIMANN, L. & REIDY, B. (2003): DYNAMO: A new calculation model for dynamic emission inventories for ammonia. Proc. International Symposium 'Gaseous and odour emissions from animal production facilities', Horsens, Denmark, June 1–4.

PHILIPPITSCH, R.; GRATH, J.; SCHIMON, W.; GMEINER, C.; DEUTSCH, K.; GRUBER, D.; TOMEK, H.; BONANI, M. & LASSNIG, M. (2001): Wassergüte in Österreich. Jahresbericht 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBl. Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.

PÖLLINGER, A. (2008): national expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution 1990-2008 carried out in June 2008. Vienna.

PÖTSCH, E.M.; GRUBER, L. & STEINWIDDER, A. (2005): Answers and comments on the additional questions, following the meeting in Bruxelles. Internal statement, HBLFA Raumberg-Gumpenstein.

REIDY, B. & MENZI, H. (2005): Ammoniakemissionen in der Schweiz: Neues Emissionsinventar 1990 bis 2000 mit Hochrechungen bis 2003 Technischer Schlussbericht Schweizerische Hochschule für Zollikofen.

REIDY, B.; DÄMMGEN, U.; DÖHLER, H.; EURICH-MENDEN, B.; EVERT, F. K. VAN; HUTCHINGS, N. J.; LUESINK, H. H.; MENZI, H.; MISSELBROOK, T. H.; MONTENY, G.J. & WEBB, J. (2008): Comparison of models used for national agricultural ammonia emission inventories in Europe : liquid manure systems. Atmospheric environment, Band 42, Heft 14, Seite 3452–3464, englisch. ISSN: 0004-6981.

REIDY, B.; RIHM, B. & MENZI, H. (2007): A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations, Reference: AEA7495, IN Journal: Atmospheric Environment.

REIDY, B.; WEBB, J.; MISSELBROOK, T.H.; MENZI, H.; LUESINK, H.H.; HUTCHINGS, N.J.; EURICH-MENDEN, B.; DÖHLER, H. & DÄMMGEN, U. (2009): Comparison of models used for national agricultural ammonia emission inventories in Europe: Litter-based manure systems. Atmospheric environment, Band 43, Heft 9, Seite 1632–1640, englisch. ISSN: 0004-6981

REIDY et al. (2008, 2009): Comparisons of models used for national agricultural ammonia emission inventories in Europe. Atmospheric Environment, Band 42 and Band 43.

RESCH, R., GUGGENBERGER, T., WIEDNER, G., KASAL, A., WURM, K., GRUBER, L., RINGDORFER, F. & BUCHGRABER, K. (2006): Futterwerttabellen im Jahr 2006 für das Grundfutter im Alpenraum. Available from Website **http://www.gumpenstein.at**

RWA (2006–2013): Expert judgements based on annual sales data of urea. Personal communication, Raiffeisen Ware Austria AG, Wien.

SBV – Swiss Farmers Union (2007): Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2006. Swiss Farmers Union, Brugg.

SCHÄFER, R. (2002): Neues Konzept zum Düngemitteleinsatz. In: VKS News 65. Ausgabe 08/2002.

SCHECHTNER (1991): Wirtschaftsdünger – Richtige Gewinnung und Anwendung, Sonderausgabe des Förderungsdienst 1991, BMLF, Wien.

STANZEL, W.; JUNGMEIER, G. & SPITZER, J. (1995): Emissionsfaktoren und energietechnische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research, Institut für Energieforschung.

STATISTIK AUSTRIA (2012): Allgemeine Viehzählung am 1. Dezember 2012. National livestock counting December 2012. Wien.

STATISTIK AUSTRIA: Statistisches Jahrbuch Österreich 1992–2002; Statistik Austria, Wien.

STATSTIK AUSTRIA (1990-2014): Agrarstrukturerhebungen 1990-2013. Schnellbericht. Statistik Austria. Wien 2014 **http://www.statistik.at/web_de/services/publikationen/8/index.html**

STEINWENDER, R. & GOLD, H. (1989): Produktionstechnik und Gebrauchskreuzungen in der Mutterkuhhaltung. Versuchsbericht. Agricultural Research Center for Alpine Regions, Gumpenstein.

STEINWIDDER, A. & GUGGENBERGER, T. (2003): Erhebungen zur Futteraufnahme und Nährstoffversorgung von Milchkühen sowie Nährstoffbilanzierung auf Grünlandbetrieben in Österreich. Die Bodenkultur 54 (1), 49–66.

STEINWIDDER, A; HÄUSLER, J.; SCHAUER, A.; MAIERHOFER, G.; GRUBER, L.; GASTEINER, J. & PODSTATZKY, L. (2006): Einfluss des Absetztermins auf die Milchleistung und Körpermasse von Mutterkühen sowie die Zuwachsleistung von Mutterkuh-Jungrindern. Versuchsbericht. Extensively managed beef cows – Effects on animal health, reproductive success, performance of calves and economics. Experiment 2004 to 2008. Interim report. Agricultural Research and Education Centre, HBLFA Raumberg-Gumpenstein.

UMWELTBUNDESAMT (1997): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998a): Götz, B.: Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Berichte, Bd. BE-087a, Umweltbundesamt, Wien, July 1998.

UMWELTBUNDESAMT (2011b): Query of data from the National Austrian Waste Water Database. Vienna 2011.

UMWELTBUNDESAMT (2013a): Data on sewage sludge application provided by the provincial governments. Vienna 2013.

UMWELTBUNDESAMT (2014c): Stakeholder Workshop on the revision of the agricultural model according to the IPCC 2006 GL.16th September 2014. Vienna

UMWELTBUNDESAMT (2015a): Haider, S.; Anderl, M.; Lampert, C.; Moosmann, L.; Pazdernik, K.; Perl, D.; Pinterits, M.; Poupa, S.; Purzner, M.; Schodl, B.; Stranner, G.; Wieser, M. & Zechmeister, A.: Austria's Informative Inventory Report 2015. Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Reports, Bd. REP-0505 Umweltbundesamt, Wien.

UNTERARBEITSGRUPPE N-ADHOC (2004): Überprüfung und Überarbeitung der N-Anfallswerte für einzelne Tierkategorien. Unterlagen ausgearbeitet vom Fachbeirat für Bodenfruchtbarkeit und Bodenschutz des BMLFUW.

ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Jahrbuch 2004. Data query 2007. **http://www.zamg.ac.at/fix/klima/jb2004/Web/index.html**

ZENTRALE ARBEITSGEMEINSCHAFT ÖSTERREICHISCHER RINDERZÜCHTER (2004): Cattle Breeding in Austria, 148 pp.

ZESSNER, M. (1999): Bedeutung und Steuerung von Nährstoff- und Schwermetallflüssen des Abwassers. Wiener Mitteilung Band 157. Wien, 1999.

LULUCF

AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG 1996: Bodenzustandsinventur Burgenland. Amt der Burgenländischen Landesregierung, Eisenstadt.

AMT DER KÄRNTNER LANDESREGIERUNG 1999: Kärntner Bodenzustandsinventur. Amt der Kärntner Landesregierung, Klagenfurt.

AMT DER NIEDERÖSTERREICHISCHEN LANDESREGIERUNG 1994: Bodenzustandsinventur Niederösterreich. Amt der Niederösterreichischen Landesregierung, St. Pölten.

AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG 1993: Oberösterreichischer Bodenkataster – Bodenzustandsinventur 1993. Amt der Oberösterreichischen Landesregierung, Linz.

AMT DER SALZBURGER LANDESREGIERUNG 1993: Salzburger Bodenzustandsinventur. Amt der Salzburger Landesregierung, Salzburg.

AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 1988–1996: Steiermärkische Bodenschutzberichte 1988–1996. Amt der Steiermärkischen Landesregierung, Graz.

AMT DER TIROLER LANDESREGIERUNG 1988: Bericht über den Zustand der Tiroler Böden. Amt der Tiroler Landesregierung, Innsbruck.

AUSTRIAN STANDARD ÖNORM B 3012 (2003): Holzarten – Kennwerte zu den Benennungen und Kurzzeichen der ÖNORM EN 13556 (Wood species – Characteristic values to terms and symbols of ÖNORM EN 13556). Austrian Standard, Wien.

BEV - BUNDESAMT FÜR EICH- UND VERMESSUNGSWESEN (2014): Regional Information derived from the Austrian real estate database BEV – Austrian Federal Office of Metrology and Surveying, Wien.

BFW (1992): Österreichische Waldbodenzustandsinventur. Mitteilungen der Forstlichen Bundesversuchsanstalt Wien, Vol. 168/I, Vol. 168/II, Federal Office and Research Centre for Forests, Wien.

BFW (2005): ERHEBUNGSNETZ DER ÖSTERREICHISCHEN WALDINVENTUR. **http://www.bfw.ac.at/rz/bfwcms.web?dok=2384**

BFW (2009): BioSoil - das europäische Waldboden-Monitoring. In: BFW-Praxisinformation Nr. 20 p. 13-15. Federal Office and Research Centre for Forests, Wien.

BFW (2011): Waldinventurergebnisse der Perioden 1992/96, 2000/02, 2007/09. Federal Office and Research Centre for Forests, Wien. **http://bfw.ac.at/rz/wi.home**

BFW (2011a pers. comm.): Annual growth indices. Personal communication, Federal Office and Research Centre for Forests, Wien.

BFW (2011b pers. comm.): Figures on needle, branch and root biomasses for the Austrian forests for the individual NFI periods. Personal communication, Federal Office and Research Centre for Forests, Wien.

BGBL. Nr. 440/1975: Forest Act of the Republic of Austria. Federal Ministry of Agriculture, Forestry, Environment and Water Management – Vienna/Austria.

BITTERMANN, W. & GERHOLD, S. (1995): Wirtschaftliche Aspekte und Holzbilanz. In: Östereichisches Statistisches Zentralamt, Forstliche Bundesversuchsanstalt (eds.): Ökobilanz Wald. Statistik Austria, Wien, 99–110.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006c): Richtlinien für die Sachgerechte Düngung. 6. Auflage. Fachbeirat für Bodenfruchtbarkeit und Bodenschutz, Wien.

BMLFUW (1964–2011): Österreichische Waldberichte; Jahresberichte über die Forstwirtschaft. Edited annually by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW (1985-2011): Grüner Bericht. Bericht über die Lage der österreichischen Land- und Forstwirtschaft. Wien. Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BMLFUW (2000): Empfehlungen für die sachgerechte Düngung von Christbaumkulturen. Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.

BORIS – Bodeninformationssystem des Umweltbundesamtes: **http://www.borisdaten.at**

DÖRFLINGER, A.; HIETZ, P.; MAIER, R.; PUNZ, W.; FUSSENEGGER, K. (1995): Ökosystem Großstadt Wien – Quantifizierung ökologischer Parameter unter besonderer Berücksichtigung der Vegetation; Bundesministerium für Wissenschaft und Forschung und MA 22.

ECKMÜLLNER, O. (2006): Allometric relations to estimate needle and branch mass of Norway spruce and Scots pine in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions. 123. Jg., Heft 1/2, 7–16.

FINNISH ENVIRONMENT INSTITUTE (2011): Soil Carbon Model Yasso. Finnish Environment Institute, Helsinki, **http://www.ymparisto.fi/default.asp?contentid=250208&lan=en&clan=en**

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2003). Quantification of carbon pools in agriculturally used soils of Austria by use of a soil information system as basis for the Austrian carbon balance model. OECD Expert Meeting: Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analyses., C. A. S. Smith (ed., 14–18 October 2002, Ottawa, Canada, Agriculture and Agri-Food Canada, Ottawa, CA & Organisation of Economic Co-operation and Development, Paris, FR.

GERZABEK, M. H.; STREBL, F.; TULIPAN, M. & SCHWARZ, S. (2005). Quantification of organic carbon pools for Austria's agricultural soils using a soil information system. Can. J. Soil Sci. 85: 491–498.

GSCHWANTNER, TH. & SCHADAUER, K. (2006): Branch biomass functions for broadleaved tree species in Austria. Austrian Journal on Forest Science, Special Issue on Austrian Biomass Functions, 123 Jg.; Heft 1/2, 17–34.

GSCHWANTNER, TH., GABLER, K., SCHADAUER, K. & WEISS, P. (2010): National Forest Inventory Reports, Chapter 1: Austria. In: TOMPPO, E.; GSCHWANTNER, TH.; LAWRENCE, M. & MCROBERTS, R.E. (Eds.): National Forest Inventories: pathways for common reporting. Springer, Heidelberg, Dordrecht, London, New York, 57–71.

HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K. & RUNNING, S.W. (1999a): Forest growth response to changing climate between 1961 and 1990. Forest Ecology and Management 122: 209–219.

HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K. & RUNNING, S.W. (1999b): Climate variations and tree growth between 1961 and 1995 in Austria. In: Karjalainen, T.; Spiecker, H. & Laroussini, O. (eds.): Causes and consequences of accelerating tree growth in Europe. European Forest Institute Joensuu, Proceedings No. 27: 75–86.

HAUK, E. & SCHADAUER, K. (2009): Instruktionen für die Feldarbeit der Österreichischen Waldinventur 2007–2009. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at:, **http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf**

HOCHBICHLER, E.; BELLOS, P. & LICK, E. (2006): Biomass functions and expansion factors for spruce, pine, beech and oak in Austria. Austrian Journal on Forest Science, Special Issue on Austrian biomassfunctions. 123. Jg., Heft 1/2, 35–46.

IPCC (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry. Edited by J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner.

JÄGER, F. (2003): Forstrecht. 3rd Edition, Verlag Österreich, Wien.

KÖRNER, C.; SCHILCHER, B. & PELAEZ-RIEDL, S. (1993): Bestandsaufsaufnahme anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – Mögliche Maßnahmen. Dokumentation, Kapitel 6.1. Österreichische Akademie der Wissenschaften. Wien.

KORTELAINEN, P.; PAJUNEN, H.; RANTAKARI, M. & SAARNISTO, M. (2004): A large carbon pool and small sink in boreal Holocene lake sediments. Global Change Biology 10/10, 1648–1653.

LEDERMANN, T. & NEUMANN, M. (2006): Biomass equations from data of old long-term experimental plots. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 47–64.

NESTROY, O.; DANNEBERG, O. H. & ENGLISCH, M. (2000): Systematische Gliederung der Böden Österreichs (Österreichische Bodensystematik 2000). Mitt. d. Österr. Bodenkundl. Ges., H. 60, Wien 2000.

OFFENTHALER, I. & HOCHBICHLER, E. (2006): Estimation of root biomass for Austrian forest tree species. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 65–86.

ÖSTAT (Österreichisches Statistisches Zentralamt) (1991): Land- und Forstwirtschaftliche Betriebszählung 1990. Hauptergebnisse Österreich. Heft 1.060/12. Wien

ÖSTAT (Österreichisches Statistisches Zentralamt) (1994): Agrarstrukturerhebung 1993. Schnellbericht 1.17. Wien

ÖSTAT (Österreichisches Statistisches Zentralamt) (1998): Agrarstrukturerhebung 1997. Schnellbericht 1.17. Wien

RUBATSCHER, D.; MUNK, K.; STÖHR, D.; BAHN, M.; MADER-OBERHAMMER, M. & CERNUSCA, A. (2006): Biomass expansion functions for Larix decidua: a contribution to the estimation of forest carbon stocks. Austrian Journal on Forest Science, Special Issue on Austrian biomass functions. 123. Jg., Heft 1/2, 86–101.

RUSS, W. (2004): Mehr Wald – ein positiver Trend? BFW Praxis Information 3/2004, pp. 4-7, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, download at: **http://bfw.ac.at/700/pdf/BFW_praxis2004_kl.pdf**

SCHIELER, K. & HAUK, E. (2001): Instruktion für die Feldarbeit – Österreichische Waldinventur 2000/2002, Fassung 2001. Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna. Download at: **http://bfw.ac.at/700/pdf/da_ges_neu.pdf**

SCHIELER, K.; BÜCHSENMEISTER, R. & SCHADAUER, K. (1995): Österreichische Forstinventur – Ergebnisse 1986/90. Bericht 92, Federal Office and Research Centre for Forests, Wien.

SPLECHTNA, B. & GLATZEL, G. (2005): Optionen der Bereitstellung von Biomasse aus Wäldern und Energieholzplantagen für die energetische Nutzung. Berlin-Brandenburgische Akademie der Wissenschaften, Berlin, Materialien Nr. 1.

STATISTIK AUSTRIA (1960–2014): Statistik der Landwirtschaft. Statistik Austria, Wien.

STATISTIK AUSTRIA (2001): Agrarstrukturerhebung 1999. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2006): Agrarstrukturerhebung 2005. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2008): Agrarstrukturerhebung 2007. Schnellbericht 1.17. Wien.

STATISTIK AUSTRIA (2010): Weingartengrunderhebung 2009. Schnellbericht 1.19. Wien.

STATISTIK AUSTRIA (2013): Agrarstrukturerhebung 2010. Gesamtergebnisse. Wien.

STATISTIK AUSTRIA (2014): Agrarstrukturerhebung 2013. Schnellbericht 1.17. Wien.

STEINER, G., M. & REITER, K. (1992): Österreichischer Moorschutzkatalog-Datenbank. Styria Medien Service. Wien.

STREBL, F.; GEBETSROITHER, E. & ORTHOFER, R. (2003): Greenhouse Gas Emission from Cropland & Grassland Management in Austria. ARC-S-0221. Austrian Research Centre, Seibersdorf.

UMWELTBUNDESAMT (2000): Weiss, P.; Schieler, K.; Schadauer, K.; Radunsky, K. & Englisch, M.: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Monographien, Bd. M-106, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004b): Pilot study on statistics on waste management in agriculture, forestry and fishing – Agriwaste. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010a): Anderl, M.; Freudenschuß, A.; Friedrich, A.; Köther, T.; Kriech, M.; Kuschel, V.; Muik, B.; Pazdernik, K.; Poupa, S.; Schodl, B.; Stranner, G.; Schwaiger, E.; Seuss, K.; Weiss, P.; Wieser, M. & Zethner, G.: Austria's National Inventory Report 2010. Reports, Bd. REP-0265. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2010b): Freudenschuß, A.; Sedy, K.; Spiegel, H. et al.: Arbeiten zur Evaluierung von ÖPUL-Maßnahmen hinsichtlich ihrer Klimawirksamkeit. REP-290. Umweltbundeamt, Wien. **http://www.umweltbundesamt.at/aktuell/publikationen/publikationssuche/publikationsdetail/?&pub_id=1875**

UMWELTBUNDESAMT (2014a): Anderl, M.; Freudenschuß, A.; Haider, S.; Jobstmann, H.; Kohlbach, M.; Köther, T.; Kriech, M.; Lampert, Ch.; Moosmann, L.; Pazdernik, K.; Pinterits, M.; Poupa, S.; Schmid, C.; Stranner, G.; Schwaiger, E.; Schwarzl, B.; Weiss, P.; Zechmeister, A.: Austria's National Inventory Report 2014 – Submission under the United Nations Framework Convention of Climate Change and the Kyoto Protocol. Report REP-475; Umweltbundesamt, Vienna

UN-FCCC (2011): Report of the technical assessment of the forest management reference level submission of Austria submitted in 2011. **http://unfccc.int/resource/docs/2011/tar/aut01.pdf**

UN-FCCC (2012): Decision 2/CMP.7 Land use, land use change and forestry, The seventh session of the Conference of the Parties serving as the meeting of the Parities to the Kyoto Protocol, 2011 in Durban, South Africa. **http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf**

WEST, T.O. (2008): Country-level estimates for Carbon distribution in U.S. croplands, 1990–2005. Environmental Science Division, Oak Ridge National Laboratory. **http://cdiac.ornl.gov/carbonmanagement/cropcarbon/**

WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports – Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5–74.

WINKLER, N. (2003): Walderschließung Österreichs im Detail. Federal Office and Research Centre for Forests, Wien, **http://bfw.ac.at/700/2109.html**

WIRTH, C.; SCHUMACHER, J. & SCHULZE, E.D. (2004): Generic biomass functions for Norway spruce in Central Europe – a meta-analysis approach toward prediction and uncertainty estimation. Tree Physiology 24, 121–139.

Waste

AMLINGER (2003): information from Dipl.Ing. Florian Amlinger – Compost Consulting & Development, Hochbergstrasse A-2380 Perchtoldsdorf.

AMLINGER, F.; PEYR, S.; HILDEBRANDT, U.; MÜSKEN, J.; CUHLS, C. & CLEMENS, J. (2005): Stand der Technik der Kompostierung. Grundlagenstudie. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. **http://www.umweltnet.at/article/articleview/30919/1/6954**

ANGERER, T. & FRÖHLICH, M. (2002): Thermisch Regenerative Oxidation als Verfahren der Abluftreinigung bei mechanisch-biologischen Anlagen zur Behandlung von Abfällen. Schriftenreihe des BMLFUW. Study is not published but can be made available to the ERT upon request.

ANGERER, T. (1997): Stand der Mechanisch-Biologischen Restabfallbehandlung vor der Deponierung (MBRVD) in Österreich – November 1997 – MUL Leoben.

BAUMELER, A.; BRUNNER, P. H.; FEHRINGER, R.; KISLIAKOVA, A. & SCHACHERMAYER, E. (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft (CH_4). Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1993, 1996, 1999, 2002): Gewässerschutzberichte gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2001): Bundesabfallbericht 2001, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006a): Bundes-Abfallwirtschaftsplan 2006 (BAWP 2006), Wien.
Latest annual update (specific chapters): Statusbericht 2009:
www.bundesabfallwirtschaftsplan.at

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006b): Kommunale Abwasserrichtlinie der EU – 91/271 EWG, Österreichischer Bericht 2006. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2008. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2009): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2009 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2010. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011a): Bundes-Abfallwirtschaftsplan 2011 (BAWP 2011). Wien.
http://www.bundesabfallwirtschaftsplan.at/

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Fragebogen 2011 der Europäischen Kommission – Überprüfung des Umsetzungsstandes in Österreich. Wien
http://www.lebensministerium.at/publikationen/wasser/abwasser/05012011.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2012): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2012. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014): Stork, C.; Windhofer, G. & Zieritz, I.: Kommunales Abwasser: Österreichischer Bericht 2014. Kombinierter Bericht gemäß Artikel 15 und Artikel 16 der Richtlinie 91/271/EWG für den Zeitraum 2011 – 2012. Wien, Juni 2014.
http://www.bmlfuw.gv.at/wasser/wasserqualitaet/abwasserreinigung/Lagebericht2014.html.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015a): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2014. Wien, Februar 2015. **http://www.bundesabfallwirtschaftsplan.at/dms/bawp/Statusbericht_2018/Statusbericht_2014.pdf**

BMLFUW – Federal Ministry of Agriculture and Forestry, Environment and Water Management (2015b): Parravicini, V.; Valkova, T.; Haslinger, J.; Saracevic, E.; Winkelbauer, A.; Tauber, J.; Svardal, K.; Hohenblum, P.; Clara, M.; Windhofer, G.; Pazdernik, K. & Lampert, C.: ReLaKO – Reduktionspotential bei den Lachgasemissionen aus Kläranlagen durch Optimierung des Betriebes. Institut für Wassergüte, Ressourcenmanagement und Abfallwirtschaft der TU Wien & Umweltbundesamt GmbH. Wien. **http://www.bmlfuw.gv.at/publikationen/wasser/abwasser/Lachgasemissionen---Kl-ranlagen.html**

BMUJF – Federal Ministry of Environment,Youth and Family Affairs (1995): Bundesabfallbericht 1995. Bundesministerium für Umwelt, Jugend und Familie, Wien.

DOEDENS, H.; CUHLS, C.; MÖNKEBERG, F.; LEVSEN, K.; KRUPPA, J.; SÄNGER, U. & KOCK, H. (1999): Bilanzierung von Umweltchemikalien bei der biologischen Vorbehandlung von Restabfällen, Phase 2: Emissionen, Schadstoffbilanzen und Abluftbehandlung. BMB+F Verbundvorhaben: Mechanisch-biologische Vorbehandlung von zu deponierenden Abfällen.

DOMENIG, M. (2004): information from Mag. Manfred Domenig, expert for waste management at the Umweltbundesamt Klagenfurt.

ENVIRONMENTAL SCIENCE & TECHNOLOGY (2011): Diaz-Valbuena, L.; Leverenz, H.L.; Cappa, C.D.; Tchobanoglous, G.; Horwath, W.R., and Darby, J.L.; Methane, carbon dioxide, and nitrous oxide emissions from septic tank systems. Department of Civil and Environmental Engineering, Department of Land, Air, and Water Resources, University of California.

GILBERG, U. et al. (2005): Waste management in Europe and the Landfill Directive, Background paper from the ETC/RWM to the ETC/ACC workshop „Inventories and Projections of Greenhouse Gas Emissions from Waste"; European Environment Agency.

HACKL, A. & MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.

KAUSEL, A. (1998): Ein halbes Jahrhundert des Erfolges, Der ökonomische Aufstieg Österreichs im OECD-Raum seit 1950. Österreichische Nationalbank, Wien.

LAHL, U.; ZESCHMAR-LAHL, B. & ANGERER, T. (2000): Entwicklungspotentiale der mechanisch-biologischen Abfallbehandlung. Eine ökologische Analyse. Wien.

LAHL, U.; ZESCHMAR-LAHL, B. & SCHEIDL, K. (1998): Abluftemissionen aus der mechanisch-biologischen Abfallbehandlung in Österreich. Klagenfurt.

ORTHOFER, R., H.M. KNOFLACHER, J. ZÜGER (1995): N_2O-Emissionen in Österreich. Seibersdorf Research Report OEFZS-A-3256, Seibersdorf.

STATISTIK AUSTRIA (2013): Statistik des Bevölkerungsstandes; revidierte Ergebnisse von 2007 bis 2011. Erstellt am 15.07.2013. **http://www.statistik.at/web_de/statistiken/bevoelkerung/bevoelkerungsstand_und_veraenderung/bevoelkerung_im_jahresdurchschnitt/index.html**

STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J. & WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemissionen. Report des Joanneum Research: Institut für Umweltgeologie und Ökosystemforschung.

UBA BERLIN (1999): MBA Bericht: Ökologische Vertretbarkeit mechanisch-biologischer Vorbehandlung von Restabfällen.

UMWELTBUNDESAMT (1995): Boos, R.; Neubacher, F.; Reiter, B.; Schindlbauer, H. & Twrdik, F.: Zusammensetzung und Behandlung von Altölen in Österreich. Monographien, Bd. M-054. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlammes in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999. Interne Berichte, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001c): Häusler, G.: Emissionen aus Abfalldeponien 1980–1998, Interner Bericht, Bd. IB-623. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001d): Perz, K.: Materialien zum Bundesabfallwirtschaftsplan 2001, Monographien, Bd. M-138, Umweltbundesamt, Klagenfurt.

UMWELTBUNDESAMT (2001e): Grech, H. & Rolland, C.: Stand der Abfallbehandlung in Österreich im Hinblick auf das Jahr 2004. Berichte, Bd. BE-182. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2003): Rolland, C. & Scheibengraf, M.: Biologisch abbaubarer Kohlenstoff im Restmüll. Berichte, Bd. BE-236. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004c): Rolland, C. & Oliva, J.: Erfassung von Deponiegas – Statusbericht von österreichischen Deponien. Berichte, Bd. BE-238. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2005): Schachermayer, E.: Vergleich und Evaluierung verschiedener Modelle zur Berechnung der Methanemissionen aus Deponien. Umweltbundesamt, Wien. Study has not been published, but can be made available upon request.

UMWELTBUNDESAMT (2006a): Neubauer, C. & Öhlinger, A.: Ist-Stand der mechanisch biologischen Abfallbehandlung (MBA) in Österreich, Zustandsbericht 2006. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007c): Lenz, K. & Kampel, E.: Nitrous Oxide emissions from industrial wastewater, Interne Studie, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008b): Query of data from the National Austrian Waste Water Database. Vienna.

UMWELTBUNDESAMT (2008c): Schachermayer, E. & Lampert, C.: Erfasste Deponiegasmengen auf Österreichischen Deponien – Zeitreihe für die Jahre 2002 bis 2007. Reports, Bd. REP-0100. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008d): Neubauer, C. & Walter, B.: Behandlung von gemischten Siedlungs- und Gewerbeabfällen in Österreich – Betrachtungszeitraum 2003–2008. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2014b): Lampert, C.: Stand der temporären Abdeckung von Deponien und Deponiegaserfassung. Report. REP-0484. Umweltbundesamt, Wien

WERF – WATER ENVIRONMENT RESEARCH FOUNDATION (2010): Leverenz, H.L.; Tchobanoglous, G.; Darby, J.L.: Evaluation of Greenhouse Gas Emissions from septic systems. University of California.

ZESSNER, M. & LINDTNER, S. (2005): Estimations of municipal point source pollution in the context of river basin management. Institute for Water Quality and Waste Management, Vienna University of Technology Published in Water Science & Technology. Vol. 52, No 9 pp 175-182. IWA Publishing 2005

ANNEX

ANNEX 1: KEY CATEGORY ANALYSIS 1

ANNEX 2: SECTOR 1.A FUEL COMBUSTION 6

Trend information by sub category 6

Activity Data Recalculations 27

Methodology 31

The National Energy Balance 31

Fuels and Fuel Categories 34

Energy Consumption and CO_2 Emissions by Sectors and Fuel Types 36

ANNEX 3: CO_2 REFERENCE APPROACH 45

ANNEX 4: NATIONAL ENERGY BALANCE 52

ANNEX 5: RECALCULATIONS 53

ANNEX 6: ADDITIONAL INFORMATION 54

Additional information on NISA 54

Additional information on the Inspection Body for Emission Inventories 58

ANNEX 7: UNCERTAINTY ASSESSMENT 63

ANNEX 8: CRF FOR 2013 64

ANNEX 9: CRF TABLES ART. 3.3 KP ACTIVITIES FOR 2013 65

ANNEX 1: KEY CATEGORY ANALYSIS

The present NIR does not contain a national key category analysis as usually performed by the Inspection Body, but refers to the results of the key category analysis created by the CRF Reporter (Table 7 Summary Overview for Key Categories). A detailed key category analysis following Tier 1 and Tier 2 will again be submitted 2016.

Table A 1: Key Categories according to CRF Table 7 (Inventory 2013)

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CH4				
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	N2O				
1.A.1 Fuel combustion - Energy Industries - Peat	CO2				
1.A.1 Fuel combustion - Energy Industries - Peat	CH4				
1.A.1 Fuel combustion - Energy Industries - Peat	N2O				
1.A.1 Fuel combustion - Energy Industries - Biomass	CH4				
1.A.1 Fuel combustion - Energy Industries - Biomass	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	CO2				

1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	N2O				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Biomass	CH4				
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Biomass	N2O				
1.A.3.a Domestic Aviation	CO2				
1.A.3.a Domestic Aviation	CH4				
1.A.3.a Domestic Aviation	N2O				
1.A.3.b Road Transportation	CO2	*X*	*X*	*X*	*X*
1.A.3.b Road Transportation	CH4				
1.A.3.b Road Transportation	N2O				
1.A.3.c Railways	CO2				
1.A.3.c Railways	CH4				
1.A.3.c Railways	N2O				
1.A.3.d Domestic Navigation - Liquid Fuels	CO2				
1.A.3.d Domestic Navigation - Liquid Fuels	CH4				
1.A.3.d Domestic Navigation - Liquid Fuels	N2O				
1.A.3.d Domestic Navigation - Gaseous Fuels	CO2				
1.A.3.d Domestic Navigation - Gaseous Fuels	CH4				
1.A.3.d Domestic Navigation - Gaseous Fuels	N2O				
1.A.3.d Domestic Navigation - Other Fossil Fuels	CO2				
1.A.3.d Domestic Navigation - Other Fossil Fuels	CH4				
1.A.3.d Domestic Navigation - Other Fossil Fuels	N2O				
1.A.3.d Domestic Navigation - Biomass Fuels	CH4				
1.A.3.d Domestic Navigation - Biomass Fuels	N2O				
1.A.3.e Other Transportation	CO2	*X*	*X*	*X*	*X*
1.A.3.e Other Transportation	CH4				
1.A.3.e Other Transportation	N2O				
1.A.4 Other Sectors - Liquid Fuels	CO2	*X*	*X*	*X*	*X*
1.A.4 Other Sectors - Liquid Fuels	CH4				
1.A.4 Other Sectors - Liquid Fuels	N2O				
1.A.4 Other Sectors - Solid Fuels	CO2		*X*	*X*	*X*
1.A.4 Other Sectors - Solid Fuels	CH4				
1.A.4 Other Sectors - Solid Fuels	N2O				
1.A.4 Other Sectors - Gaseous Fuels	CO2	*X*	*X*	*X*	*X*
1.A.4 Other Sectors - Gaseous Fuels	CH4				
1.A.4 Other Sectors - Gaseous Fuels	N2O				
1.A.4 Other Sectors - Other Fossil Fuels	CO2		*X*	*X*	*X*
1.A.4 Other Sectors - Other Fossil Fuels	CH4				
1.A.4 Other Sectors - Other Fossil Fuels	N2O				
1.A.4 Other Sectors - Peat	CO2				
1.A.4 Other Sectors - Peat	CH4				
1.A.4 Other Sectors - Peat	N2O				
1.A.4 Other Sectors - Biomass	CH4		*X*	*X*	*X*
1.A.4 Other Sectors - Biomass	N2O				
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Solid Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CO2				

1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Other Fossil Fuels	CO2				
1.A.5 Other (Not specified elsewhere) - Other Fossil Fuels	CH4				
1.A.5 Other (Not specified elsewhere) - Other Fossil Fuels	N2O				
1.A.5 Other (Not specified elsewhere) - Peat	CO2				
1.A.5 Other (Not specified elsewhere) - Peat	CH4				
1.A.5 Other (Not specified elsewhere) - Peat	N2O				
1.A.5 Other (Not specified elsewhere) - Biomass	CH4				
1.A.5 Other (Not specified elsewhere) - Biomass	N2O				
1.B.1 Fugitive emissions from Solid Fuels	CO2				
1.B.1 Fugitive emissions from Solid Fuels	CH4				
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO2				
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH4				
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO2				
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH4	*X*			*X*
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO2				
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4				
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N2O				
1.B.2.d Fugitive Emissions from Fuels - Other	CO2				
1.B.2.d Fugitive Emissions from Fuels - Other	CH4				
1.B.2.d Fugitive Emissions from Fuels - Other	N2O				
1.C CO2 Transport and Storage	CO2				
2.A.1 Cement Production	CO2	*X*	*X*	*X*	*X*
2.A.2 Lime Production	CO2	*X*	*X*	*X*	*X*
2.A.3 Glass Production	CO2				
2.A.4 Other Process Uses of Carbonates	CO2	*X*	*X*	*X*	*X*
2.B.1 Ammonia Production	CO2	*X*		*X*	*X*
2.B.1 Ammonia Production	CH4				
2.B.1 Ammonia Production	N2O				
2.B.2 Nitric Acid Production	N2O		*X*	*X*	*X*
2.B.3 Adipic Acid Production	CO2				
2.B.3 Adipic Acid Production	N2O				
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	CO2				
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O				
2.B.5 Carbide Production	CO2				
2.B.5 Carbide Production	CH4				
2.B.6 Titanium Dioxide Production	CO2				
2.B.7 Soda Ash Production	CO2				
2.B.8 Petrochemical and Carbon Black Production	CO2				
2.B.8 Petrochemical and Carbon Black Production	CH4				
2.B.9 Fluorochemical Production	Aggregate F-gases				
2.B.10 Other	CO2				
2.B.10 Other	CH4				
2.B.10 Other	N2O				
2.B.10 Other	Aggregate F-gases				
2.C.1 Iron and Steel Production	CO2	*X*	*X*	*X*	*X*
2.C.1 Iron and Steel Production	CH4				
2.C.2 Ferroalloys Production	CO2				
2.C.2 Ferroalloys Production	CH4				

2.C.3 Aluminium Production	CO2		X	X	
2.C.3 Aluminium Production	PFCs				
2.C.3 Aluminium Production	SF6				
2.C.4 Magnesium Production	CO2				
2.C.4 Magnesium Production	HFCs				
2.C.4 Magnesium Production	PFCs				
2.C.4 Magnesium Production	SF6				
2.C.4 Magnesium Production	Unspecified mix of HFCs and PFCs				
2.C.5 Lead Production	CO2				
2.C.6 Zinc Production	CO2				
2.C.7 Other	CO2				
2.C.7 Other	CH4				
2.C.7 Other	N2O				
2.C.7 Other	Aggregate F-gases		X	X	X
2.D Non-energy Products from Fuels and Solvent Use	CO2				
2.D Non-energy Products from Fuels and Solvent Use	CH4				
2.D Non-energy Products from Fuels and Solvent Use	N2O				
2.E Electronics Industry	Aggregate F-gases				
2.F.1 Refrigeration and Air conditioning	Aggregate F-gases	X	X	X	X
2.F.2 Foam Blowing Agents	Aggregate F-gases				
2.F.3 Fire Protection	Aggregate F-gases				
2.F.4 Aerosols	Aggregate F-gases				
2.F.5 Solvents	Aggregate F-gases				
2.F.6 Other Applications	Aggregate F-gases				
2.G Other Product Manufacture and Use	CO2				
2.G Other Product Manufacture and Use	CH4				
2.G Other Product Manufacture and Use	N2O				
2.G Other Product Manufacture and Use	Aggregate F-gases				
2.H Other	CO2				
2.H Other	CH4				
2.H Other	N2O				
2.H Other	Aggregate F-gases				
3.A Enteric Fermentation	CH4	X	X	X	X
3.B Manure Management	CH4	X	X	X	X
3.B Manure Management	N2O	X		X	X
3.C Rice Cultivation	CH4				
3.D Agricultural Soils	CH4				
3.D.1 Direct N2O Emissions From Managed Soils	N2O	X	X	X	X
3.D.2 Indirect N2O Emissions From Managed Soils	N2O	X			X
3.E Prescribed burning of savannas	CH4				
3.E Prescribed burning of savannas	N2O				
3.F Field burning of agricultural residues	CH4				
3.F Field burning of agricultural residues	N2O				
3.G Liming	CO2				
3.H Urea Application	CO2				

3.I. Other carbon-containing fertlizers	CO2				
3.J. Other	CO2				
3.J. Other	CH4				
3.J. Other	N2O				
4.A.1 Forest Land Remaining Forest Land	CO2	*X*	*X*		*X*
4.A.2 Land Converted to Forest Land	CO2	*X*	*X*		*X*
4.B.1 Cropland Remaining Cropland	CO2				
4.B.2 Land Converted to Cropland	CO2				
4.C.1 Grassland Remaining Grassland	CO2				
4.C.2 Land Converted to Grassland	CO2		*X*		*X*
4.D.1.1 Peat Extraction Remaining Peat Extraction	CO2				
4.D.1.2 Flooded Land Remaining Flooded Land	CO2				
4.D.1.3 Other Wetlands Remaining Other Wetlands	CO2				
4.D.2 Land Converted to Wetlands	CO2				
4.E.1 Settlements Remaining Settlements	CO2				
4.E.2 Land Converted to Settlements	CO2		*X*		*X*
4.F.1 Other Land Remaining Other Land	CO2		*X*		*X*
4.F.2 Land Converted to Other Land	CO2		*X*		*X*
4.G Harvested Wood Products	CO2	*X*	*X*		*X*
4(I). Direct N2O emissions from N inputs to managed soils	N2O				
4(II). Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO2				
4(II). Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH4				
4(II). Emissions and removals from drainage and rewetting and other management of organic and mineral soils	N2O				
4(III).Direct N2O emissions from N mineraliza-tion/immobilization	N2O				
4(IV) Indirect N2O Emissions from Managed Soils	N2O				
4(V) Biomass Burning	CO2				
4(V) Biomass Burning	CH4				
4(V) Biomass Burning	N2O				
4.H Other	CO2				
4.H Other	CH4				
4.H Other	N2O				
5.A Solid Waste Disposal	CH4	*X*	*X*	*X*	*X*
5.A Solid Waste Disposal	CO2				
5.B Biological Treatment of Soild Waste					
5.B Biological Treatment of Soild Waste					
5.C Incineration and Open Burning of Waste	CO2				
5.C Incineration and Open Burning of Waste	CH4				
5.C Incineration and Open Burning of Waste	N2O				
5.D Wastewater Treatment and Discharge	CH4				
5.D Wastewater Treatment and Discharge	N2O				
5.E Other	CO2				
5.E Other	CH4				
5.E Other	N2O				
6. Other	CO2				
6. Other	CH4				
6. Other	N2O				
6. Other	Aggregate F-gases				

ANNEX 2: SECTOR 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 2: Greenhouse gas emissions from Category 1.A.1.a

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	10 888	0.15	0.13	10 931
1991	11 644	0.17	0.15	11 694
1992	8 404	0.14	0.12	8 443
1993	8 310	0.15	0.12	8 350
1994	8 600	0.14	0.13	8 641
1995	9 717	0.14	0.14	9 762
1996	10 898	0.17	0.14	10 943
1997	10 958	0.18	0.13	11 001
1998	10 017	0.17	0.15	10 066
1999	9 973	0.16	0.15	10 021
2000	9 689	0.15	0.15	9 737
2001	11 271	0.19	0.17	11 328
2002	10 567	0.19	0.17	10 624
2003	13 017	0.22	0.20	13 083
2004	12 721	0.25	0.22	12 794
2005	12 756	0.23	0.23	12 832
2006	11 678	0.28	0.27	11 764
2007	10 445	0.29	0.28	10 537
2008	10 337	0.30	0.31	10 436
2009	9 314	0.35	0.30	9 412
2010	10 838	0.39	0.36	10 956
2011	10 462	0.42	0.36	10 578
2012	9 064	0.44	0.34	9 176
2013	8 092	0.42	0.32	8 199
Trend 1990-2013	-25.7%	184.7%	142.7%	-25.0%

Solid fossil fuels and natural gas are dominant compared to other fuel types. Since 2000 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 16% in 2013.

Table A 3: Share of fuel types on total CO_2 emissions from Category 1.A.1.a

	Liquid	Solid	Gaseous	Other
1990	11%	57%	30%	1%
1991	13%	59%	27%	1%
1992	18%	48%	33%	2%
1993	25%	37%	36%	2%
1994	22%	38%	38%	2%
1995	16%	47%	35%	2%
1996	14%	43%	41%	2%
1997	18%	46%	35%	2%
1998	22%	35%	41%	2%
1999	18%	38%	42%	2%
2000	12%	50%	36%	2%
2001	14%	52%	31%	3%
2002	8%	52%	36%	4%
2003	9%	53%	34%	4%
2004	9%	52%	34%	5%
2005	9%	46%	41%	4%
2006	8%	48%	37%	6%
2007	7%	49%	38%	7%
2008	7%	43%	43%	7%
2009	7%	32%	50%	11%
2010	6%	36%	48%	10%
2011	4%	41%	44%	12%
2012	2%	38%	45%	14%
2013	2%	41%	41%	16%

1.A.1.b Petroleum Refining

Table A 4: Greenhouse gas emissions from Category 1.A.1.b.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	2 394	0.04	0.01	2 399
1991	2 428	0.04	0.01	2 433
1992	2 389	0.04	0.01	2 395
1993	2 732	0.04	0.02	2 737
1994	2 709	0.04	0.01	2 714
1995	2 590	0.04	0.01	2 596
1996	2 647	0.04	0.02	2 652
1997	2 640	0.04	0.02	2 646
1998	2 633	0.04	0.02	2 639

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1999	2 152	0.03	0.01	2 157
2000	2 199	0.04	0.01	2 204
2001	2 219	0.04	0.02	2 224
2002	2 565	0.04	0.02	2 571
2003	2 687	0.04	0.02	2 694
2004	2 844	0.03	0.02	2 850
2005	2 827	0.05	0.02	2 834
2006	2 830	0.05	0.02	2 836
2007	2 868	0.05	0.02	2 874
2008	2 806	0.05	0.02	2 813
2009	2 809	0.04	0.02	2 817
2010	2 724	0.04	0.02	2 731
2011	2 768	0.04	0.02	2 775
2012	2 836	0.03	0.02	2 843
2013	2 827	0.04	0.02	2 833
Trend 1990-2013	18.1%	-13.9%	48.2%	18.1%

Table A 5: Share of fuel types on total CO_2 emissions from Category 1.A.1.b.

	Liquid	Gaseous
1990	82%	18%
1991	79%	21%
1992	80%	20%
1993	80%	20%
1994	86%	14%
1995	84%	16%
1996	82%	18%
1997	82%	18%
1998	82%	18%
1999	87%	13%
2000	84%	16%
2001	82%	18%
2002	86%	14%
2003	86%	14%
2004	88%	12%
2005	82%	18%
2006	83%	17%
2007	84%	16%
2008	82%	18%
2009	92%	8%
2010	82%	18%
2011	82%	18%
2012	84%	16%
2013	77%	23%

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

Table A 6: Greenhouse gas emissions from Category 1.A.1.c.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	510	0.04	0.0010	511
1991	549	0.05	0.0010	551
1992	522	0.05	0.0009	523
1993	424	0.04	0.0008	425
1994	453	0.04	0.0008	454
1995	611	0.05	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	402	0.04	0.0007	403
2000	333	0.04	0.0006	334
2001	334	0.04	0.0006	335
2002	346	0.04	0.0006	347
2003	588	0.05	0.0011	590
2004	762	0.05	0.0014	764
2005	696	0.05	0.0013	698
2006	645	0.06	0.0012	646
2007	562	0.05	0.0010	564
2008	523	0.05	0.0009	525
2009	512	0.06	0.0009	513
2010	462	0.05	0.0008	463
2011	521	0.05	0.0009	523
2012	504	0.06	0.0009	506
2013	286	0.05	0.0005	288
Trend 1990-2013	-43.9%	5.3%	-47.0%	-43.8%

Almost all emissions of category 1.A.1.c originated from natural gas combustion.

Table A 7: Share of fuel types on total CO_2 emissions from Category 1.A.1.c.

	Liquid	Gaseous
1990	1%	99%
1991	0%	100%
1992	0%	100%
1993	0%	100%
1994	0%	100%
1995	0%	100%
1996	NO	100%
1997	NO	100%
1998	NO	100%
1999	NO	100%
2000	NO	100%
2001	NO	100%

	Liquid	Gaseous
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%

1.A.2.a Iron and Steel

Table A 8: Greenhouse gas emissions from Category 1.A.2.a.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	2 062	0.02	0.02	2 067
1991	1 685	0.02	0.01	1 689
1992	1 354	0.02	0.01	1 357
1993	1 529	0.02	0.01	1 533
1994	1 533	0.02	0.01	1 537
1995	1 508	0.02	0.01	1 511
1996	1 808	0.03	0.01	1 813
1997	1 886	0.03	0.01	1 890
1998	1 161	0.03	0.00	1 163
1999	1 293	0.03	0.00	1 295
2000	1 231	0.03	0.00	1 233
2001	1 315	0.03	0.01	1 318
2002	1 626	0.03	0.01	1 630
2003	1 655	0.03	0.01	1 658
2004	1 825	0.03	0.01	1 828
2005	2 106	0.03	0.01	2 110
2006	1 726	0.03	0.01	1 729
2007	1 430	0.03	0.01	1 433
2008	1 523	0.03	0.01	1 526
2009	1 257	0.03	0.01	1 259
2010	1 462	0.03	0.01	1 464
2011	1 622	0.03	0.01	1 625
2012	1 661	0.03	0.01	1 663
2013	1 971	0.04	0.01	1 975
Trend 1990-2013	-4.4%	103.1%	-42.6%	-4.4%

CO_2 emissions from category *1.A.2.a* mainly arise from solid fossil fuels (coke oven coke for blast furnaces).

Table A 9: 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	4.3%	55.9%	39.8%
1992	4.1%	48.7%	47.2%
1993	4.8%	55.3%	40.0%
1994	4.8%	50.9%	44.2%
1995	5.5%	44.2%	50.2%
1996	6.5%	41.9%	51.5%
1997	3.7%	38.8%	57.5%
1998	5.7%	2.5%	91.7%
1999	2.7%	19.4%	77.9%
2000	6.0%	14.6%	79.4%
2001	3.4%	20.9%	75.7%
2002	1.8%	34.6%	63.6%
2003	1.4%	37.0%	61.6%
2004	1.8%	36.5%	61.7%
2005	2.8%	43.7%	53.5%
2006	3.1%	31.6%	65.3%
2007	1.5%	25.7%	72.9%
2008	6.1%	28.3%	65.6%
2009	1.8%	24.0%	74.2%
2010	2.1%	25.7%	72.2%
2011	1.6%	23.1%	75.4%
2012	1.7%	23.4%	74.9%
2013	4.5%	27.5%	68.0%

1.A.2.b Non-Ferrous Metals

Table A 10: Greenhouse gas emissions from Category 1.A.2.b.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	132	0.00	0.00	132
1991	119	0.00	0.00	119
1992	127	0.00	0.00	127
1993	158	0.00	0.00	158
1994	261	0.01	0.00	262
1995	255	0.01	0.00	255
1996	177	0.00	0.00	177
1997	221	0.00	0.00	222
1998	205	0.00	0.00	206
1999	190	0.00	0.00	190
2000	193	0.00	0.00	193
2001	207	0.00	0.00	207
2002	208	0.01	0.00	208
2003	213	0.01	0.00	213
2004	220	0.01	0.00	221
2005	219	0.01	0.00	219

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2006	224	0.01	0.00	224
2007	252	0.01	0.00	253
2008	255	0.01	0.00	255
2009	230	0.01	0.00	230
2010	235	0.01	0.00	236
2011	247	0.01	0.00	247
2012	243	0.01	0.00	243
2013	260	0.01	0.00	261
Trend 1990-2013	97.2%	116.7%	-8.4%	97.0%

CO_2 emissions arise from combustion of natural gas and residual fuel oil.

Table A 11: Share of fuel types in total CO2 emissions from Category 1.A.2.b

	Liquid	Solid	Gaseous
1990	27%	17%	57%
1991	29%	15%	56%
1992	25%	6%	69%
1993	21%	12%	67%
1994	15%	6%	79%
1995	16%	4%	80%
1996	28%	9%	63%
1997	32%	9%	59%
1998	30%	8%	62%
1999	25%	12%	63%
2000	24%	9%	66%
2001	26%	5%	70%
2002	21%	8%	71%
2003	19%	8%	73%
2004	17%	7%	76%
2005	15%	6%	79%
2006	14%	6%	80%
2007	12%	6%	83%
2008	9%	6%	85%
2009	7%	6%	87%
2010	8%	3%	89%
2011	9%	3%	88%
2012	9%	3%	88%
2013	8%	5%	86%

1.A.2.c Chemicals

Table A 12: Greenhouse gas emissions from Category 1.A.2.c.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	881	0.04	0.02	887
1991	905	0.05	0.02	912
1992	987	0.06	0.02	995

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1993	1 033	0.05	0.02	1 039
1994	984	0.05	0.01	989
1995	1 034	0.05	0.01	1 039
1996	1 124	0.06	0.02	1 131
1997	1 200	0.06	0.02	1 208
1998	1 117	0.05	0.02	1 124
1999	1 350	0.07	0.03	1 360
2000	1 376	0.07	0.02	1 385
2001	1 417	0.07	0.02	1 423
2002	1 438	0.09	0.02	1 445
2003	1 541	0.11	0.02	1 551
2004	1 463	0.12	0.02	1 473
2005	1 537	0.08	0.02	1 545
2006	1 324	0.08	0.02	1 331
2007	1 271	0.07	0.02	1 277
2008	1 526	0.11	0.02	1 535
2009	1 608	0.12	0.02	1 618
2010	1 645	0.12	0.02	1 655
2011	1 883	0.12	0.02	1 893
2012	1 622	0.09	0.02	1 630
2013	1 860	0.09	0.02	1 869
Trend 1990-2013	111.0%	101.4%	29.9%	110.6%

In 2013 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 13: Share of fuel types in total CO_2 emissions from Category 1.A.2.c

	Liquid	Solid	Gaseous	Other
1990	9%	12%	59%	20%
1991	10%	15%	51%	24%
1992	6%	19%	50%	26%
1993	7%	18%	58%	16%
1994	9%	15%	56%	19%
1995	9%	15%	55%	22%
1996	8%	16%	51%	24%
1997	11%	21%	50%	18%
1998	10%	22%	52%	16%
1999	5%	23%	60%	12%
2000	4%	18%	64%	15%
2001	5%	18%	60%	16%
2002	4%	17%	58%	21%
2003	4%	16%	54%	25%
2004	4%	16%	57%	22%
2005	5%	10%	68%	17%
2006	5%	8%	66%	21%
2007	6%	6%	69%	19%

	Liquid	Solid	Gaseous	Other
2008	6%	5%	63%	26%
2009	6%	4%	61%	29%
2010	9%	5%	61%	26%
2011	7%	4%	67%	23%
2012	8%	4%	69%	19%
2013	6%	4%	76%	14%

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

Table A 14: Greenhouse gas emissions from Category 1.A.2.d.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv.[Gg]
1990	2 214	0.12	0.06	2 234
1991	2 675	0.13	0.06	2 698
1992	2 167	0.12	0.06	2 188
1993	2 023	0.12	0.08	2 049
1994	2 555	0.14	0.08	2 582
1995	2 315	0.14	0.08	2 341
1996	2 416	0.14	0.07	2 439
1997	2 820	0.15	0.08	2 848
1998	2 634	0.14	0.07	2 657
1999	2 338	0.14	0.08	2 364
2000	2 380	0.13	0.06	2 401
2001	2 252	0.14	0.08	2 280
2002	2 259	0.13	0.06	2 282
2003	2 437	0.14	0.07	2 460
2004	2 296	0.14	0.07	2 319
2005	2 304	0.15	0.09	2 334
2006	2 208	0.14	0.08	2 235
2007	2 186	0.14	0.08	2 214
2008	2 197	0.14	0.08	2 224
2009	2 239	0.14	0.08	2 267
2010	2 350	0.15	0.08	2 379
2011	2 043	0.14	0.08	2 071
2012	1 975	0.14	0.08	2 003
2013	1 478	0.13	0.08	1 504
Trend 1990-2013	-33.3%	10.7%	34.6%	-32.7%

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 quite constant.

Table A 15: 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%	75%	0%
2006	6%	21%	73%	0%
2007	4%	17%	78%	1%
2008	4%	15%	81%	0%
2009	5%	15%	80%	0%
2010	3%	14%	83%	0%
2011	3%	17%	80%	0%
2012	2%	18%	80%	0%
2013	3%	25%	70%	1%

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

Table A 16: Greenhouse gas emissions from Category 1.A.2.e.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	870	0.02	0.00	872
1991	933	0.02	0.01	935
1992	854	0.02	0.00	856
1993	886	0.02	0.01	888
1994	916	0.02	0.00	918
1995	931	0.02	0.00	933
1996	888	0.02	0.00	889
1997	1 042	0.02	0.00	1 043
1998	943	0.02	0.00	944
1999	826	0.02	0.00	828
2000	882	0.02	0.00	884
2001	926	0.02	0.01	928
2002	1 100	0.03	0.00	1 103
2003	945	0.02	0.00	947
2004	948	0.02	0.00	950

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2005	964	0.02	0.01	967
2006	942	0.02	0.01	944
2007	891	0.02	0.01	893
2008	880	0.02	0.00	882
2009	905	0.02	0.00	907
2010	967	0.02	0.00	969
2011	959	0.02	0.00	961
2012	982	0.02	0.00	984
2013	940	0.02	0.00	942
Trend 1990-2013	8.1%	24.2%	-18.8%	8.0%

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 combustion in total CO_2 emissions decreased since 1990.

Table A 17: Share of fuel types in total CO_2 emissions from Category 1.A.2.e.

	Liquid	Solid	Gaseous	Other
1990	40%	2%	58%	0.00%
1991	42%	2%	55%	0.00%
1992	40%	1%	59%	0.00%
1993	44%	2%	54%	0.00%
1994	38%	2%	59%	0.00%
1995	37%	1%	63%	0.00%
1996	29%	1%	70%	0.07%
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	22%	1%	77%	0.00%
2009	22%	2%	76%	0.00%
2010	21%	2%	77%	0.05%
2011	21%	2%	78%	0.02%
2012	20%	2%	78%	0.02%
2013	20%	2%	78%	0.01%

1.A.2.f Non-Metallic Minerals

Table A 18: Greenhouse gas emissions from Category 1.A.2.f.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	1 669	0.07	0.02	1 677
1991	1 668	0.07	0.02	1 675
1992	1 673	0.08	0.02	1 681
1993	1 621	0.08	0.02	1 628
1994	1 693	0.07	0.02	1 700
1995	1 520	0.07	0.02	1 527
1996	1 551	0.08	0.02	1 557
1997	1 698	0.08	0.02	1 705
1998	1 600	0.09	0.02	1 608
1999	1 467	0.08	0.02	1 473
2000	1 540	0.09	0.02	1 548
2001	1 508	0.10	0.02	1 515
2002	1 659	0.10	0.02	1 668
2003	1 687	0.10	0.02	1 695
2004	1 831	0.11	0.02	1 841
2005	1 656	0.11	0.03	1 667
2006	1 772	0.13	0.03	1 783
2007	1 895	0.14	0.03	1 908
2008	1 845	0.13	0.03	1 859
2009	1 554	0.11	0.03	1 566
2010	1 528	0.11	0.03	1 539
2011	1 546	0.11	0.03	1 558
2012	1 530	0.11	0.03	1 542
2013	1 552	0.11	0.02	1 561
Trend 1990-2013	-7.0%	58.9%	20.3%	-6.9%

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 is has been increased while liquid and solid fuels has been decreased.

Table A 19: Share of fuel types in total CO_2 emissions from category 1.A.2.f

	Liquid	Solid	Gaseous	Other
1990	31%	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	17%	33%	45%	5%
1999	22%	24%	41%	12%

	Liquid	Solid	Gaseous	Other
2000	13%	33%	42%	13%
2001	11%	31%	44%	15%
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%

1.A.2.g.7 Manufacturing Industries and Construction – Mobile sources

Table A 20: Greenhouse gas emissions from Category 1.A.2.g.7.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
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
Trend 1990-2013	339.6%	80.3%	91.3%	315.7%

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 21: Greenhouse gas emissions from Category 1.A.2.g.8.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	1 720	0.04	0.03	1 729
1991	1 870	0.05	0.03	1 881
1992	1 903	0.06	0.03	1 913
1993	2 012	0.05	0.03	2 022
1994	2 050	0.06	0.03	2 060
1995	2 302	0.06	0.03	2 312
1996	2 434	0.07	0.03	2 446
1997	2 551	0.06	0.02	2 559
1998	2 281	0.06	0.03	2 291
1999	1 714	0.06	0.05	1 730
2000	1 753	0.06	0.04	1 767
2001	1 729	0.06	0.04	1 744
2002	1 539	0.06	0.04	1 553
2003	1 761	0.06	0.05	1 778
2004	1 878	0.07	0.05	1 895
2005	2 105	0.09	0.06	2 125
2006	2 117	0.09	0.07	2 140
2007	1 930	0.11	0.09	1 959
2008	1 885	0.12	0.09	1 915
2009	1 970	0.14	0.10	2 004
2010	2 107	0.13	0.11	2 143
2011	1 976	0.14	0.11	2 013
2012	1 928	0.16	0.13	1 971
2013	1 817	0.13	0.13	1 859
Trend 1990-2013	5.7%	189.4%	361.6%	7.5%

Natural gas and liquid fossil fuel combustion is the main source of CO_2 emissions from category *1.A.2.g.8*. Solid and liquid fuels got less important but CO_2 emissions from combustion of natural gas..

Table A 22: Share of fuel types on total CO_2 emissions from Category 1.A.2.g.8

	Liquid	Solid	Gaseous	Other
1990	35%	5%	59%	0%
1991	35%	5%	57%	3%
1992	27%	2%	67%	4%
1993	40%	3%	54%	3%
1994	32%	2%	63%	3%
1995	34%	1%	62%	3%

	Liquid	Solid	Gaseous	Other
1996	40%	1%	56%	3%
1997	55%	2%	37%	6%
1998	51%	2%	41%	7%
1999	36%	7%	51%	5%
2000	35%	2%	61%	3%
2001	39%	0%	55%	5%
2002	33%	1%	62%	4%
2003	37%	1%	58%	4%
2004	36%	1%	57%	6%
2005	34%	2%	62%	2%
2006	34%	2%	62%	2%
2007	30%	2%	66%	2%
2008	26%	2%	70%	2%
2009	25%	1%	72%	2%
2010	24%	1%	73%	2%
2011	26%	1%	71%	2%
2012	26%	0%	71%	2%
2013	26%	0%	73%	2%

1.A.3.e Other Transportation – Pipeline Compressors

Table A 23: Greenhouse gas emissions from Category 1.A.3.e.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	224	0.01	0.00	225
1991	225	0.01	0.00	226
1992	220	0.01	0.00	220
1993	214	0.01	0.00	214
1994	209	0.01	0.00	210
1995	227	0.01	0.00	227
1996	234	0.01	0.00	234
1997	233	0.01	0.00	233
1998	351	0.01	0.00	352
1999	434	0.01	0.00	435
2000	338	0.01	0.00	338
2001	497	0.01	0.00	497
2002	277	0.01	0.00	277
2003	371	0.01	0.00	372
2004	372	0.01	0.00	372
2005	362	0.01	0.00	362
2006	471	0.01	0.00	472
2007	447	0.01	0.00	447
2008	569	0.02	0.00	569
2009	419	0.01	0.00	419
2010	317	0.01	0.00	317
2011	397	0.01	0.00	398

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2012	394	0.01	0.00	394
2013	607	0.02	0.00	608
Trend 1990-2013	170.5%	170.5%	170.5%	170.5%

All emissions pipeline compressors arise from gaseous fuels.

1.A.4 Other sectors

Table A 24: Greenhouse gas emissions from Category 1.A.4.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	13 785	18.44	0.76	14 471
1991	14 883	19.95	0.81	15 623
1992	14 439	18.16	0.79	15 128
1993	14 261	17.84	0.79	14 943
1994	12 978	16.15	0.75	13 605
1995	14 115	16.81	0.78	14 767
1996	15 264	17.82	0.83	15 958
1997	13 777	13.50	0.81	14 356
1998	13 728	13.03	0.80	14 291
1999	14 266	13.36	0.82	14 844
2000	13 094	12.60	0.78	13 642
2001	14 225	12.79	0.82	14 791
2002	13 489	11.63	0.79	14 016
2003	14 226	11.35	0.79	14 744
2004	13 736	10.80	0.78	14 238
2005	13 180	11.11	0.81	13 698
2006	12 672	10.08	0.76	13 150
2007	10 866	9.58	0.72	11 320
2008	11 529	9.82	0.73	11 992
2009	10 582	9.23	0.68	11 015
2010	10 994	10.24	0.70	11 458
2011	9 687	9.03	0.65	10 107
2012	9 141	9.65	0.65	9 576
2013	8 807	9.66	0.64	9 238
Trend 1990-2013	-36.1%	-47.6%	-16.0%	-36.2%

As can be seen from the following table liquid fossil fuels are the main source of CO_2 emissions from category *1.A.4* with a quite constant share over the 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 25: Share of fuel types on total CO_2 emissions from Category 1.A.4.

	Liquid	Solid	Gaseous	Other
1990	60%	19%	19%	3%
1991	58%	20%	21%	2%

	Liquid	Solid	Gaseous	Other
1992	56%	17%	24%	2%
1993	56%	15%	28%	1%
1994	57%	14%	27%	2%
1995	57%	12%	29%	1%
1996	60%	11%	27%	2%
1997	61%	9%	28%	2%
1998	61%	8%	30%	1%
1999	61%	8%	30%	1%
2000	60%	7%	31%	1%
2001	58%	7%	35%	0%
2002	60%	5%	34%	0%
2003	60%	5%	35%	0%
2004	57%	4%	38%	0%
2005	60%	4%	36%	0%
2006	59%	3%	38%	0%
2007	57%	3%	40%	0%
2008	59%	3%	38%	0%
2009	57%	2%	41%	0%
2010	54%	2%	43%	0%
2011	54%	2%	44%	0%
2012	53%	2%	45%	0%
2013	54%	2%	44%	0%

1.A.4 Other sectors – stationary sources

Table A 26: Greenhouse gas emissions from Category 1.A.4 Other sectors - stationary sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	12 869	18.30	0.48	13 469
1991	13 971	19.82	0.53	14 551
1992	13 519	18.03	0.50	14 054
1993	13 336	17.71	0.51	13 865
1994	12 047	16.01	0.46	12 526
1995	13 217	16.68	0.50	13 722
1996	14 338	17.69	0.54	14 875
1997	12 813	13.38	0.49	13 247
1998	12 780	12.91	0.48	13 201
1999	13 311	13.24	0.50	13 743
2000	12 163	12.49	0.47	12 570
2001	13 270	12.67	0.50	13 690
2002	13 270	12.67	0.50	13 690
2003	13 306	11.24	0.48	13 692
2004	12 795	10.69	0.48	13 167
2005	12 200	11.00	0.49	12 584
2006	11 715	9.97	0.46	12 067
2007	9 903	9.48	0.43	10 237

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2008	10 563	9.72	0.45	10 908
2009	9 699	9.14	0.44	10 026
2010	10 130	10.15	0.47	10 490
2011	8 761	8.94	0.42	9 080
2012	8 251	9.57	0.45	8 590
2013	7 919	9.58	0.44	8 257
Trend 1990-2013	-38.5%	-47.7%	-7.5%	-38.7%

Liquid fossil fuels are the main stationary source of CO_2 emissions from category *1.A.4* until 2010 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 27: Share of fuel types in total CO_2 emissions from Category 1.A.4 stationary sources.

	Liquid	Solid	Gaseous	Other
1990	57%	21%	20%	2.7%
1991	55%	21%	22%	2.0%
1992	53%	19%	26%	2.5%
1993	53%	16%	30%	1.4%
1994	54%	15%	29%	1.7%
1995	54%	13%	31%	1.4%
1996	58%	12%	29%	2.1%
1997	58%	10%	30%	2.1%
1998	58%	9%	32%	1.3%
1999	59%	8%	32%	1.1%
2000	57%	8%	33%	1.2%
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	56%	4%	39%	0.3%
2006	55%	4%	41%	0.2%
2007	53%	3%	44%	0.2%
2008	55%	3%	42%	0.0%
2009	53%	2%	45%	0.1%
2010	50%	2%	47%	0.1%
2011	49%	2%	49%	0.0%
2012	48%	2%	50%	0.0%
2013	49%	2%	49%	0.1%

1.A.4.a.1 Commercial/Institutional – stationary sources

Table A 28: Greenhouse gas emissions from Category 1.A.4.a.1 Commercial/Institutional- stationary sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	2 569	0.22	0.04	2 587
1991	2 608	0.24	0.04	2 627
1992	3 126	0.23	0.05	3 148
1993	3 184	0.20	0.06	3 205
1994	2 671	0.18	0.05	2 689
1995	3 262	0.16	0.06	3 283
1996	3 527	0.17	0.06	3 548
1997	3 575	0.48	0.06	3 605
1998	3 275	0.45	0.06	3 303
1999	3 751	0.73	0.07	3 789
2000	2 985	0.78	0.06	3 022
2001	3 900	0.51	0.07	3 933
2002	3 758	0.43	0.07	3 788
2003	4 436	0.48	0.08	4 472
2004	4 223	0.45	0.08	4 258
2005	3 421	0.26	0.06	3 447
2006	3 648	0.23	0.07	3 673
2007	2 771	0.22	0.05	2 793
2008	3 248	0.23	0.06	3 273
2009	2 693	0.20	0.05	2 714
2010	2 383	0.23	0.05	2 404
2011	1 736	0.19	0.04	1 752
2012	1 425	0.20	0.04	1 440
2013	1 016	0.19	0.03	1 029
Trend 1990-2013	-60.4%	-15.0%	-30.8%	-60.2%

1.A.4.b.1 Residential – stationary sources

Table A 29: Greenhouse gas emissions from Category 1.A.4.b.1 Residential – stationary sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	9 819	17.94	0.42	10 391
1991	10 920	19.42	0.46	11 544
1992	9 993	17.65	0.43	10 562
1993	9 864	17.37	0.43	10 426
1994	9 154	15.71	0.40	9 665
1995	9 715	16.39	0.42	10 250
1996	10 548	17.38	0.46	11 118
1997	8 973	12.10	0.41	9 397
1998	9 230	11.66	0.40	9 642
1999	9 265	11.72	0.40	9 678

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2000	8 920	10.93	0.38	9 307
2001	9 113	11.35	0.40	9 517
2002	8 564	10.37	0.38	8 936
2003	8 633	10.04	0.38	8 996
2004	8 345	9.54	0.36	8 692
2005	8 631	10.11	0.39	9 001
2006	7 932	9.17	0.36	8 268
2007	7 022	8.70	0.34	7 341
2008	7 201	8.92	0.35	7 528
2009	6 926	8.38	0.34	7 237
2010	7 667	9.29	0.37	8 011
2011	6 967	8.19	0.34	7 273
2012	6 776	8.75	0.36	7 101
2013	6 854	8.77	0.36	7 180
Trend 1990-2013	-30.2%	-51.1%	-13.8%	-30.9%

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 30: Greenhouse gas emissions from Category 1.A.4.c.1 Agriculture/Forestry/Fisheries – stationary sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	482	0.14	0.02	491
1991	443	0.16	0.02	453
1992	400	0.15	0.02	410
1993	288	0.14	0.02	298
1994	222	0.12	0.02	230
1995	240	0.14	0.02	249
1996	263	0.14	0.02	274
1997	265	0.80	0.02	292
1998	275	0.80	0.02	302
1999	295	0.80	0.02	322
2000	258	0.78	0.02	285
2001	257	0.81	0.03	285
2002	216	0.72	0.03	242
2003	237	0.72	0.03	263
2004	226	0.70	0.03	253
2005	147	0.63	0.04	174
2006	135	0.57	0.04	160
2007	111	0.56	0.04	136
2008	114	0.58	0.04	140
2009	80	0.56	0.04	107

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
2010	80	0.63	0.05	111
2011	58	0.56	0.04	85
2012	51	0.62	0.05	82
2013	48	0.62	0.05	80
Trend 1990-2012	-90.0%	345.1%	171.4%	-83.7%

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 31: Activity data recalculations by sub categories with respect to previous submission [PJ absolut values].

All values in [PJ]	1990			2011			2013		
IPCC Category / Fuel Group	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference
1 A FUEL COMBUSTION ACTIVITIES	827.89	792.99	-34.90	1 096.95	1 049.60	-47.35	1 076.45	1 033.24	-43.22
1 A liquid	*379.04*	*368.12*	*-10.92*	*422.16*	*419.00*	*-3.16*	*414.15*	*410.86*	*-3.29*
1 A solid	139.89	115.87	-24.02	97.20	59.81	-37.40	87.86	51.01	-36.85
1 A gaseous	203.98	203.98	-	315.05	314.10	-0.95	298.10	297.03	-1.07
1 A other	8.99	8.99	-	35.13	35.43	0.30	33.68	34.89	1.21
1 A peat		0.00	0.00		0.00	0.00		0.00	0.00
1 A biomass	95.99	96.02	0.03	227.41	221.26	-6.15	242.67	239.44	-3.23
1 A 1 Energy Industries	188.35	185.09	-3.26	261.14	260.16	-0.97	241.66	242.79	1.13
1 A 1 liquid	46.43	43.14	-3.29	35.01	36.00	0.99	34.39	34.43	0.04
1 A 1 solid	61.40	61.40	0.00	45.64	45.64	-	37.18	37.18	-
1 A 1 gaseous	76.48	76.48	-	101.90	101.77	-0.12	90.17	91.26	1.09
1 A 1 other	2.41	2.41	-	19.50	19.83	0.33	20.62	20.75	0.13
1 A 1 peat		NO	-		NO	-		NO	-
1 A 1 biomass	1.63	1.66	0.03	59.10	56.92	-2.18	59.30	59.17	-0.12
1 A 1 a Public Electricity and Heat Production	140.54	140.54	0.00	212.57	210.55	-2.02	192.49	193.63	1.15
1 A 1 a liquid	15.63	15.63	-	4.85	4.83	-0.03	2.81	2.86	0.05
1 A 1 a solid	61.40	61.40	0.00	45.64	45.64	-	37.18	37.18	-
1 A 1 a gaseous	59.46	59.46	-	83.48	83.37	-0.11	72.58	73.72	1.13
1 A 1 a other	2.41	2.41	-	19.50	19.83	0.33	20.62	20.75	0.13
1 A 1 a peat		NO	-		NO	-		NO	-
1 A 1 a biomass	1.63	1.63	-	59.10	56.88	-2.21	59.30	59.13	-0.17
1 A 1 b Petroleum refining	38.62	35.33	-3.29	39.16	40.17	1.02	40.04	40.02	-0.02
1 A 1 b liquid	30.74	27.45	-3.29	30.16	31.18	1.02	31.59	31.57	-0.01
1 A 1 b solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 b gaseous	7.88	7.88	-	9.00	9.00	0.00	8.45	8.44	-0.01
1 A 1 b other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 b peat		NO	-		NO	-		NO	-
1 A 1 b biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	9.20	9.23	0.03	9.41	9.44	0.03	9.13	9.14	0.01
1 A 1 c liquid	0.06	0.06	-	NO	NO	-	NO	NO	-
1 A 1 c solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c gaseous	9.13	9.13	-	9.41	9.41	-0.01	9.13	9.10	-0.04
1 A 1 c other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c peat		NO	-		NO	-		NO	-
1 A 1 c biomass	NO	0.03	0.03	NO	0.04	0.04	NO	0.04	0.04

All values in [PJ]	1990			2011			2013		
IPCC Category / Fuel Group	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference
1 A 2 Manufacturing Industries and Construction	200.81	172.03	-28.78	297.29	254.65	-42.63	299.11	255.80	-43.31
1 A 2 liquid	40.68	35.90	-4.78	34.63	29.51	-5.12	33.58	29.18	-4.40
1 A 2 solid	50.28	26.28	-24.00	49.30	11.88	-37.42	48.90	12.05	-36.84
1 A 2 gaseous	76.99	76.99	-	126.89	128.10	1.21	126.39	124.19	-2.20
1 A 2 other	3.22	3.22	-	15.61	15.58	-0.03	13.03	14.11	1.08
1 A 2 peat		NO	-		NO	-		NO	-
1 A 2 biomass	29.63	29.63	-	70.86	69.59	-1.28	77.20	76.26	-0.94
1 A 2 a Iron and Steel	55.63	26.85	-28.78	69.86	26.34	-43.53	69.09	26.91	-42.18
1 A 2 a liquid	5.79	1.01	-4.77	5.70	0.33	-5.37	4.92	0.37	-4.55
1 A 2 a solid	38.11	14.11	-24.00	41.36	3.94	-37.42	40.99	4.09	-36.90
1 A 2 a gaseous	11.73	11.73	-	22.80	22.07	-0.74	23.18	22.45	-0.73
1 A 2 a other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 a peat		NO	-		NO	-		NO	-
1 A 2 a biomass	NO	NO	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 b Non-ferrous Metals	2.08	2.08	-	4.47	4.30	-0.17	4.26	4.23	-0.03
1 A 2 b liquid	0.51	0.51	-	0.29	0.29	0.00	0.30	0.29	-0.01
1 A 2 b solid	0.21	0.21	-	0.06	0.07	0.00	0.06	0.06	0.00
1 A 2 b gaseous	1.35	1.35	-	4.11	3.94	-0.17	3.90	3.88	-0.03
1 A 2 b other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 b peat		NO	-		NO	-		NO	-
1 A 2 b biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 c Chemicals	16.09	16.08	-0.01	32.45	34.37	1.92	32.77	29.63	-3.14
1 A 2 c liquid	1.06	1.06	-	1.65	1.62	-0.02	1.67	1.67	0.00
1 A 2 c solid	1.10	1.09	-0.01	0.72	0.72	-	0.73	0.73	-
1 A 2 c gaseous	9.36	9.36	-	20.60	22.82	2.22	21.63	20.06	-1.57
1 A 2 c other	1.67	1.67	-	6.55	6.55	-	5.87	4.29	-1.58
1 A 2 c peat		NO	-		NO	-		NO	-
1 A 2 c biomass	2.90	2.90	-	2.92	2.65	-0.27	2.87	2.88	0.01
1 A 2 d Pulp, Paper and Print	54.15	54.16	0.01	71.52	71.59	0.07	71.25	71.28	0.03
1 A 2 d liquid	10.94	10.94	-	0.70	0.72	0.02	0.53	0.49	-0.04
1 A 2 d solid	4.12	4.13	0.01	3.94	3.94	-	3.95	3.95	-
1 A 2 d gaseous	17.01	17.01	-	29.37	29.37	-	28.55	28.55	-
1 A 2 d other	0.19	0.19	-	0.09	0.09	-	0.06	0.06	-
1 A 2 d peat		NO	-		NO	-		NO	-
1 A 2 d biomass	21.88	21.88	-	37.43	37.48	0.05	38.16	38.23	0.07
1 A 2 e Food Processing, Beverages and Tobacco	13.91	13.91	-	16.47	16.48	0.01	17.29	17.29	0.00
1 A 2 e liquid	4.45	4.45	-	2.63	2.65	0.02	2.62	2.63	0.01
1 A 2 e solid	0.18	0.18	-	0.15	0.15	-	0.16	0.16	-
1 A 2 e gaseous	9.15	9.15	-	13.44	13.43	-0.01	13.84	13.83	0.00
1 A 2 e other	NO	NO	-	0.00	0.00	-	0.00	0.00	0.00
1 A 2 e peat		NO	-		NO	-		NO	-
1 A 2 e biomass	0.13	0.13	-	0.25	0.25	-	0.67	0.66	0.00

All values in [PJ]	1990			2011			2013		
IPCC Category / Fuel Group	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference
1 A 2 f+g Non-Metallic Minerals + Other	58.96	58.96	0.00	102.52	101.58	-0.94	104.45	106.46	2.01
1 A 2 f+g liquid	17.94	17.93	-0.01	23.66	23.90	0.24	23.55	23.74	0.19
1 A 2 f+g solid	6.56	6.57	0.01	3.07	3.07	0.00	3.01	3.06	0.05
1 A 2 f+g gaseous	28.38	28.38	-	36.56	36.47	-0.09	35.28	35.41	0.13
1 A 2 f+g other	1.36	1.36	-	8.97	8.94	-0.03	7.10	9.76	2.66
1 A 2 f+g peat		0.00	-		0.00	-		0.00	-
1 A 2 f+g biomass	4.73	4.73	-	30.27	29.21	-1.06	35.51	34.49	-1.02
1 A 3 Transport	186.67	183.88	-2.79	311.10	308.37	-2.73	309.71	307.66	-2.04
1 A 3 liquid	182.55	179.76	-2.79	281.95	282.70	0.76	280.75	281.26	0.51
1 A 3 solid	0.07	0.07	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 gaseous	4.05	4.05	-	7.57	7.46	-0.11	7.53	7.45	-0.08
1 A 3 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 biomass	NO	NO	-	21.58	18.20	-3.38	21.43	18.95	-2.48
1 A 3 a Civil Aviation	0.44	0.44	-0.01	0.85	0.84	-0.01	0.75	0.75	-0.01
1 A 3 a aviation gasoline	0.11	0.10	-0.01	0.19	0.18	-0.01	0.11	0.11	-0.01
1 A 3 a jet kerosene	0.33	0.33	0.00	0.66	0.66	0.00	0.64	0.64	-
1 A 3 a biomass		NO	-	301.19	NO	-301.19	299.90	NO	-299.90
1 A 3 b Road Transportation	179.60	176.82	-2.78	301.19	298.46	-2.73	299.90	297.86	-2.04
1 A 3 b gasoline	106.76	103.89	-2.86	68.21	66.86	-1.35	66.36	65.08	-1.28
1 A 3 b diesel oil	72.43	72.51	0.09	210.34	212.36	2.02	210.99	212.71	1.71
1 A 3 b LPG	0.41	0.41	0.00	0.79	0.85	0.07	0.84	0.90	0.06
1 A 3 b other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b gaseous	NO	NO	-	0.40	0.30	-0.11	0.42	0.35	-0.08
1 A 3 b other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b biomass	NO	NO	-	21.44	18.09	-3.35	21.28	18.82	-2.46
1 A 3 c Railways	2.38	2.38	0.00	1.74	1.74	0.00	1.79	1.78	0.00
1 A 3 c solid	2.32	2.31	0.00	1.60	1.62	0.03	1.65	1.66	0.02
1 A 3 c liquid	0.07	0.07	-	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 c other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 c biomass		NO	-		0.11	0.11		0.12	0.12
1 A 3 d Navigation	0.19	0.20	0.01	0.16	0.17	0.00	0.17	0.17	0.01
1 A 3 d residual oil	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d gas/diesel oil	0.05	0.07	0.02	0.04	0.06	0.02	0.04	0.07	0.03
1 A 3 d gasoline	0.14	0.12	-0.01	0.11	0.10	-0.02	0.11	0.09	-0.02
1 A 3 d other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d other	NO	NO	-	NO	0.01	0.01	NO	0.01	0.01
1 A 3 e Other	4.05	4.05	-	7.17	7.17	0.00	7.10	7.10	0.00
1 A 3 e liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e gaseous	4.05	4.05	-	7.17	7.17	0.00	7.10	7.10	0.00
1 A 3 e other	NO	NO	-	NO	NO	-	NO	NO	-

All values in [PJ]	1990			2011			2013		
IPCC Category / Fuel Group	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference	Subm, 2014	Subm, 2015	Difference
1 A 3 e biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 Other Sectors	251.58	251.50	-0.07	226.78	225.77	-1.01	225.33	226.33	1.00
1 A 4 liquid	108.90	108.83	-0.06	69.93	70.14	0.21	64.78	65.33	0.56
1 A 4 solid	28.14	28.12	-0.01	2.27	2.29	0.02	1.78	1.78	0.00
1 A 4 gaseous	46.46	46.46	-	78.69	76.76	-1.93	74.01	74.13	0.13
1 A 4 other	3.36	3.36	-	0.02	0.02	0.00	0.02	0.02	0.00
1 A 4 peat		0.00	0.00		0.00	0.00		0.00	0.00
1 A 4 biomass	64.73	64.73	-	75.87	76.56	0.68	84.74	85.05	0.31
1 A 4 a Commecial/Institutional	37.80	37.81	0.01	36.72	33.01	-3.71	28.45	28.61	0.16
1 A 4 a liquid	18.69	18.69	0.00	5.82	5.22	-0.61	2.71	2.69	-0.02
1 A 4 a solid	0.95	0.96	0.01	0.18	0.18	0.00	0.16	0.16	0.00
1 A 4 a gaseous	12.75	12.75	-	27.26	24.18	-3.08	21.96	22.01	0.05
1 A 4 a other	3.36	3.36	-	0.02	0.02	0.00	0.02	0.02	0.00
1 A 4 a peat		NO	-		NO	-		NO	-
1 A 4 a biomass	2.05	2.05	-	3.44	3.41	-0.03	3.59	3.73	0.14
1 A 4 b Residential	192.92	192.87	-0.05	169.66	172.26	2.60	175.80	176.28	0.48
1 A 4 b liquid	74.45	74.42	-0.03	53.11	53.80	0.69	51.92	52.09	0.17
1 A 4 b solid	26.64	26.62	-0.02	2.04	2.06	0.02	1.59	1.59	0.00
1 A 4 b gaseous	33.34	33.34	-	50.86	51.99	1.13	51.46	51.54	0.08
1 A 4 b other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 b peat		0.00	0.00		0.00	0.00		0.00	0.00
1 A 4 b biomass	58.49	58.49	-	63.65	64.41	0.76	70.83	71.06	0.23
1 A 4 c Agricul-ture/Forestry/Fisheries	20.86	20.83	-0.04	20.39	20.49	0.10	21.08	21.44	0.36
1 A 4 c liquid	15.76	15.73	-0.03	10.99	11.12	0.13	10.14	10.56	0.41
1 A 4 c solid	0.55	0.55	0.00	0.04	0.04	0.00	0.03	0.03	0.00
1 A 4 c gaseous	0.37	0.37	-	0.58	0.59	0.01	0.58	0.58	0.00
1 A 4 c other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c peat		NO	-		NO	-		NO	-
1 A 4 c biomass	4.19	4.19	-	8.78	8.74	-0.04	10.32	10.26	-0.05
1 A 5 Other	0.48	0.48	0.00	0.65	0.65	0.00	0.65	0.65	0.00
1 A 5 liquid	0.48	0.48	0.00	0.64	0.64	0.00	0.65	0.65	0.00
1 A 5 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 peat		NO	-		NO	-		NO	-
1 A 5 biomass	NO	NO	-	0.00	0.00	0.00	0.00	0.00	0.00
International Aviation Bunkers	12.26	12.19	-0.07	29.82	29.81	-0.02	28.49	28.49	-
International Marine Bunkers	0.52	0.67	0.14	0.59	0.84	0.25	0.61	0.86	0.25

A "-" indicates that no recalculations were carried out or recalculations are lower than ± 0.005 TJ (mostly due to rounding) .

Methodology

Emissions from *1.A Fuel Combustion* have been calculated using the CORINAIR methodology. 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.

The National Energy Balance

There are five different IEA questionnaires for each of: oil; natural gas; coal; renewable fuels; electricity and heat. Table A 32 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.

Table A 32: Categories of the national energy balance (JQ 2012) and their correspondence to IPCC categories.

IEA-Category and ISIC Codes(2)	Comments	SNAP	IPCC-Category
Production			Reference Approach: Production
Imports			Reference Approach: Import
Exports			Reference Approach: Export
Bunkers	No consumption (1)		
Stock Changes			Reference Approach: Stock Change
Refinery Fuel		0103	1 A 1 b Petroleum Refining
Transformation Sector, of which:			
Public Electricity plants	In the inventory plant specific data are considered.	0101 0102	1 A 1 a Public Electricity and Heat Production
Public CHP plants			
Public Heat plants			
Auto Producer Electricity plants	For autoproducers by sectors see table below.		
Auto Producer CHP plants			
Auto Producer Heat plants			
Coke Ovens	Transformation from *Coking Coal* to *Coke Oven Coke*.		
Blast furnaces	Coke Oven Coke.	030326	1 A 2 a Iron and Steel
Gas Works	Transformation of *Other Oil Products* to *Gas Works Gas*.		
Petrochemical Industry	No consumption (1)		
Patent Fuel Plants	No consumption (1)		
Not Elsewhere Specified	No consumption (1)		
Energy Sector, of which (ISIC 10, 11, 12, 23, 40):			
Coal Mines	No consumption (1)		
Oil and Gas Extraction		0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Inputs to oil refineries		0103	1 A 1 b Petroleum Refining

IEA-Category and ISIC Codes[(2)]	**Comments**	**SNAP**	**IPCC-Category**
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 Road Rail Inland Waterways	Division to SNAP categories is performed by means of studies.	07 08 0201	1 A 2 f Manuf. Ind. and Constr. - Other 1 A 3 Transport 1 A 4 b Residential 1 A 4 c Agriculture/ Forestry/ Fisheries
Pipeline Transport	*Natural Gas*.	010506	1 A 3 e Transport-Other
Non Specified	*Other biofuels* and *Lubricants*.	0201	1 A 4 a Commercial/ Institutional
Total Industry, of which:			
Iron and Steel (ISIC 271, 2731)		0301 030301 030326	1 A 2 a Iron and Steel
Chemical incl.Petro-Chemical (ISIC 24)		0301	1 A 2 c Chemicals
Non ferrous Metals (ISIC 272, 2732)		0301	1 A 2 b Non-ferrous Metals
Non metallic Mineral Products (ISIC 26)		0301 030311 030317 030319	1 A 2 Non-metallic minerals
Transportation Equipment (ISIC 34, 35)		0301	1 A 2 g Manuf. Ind. and Constr. – Other
Machinery (ISIC 28, 29, 30, 31, 32)		0301	1 A 2 g Manuf. Ind. and Constr. – Other
Mining and Quarrying (ISIC 13, 14)		0105	1 A 2 g Manuf. Ind. and Constr. – Other
Food, Beverages and Tobacco (ISIC 15, 16)		0301	1 A 2 e Food Processing, Beverages and Tobacco
Pulp, Paper and Printing (ISIC 21, 22)		0301	1 A 2 d Pulp, Paper and Print
Wood and Wood Products (ISIC 20)		0301	1 A 2 g Manuf. Ind. and Constr. - Other
Construction (ISIC 45)		0301	1 A 2 g Manuf. Ind. and Constr. - Other
Textiles and Leather (ISIC 17, 18, 19)		0301	1 A 2 g Manuf. Ind. and Constr. - Other

IEA-Category and ISIC Codes[2]	Comments	SNAP	IPCC-Category
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 33: Categories of the national energy balance (JQ 2013) and their correspondence to IPCC categories: Autoproducers by sector.

Auto Producers (Electricity + CHP + Heat), of which:			
Energy Sector, of which:			
Coal Mines	No consumption [1]		
Oil and Gas Extraction		0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Inputs to oil refineries		0103	1 A 1 b Petroleum Refining
Coke Ovens	No consumption [1]		
Gas Works	No consumption [1]		
Liquefaction Plants	No consumption [1]		
Not Elsewhere Specified	No consumption [1]		
Industrie, of which:			
Iron and Steel		030326	1 A 2 a Iron and Steel
Chemical (incl.Petro-Chemical)		0301	1 A 2 c Chemicals
Non ferrous Metals		0301	1 A 2 b Non-ferrous Metals
Non metallic Mineral Products		0301	1 A 2 f Non-metallic minerals
Transportation Equipment		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Machinery		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Mining and Quarrying		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Food, Beverages and Tobacco		0301	1 A 2 e Food Processing, Beverages and Tobacco
Pulp, Paper and Printing		0301	1 A 2 d Pulp, Paper and Print
Wood and Wood Products		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Construction		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Textiles and Leather		0301	1 A 2 g Manuf. Ind. and Constr. -Other

Auto Producers (Electricity + CHP + Heat), of which:			
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 34.

Table A 34: 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	28.50	Solid (coal)
104 A	Hard Coal Briquettes	Patent Fuel	31.00	Solid (coal)
105 A	Brown Coal	Lignite/Brown Coal	20.09	Solid (coal)
106 A	Brown Coal Briquettes	BKB/PB	19.30	Solid (coal)
107 A	Coke	Coke Oven Coke	29.00	Solid (coal)
113 A	Peat	Peat	8.80	Solid
304 A	Coke Oven Gas	Coke Oven Gas	19.08	Solid
305 A	Blast Furnace Gas	Blast Furnace Gas	3.96	Solid
110 A	Petrol Coke	Petrol Coke	30.80	Liquid
203 B	Light Fuel Oil Sulphur Content < 0,2 %	Residual Fuel Oil	41.35	Liquid (residual oil)

Inventory Fuel Category		**IEA Fuel Category**		**IPCC Fuel Category** [3]
Code [1]	**Category**	**Category**	**Average Net Calorific Value**[2]	
203 C	Medium Fuel Oil Sulphur Content < 0,4%			
203 D	Heavy Fuel Oil Sulphur Content >= 1%			
204 A	Gasoil	Heating and other Gasoil	42.79	Liquid (gas/diesel oil)
205 0	Diesel	Transport Diesel	42.11	Liquid (diesel oil; gas/diesel oil)
206 A	Petroleum	Other Kerosene	43.32	Liquid
206 B	Kerosene	Kerosene Type Jet Fuel	43.34	Liquid (jet kerosene)
207 A	Aviation Gasoline	Gasoline Type Jet Fuel	42.60	Liquid (aviation gasoline)
208 0	Motor Gasoline	Motor Gasoline	40.84	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	32.00	Liquid
301 A	Natural Gas	Natural Gas	36.29	Gaseous (natural gas)
114 B	Municipal Waste	Municipal Solid Waste Renewable	[4]10.33	Other Fuels
		Municipal Solid Waste Non Renewable	[4]10.38	Other Fuels
115 A	Industrial Waste	Industrial Wastes	11.32	Other Fuels
111 A	Fuel Wood	*Wood/Wood wastes/Other Solid Wastes, of which:* Wood	14.31	Biomass
112 A	Char Coal	Char coal	31.00	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)	7.42	Biomass
118 A	Sewage Sludge (dry substance)	*Wood/Wood wastes/Other Solid Wastes, of which:* Other vegetal materials and waste (including straw, sawdust, wood chips)	12.00	Biomass
215 A	Black Liquor	*Wood/Wood wastes/Other Solid Wastes, of which:* Black Liquor	[4]9.31	Biomass
309 A	Biogas	Biogas	[4]15.69	Biomass
309 B	Sewage Sludge Gas	Sewage Sludge Gas	[4]18.87	Biomass
310 A	Landfill Gas	Landfill Gas	[4]17.33	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 2012 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 2013. For information on completeness, in particular on CO_2 emissions included elsewhere, please refer to the documentation boxes of the CRF and to Chapter 3.2.1 subchapter *Completeness* of the NIR.

Table A 35: 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**	**13.76**	**0.00**	**1.78**	**51.33**	**3.29**	**1.29**	**0.00**	**0.17**	**4.75**
102A	Hard Coal	35.78	6.36	0.00	0.31	42.45	3.29	0.58	0.00	0.03	3.90
104A	Hard Coal Briquettes										
105A	Brown Coal		1.70		0.07	1.77		0.17		0.01	0.17
106A	Brown Coal Briquettes		0.00		0.43	0.43		0.00		0.04	0.04
107A	Coke		0.37		0.96	1.33		0.04		0.09	0.13
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		5.33			5.33		0.50			0.50
	Total Liquid	**31.45**	**29.23**	**295.34**	**64.18**	**420.19**	**2.36**	**2.22**	**22.02**	**4.79**	**31.38**
110A	Petrol Coke	2.25	1.59			3.84	0.23	0.15			0.38
203B	Light Fuel Oil	0.12	4.74		0.32	5.18	0.01	0.37		0.02	0.40
203C	Medium Fuel Oil	1.15				1.15	0.09				0.09
203D	Heavy Fuel Oil	0.95	3.16			4.11	0.08	0.25			0.32
204A	Gasoil	0.13	2.83		49.81	52.77	0.01	0.21		3.74	3.96
2050	Diesel	0.00	15.05	229.19	10.71	254.94	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	63.89	1.24	65.25		0.01	4.87	0.09	4.97
224A	Other Petroleum Products	16.61				16.61	1.30				1.30
303A	Liquified Petroleum Gas (LPG)	0.28	1.75	0.88	1.93	4.84	0.02	0.11	0.06	0.12	0.31
308A	Refinery Gas	9.96				9.96	0.63				0.63
301A	**Total Gaseous (Natural Gas)**	**77.03**	**120.85**	**11.35**	**69.47**	**278.71**	**4.27**	**6.70**	**0.63**	**3.85**	**15.44**
	Total Other Fuel	**20.70**	**11.54**		**0.07**	**32.31**	**1.29**	**0.80**		**0.00**	**2.10**
114B	Municipal Waste	15.72				15.72	0.77				0.77
115A	Industrial Waste	4.98	11.54		0.07	16.59	0.52	0.80		0.00	1.33
	Total Biomass[(1)]	**56.24**	**74.20**	**18.58**	**85.67**	**234.69**	**(8.12)**	**(1.32)**	**(1.32)**	**(0.00)**	**(24.41)**
111A	Fuel Wood	0.05	0.55		61.28	61.89	0.01	0.06		6.13	6.19
112A	Char coal	0.04			0.38	0.42				0.04	0.04
116A	Wood Wastes	47.92	39.98		22.75	110.65	5.27	4.40		2.50	12.17
118A	Sewage Sludge	2.10	0.73			2.83	0.23	0.08			0.31
215A	Black Liquor		30.09			30.09		3.31			3.31
250A	Liquid Biofuels		1.00	18.58	0.77	20.35		0.07	1.32	0.05	1.44
309A	Biogas	5.83	1.37		0.24	7.44	0.65	0.15		0.03	0.83
309B	Sewage Sludge Gas	0.20	0.49		0.19	0.88	0.02	0.05		0.02	0.10
310A	Landfill Gas	0.10			0.06	0.15	0.01			0.01	0.02
	Total[(1)]	**221.19**	**249.59**	**325.28**	**221.18**	**1 017.23**	**11.21**	**11.00**	**22.65**	**8.81**	**53.67**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 36: 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**	**12.05**	**0.00**	**1.78**	**51.02**	**3.45**	**1.12**	**0.00**	**0.17**	**4.75**
102A	Hard Coal	37.18	5.95	0.00	0.12	43.25	3.45	0.54	0.00	0.01	4.00
104A	Hard Coal Briquettes				0.22	0.22				0.02	0.02
105A	Brown Coal		1.73		0.07	1.80		0.17		0.01	0.18
106A	Brown Coal Briquettes				0.42	0.42				0.04	0.04
107A	Coke		0.37		0.95	1.32		0.04		0.09	0.13
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		4.01			4.01		0.38			0.38
	Total Liquid	**34.43**	**29.18**	**281.91**	**65.33**	**410.86**	**2.59**	**2.21**	**21.03**	**4.86**	**30.70**
110A	Petrol Coke	2.30	1.64			3.94	0.23	0.15			0.38
203B	Light Fuel Oil	0.11	5.04		0.40	5.55	0.01	0.39		0.03	0.43
203C	Medium Fuel Oil	1.25				1.25	0.10				0.10
203D	Heavy Fuel Oil	1.36	2.64			3.99	0.11	0.21			0.31
204A	Gasoil	0.13	2.95		49.92	53.00	0.01	0.22		3.74	3.98
2050	Diesel	0.00	14.91	214.46	10.72	240.10	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	19.21				19.21	1.50				1.50
303A	Liquified Petroleum Gas (LPG)	0.19	1.89	0.90	2.79	5.77	0.01	0.12	0.06	0.18	0.37
308A	Refinery Gas	9.88				9.88	0.63				0.63
301A	**Total Gaseous (Natural Gas)**	**91.26**	**124.19**	**7.45**	**74.13**	**297.03**	**5.06**	**6.88**	**0.41**	**4.11**	**16.46**
	Total Other Fuel	**20.75**	**14.11**		**0.02**	**34.89**	**1.30**	**0.84**		**0.00**	**2.15**
114B	Municipal Waste	15.55				15.55	0.76				0.76
115A	Industrial Waste	5.20	14.11		0.02	19.34	0.54	0.84		0.00	1.39
	Total Biomass(1)	**59.17**	**76.26**	**18.95**	**85.05**	**239.44**	**(8.35)**	**(1.34)**	**(1.34)**	**(0.00)**	**(24.92)**
111A	Fuel Wood	0.05	0.59		60.70	61.34	0.01	0.06		6.07	6.13
112A	Char Coal	0.04			0.40	0.44				0.04	0.04
116A	Wood Wastes	50.29	42.09		22.77	115.16	5.53	4.63		2.51	12.67
118A	Sewage Sludge	2.15	0.61			2.75	0.24	0.07			0.30
215A	Black Liquor		30.12			30.12		3.31			3.31
250A	Liquid Biofuels		1.04	18.95	0.82	20.81		0.07	1.34	0.06	1.47
309A	Biogas	6.31	1.28		0.13	7.72	0.71	0.14		0.01	0.86
309B	Sewage Sludge Gas	0.23	0.53		0.17	0.93	0.03	0.06		0.02	0.10
310A	Landfill Gas	0.10			0.06	0.16	0.01			0.01	0.02
	Total(1)	**242.79**	**255.80**	**308.32**	**226.33**	**1 033.24**	**12.40**	**11.05**	**21.45**	**9.14**	**54.04**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 37: 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**	**11.88**	**0.00**	**2.29**	**59.81**	**4.25**	**1.11**	**0.00**	**0.22**	**5.58**
102A	Hard Coal	45.64	5.84	0.00	0.45	51.93	4.25	0.53	0.00	0.04	4.82
104A	Hard Coal Briquettes										
105A	Brown Coal		1.81		0.08	1.89		0.18		0.01	0.19
106A	Brown Coal Briquettes				0.52	0.52				0.05	0.05
107A	Coke		0.38		1.23	1.62		0.04		0.11	0.15
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		3.85			3.85		0.36			0.36
	Total Liquid	**36.00**	**29.51**	**283.35**	**70.14**	**419.00**	**2.65**	**2.23**	**21.14**	**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	5.20		1.58	6.87	0.01	0.41		0.12	0.53
203C	Medium Fuel Oil	0.97				0.97	0.08				0.08
203D	Heavy Fuel Oil	3.63	2.97			6.60	0.29	0.23			0.52
204A	Gasoil	0.13	2.89		52.54	55.56	0.01	0.22		3.94	4.17
2050	Diesel	0.00	14.43	214.08	11.19	239.69	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				14.49	1.13				1.13
303A	Liquified Petroleum Gas (LPG)	1.20	1.93	0.85	3.52	7.50	0.08	0.12	0.05	0.23	0.48
308A	Refinery Gas	13.44				13.44	0.86				0.86
301A	**Total Gaseous (Natural Gas)**	**101.77**	**128.10**	**7.46**	**76.76**	**314.10**	**5.64**	**7.10**	**0.41**	**4.25**	**17.40**
	Total Other Fuel	**19.83**	**15.58**		**0.02**	**35.43**	**1.21**	**0.91**		**0.00**	**2.12**
114B	Municipal Waste	15.47				15.47	0.76				0.76
115A	Industrial Waste	4.36	15.58		0.02	19.97	0.45	0.91		0.00	1.37
	Total Biomass[(1)]	**56.92**	**69.59**	**18.20**	**76.56**	**221.26**	**(7.61)**	**(1.29)**	**(1.29)**	**(0.00)**	**(22.99)**
111A	Fuel Wood	0.04	1.05		56.34	57.43	0.00	0.10		5.63	5.74
112A	Char Coal	0.04			0.34	0.38				0.04	0.04
116A	Wood Wastes	49.36	36.65		18.64	104.66	5.43	4.03		2.05	11.51
118A	Sewage Sludge	2.00	0.64			2.64	0.22	0.07			0.29
215A	Black Liquor		28.91			28.91		3.18			3.18
250A	Liquid Biofuels		0.97	18.20	0.82	19.99		0.07	1.29	0.06	1.42
309A	Biogas	5.05	0.86		0.13	6.04	0.57	0.10		0.02	0.68
309B	Sewage Sludge Gas	0.33	0.50		0.21	1.04	0.04	0.06		0.02	0.12
310A	Landfill Gas	0.10			0.07	0.18	0.01			0.01	0.02
	Total[(1)]	**260.16**	**254.65**	**309.02**	**225.77**	**1 049.60**	**13.75**	**11.35**	**21.56**	**9.69**	**56.35**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 38: 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**	**11.99**	**0.00**	**2.64**	**56.10**	**3.87**	**1.12**	**0.00**	**0.25**	**5.24**
102A	Hard Coal	41.47	6.13	0.00	0.20	47.80	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		1.70		0.09	1.79		0.16		0.01	0.17
106A	Brown Coal Briquettes				0.57	0.57				0.06	0.06
107A	Coke		0.35		1.37	1.71		0.04		0.13	0.16
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		3.81			3.81		0.36			0.36
	Total Liquid	**39.31**	**29.69**	**293.57**	**80.07**	**442.64**	**2.91**	**2.25**	**21.91**	**5.96**	**33.02**
110A	Petrol Coke	2.00	1.44			3.44	0.20	0.14			0.34
203B	Light Fuel Oil	0.15	5.00		4.20	9.36	0.01	0.39		0.32	0.73
203C	Medium Fuel Oil	1.26				1.26	0.10				0.10
203D	Heavy Fuel Oil	7.11	3.57			10.68	0.57	0.28			0.84
204A	Gasoil	0.09	3.17		59.63	62.89	0.01	0.24		4.47	4.72
2050	Diesel	0.00	14.37	221.69	10.35	246.41	0.00	1.07	16.44	0.77	18.27
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	69.51	1.26	70.88		0.01	5.30	0.10	5.41
224A	Other Petroleum Products	13.96				13.96	1.09				1.09
303A	Liquified Petroleum Gas (LPG)	1.34	2.02	0.89	4.45	8.70	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)**	**110.97**	**128.19**	**5.99**	**86.32**	**331.47**	**6.15**	**7.10**	**0.33**	**4.78**	**18.36**
	Total Other Fuel	**18.18**	**14.57**		**0.06**	**32.81**	**1.10**	**0.89**		**0.01**	**2.00**
114B	Municipal Waste	14.38				14.38	0.70				0.70
115A	Industrial Waste	3.80	14.57		0.06	18.43	0.40	0.89		0.01	1.30
	Total Biomass[(1)]	**57.03**	**68.19**	**18.58**	**84.55**	**228.36**	**(7.45)**	**(1.32)**	**(1.32)**	**(0.00)**	**(23.70)**
111A	Fuel Wood	0.05	1.20		62.60	63.86	0.01	0.12		6.26	6.39
112A	Char Coal	0.04			0.37	0.41				0.04	0.04
116A	Wood Wastes	51.02	35.89		20.38	107.29	5.61	3.95		2.24	11.80
118A	Sewage Sludge	0.71	0.69			1.40	0.08	0.08			0.15
215A	Black Liquor		28.53			28.53		3.14			3.14
250A	Liquid Biofuels		0.95	18.58	0.75	20.28		0.07	1.32	0.05	1.44
309A	Biogas	4.78	0.42		0.11	5.30	0.53	0.05		0.01	0.59
309B	Sewage Sludge Gas	0.32	0.51		0.27	1.10	0.04	0.06		0.03	0.12
310A	Landfill Gas	0.12			0.07	0.19	0.01			0.01	0.02
	Total[(1)]	**266.95**	**252.62**	**318.16**	**253.64**	**1 091.37**	**14.02**	**11.37**	**22.24**	**10.99**	**58.63**

[(1)] CO_2 emissions of Biomass are not included in Total.

Table A 39: 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**	**20.82**	**0.01**	**5.01**	**87.46**	**5.84**	**1.94**	**0.00**	**0.47**	**8.26**
102A	Hard Coal	51.50	7.73	0.01	1.49	60.73	4.80	0.72	0.00	0.14	5.66
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal	10.12	2.54		0.20	12.86	1.04	0.22		0.02	1.28
106A	Brown Coal Briquettes		0.00		0.98	0.98		0.00		0.09	0.09
107A	Coke		1.16		2.31	3.47		0.12		0.21	0.33
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		9.39			9.39		0.89			0.89
	Total Liquid	**46.67**	**30.89**	**327.22**	**105.54**	**510.32**	**3.42**	**2.36**	**24.43**	**7.87**	**38.09**
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	4.31			15.70	0.90	0.34			1.24
204A	Gasoil	0.19	4.94		77.61	82.74	0.01	0.37		5.82	6.21
2050	Diesel	0.02	10.80	240.59	11.74	263.15	0.00	0.80	17.84	0.87	19.52
206A	Other Kerosene		0.02		0.13	0.15		0.00		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	10.93				10.93	0.85				0.85
303A	Liquified Petroleum Gas (LPG)	3.91	1.52	0.98	5.39	11.79	0.25	0.10	0.06	0.34	0.75
308A	Refinery Gas	15.66				15.66	1.00				1.00
301A	**Total Gaseous (Natural Gas)**	**116.24**	**121.85**	**6.54**	**86.66**	**331.29**	**6.44**	**6.75**	**0.36**	**4.80**	**18.35**
	Total Other Fuel	**10.22**	**9.89**		**0.40**	**20.50**	**0.57**	**0.64**		**0.04**	**1.26**
114B	Municipal Waste	8.88				8.88	0.43				0.43
115A	Industrial Waste	1.34	9.89		0.40	11.62	0.14	0.64		0.04	0.82
	Total Biomass(1)	**20.27**	**53.01**	**2.60**	**76.89**	**152.77**	**(5.82)**	**(0.18)**	**(0.18)**	**(0.00)**	**(16.07)**
111A	Fuel Wood	0.05	1.14		61.74	62.93	0.01	0.11		6.17	6.29
112A	Char Coal	0.03			0.36	0.39				0.04	0.04
116A	Wood Wastes	16.05	23.80		14.27	54.12	1.77	2.62		1.57	5.95
118A	Sewage Sludge	0.75	0.04			0.79	0.08	0.00			0.09
215A	Black Liquor		26.65			26.65		2.93			2.93
250A	Liquid Biofuels		0.12	2.60	0.13	2.85		0.01	0.18	0.01	0.20
309A	Biogas	2.66	0.68		0.14	3.48	0.30	0.08		0.02	0.39
309B	Sewage Sludge Gas	0.69	0.59		0.06	1.34	0.08	0.07		0.01	0.15
310A	Landfill Gas	0.04			0.19	0.23	0.00			0.02	0.03
	Total(1)	**255.02**	**236.46**	**336.37**	**274.50**	**1 102.35**	**16.28**	**11.70**	**24.80**	**13.18**	**65.96**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 40: 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	**41.52**	**24.53**	**245.21**	**105.72**	**416.98**	**3.03**	**1.86**	**18.35**	**7.92**	**31.16**
110A	Petrol Coke	1.61	0.81			2.42	0.16	0.08			0.24
203B	Light Fuel Oil	1.81	5.52		15.69	23.02	0.14	0.43		1.21	1.78
203C	Medium Fuel Oil				1.47	1.47				0.11	0.11
203D	Heavy Fuel Oil	13.04	6.59		0.14	19.77	1.04	0.51		0.01	1.56
204A	Gasoil	0.01	1.61		71.98	73.59	0.00	0.12		5.40	5.52
2050	Diesel	0.03	7.33	162.80	11.06	181.22	0.00	0.54	12.07	0.82	13.44
206A	Other Kerosene		0.01		0.24	0.26		0.00		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 Products	9.74				9.74	0.76				0.76
303A	Liquified Petroleum Gas (LPG)	0.94	2.54	0.67	3.70	7.85	0.06	0.16	0.04	0.24	0.50
308A	Refinery Gas	14.33				14.33	0.86				0.86
301A	**Total Gaseous (Natural Gas)**	**74.73**	**111.00**	**6.10**	**73.27**	**265.10**	**4.14**	**6.15**	**0.34**	**4.06**	**14.69**
	Total Other Fuel	**4.64**	**6.25**		**1.38**	**12.27**	**0.23**	**0.45**		**0.14**	**0.82**
114B	Municipal Waste	4.64				4.64	0.23				0.23
115A	Industrial Waste		6.25		1.38	7.63		0.45		0.14	0.59
	Total Biomass(1)	**8.08**	**40.83**		**69.99**	**118.90**	**(4.48)**				**(12.48)**
111A	Fuel Wood		0.95		59.22	60.17		0.10		5.92	6.02
112A	Char Coal	0.03			0.31	0.34				0.03	0.03
116A	Wood Wastes	6.98	15.15		9.96	32.09	0.77	1.67		1.10	3.53
118A	Sewage Sludge	0.96				0.96	0.11				0.11
215A	Black Liquor		24.06			24.06		2.65			2.65
250A	Liquid Biofuels										
309A	Biogas	0.00	0.31		0.05	0.36	0.00	0.03		0.01	0.04
309B	Sewage Sludge Gas	0.08	0.36		0.03	0.47	0.01	0.04		0.00	0.05
310A	Landfill Gas	0.01			0.43	0.44	0.00			0.05	0.05
	Total(1)	**178.13**	**197.82**	**251.34**	**260.69**	**887.97**	**12.22**	**9.91**	**18.69**	**13.09**	**53.91**

(1) CO_2 emissions of Biomass are not included in Total.

Table A 41: 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	**45.49**	**17.52**	**0.06**	**18.59**	**81.66**	**4.53**	**1.67**	**0.01**	**1.75**	**7.95**
104A	Hard Coal Briquettes	29.90	7.45	0.06	4.11	41.52	2.82	0.70	0.01	0.38	3.91
105A	Brown Coal										
106A	Brown Coal Briquettes	15.58	2.29		1.14	19.00	1.71	0.22		0.12	2.05
107A	Coke		0.28		3.05	3.32		0.03		0.30	0.32
113A	Peat		0.78		10.30	11.08		0.08		0.95	1.03
304A	Coke Oven Gas				0.00	0.00				0.00	0.00
	Total Liquid		6.73			6.73		0.64			0.64
110A	Petrol Coke	**46.34**	**33.64**	**206.13**	**107.58**	**393.70**	**3.73**	**2.57**	**15.49**	**8.06**	**29.85**
203B	Light Fuel Oil	1.87	0.36			2.23	0.19	0.04			0.23
203C	Medium Fuel Oil	1.39	11.55		17.79	30.73	0.11	0.90		1.37	2.38
203D	Heavy Fuel Oil	0.11	0.00		2.32	2.43	0.01	0.00		0.18	0.19
204A	Gasoil	17.70	13.77		0.46	31.93	1.41	1.07		0.04	2.52
2050	Diesel	0.09	0.20		70.50	70.80	0.01	0.02		5.29	5.31
206A	Other Kerosene	0.28	4.82	106.98	10.61	122.69	0.02	0.36	7.93	0.79	9.10
206B	Jet Kerosene				0.25	0.25				0.02	0.02
207A	Aviation Gasoline			1.11		1.11			0.08		0.08
2080	Motor Gasoline			0.09		0.09			0.01		0.01
224A	Other Petroleum Pro-ducts		0.07	97.45	1.48	99.00		0.01	7.43	0.11	7.55
303A	Liquified Petroleum Gas (LPG)	8.88			0.01	8.89	0.69			0.00	0.69
308A	Refinery Gas	1.06	2.87	0.49	4.18	8.61	0.07	0.18	0.03	0.27	0.55
301A	**Total Gaseous (Natu-ral Gas)**	14.95				14.95	1.23				1.23
	Total Other Fuel	**80.70**	**99.58**	**4.09**	**74.46**	**258.83**	**4.47**	**5.52**	**0.23**	**4.13**	**14.34**
114B	Municipal Waste	**3.91**	**5.27**		**1.74**	**10.92**	**0.19**	**0.47**		**0.18**	**0.84**
115A	Industrial Waste	3.91				3.91	0.19				0.19
	Total Biomass(1)		5.27		1.74	7.01		0.47		0.18	0.65
111A	Fuel Wood	**4.05**	**35.89**		**70.32**	**110.26**	**(3.94)**				**(11.45)**
112A	Char Coal		1.08		66.28	67.35		0.11		6.63	6.74
116A	Wood Wastes	0.03			0.28	0.31				0.03	0.03
118A	Sewage Sludge	3.25	13.03		3.10	19.39	0.36	1.43		0.34	2.13
215A	Black Liquor	0.73				0.73	0.08				0.08
250A	Liquid Biofuels		21.63			21.63		2.38			2.38
309A	Biogas										
309B	Sewage Sludge Gas		0.04			0.04		0.00			0.00
310A	Landfill Gas	0.01	0.00		0.61	0.62	0.00	0.00		0.07	0.07
	Total(1)	0.03	0.12		0.05	0.20	0.00	0.01		0.01	0.02

(1) CO_2 emissions of Biomass are not included in Total.

Table A 42: 1990 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	**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	**43.14**	**35.90**	**180.24**	**108.83**	**368.12**	**3.19**	**2.77**	**13.58**	**8.21**	**27.75**
110A	Petrol Coke	1.95	0.98			2.92	0.20	0.10			0.29
203B	Light Fuel Oil	1.61	10.99		33.54	46.14	0.13	0.86		2.58	3.57
203C	Medium Fuel Oil	0.29	0.01		4.47	4.77	0.02	0.00		0.35	0.37
203D	Heavy Fuel Oil	13.67	17.40		1.63	32.71	1.08	1.36		0.13	2.56
204A	Gasoil	0.00	0.06		52.94	53.00	0.00	0.00		3.97	3.97
2050	Diesel	0.01	3.40	74.93	10.80	89.14	0.00	0.25	5.56	0.80	6.61
206A	Other Kerosene				0.77	0.77				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	104.01	1.50	105.56		0.00	7.93	0.11	8.05
224A	Other Petroleum Pro-ducts	6.93	0.02		0.87	7.82	0.54	0.00		0.06	0.60
303A	Liquified Petroleum Gas (LPG)	0.41	2.99	0.41	2.32	6.14	0.03	0.19	0.03	0.15	0.39
308A	Refinery Gas	18.28				18.28	1.20				1.20
301A	**Total Gaseous (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	**2.41**	**3.22**		**3.36**	**8.99**	**0.12**	**0.26**		**0.35**	**0.73**
114B	Municipal Waste	2.41				2.41	0.12				0.12
115A	Industrial Waste		3.22		3.36	6.58		0.26		0.35	0.61
	Total Biomass(1)	**1.66**	**29.63**		**64.73**	**96.02**	**(3.25)**				**(9.93)**
111A	Fuel Wood		0.66		62.46	63.12		0.07		6.25	6.31
112A	Char Coal	0.03			0.22	0.25				0.02	0.02
116A	Wood Wastes	0.97	10.99		2.05	14.01	0.11	1.21		0.23	1.54
118A	Sewage Sludge	0.66				0.66	0.07				0.07
215A	Black Liquor		17.98			17.98		1.98			1.98
250A	Liquid Biofuels										
309A	Biogas										
309B	Sewage Sludge Gas										
310A	Landfill Gas										
	Total(1)	**185.09**	**172.03**	**184.36**	**251.50**	**792.99**	**13.79**	**9.80**	**13.81**	**13.78**	**51.19**

[(1)] *CO_2 emissions of Biomass are not included in Total.*

ANNEX 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 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 47.

Fraction of carbon oxidised

The default values of table 1-6 of the IPCC Reference Manual have been used. Selected values are presented Table A 47.

Activity data

Production, Imports, Exports, Stock Change

Activity data are taken from the national energy balance (IEA JQ 2014) (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).

Total Coal tar is 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

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 2014). Changes of activity data are based on energy balance recalculations as described in Annex 2.

Results of the Reference Approach

Table A 43 to Table A 47 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 43 presents the calculation results for each fuel type of the Reference Approach for selected years.

Table A 43: Actual CO_2 emissions (kt CO_2) for selected years.

Fuel Type	**1990**	**2000**	**2005**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Crude Oil	24 535.90	25 436.64	26 985.40	26 870.13	25 628.16	23 909.54	25 603.48	25 760.84	26 430.39
Orimulsion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Liquids	108.79	284.06	291.98	314.65	347.61	355.57	618.27	329.04	214.94
Gasoline	-217.42	490.55	822.12	443.34	297.11	931.66	406.80	416.52	238.72
Jet Kerosene	-843.3	-1 571.3	-1 718.2	-1 344.9	-859.8	-1 365.9	-1 797.8	-1 801.8	-1 915.9
Other Kerosene	-43.17	15.02	7.77	4.60	6.16	3.08	3.08	18.50	12.33
Shale Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas / Diesel Oil	1 746.21	7 031.38	13 194.82	10 904.68	10 086.19	12 254.11	9 419.17	9 794.16	10 813.12
Residuel Fuel Oil	644.43	395.62	-420.63	-568.59	-990.87	-413.27	-890.55	-852.00	-1 208.19
LPG	246.20	393.77	326.18	213.36	260.11	292.95	178.07	167.01	112.30
Ethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphtha	-1 059.56	-1 428.81	-1 387.97	-2 120.75	-2 217.97	-2 236.76	-2 094.61	-2 623.98	-2 628.07
Bitumen	-897.96	-1 194.76	-1 612.97	-1 589.86	-1 402.02	-974.74	-1 255.14	-1 221.76	-1 048.18
Lubricants	153.29	-171.46	-215.46	-279.20	-203.32	-192.70	-112.28	113.80	68.28
Petroleum Coke	-18.83	18.35	157.01	84.07	101.23	151.15	204.58	173.69	159.88
Refinery Feedstocks	2 988.42	1 603.72	1 086.43	1 216.53	1 386.56	758.80	1 439.57	254.75	12.09
OtherOil	427.89	-26.12	-65.29	-96.84	-167.67	-319.40	-181.32	-15.17	-69.80
Liquid Fossil Totals	**27 770.82**	**31 276.69**	**37 451.19**	**34 051.23**	**32 271.53**	**33 154.08**	**31 541.35**	**30 513.56**	**31 191.97**
Anthracite	40.45	6.74	12.13	6.74	4.04	4.04	0.00	26.96	2.70
Coking Coal	7 004.27	5 626.33	5 670.44	4 818.50	4 420.10	4 784.74	4 616.91	4 637.28	4 638.75
Other Bit. Coal	4 712.74	4 809.32	5 630.27	5 118.76	3 711.43	4 546.30	4 878.70	4 041.59	3 906.52
Sub- Bit. Coal	0.00	79.42	137.00	165.45	151.05	141.89	146.96	153.45	152.24
Lignite	2 729.15	1 318.72	1 210.83	16.10	54.69	58.12	56.03	28.36	25.42
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	80.24	76.21	48.06	51.80	39.68
Coke Oven / Gas Coke	-3 268.72	-3 383.49	-3 408.46	-3 770.12	-3 624.93	-3 920.36	-3 744.51	-3 853.48	-3 754.73
Coal Tar	0.00	-161.98	-3.31	0.00	-33.06	-9.29	-12.83	-7.78	67.36
Solid Fuel Totals	**11 765.95**	**8 492.89**	**9 341.23**	**6 515.66**	**4 763.56**	**5 681.64**	**5 989.31**	**5 078.18**	**5 077.93**
Gaseous Fossil	11 359.86	14 708.14	18 395.84	17 147.79	16 796.83	18 426.11	17 457.15	16 513.70	15 495.12
Waste (non-biomass fraction)	758.20	935.55	1 690.53	2 257.54	2 509.25	2 290.35	2 400.77	2 399.15	2 134.81
Peat	0.47	0.47	0.47	0.44	0.44	0.47	0.47	0.47	0.47
TOTAL	**51 655.30**	**55 413.73**	**66 879.26**	**59 972.66**	**56 341.62**	**59 552.64**	**57 389.05**	**54 505.06**	**53 900.30**
Biomass Total	**9 416.02**	**11 831.39**	**15 482.87**	**19 550.23**	**19 823.11**	**22 294.36**	**21 616.04**	**23 582.50**	**23 291.14**
Solid Biomass	9 196.61	11 253.98	13 714.54	16 643.59	16 954.83	19 359.05	18 647.62	20 235.93	20 082.34
Liquid Biomass	18.54	50.96	303.06	934.75	979.78	970.07	922.52	1 081.44	956.52
Gas Biomass	0.00	139.79	520.89	783.68	702.27	703.66	776.20	947.24	896.50
Other non-fossil fuels (biogenic waste)	200.88	386.65	944.38	1 188.20	1 186.23	1 261.59	1 269.69	1 317.89	1 355.78

Table A 44 presents the apparent fuel consumption for each fuel type of the Reference Approach.

Table A 44: Apparent Consumption (TJ) for selected years.

Fuel Type	1990	2000	2005	2008	2009	2010	2011	2012	2013
Crude Oil	337 960	350 367	371 700	370 112	353 005	329 333	352 665	354 833	364 055
Orimulsion	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	1 743	4 550	4 677	5 040	5 568	5 695	9 903	5 270	3 443
Gasoline	-3 169	7 150	11 983	6 776	4 578	14 421	6 300	6 470	3 676
Jet Kerosene	-11 914	-22 198	-24 273	-19 000	-12 146	-19 297	-25 398	-25 455	-27 066
Other Kerosene	-607	211	109	65	87	43	43	260	173
Shale Oil	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	23 814	95 892	181 645	155 017	145 578	177 159	136 283	141 832	156 668
Residuel Fuel Oil	13 251	14 778	4 221	1 860	-7 952	2 997	-6 128	-6 440	-10 633
LPG	3 943	6 307	5 224	3 417	4 166	4 692	2 852	2 675	1 799
Ethane	0	0	0	0	0	0	0	0	0
Naphtha	90	0	-450	-4 906	-4 996	-4 816	-5 221	-8 327	-8 282
Bitumen	11 328	10 643	8 018	2 780	3 428	6 688	3 469	3 386	4 138
Lubricants	5 506	-84	-1 296	-2 341	-1 547	-1 296	-84	3 260	1 965
Petroleum Coke	2 889	2 068	3 396	2 982	1 965	3 350	2 644	2 593	2 556
Refinery Feedstocks	41 163	22 090	14 965	16 757	19 099	10 452	19 829	3 509	167
OtherOil	6 646	393	-347	986	-1 588	-3 051	-1 588	1 672	1 170
Liquid Fossil Totals	**432 644**	**492 167**	**579 571**	**539 545**	**509 243**	**526 370**	**495 569**	**485 538**	**493 829**
Anthracite	448	84	140	84	56	56	0	280	28
Coking Coal	67 937	54 564	55 204	54 157	49 216	53 622	51 890	52 268	52 314
Other Bit. Coal	50 568	51 604	60 398	61 273	43 558	53 300	57 501	47 500	48 565
Sub- Bit. Coal	0	844	1 455	1 757	1 604	1 507	1 561	1 630	1 617
Lignite	27 294	13 188	11 915	166	568	601	567	290	261
Oil Shale	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	5 912	2 134	996	1 728	865	822	518	559	428
Coke Oven / Gas Coke	19 304	30 110	38 472	37 817	24 162	33 777	35 982	33 899	35 786
Coal Tar	0	-2 048	-42	0	-418	84	334	460	1 756
Solid Fuel Totals	**171 462**	**150 480**	**168 538**	**156 983**	**119 611**	**143 769**	**148 353**	**136 886**	**140 755**
Gaseous Fossil	219 239	275 681	341 608	319 643	312 764	343 921	325 971	310 433	293 566
Waste (non-biomass fraction)	8 073	10 509	18 652	26 440	29 831	28 360	30 420	29 782	26 686
Peat	4	4	4	4	4	4	4	4	4
TOTAL	**831 422**	**928 841**	**1 108 374**	**1 042 615**	**971 454**	**1 042 425**	**1 000 318**	**962 643**	**954 840**
Biomass Total	**96 503**	**120 409**	**155 319**	**198 160**	**201 258**	**226 468**	**219 180**	**239 678**	**236 031**
Solid Biomass	95 324	116 649	142 153	172 513	175 739	200 659	193 285	209 748	208 156
Liquid Biomass	262	720	4 104	13 075	13 698	13 631	13 019	15 274	13 508
Gas Biomass	0	1 275	4 751	7 148	6 406	6 418	7 080	8 640	8 177
Other non-fossil fuels (biogenic waste)	917	1 765	4 311	5 424	5 415	5 759	5 796	6 016	6 189

Table A 45 presents the carbon stored for each fuel type of the Reference Approach.

Table A 45: Carbon Stored (kt C) for selected years

Fuel Type	1990	2000	2005	2008	2009	2010	2011	2012	2013
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	195.89	105.19	177.08	116.03	98.83	108.48
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	486.11	511.09	519.87	472.61	556.32	558.35
Bitumen	496.58	563.27	620.75	499.14	461.64	415.66	422.10	411.06	379.79
Lubricants	67.90	45.56	33.44	30.10	25.08	27.17	29.26	33.86	20.48
Petroleum Coke	84.65	51.81	50.12	58.84	26.15	50.50	16.36	23.47	26.26
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	11.05	46.41	14.42	26.96	18.18	37.62	42.64
Liquid Fossil Totals	**1 059.94**	**1 272.14**	**1 293.67**	**1 316.49**	**1 143.56**	**1 217.23**	**1 074.54**	**1 161.17**	**1 135.99**
Anthracite	0.75	0.38	0.38	0.38	0.38	0.38	0.00	0.00	0.00
Coking Coal	37.10	29.59	42.04	42.21	21.94	30.44	36.42	39.50	44.05
Other Bit. Coal	0.00	0.00	0.00	157.16	93.27	116.01	128.22	98.51	152.91
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	2 173.61	1 725.51	2 092.32	2 109.94	2 077.40	2 101.39
Coal Tar	0.00	0.00	0.00	0.00	0.00	4.43	10.93	12.29	19.89
Solid Fuel Totals	**1 512.83**	**1 853.35**	**2 109.15**	**2 373.35**	**1 841.10**	**2 239.14**	**2 274.59**	**2 215.41**	**2 298.36**
Gaseous Fossil	198.79	133.83	119.13	129.34	121.61	145.78	140.16	163.99	188.34
Waste (non-biomass fraction)	0.00	0.00	0.00	47.62	40.58	51.06	63.64	47.97	32.20
Peat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**2 771.56**	**3 259.32**	**3 521.95**	**3 819.18**	**3 106.27**	**3 602.15**	**3 489.28**	**3 540.56**	**3 622.69**
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 46 presents international bunker fuels for the relevant fuel types of the Reference Approach.

Table A 46: International Bunkers [kt fuel].

Fuel Type	1990	2000	2005	2008	2009	2010	2011	2012	2013
Jet Kerosene	281	538	622	692	601	650	688	657	627
Diesel	12	18	20	17	15	17	16	16	18

Table A 47 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 47: 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 2013	Default value	Country specific value 2013	
Crude Oil	42.75	42.50	20.00	-	0.99
Orimulsion	-	-	-	-	-
Natural Gas Liquids	45.22	42.50	17.20	-	0.99
Gasoline	44.80	40.84	18.90	17.89	0.99
Jet Kerosene	44.59	43.34	19.50	-	0.99
Other Kerosene	44.75	43.34	19.60	-	0.99
Shale Oil	-	-	-	-	-
Gas / Diesel Oil	43.33	40.28	20.20	19.01	0.99
Residuel Fuel Oil	40.19	40.36	21.10	-	0.99
LPG	47.31	46.12	17.20	-	0.99
Ethane	-	-	-	-	-
Naphtha	45.01	45.01	20.00	-	0.99
Bitumen	40.19	41.80	22.00	-	0.99
Lubricants	40.19	41.80	20.00	-	0.99
Petroleum Coke	31.00	30.80	27.50	-	0.99
Refinery Feedstocks	42.50	41.65	20.00	-	0.99
OtherOil	40.19	41.80	20.00	-	0.99
Anthracite	28.00		26.80	-	0.98
Coking Coal	28.00	29.29	25.80	25.52	0.98
Other Bit. Coal	28.00	28.50	25.80	25.53	0.98
Sub- Bit. Coal	22.20	21.85	26.20	-	0.98
Lignite	10.90	20.09	27.60	27.08	0.98
Oil Shale	-	-	-	-	-
Peat	8.80	8.80	28.90	-	0.98
BKB & Patent Fuel	19.30	19.30	25.80	-	0.98
Coke Oven / Gas Coke	28.20	29.00	29.50	29.65	0.98

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 2013**	**Default value**	**Country specific value 2013**	
Coal Tar		41.80	22.01	-	0.98
Natural Gas	-	-	15.30	15.11	1.00
Solid Biomass	-	-	29.90	-	0.88
Liquid Biomass	-	-	-	19.31	-
Gas Biomass	-	-	29.90	-	0.99

Table A 48 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 48: Country specific conversion factors for selected fuels [TJ/kt]

Fuel Type	1990	2000	2005	2008	2009	2010	2011	2012	2013
Other Bit. Coal	28.00	27.99	28.14	27.92	28.46	28.62	28.08	28.16	28.26
Lignite	10.90	9.82	9.84	21.93	20.76	18.32	17.18	17.71	19.35
Coke	28.50	28.67	29.00	29.00	29.00	29.00	28.88	29.75	29.03

ANNEX 4: NATIONAL ENERGY BALANCE

The tables presenting the data of the national energy balance by IEA categories as well as the calorific values for unit conversion will again be submitted 2016 when an official submission under the Kyoto Protocol can take place.

ANNEX 5: RECALCULATIONS

The tables showing the recalculations for emission levels by category for CO_2, CH_4, N_2O and FCs and the recalculation differences of national total emissions by gas will again be submitted 2016 when an official submission under the Kyoto Protocol can take place.

ANNEX 6: ADDITIONAL INFORMATION

Additional information on 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 SO2, NOX, NMVOCs, NH3, CO, TSP, PM10, and PM2.5 as well as on the heavy metals Pb, Cd and Hg and persistent organic hydrocarbons (PAHs), dioxins and furans and hexachlorobenzene (HCB).
- Obligation under the Austrian Ambient Air Quality Law[1] concerning the reporting of national emission data on SO_2, NOx, 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 ISO/IEC 17020 as *Inspection Body for Emission Inventories.*
- In 2011: re-accreditation according to ISO/IEC 17020 as *Inspection Body for Emission Inventories.*

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 1.

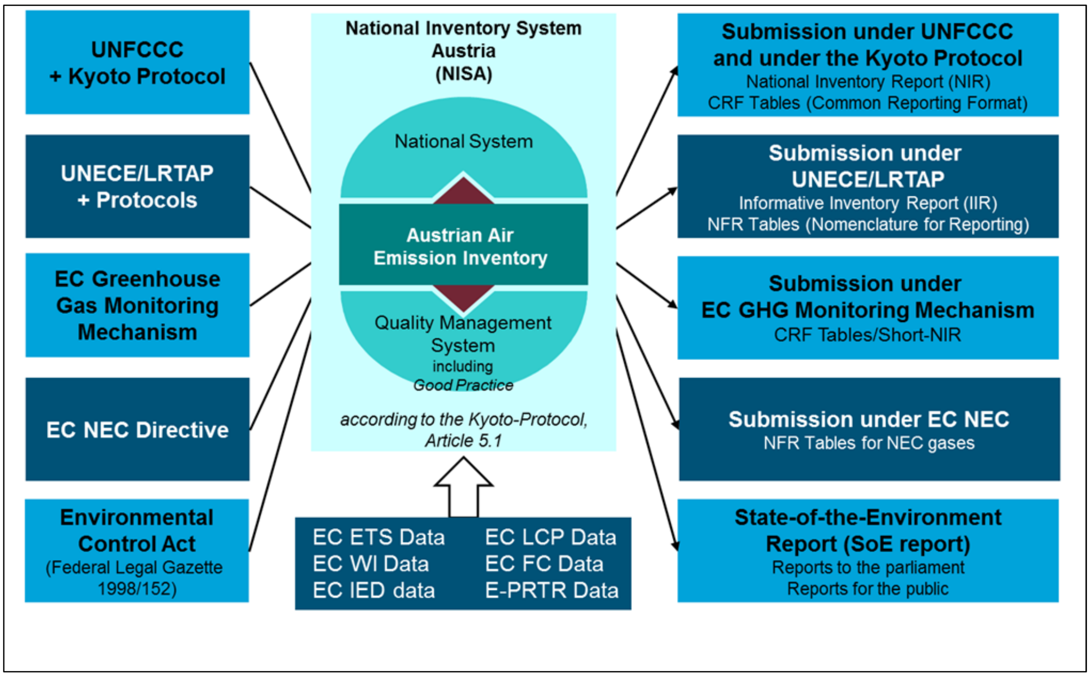

Figure 1: Structure of the National Inventory System in Austria (NISA).

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 [IPCC Guidelines and Good Practice Guidance (GPG)] to comply with the requirements of the Kyoto Protocol.

The general principles for National Inventories are transparency, consistency, comparability, completeness and accuracy of inventories and the quality of inventory activities (e.g. collecting activity data, selecting methods and emission factors).

The general functions are

- to establish and maintain the institutional, legal, and procedural arrangements defined in the guidelines for national systems between the government agencies and other entities,
- to ensure sufficient capacity for timely performance,
- to designate a single national entity with overall responsibility for the national inventory,
- to prepare national annual inventories and supplementary information in a timely manner and
- to provide information necessary to meet the reporting requirements.

Specific functions stipulated in these guidelines are inventory planning, preparation and management.

Austria has taken significant steps to establish a high-quality emission inventory in which uncertainties are reduced as far as feasible and in which data are developed in a transparent, consistent, complete, comparable and accurate manner.

The following steps have been taken to prepare NISA to meet the requirements of the Kyoto Protocol:

- the Umweltbundesamt has been designated as the single national entity with the overall responsibility for the national inventory by law: the Environmental Control Act ("Umweltkontrollgesetz"; Federal Law Gazette I No. 152/1998) regulates responsibilities of environmental control in Austria and lists the tasks of the Umweltbundesamt. One task is the preparation of technical expertise and basic data for the fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. For further institutional arrangements, please refer to 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 2000 Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance (GPG) and Uncertainty Management of Greenhouse Gas Inventories and to the 2003 IPCC GPG for Land Use, Land-Use Change and Forestry.
- 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.
- 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). Para 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.

Additional information on the Inspection Body for Emission Inventories

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.

Table A 49: presents the timetable for the implementation of the quality management system.

Table A 49: *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
Re-Accreditation Audit	January 2011

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-GPG as a basis for any kind of international emission trading.

The International Standard ISO/IEC 17020

The QMS was drawn up to meet the requirements of the International Standard 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 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 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 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 ("Akkreditierungsgesetz", Federal Law Gazette 468/1992 as amended by 430/1996) regulates the accreditation of testing, inspection and certification bodies. It designates the Federal Ministry for Economic Affairs and Labour 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 2 shows the inter-relationship between the Austrian Accreditation Act, the EN 45000/ISO 17000 series and the ISO 9000 series.

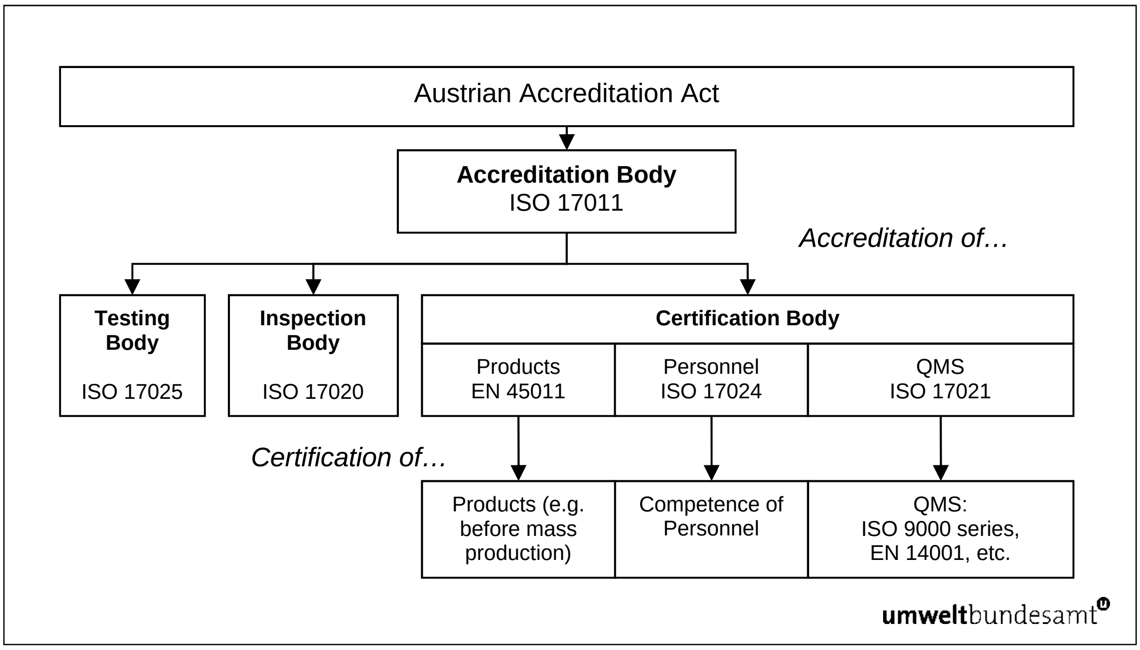

Figure 2: Inter-relationship between the Austrian Accreditation Act, the EN 45000/ISO 17000 and the ISO 9000 series.

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 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 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 GPG

The implementation of QA/QC procedures as required by the IPCC-GPG 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 IPCC-GPG Chapter 8 „Quality Assurance and Quality Control" (see next subchapter), 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*. It is illustrated in Figure 3.

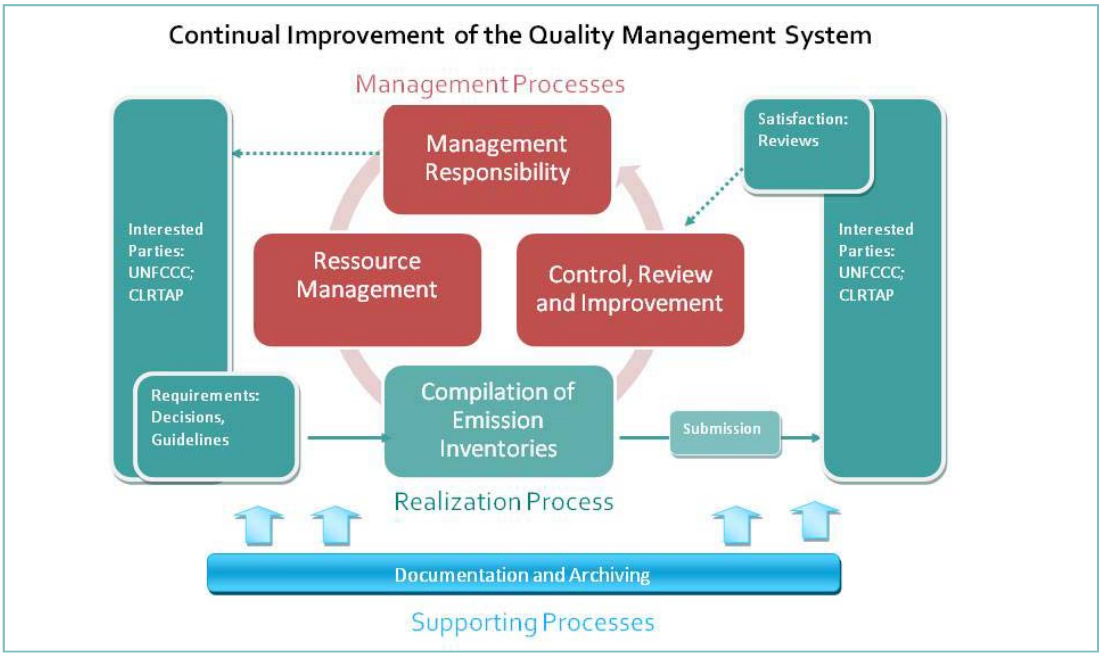

Figure 3: Process-based QMS of the IBE

In the following the processes are explained:

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 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.

ANNEX 7: UNCERTAINTY ASSESSMENT

For the submission 2015 the uncertainty calculation was performed applying the 'Tier 1' approach of the IPCC 2006 GL, for all sectors except LULUCF. Please see Chapter 1.7 of the NIR 2015. A Tier 1 uncertainty calculation for all sectors including LULUCF and a 'Tier 2' approach (Monte Carlo Simulation) as well as a detailed description will be submitted in 2016.

ANNEX 8: CRF FOR 2013

The full set of tables is submitted electronically together with this report.

ANNEX 9: CRF TABLES ART. 3.3 KP ACTIVITIES FOR 2013

KP LULUCF tables will not be submitted in 2015. The CRF reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it is therefore not yet functioning to allow a submission of all the information required under the Kyoto Protocol.