umweltbundesamt

AUSTRIA'S NATIONAL INVENTORY REPORT 2005

Submission under the United Nations Framework Convention on Climate Change

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Project management

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EXECUTIVE SUMMARY

ES.1 Background Information

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. To date, National Greenhouse Gas Inventories have been produced for the years 1990 to 2003.

By taking decision 18/CP.8 (see document FCCC/CP/2002/7/Add.2) the Conference of the Parties (COP) has undertaken to implement the UNFCCC guidelines on reporting and reviewing (FCCC/CP/2002/8). According to this decision 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 (see paragraph 38 of FCCC/CP/2002/8). This is the fifth version of the National Inventory Report (NIR) submitted by Austria, it is an update of the NIR submitted in 2004[1]. This report is based on data submitted to the UNFCCC in the common reporting format (CRF submission 2005). They differ from last year's reported data as some activity data have been updated or changes in methodology have been made retrospectively to enhance the accuracy of the greenhouse gas inventory (for further information see Chapter 9 Recalculations and Improvements). Thus the inventory as presented in the NIR 2005 and as submitted to the UNFCCC in the data submission 2005 replaces all previous versions of data submissions.

The structure of the NIR follows closely the proposal as included in Appendix A of document FCCC/SBSTA/2002/8. First, there is an Executive Summary that gives an overview on 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), it also describes improvements made in response to the UNFCCC centralized review 2004.

The underlying emission data for the year 2003 as reported in the tables of the common reporting format of the data submission 2004 to the convention are also included as well as abbreviations and references used. Furthermore detailed results from the key source analysis, detailed information on the methodology of emission estimates for the fuel combustion sector, the CO_2 reference approach as well as the National Energy Balance are presented in the Annexes.

The aim of this report is to document the methodology in order to facilitate understanding the calculation of the Austrian GHG emission data. The more interested reader is kindly referred to the background literature cited in this document.

Manfred Ritter in his function as head of the *Department of Air Emissions* of the UMWELTBUNDESAMT is responsible for the preparation and review of Austria's National Greenhouse Gas Inventory as well as the preparation of the NIR.

[1] Austria's National Inventory Report 2003 – Submission Under the United Nations Framework Convention of Climate Change. BE-225; Austria's Federal Environment Agency, Vienna.

Klaus Radunsky in his function as head of the *Inspection Body for Emission Inventories* is responsible for the content of this report and for the quality management system of the Austrian Greenhouse Gas Inventory.

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

Project leader for the preparation of the NIR is Manuela Wieser.

Specific responsibilities for the NIR 2005 have been as follows:

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Chapters 1.6, 1.8	Doris Halper
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Chapter 3.2 Aviation	Agnes Kurzweil
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Chapter 7	Alexandra Freudenschuß, Manuela Wieser
Chapter 8	Daniela Wappel, Stephan Poupa
Chapter 9	Stephan Poupa, Manuela Wieser
Annexes	Stephan Poupa, Manuela Wieser

ES.2 Summary of National Emission and Removal Related Trends

The most important GHG in Austria is carbon dioxide (CO_2), it contributed 83.2% to total national GHG emissions expressed in CO_2 equivalent in 2003, followed by CH_4, 8.5% and N_2O, 6.1%. PFCs, HFCs and SF_6 contributed for 2.2% to the overall GHG emissions in the country. The energy sector accounted for 75.7% of the total GHG emissions followed by Industrial Processes 12.1%, Agriculture 8.0% and Waste 3.7%.

Total GHG emissions (excluding land-use change and forestry (LUCF)) amounted to 91 566 Gg CO_2 equivalent and increased by 16.5% from 1990 to 2003 (16.6% if calculated from the base year: 1990 for CO_2, CH_4 and N_2O and 1995 for HFCs, PFCs and SF_6).

Table 1 provides data on emissions by sector and Table 2 by gas from 1990 to 2003.

Table 1: Austria's greenhouse gas emissions by sector

GHG Source and Sink categories		**Total (with net CO_2 emissions/removals)**	**Total (without CO_2 from LUCF)**	1 Energy	2 Industrial Processes	3 Solvent and Other Product Use	4 Agriculture	5 Land-Use Change and Forestry	6 Waste
BY*	[Gg CO_2 equivalent]	69 521.89	78 535.22	54 945.90	10 114.82	515.17	8 456.23	-9 013.33	4 503.10
1990		69 559.72	78 573.05	54 945.90	10 152.65	515.17	8 456.23	-9 013.33	4 503.10
1991		70 873.96	82 647.00	58 769.48	10 269.45	469.27	8 643.69	-11 773.04	4 495.12
1992		67 627.81	76 062.64	53 932.46	9 118.31	420.24	8 187.31	- 8 434.82	4 404.33
1993		67 416.92	76 177.63	54 573.05	8 842.87	419.85	7 970.20	- 8 760.71	4 371.66
1994		69 405.45	77 045.38	54 536.96	9 376.47	404.04	8 492.49	- 7 639.93	4 235.43
1995		73 112.74	80 159.10	57 200.73	9 875.84	422.38	8 557.75	- 7 046.36	4 102.39
1996		78 045.80	83 237.39	61 019.19	9 751.84	405.31	8 089.34	- 5 191.59	3 971.72
1997		71 355.65	83 046.10	60 283.20	10 345.24	422.59	8 144.83	-11 690.45	3 850.23
1998		69 806.62	82 513.72	60 287.29	9 897.07	404.74	8 146.26	-12 707.10	3 778.36
1999		67 765.51	80 402.96	58 865.23	9 590.82	390.87	7 860.19	-12 637.45	3 695.85
2000		67 437.64	81 083.55	59 014.77	10 328.82	413.52	7 724.46	-13 645.91	3 601.98
2001		71 527.01	84 871.78	62 927.72	10 234.05	426.10	7 753.92	-13 344.77	3 529.99
2002		75 122.83	86 433.79	64 026.01	10 963.93	426.10	7 552.64	-11 310.96	3 465.11
2003		78 793.87	91 566.42	69 330.63	11 046.05	426.10	7 349.06	-12 772.55	3 414.59

**BY= Base Year: 1990 for CO_2, CH_4 and N_2O and 1995 for HFCs, PFCs and SF_6*

Over the period 1990-2003 CO_2 emissions increased by 24.4%, mainly due to increased emissions from transport. Methane emissions decreased during the same period by 20.3% mainly due to lower emissions from *Solid Waste Disposal*; N_2O emissions decreased by 3.0% over the same period due to lower emissions from agricultural soils. Emissions from HFCs and PFCs increased by 135.6% and 49.2% respectively whereas SF_6 emissions decreased by 47.9% from the base year (1995) to 2003[2].

[2] Data for fluorinated compounds is only available until 2000, for 2001 and 2002 the values of 2000 was used. However, new data will become available in 2004.

Table 2: Austria's greenhouse gas emissions by gas

GHG	[Gg CO2 equivalent]	**Total**	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
BY*		**78 535.22**	61 262.62	9 797.69	5 711.76	555.26	68.74	1 139.16
1990		**78 573.05**	61 262.62	9 797.69	5 711.76	219.16	1 079.24	502.58
1991		**82 647.00**	64 752.08	9 759.88	6 060.03	334.57	1 087.08	653.36
1992		**76 062.64**	59 348.14	9 460.60	5 706.80	386.59	462.67	697.85
1993		**76 177.63**	59 899.64	9 425.66	5 561.46	444.24	52.92	793.71
1994		**77 045.38**	60 203.24	9 257.72	6 034.88	505.20	58.65	985.70
1995		**80 159.10**	63 115.45	9 142.84	6 137.65	555.26	68.74	1 139.16
1996		**83 237.39**	66 562.46	8 958.72	5 794.74	637.15	66.27	1 218.05
1997		**83 046.10**	66 527.30	8 681.40	5 890.80	729.62	96.83	1 120.15
1998		**82 513.72**	66 217.81	8 557.07	5 973.57	812.53	44.75	907.99
1999		**80 402.96**	64 614.14	8 365.73	5 807.59	866.99	64.54	683.96
2000		**81 083.55**	65 454.12	8 146.25	5 758.53	1 019.00	72.33	633.31
2001		**84 871.78**	69 279.64	8 020.50	5 730.53	1 122.34	82.15	636.62
2002		**86 433.79**	70 994.47	7 856.28	5 636.41	1 218.92	86.87	640.83
2003		**91 566.42**	76 213.26	7 806.62	5 542.26	1 308.22	102.54	593.52

**BY= Base Year: 1990 for CO2, CH4 and N2O and 1995 for HFCs, PFCs and SF6*

NOTE: Total without CO_2 from LUCF

ES.3 Overview of Source and Sink Category Emission Estimates and Trends

In the year 2003, 69 331 Gg CO_2 equivalent, that are 75.7% of national total emissions arose from the sector *Energy*. 99.2% of these emissions arise from fuel combustion activities. The most important subsector of *Fuel Combustion* with 33.2% of total emissions from this sector in 2003 is transport. From 1990 to 2003 emissions from the energy sector increased by 26.2%.

Industrial Processes is the second largest sector in Austria with 12.1% of total GHG emissions in 2003 (11 046 Gg CO_2 equivalent). In the year 2003, 41.0% of these emissions arose from *Metal Production*. From the base year to 2003 emissions from industrial processes increased by 9.2%.

In the year 2003, 0.5% of total GHG emissions in Austria (426 Gg CO_2 equivalent) arose from the sector *Solvent and Other Product Use*. From 1990-2003 emissions from this category decreased by 17.3%.

Emissions from *Agriculture* amounted to 7 349 Gg CO_2 equivalent in the year 2003, that are 8.0% of national total emissions. The most important sub sector is *Enteric Fermentation* with 42.1% of the greenhouse gas emissions from the agricultural sector in 2003, the second important sub source is *Agricultural Soils* with 36.3%. In the year 2003 emissions from that category were 13.1% below the level of the base year.

3.7% of Austria's total greenhouse gas emissions in the year 2003 arose from the IPCC Category *Waste.* Emissions from this category decreased: from 1990 to 2003 emissions by 24.2% from 4 503 Gg CO_2 equivalent to 3 414 Gg.

ES.4 Overview of Emission Estimates and Trends of Indirect GHGs and SO_2

Emission estimates of indirect GHGs and SO_2 are presented in Table 3.

Table 3: Emissions of indirect GHGs and SO_2 1990-2003

Gas	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
	[Gg]									
NOX	210.99	192.13	211.78	199.12	211.13	199.16	204.43	213.67	219.72	229.03
CO	1243.6	1018.0	1032.2	962.3	923.4	875.7	810.3	804.0	775.5	801.8
NM-VOC	286.02	221.31	216.47	203.72	190.96	180.15	181.01	185.26	181.69	182.30
SO2	76.18	48.21	46.27	42.13	37.25	36.08	33.06	34.22	33.01	34.14

Emissions of indirect greenhouse gases except NOx decreased from the period from 1990 to 2003: for NMVOCs and CO by 36% and for SO_2 emissions by 55%. NOx emissions increased by 9% over the considered period.

The most important emission source for indirect greenhouse gases and SO_2 are fuel combustion activities.

1 INTRODUCTION

1.1 Background Information

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 0.6-0.7°C in the past 100 years and, according to the IPCC, will rise by another 1.4-5.8°C in the next 100 years, depending on the emission scenario.

The increase of the average surface temperature of the earth will lead, by increase of the surface temperature of the oceans and the continents, to changes in the hydrologic cycle as well as 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.

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 for 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.

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, leading to a high risk of extreme floods, whereas south of the alps there will 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, in 2003 Austria has launched StartClim and FloodRisk, two research programs.

The Convention, its Kyoto Protocol and the flexible mechanisms there under

In 1992 Austria has 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[3]: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) as well as hydrogenated fluorocarbons (HFCs), perfluorated halocarbons (PFCs) and sulfurhexa flourid (SF_6).

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

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

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 ratify (or approve, accept, or accede to) the Protocol, including Annex I Parties accounting for 55% of that group's carbon dioxide emissions in 1990: by the end of March 2005, 146 Parties have ratified the KP, accounting for 61.6% of emissions of Annex 1 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 country 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 fund projects in developing countries (non-Annex I Party) to get credits for certified emission reductions providing that "benefits" accrue to host country.

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

National 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 2003. 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 preparation of Austria's National Greenhouse Gas Inventory as well as the preparation of the NIR is the responsibility of the *Department of Air Emissions* of the *UMWELTBUNDESAMT* in Vienna.

For the means of Quality Assurance due to increased requirements in transparency, consistency, comparability, completeness and accuracy of the national greenhouse gas inventory related to the new standards defined in the KP, the inventories will be annually reviewed by international experts managed by the Climate Change Secretariat in Bonn (expert review team ERT) starting in 2003. To date, Austria's Greenhouse Gas Inventory has been reviewed by an in-country review and a centralized review in 2001 during the trial period of the review process as well as during the centralized reviews in 2003 and 2004. The reports on these reviews can be found on the UNFCCC website[4].

1.2 Institutional Arrangement for Inventory Preparation

1.2.1 Austria's Obligations

Austria has to comply with the following obligations:

- Austria's annual obligation under the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and its Protocols (1979) comprising the annual reporting of national emission data on SO_2, NO_X, NMVOCs, NH_3, CO, TSP, PM_{10}, and $PM_{2,5}$ as well as on the heavy metals Pb, Cd and Hg and persistent organic hydrocarbons (PAHs), dioxins and furans and hexachlorbenzene (HCB).
- Austria's annual obligations under the European Council Decision 280/2004/EC ("Monitoring Decision"; replacing Decision 389/1992/EEC amended by Decision 296/1999/EEC) concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol..
- Austria's obligation under the United Nations Framework Convention on Climate Change. Relevant COP Decisions and Guidelines are:

  - 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).

  - Document FCCC/CP/1999/7 Review of the Implementation of Commitments and of other Provisions of the Convention – UNFCCC Guidelines on Reporting and Review revised with Document FCCC/CP/2002/8.

  - Decision 11/CP.4 National communications from Parties included in Annex I to the Convention.

  - Document FCCC/CP/2001/13/Add.3 Report of the Conference of the Parties on its seventh session, held at Marrakech from 29 October to 10 November 2001, Addendum, Part two: Action taken by the Conference of the Parties, Volume III (Decision 20/CP.7: Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol; Decision 21/CP.7: Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol; Decision 22/C.7: Guidance for the preparation of the information

[4] http://unfccc.int/resource/webdocs/iri(2)/2001/aut.pdf, http://unfccc.int/resource/webdocs/iri(3)/2001/aut.pdf, http://unfccc.int/program/mis/ghg/countrep/autrep03.pdf and http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_centralized_review_austria.pdf

required under Article 7 of the Kyoto Protocol; Decision 23/CP.7: Guidelines for review under Article 8 of the Kyoto Protocol).

- Obligation under the Austrian Ambient Air Quality Law[5] comprising the reporting of national emission data on SO_2, NO_X, NMVOC, CO, heavy metals (Pb, Cd, Hg), benzene and particulate matter.
- Austria's obligation according to Article 15 of the European IPPC Directive 1996/61/EC is to implement a European Pollutant Emission Register (EPER). Article 15 of the IPPC Directive can be 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.

1.2.2 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: SO_X 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.

1.2.3 Institutional arrangements in place

The Umweltbundesamt is designated as single national entity responsible for preparation of the annual greenhouse gas inventory by law: the Environmental Control Act ("Umweltkontrollgesetz"; Federal Law Gazette 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 the data basis for fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. Thus the Umweltbundesamt prepares and annually updates the Austrian air emissions inventory ("Österreichische Luftschadstoff-Inventur OLI"), which covers greenhouse gases and emissions of other air pollutants as stipulated in the reporting obligations further explained in the following Chapter.

[5] AUSTRIAN AMBIENENT AIR QUALITY LAW (1997): Immissionsschutzgesetz-Luft. Federal Law Gazette I 115/1997.

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 be a basis for policies to reduce emissions.

Regulations under the UNFCCC and the Kyoto Protocol define new standards for national emission inventories. Therefore the present National Inventory System Austria is currently being adapted to meet all the requirements according Article 5.1 of the Kyoto Protocol (see following sub chapter).

Within the Umweltbundesamt the department of air emissions, with its head Manfred Ritter, is responsible for preparation of the inventory and all work related to inventory preparation. The department for climate change, with its head Klaus Radunsky, is responsible for the quality management of the greenhouse gas inventory.

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

- the Austrian statistical office (Statistik Austria) is required by contract to annually prepare the national energy balance as the most important data basis for the Austrian Air Emissions Inventory (the contract also covers some quality aspects).
- the ordinance that regulates monitoring and reporting in the context of the EU Emissions Trading scheme in Austria[6] also regulates that data reported from the plant operators will be used for the inventory, thus ensuring consistency of data sets. 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 sources (see Chapter 4 for details). However, first data from the EU Emissions Trading scheme will be only available for the year 2005, this data will be considered in the submission 2007.
- According to national legislation, the Austrian statistical office also has to annually prepare import/export statistics, production statistics and statistics on agricultural issues (livestock counts etc.), which is an important data basis for calculating emissions from the Sectors *Industrial Processes*, *Solvents and Other Product Use* and *Agriculture*.
- According to the Landfill Ordinance [Deponieverordnung (Federal Gazette BGBl. Nr 164/1996)], which came into force in 1997, the operators of landfill sites have to report their activity data annually to the UMWELTBUNDESAMT, where they are stored in the database for solid waste disposals (*Deponiedatenbank*). This data is the main data basis for calculating emissions from the waste sector.
- Since 2004 there is also a reporting obligation under the Austrian Fluorinated Compounds (FC)-regulation[7] for users of FCs in the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. This data is used for estimating emissions from the consumption of fluorinated compounds (*IPCC Category 2 F*).

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[6] „Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Überwachung und Berichterstattung betreffend Emissionen von Treibhausgasen“ Federal Law Gazette 458/2004

[7] „Industriegas-Verordnung (HFKW-FKW-SF6-VO)“; Federal Law Gazette 447/2002

1.2.4 Adaptation of NISA according to the Kyoto Protocol

Regulations under the UNFCCC and the Kyoto Protocol define 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, no later than one year prior to the start of the first commitment period. Also the European Community has to implement such a national system, and as this system also bases upon the national systems of the member states, member states are required to implement their national system earlier than required by the UNFCCC and the KP, by 31 December 2005 (Article 4 of the Monitoring Mechanism Decision 280/2004/EC).

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 is 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, which is currently being finalized, has a structure as illustrated in Figure 1.

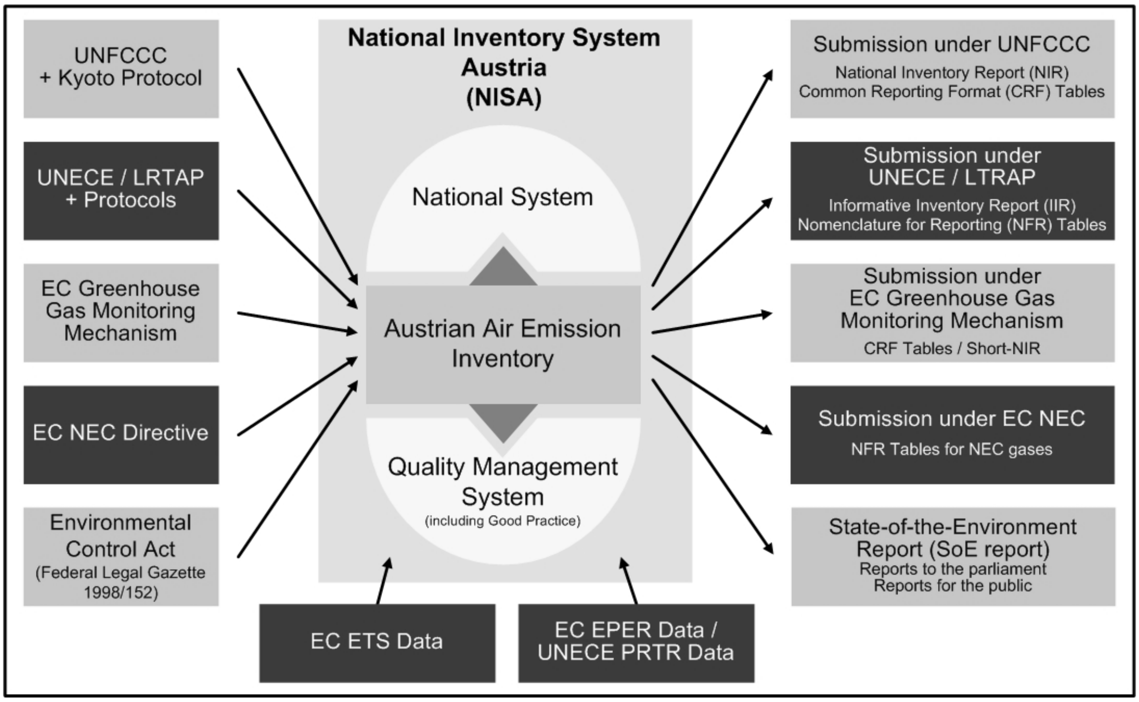

Figure 1: Structure of the emission inventory system in Austria (NISA)

The Austrian Air Emission Inventory comprising all air pollutants stipulated in the various national and international obligations will be the centre of NISA. The national system and the quality management system are 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 20/CP.7) describe the elements which shall be included in a national system. The main characteristics are that the national system shall ensure 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 system,
- to prepare national annual inventories and supplementary information in timely manner and
- to provide information necessary to meet the reporting requirements.

Specific functions in these guidelines are the inventory planning, preparation and management.

Austria is taking significant steps to ensure 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 already been made to prepare NISA to meet the requirements of the Kyoto Protocol:

- the Umweltbundesamt has been designated as single national entity responsible for inventory preparation: the Environmental Control Act ("Umweltkontrollgesetz"; Federal Law Gazette 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 the data basis for fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. For further institutional arrangements in place please refer to sub chapter 1.2.3)
- Development of a quality management system
- Implementation of the quality management system
- First comprehensive uncertainty analysis (and an update for key sources where methodologies have been improved since then)
- Identification of key source categories

The inventory preparation process is described in the following sub chapter.

In 2005 the national system will be evaluated and further improved to be fully in line with the requirements of Article 5.1 of the Kyoto Protocol.

1.3 Inventory Preparation Process

The present Austrian greenhouse gas inventory for the period 1990 to 2003 was compiled according to the recommendations for inventories set out in the UNFCCC reporting guidelines according to Decision 18/CP.8, the Common Reporting Format (CRF)[8] (version 1.01), Decision 13/CP.9, the new CRF for the Land Use Change and Forestry Sector, the IPCC 1996 Guidelines for National Greenhouse Gas Inventories, which specify the reporting obligations according to Articles 4 and 12 of the UNFCCC [IPCC Guidelines, 1997] as well as the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories [IPCC GPG, 2000].

The preparation of the inventory includes the following three stages:

(i) inventory planning

(ii) inventory preparation and

(iii) inventory management.

In the first stage specific responsibilities are defined and allocated: as mentioned before, the UMWELTBUNDESAMT has the overall responsibility for the national inventory, comprising greenhouse gases as well as other air pollutants. Within the inventory system specific responsibilities for the different emission source categories are defined ("sector experts"), as well as for all activities related to the preparation of the inventory, including QA/QC, data management and reporting.

In Austria, emissions of greenhouse gases are estimated together with emissions of air pollutants in a single data base based on the CORINAIR (CORe INventory AIR)/ SNAP (Selected Nomenclature for sources of Air Pollution) systematic. 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.

Like the IPCC Sectors of the CRF format the CORINAIR system has its own nomenclature, called SNAP (Selected Nomenclature for sources of Air Pollution), which may be expanded by so called SPLIT codes and additionally each SNAP/SPLIT category can be extended using a fuel code, a four digit alphanumeric code. The first three digits are based on the NAPFUE code (further information about fuel codes can be found in Chapter 3, the source analysis of the sector Energy).

In the second stage, 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 methodological choices and for contracting studies, if needed. 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.

As mentioned above, the Austrian Inventory is based on the SNAP systematic, 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. Additionally to the actual emission data also the background tables of the CRF are filled in by the sector experts, and finally

[8] http://www.unfccc.de/resource/CRFV1_01o01.zip

QA/QC procedures as defined in the inventory planning process are carried out before the data is 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 collection is performed 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 is stored on a central network server which is backed up daily for the needs of data security. The inventory management also includes quality management as well as documentation on QA/QC activities (see Chapter 1.6).

1.4 Methodologies and Data Sources Used

The following table presents the main data sources used for activity data as well as information on who did the actual calculations:

Table 4: Main data sources for activity data and emission values

Sector	Data Sources for Activity Data	Emission Calculation
Energy	Energy Balance from STATISTIK AUSTRIA, Steam boiler database;	UMWELTBUNDESAMT, plant operators
Industry	National production statistics, import/export statistics, direct information from industry or associations of industry;	UMWELTBUNDESAMT, plant operators
Waste	Database on landfills	UMWELTBUNDESAMT
LUCF	National forest inventory obtained from the Austrian Federal Office and Research Centre for Forest	UMWELTBUNDESAMT
Solvent	Import/ export statistics, production statistics, consumption statistics;	Contractor: Forschungsinstitut für Energie und Umweltplanung, Wirtschaft und Marktanalysen GmbH and Institut für industrielle Ökologie*
Agriculture	National Studies, national agricultural statistics obtained from STATISTIK AUSTRIA;	Contractors: University of Natural Resources and Applied Life Sciences, Research Center Seibersdorf;

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

A complete list of data sources for activity and emission data or emission factors used by sector can be found on page 297.

If emission data are reported (e.g. by the plant owner) this data is taken over into the inventory. This method is mainly used for large point sources.

If no such information is available an emission factor is multiplied with the activity data to obtain the emission data for a specific source. This method is mainly used for area sources.

For the preparation of the greenhouse gas inventory, the UMWELTBUNDESAMT prefers 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, national emission factors are used or, if there are no national emission factors, international emission factors are used to estimate the emissions.

The main sources for emission factors are:

- National studies for country specific emission factors
- IPCC GPG
- Revised IPCC 1996 Guidelines
- EMEP/CORINAIR Guidebook

Table *Summary 3* of the CRF (Summary Report for Methods and Emission Factors Used) 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 source 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).

Main Data Suppliers

The main data supplier for the Austrian air emission inventory is STATISTIK AUSTRIA who provides the underlying energy source data. The Austrian energy balances are based on several databases mainly prepared by the Ministry of Economic Affairs and Labour, "Bundeslastverteiler" and STATISTIK AUSTRIA. Their methodology follows the IEA and Eurostat conventions. The aggregates of the 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.

The main data suppliers are also presented in Table 4.

Information about activity data and emissions of the industry sector is obtained from *Association of the Austrian Industries* or directly from individual plants. Activity data for some sources is obtained from STATISTIK AUSTRIA which provides statistics on production data[9]. The methodology of this statistic has changed in 1996, no data is available for that year and there are some product groups that are not reported anymore in the new statistics.

Operators of steam boilers with more than 50 MW report their emissions and their activity data directly to the UMWELTBUNDESAMT. National and sometimes international studies are also used as data suppliers. Operators of landfill sites also report their activity data directly to UMWELTBUNDESAMT. Emissions for the years 1998-2002 are calculated on the basis of these data. Activity data needed for the calculation of non energetic emissions are based on several statistics collected by STATISTIK AUSTRIA and national and international studies.

Data from EPER

The European Pollutant Emission Register (EPER) is the first Europe-wide register for emissions from industrial facilities both to air and to water. The legal basis of EPER is Article 15 of the IPPC Directive (EPER Decision 2000/479/EG), the scope is to provide information to the public[10.]

It is covering 50 pollutants including CO_2, CH_4, N_2O, SF_6 and PFCs. However, emissions only have to be reported if they exceed certain thresholds.

The Umweltbundesamt implemented EPER in Austria using an electronic system that enabled the facilities and the authorities to fulfil the requirements of the EPER decision electronically via the internet.

The Austrian industrial facilities had to report their annual emissions of the year 2001 or 2002. There were about 400 facilities in Austria, that had to report to EPER. As the thresholds for reporting emissions are relatively high only about 130 of them reported emissions according to the EPER Regulation. The plausibility of the reports were checked by the competent authorities. The Umweltbundesamt finally checked the data for completeness and consistency with the national inventory.

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[9] "Industrie und Gewerbestatistik" published by STATISTIK AUSTRIA for the years until 1995; "Konjunkturstatistik im produzierenden Bereich" published by STATISTIK AUSTRIA for the years 1997 to 2000.

[10] data can be obtained from: http://www.umweltbundesamt.at/umweltdaten/datenbanken10/eper/

However, data from EPER could not be used as data source for the national inventory. On one hand this is due to the high threshold for emissions reporting, that's why for example only four facilities reported N_2O emissions and no reported fluorinated compounds. On the other hand this is because the EPER report only contains very little information beyond the emission data, the only information included is whether emissions are estimated, measured or calculated, also included is one activity value that is often not useful in the context of emissions.

Additionally emission information of EPER is not complete regarding IPCC sectors, and it is difficult to include this point source information when no background information (as fuel consumption data) is available.

Thus the top-down approach of the national inventory was considered more reliable and data of EPER was not used as point source data for the national inventory.

1.5 Key Source Analysis

The identification of key source categories is described in the IPCC Good Practice Guidance [IPCC-GPG, 2000], Chapter 7. It stipulates that a key source category is one that is prioritised within the National System because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both.

All notations, descriptions of identification and results for source and key source categories included in this chapter are based on the IPCC Good Practice Guidance.

The identification includes all reported greenhouse gases CO_2, CH_4, N_2O, HFC, PFC and SF_6, and all IPCC source categories, emissions and removals from LULUCF have not been considered in the key source analysis.

The presented key source analysis was performed by UMWELTBUNDESAMT with data for greenhouse gas emissions of the submission 2005 to the UNFCCC and comprises a level assessment for all years between 1990 and 2003 and a trend assessment for the trend of the years 1996 to 2003 with respect to base year emissions (base year for CO_2, CH_4, N_2O is 1990 and 1995 for HFC, PFC and SF_6).

1.5.1 Austria's Key Source Categories

This chapter presents the results of Austria's key source analysis. The methodology is described in Chapter 1.5.2.

The identified key source categories are listed in Table 5. They comprise 81 771.3 Gg CO_2e in the year 2003, which is a share of 96.6% of Austria's total greenhouse gas emissions (without LUCF).

Table 5: Austrian key source categories based on emission data submitted 2005 to the UNFCCC

IPCC Category Description		Gas	Emissions 2003 [Gg CO_2e]	Share in National Total Emissions 2003
1 A gaseous	Fuel Combustion (stationary)	CO_2	16 569.4	18.1%
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	1 110.7	1.2%
1 A 1 a other	Public Electricity and Heat Production	CO_2	402.7	0.4%
1 A 1 a solid	Public Electricity and Heat Production	CO_2	6 913.3	7.6%
1 A 1 b liquid	Petroleum refining	CO_2	2 051.0	2.2%
1 A 2 mob-liquid	Manufacturing Industries and Constr.	CO_2	1 104.7	1.2%
1 A 2 other	Manufacturing Industries and Constr.	CO_2	344.8	0.4%
1 A 2 solid	Manufacturing Industries and Constr.	CO_2	4 545.3	5.0%
1 A 2 stat-liquid	Manufacturing Industries and Constr.	CO_2	2 347.6	2.6%
1 A 3 b diesel	Road Transportation	CO_2	15 099.5	16.5%
1 A 3 b gasoline	Road Transportation	CO_2	6 783.4	7.4%
1 A 3 b gasoline	Road Transportation	N_2O	164.6	0.2%
1 A 4 biomass	Other Sectors	CH_4	271.9	0.3%
1 A 4 mob-diesel	Other Sectors	CO_2	1 418.7	1.5%

IPCC Category Description		Gas	Emissions 2003 [Gg CO_2e]	Share in National Total Emissions 2003
1 A 4 solid	Other Sectors	CO_2	669.9	0.7%
1 A 4 stat-liquid	Other Sectors	CO_2	7 701.6	8.4%
2 A 1	Cement Production	CO_2	1 735.7	1.9%
2 A 2	Lime Production	CO_2	546.6	0.6%
2 A 7 b	Magnesit Sinter Plants	CO_2	373.5	0.4%
2 B 1	Ammonia Production	CO_2	493.6	0.5%
2 B 2	Nitric Acid Production	N_2O	883.4	1.0%
2 C 1	Iron and Steel Production	CO_2	4 513.1	4.9%
2 C 3	Aluminium production	PFCs	0.0	0.0%
2 C 4	SF_6 used in Al and Mg Foundries	SF_6	0.0	0.0%
2 F 1/2/3	ODS Substitutes	HFCs	1 304.7	1.4%
2 F 6	Semiconductor Manufacture	FCs	483.0	0.5%
2 F 8	Other Sources of SF_6	SF_6	185.1	0.2%
3	Solvent and Other Product Use	CO_2	193.6	0.2%
4 A 1	Cattle	CH_4	2 887.7	3.2%
4 B 1	Cattle	N_2O	449.5	0.5%
4 B 1	Cattle	CH_4	588.3	0.6%
4 B 8	Swine	CH_4	410.3	0.4%
4 D 1	Direct Soil Emissions	N_2O	1 414.1	1.5%
4 D 3	Indirect Emissions	N_2O	1 016.1	1.1%
6 A	Solid Waste disposal on land	CH_4	2 828.9	3.1%
6 B	Wastewater handling	N_2O	192.4	0.2%

The key source with the highest contribution to national total emissions is *1 A Fuel Combustion – gaseous fuels*, this source has not been further disaggregated for the key source analysis because the same emission factor is used for all sub categories. The contribution to national total emissions in the base year was 14.1% compared to 18.1% in 2003. It ranked number one in all level assessments, and number two in all trend assessments – the trend of emissions from this category was almost plus 50%.

The second most important source for greenhouse gas emissions in Austria is *1 A 3 b Road Transportation - diesel oil (CO_2)* for the years since 1995 and *1 A 3 b Road Transportation – gasoline (CO_2)* for the years after 1995, respectively. The contribution to national total emissions in the base year was 5.1% for diesel and 10.1% for gasoline, respectively, whereas in the last year of the inventory, namely 2003, the contribution was 16.5% and7.4% respectively. Furthermore, *1 A 3 b Road Transportation - diesel oil (CO_2)* was the most important source of GHG emissions regarding the trend of emissions: emissions increased by 276% since the base year (this source ranked number one in all trend assessments).

The third most important source regarding the contribution to national total emissions is *1 A 4 stationary-liquid* (commercial and residential plants and plants in agriculture and forestry as well as off road traffic of these sources), it was the third important source for all years. It was also rated a key source in all trend assessments (ranks: 7-13). In the year 2003 it contributed 8.4%

to national total greenhouse gas emissions, emissions from this source increased by 4% from 1990 to 2003.

Comparison to last year's submission

There is a difference in the identified key source categories compared to the results of last year's analysis, as the methodology this year follows more closely the guidance of the GPG (also recalculations and introduction of new source categories might change the result of the KS analysis; for further information see Chapter 9 Recalculations and Improvements).

Compared to last year's key source analysis, one source – 6 B Waste Water Handling - has additionally been identified as key source.

The following key sources have been identified in last year's analysis but not in this:

- *1 A 1 c liquid Manufacture. of Solid fuels and Other Energy Industries* (CO_2)
- *2 A 3 Limestone and Dolomite Use* (CO_2)
- *2 C 3 Aluminium Production* (CO_2)
- *3 Solvent and Other Product Use (N_2O)*

The main reason is that the methodology has changed compared to last years analysis (now the aggregation follows more closely the proposal of the GPG[11]), but also recalculations and newly added source categories might influence the result.

1.5.2 Description of Methodology

The method used to identify key source categories follows the Tier 1 method - quantitative approach described in the Good Practice Guidance [IPCC-GPG, 2000], Chapter 7 *Methodological Choice and Recalculation*.

The analysis includes all greenhouse gases reported under UNFCCC: CO_2, CH_4, N_2O, HFC, PFC and SF_6. All IPCC source categories are included, except emissions and sinks of LULUCF are not included.

The identification of key source categories consists of three steps:

- Identifying source categories
- Level Assessment
- Trend Assessment

Level of disaggregation and identification of key source categories

To identify key source categories total emissions have been split into those source categories that have been estimated using the same methodology and the same emission factor.

Table A1.3 of Annex 1 presents the determined 153 source categories and their greenhouse gas emissions expressed in CO_2 equivalent emissions for the years 1990 to 2003.

[11] This year CO2 emissions from gaseous fuels of category 1 A Combustion Activities have been aggregated because the same emission factor is used, whereas in all previous key source analysis this source has been split into sub sources.

Further details and a list of the source categories and key source categories for each category are given in the corresponding subchapter of the chapter analysis chapters *3 Energy – 8 Waste*.

Level Assessment

For the Level Assessment the contribution of GHG emissions (expressed in CO_2-equivalent emissions) of each source category to national total emissions was calculated. The calculation was performed for the years 1990 to 2003 according to Equation 7.1 of the GPG. Then the sources were ranked in descending order of magnitude according to the results of the level assessment and finally a cumulative total was calculated.

For the year 2003, 29 source categories comprised > 95% of the cumulative total and were thus rated as key sources. For the years 1991 and 2002 30 source categories were identified as key sources in the level assessment, for 1992 33 and for all other years 31 categories were identified as key sources. The results of each level assessment is presented in Annex 1.

Trend Assessment

The Trend Assessment identifies source categories that have a different trend compared to the trend of the overall inventory. As differences in trend are more significant to the overall inventory level for larger source categories, the result of the trend difference (i.e. the source category trend minus total trend) is weighted according to the source's level assessment.

For the Trend Assessment emissions of the years 1996 to 2003 were compared with base year emissions (1990 for CO_2, CH_4, N_2O and 1995 for HFCs, PFCs and SF_6), resulting in eight calculations.

The calculation was performed according to Equation 7.2 of the GPG. The results were ranked in descending order of magnitude and a cumulative total was calculated. Those sources that make up > 95% of the total trend were rated key source categories. Between 22 and 26 sources were identified as key source categories for the different trend assessments. Results are presented in Annex 1.

Identification of key source categories

Any source category meeting the 95% threshold in any year of the Level or the Trend Assessment is considered as key source. The key sources are presented in Table 5 in ascending IPCC category order, in Annex 1 they are presented together with their ranking of all assessments where they are within the 95% threshold.

Consequences of key source category selection

Whenever a method used for the estimation of emissions of a key source category is not consistent with the requirements of the IPCC Good Practice Guidance, the method will have to be improved in order to reduce uncertainty, which is considered in the emission inventory improvement programme (see Chapter 9.4).

1.6 Quality Assurance and Quality Control (QA/QC)

A quality management system (QMS) has been designed to contribute to the objectives of *good practice guidance*, namely to improve transparency, consistency, comparability, completeness and confidence in national inventories of emissions estimates. After having been fully implemented during the development of the UNFCCC submission 2004, the accreditation audit of the *Department for Air Emissions* as inspection body is scheduled to take place in autumn 2005.

The International Standard ISO17020 and the Compilation of the National Greenhouse Gas Inventory

The QMS was drawn up to meet requirements of the International Standard ISO/IEC 17020:1998 *General Criteria for the operation of various types of bodies performing inspections*. The International Standard ISO 17020 has replaced the European Standard EN 45004. This standard covers the functions of bodies whose work includes assessments of conformity against requirements, and the subsequent reporting of results of these activities to clients and, when required, to supervisory authorities. In the case of greenhouse gas emissions inventories, inspection covers the collection of emission data and/or of data which are used to estimate emissions, application of IPCC, CORINAIR and country specific methodologies to estimate emissions, compilation of the emissions inventory and the determination of conformity with national emissions reduction targets. The QMS ensures that all requirements of a Type A inspection body as stipulated in ISO 17020 are met, including strict independence, impartiality and integrity of accredited bodies.

Inspection bodies carry out assessments on behalf of private clients, their parent organisations, and/or official authorities with the objective of providing information to those parties relative to conformity with regulations, standards, or specifications. 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 17020.

According to ISO 17020, *accreditation* is the procedure by which an authorized body - in Austria this is the Federal Ministry of Economic Affairs and Labour - formally recognizes that an organisation is competent to perform a given conformity-assessment activity.

A Type A inspection body provides "third party" services. This means that the inspection body shall be independent of the parties involved (e.g. industry, government). The inspection body and its staff responsible for carrying out the inspection shall not be the authorized representative of any of these parties. Furthermore, the inspection body and its staff shall not engage in any activities that may conflict with their independence of judgement and integrity in relation to their inspection activities. Finally, all interested parties shall have access to the services of the inspection body. There shall not be undue financial or other conditions. The procedures under which the body operates shall be administered in a non-discriminatory manner.

The International Standard ISO 17020 has been drawn up with the objective of promoting confidence in those bodies performing inspections which conform to it. The ISO 17020 takes into account requirements and recommendation of European and international documents such as the ISO 9000 (EN/ISO 9000) series of standards and Guide EA-5/01 (Guidance on the Application of EN 45004 which is identical with ISO 17020, European Co-operation for Accreditation, 2003).

ISO 17020 forms part of the following series of standards covering testing, inspection and certification.

- ISO 17000 (Conformity assessment – vocabulary and general principles)
- ISO 17011 (General requirements for bodies providing assessment and accreditation)
- ISO 17020 (General criteria for the operation of various types of bodies performing inspection) replacing EN 45004
- ISO 17021 (Conformity assessment: Requirements of bodies providing audit and certification of management systems) replacing EN 45012 (General criteria for certification bodies operating quality system certification)
- ISO 17024 (Conformity assessment - General requirements for bodies operating certification of persons) replacing EN 45013 (General criteria for certification bodies operating certification of personnel)
- ISO/IEC 17025 (General requirements for the competence of testing and calibration laboratories) replacing EN 45001 (General criteria for the operation of testing laboratories)
- EN 45002 (General criteria for the assessment of testing laboratories)
- EN 45003 (General criteria for the laboratory accreditation bodies)
- EN 45010 (General Criteria for the assessment and accreditation of certification bodies)
- EN 45011 (General criteria for certification bodies operating product certification)
- EN 45020 (General terms and their definitions concerning standardisation and related activities)

Quality Management System (QMS)

The Quality Assurance and Quality Control (QA/QC) procedures within the QMS correspond to the QA/QC system outlined in IPCC-GPG Chapter 8 "Quality Assurance and Quality Control".

The implementation of QA/QC procedures as required by IPCC-GPG support the development of national greenhouse gas inventories that can be readily assessed in terms of quality and completeness. A QMS goes beyond QA/QC activities and comprises supporting and management processes in addition to the QA/QC procedures in inventory compilation. A system of standard operating procedures (SOPs) ensures agreed standards as well as transparency within (i) the inventory compilation process (ii) supporting processes (e.g. achieving) and (iii) management processes (e.g. annual management reviews, internal audits, regular training of personnel, error prevention).

With the Kyoto Protocol having entered into force, 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 *Department of Air Emissions* at the UMWELTBUNDESAMT has decided to implement a QMS based on the International Standard ISO 17020 *General Criteria for the operation of various types of bodies performing inspections*. The QMS ensures the fulfilment of requirements as stipulated in Chapter 8 of the IPCC-GPG. The department has scheduled its accreditation audit for autumn 2005.

The *Department of Air Emissions* of the UMWELTBUNDESAMT has implemented a QMS based on the International Standard ISO 17020. This process-based approach is illustrated in Figure 2.

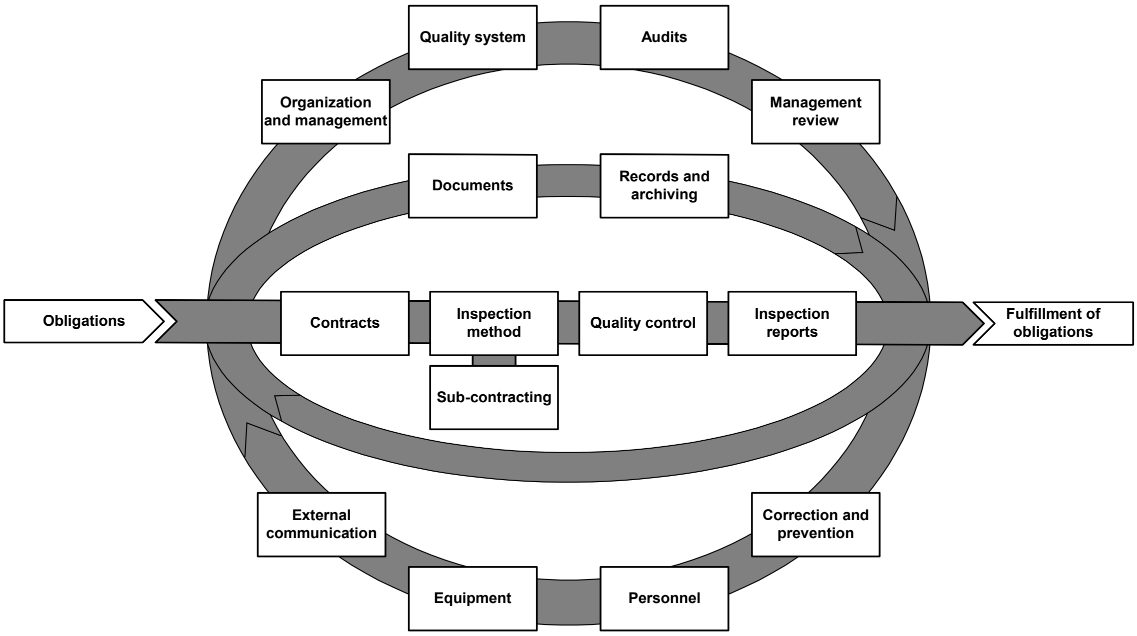


Figure 2: Process-based QMS (the outer circle corresponds to management processes, the straight line to realisation processes and the inner circle to supporting processes)

The QMS is characterized by a *process based approach*, referring to the application of three processes within its organisation, along with the identification and interactions of these processes and their management.

1) **Management processes** (outer circle)

Management Processes comprise all activities necessary for management and control of an organisation, e.g. organisation and management, quality system, audits, quality management review, corrective actions and prevention, personnel, equipment, 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 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.

2) **Realisation processes (horizontal bar)**

Realisation processes are the *Department of Air Emissions* core competences as they concern the compilation of emission inventories. The first process constitutes a contract control system which ensures that methods to be used are selected in advance, taking into account that for key source categories the most accurate method, i.e. the method with the lowest uncertainty, is the most appropriate. 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. The country-specific methods have to be 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. Any subcontractor performing part of the inspection is required to work in compliance with ISO 17020.

3) Supporting processes (inner circle)

Supporting processes support both management and realisation processes. They include a control system for all documents and data as well as for records and their archiving.

The quality management system is in compliance with all relevant requirements addressed in the IPCC-GPG.

Accreditation Act

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, partially or in total for all or part of the testing, inspection or certification body's scope of accreditation. It requires re-assessment in the event of changes affecting the activity and operation of the testing, inspection or certification body, such as changes in personnel or equipment, or if analysis of a complaint or any other information indicates that the testing, inspection or certification body no longer complies with the requirements of the accreditation body.

In Figure 3 the inter-relationship between the Austrian Accreditation Act, the EN 45000/ISO 17000 series and the ISO 9000 series is shown.

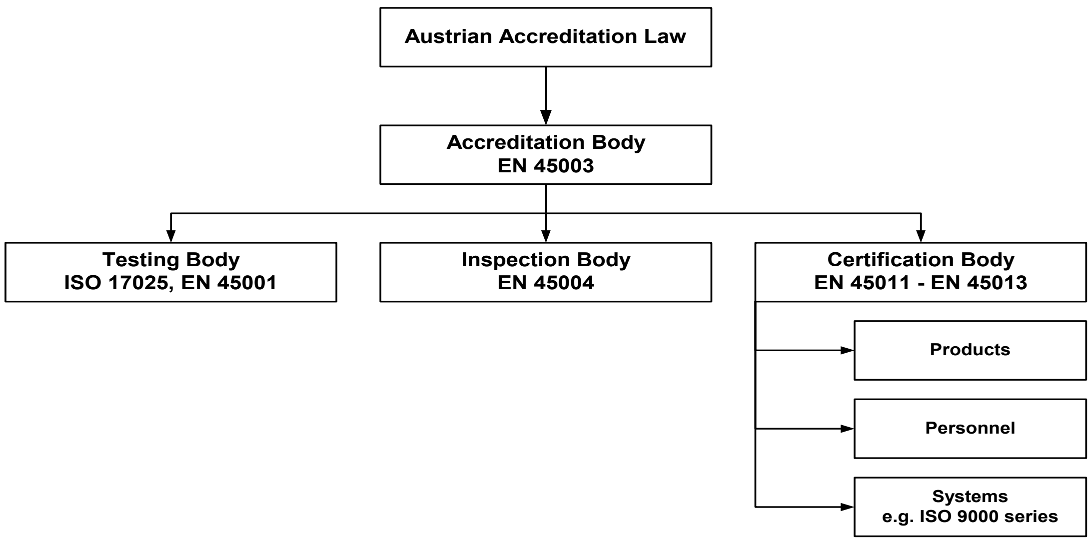


Figure 3: Inter-relationship between the Austrian Accreditation Act, the EN 45000/ISO 17000 series and the ISO 9000 series.

The personnel of the inspection body have to 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 the real emissions as truly as possible.

Reports issued by an accredited body may carry the federal emblem in addition to the accreditation logo. These reports are official documents.

QA/QC Activities

During the year 2004 QA/QC activities were focused on transparent documentation, adaptation of SOPs (Standard Operation Procedures) to be more practical and user friendly. SOPs comply with both IPCC-GPG and ISO 17020 requirements. QC procedures follow the recommendations of IPCC-GPG chapter 8 on *Quality Assurance and Quality Control*. Priority is given to key sources. For all sources, fundamental checks such as completeness of estimates, time series consistencies, data transcription and documentation are performed. For key sources, activity data, emission factors, emissions and uncertainty analysis are assessed using the Tier 1 checklist. In addition, where applicable Tier 2 QC procedures are employed. Special attention is given to documentation, achieving and reporting as outlined in chapter 8.10 of IPCC-GPG.

One of the core activities was the re-design of the key management process "Corrective and Preventive Actions". An efficient process was established to gain transparency when collecting and analyzing findings by UNFCCC reviews experts or any other discrepancies found during inventory compilation. Any findings and discrepancies are documented, responsibilities, resources and a time schedule are attributed to each of these. A periodic review assesses the progress of the inventory improvement process.

Table 6 presents the timetable for the implementation of the quality management system:

Table 6: Timetable for steps

Step	Date
1. Development of a quality management system including quality manual	1999 – 2002
2. Implementation of the quality management system	2003 – 2004
3. Accreditation of the inspection body	2005

1.7 Uncertainty Assessment

In this submission uncertainty estimates for all key sources are presented. They are mainly based on results from the first comprehensive uncertainty analysis that was performed in 2001 based on data from submission 1999 [Winiwarter & Rypdal, 2001].

However, the methodologies for some sectors have been improved. In those cases the uncertainty was estimated for the new methodology. Furthermore, the first uncertainty analysis did not cover fluorinated compounds. Thus for key sources regarding FC emissions uncertainty estimates are presented for the first time.

The following table presents uncertainties for activity data and emission factors (or a combined uncertainty) for all key sources[12]. For information on the uncertainty estimates of the different sources please refer to the respective chapters of this report.

Table 7: Uncertainty estimates for key sources

IPCC Category	Description	Gas	AD	EF	Combined
			Uncertainty[13] [%]		
1 A gaseous	Stationary Combustion	CO_2	2	0.5	2.1
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	0.5	0.5	0.7
1 A 1 a other	Public Electricity and Heat Production	CO_2	10	20	22.4
1 A 1 a solid	Public Electricity and Heat Production	CO_2	0.5	0.5	0.7
1 A 1 b liquid	Petroleum refining	CO_2	0.5	0.5	0.7
1 A 1 c liquid	Manuf. of Solid fuels and Other Energy Ind.	CO_2	0.5	0.5	0.7
1 A 2 mob-liquid	Manufacturing Industries and Construction	CO_2	1	0.5	0.7
1 A 2 solid	Manufacturing Industries and Construction	CO_2	1	0.5	0.7
1 A 2 stat-liquid	Manufacturing Industries and Construction	CO_2	1	0.5	0.7
1 A 2 other	Manufacturing Industries and Construction	CO_2	10	20	22.4
1 A 3 b diesel oil	Road Transportation	CO_2	0.5	0.5	0.7
1 A 3 b gasoline	Road Transportation	CO_2	0.5	0.5	0.7
1 A 3 b gasoline	Road Transportation	N_2O	10	40	41.2
1 A 4 mob-diesel	Other Sectors	CO_2	0.5	0.5	0.7
1 A 4 biomass	Other Sectors	CH_4	10	50	51.0
1 A 4 gaseous	Other Sectors	CO_2	2	0.5	2.1
1 A 4 stat-liquid	Other Sectors	CO_2	0.5	0.5	0.7

[12] values refer to random uncertainty only (in the comprehensive uncertainty estimate described in Chapter 1.7.1 both random and systematic uncertainties were considered)

[13] referring to 2 standard deviations (95% confidence interval)

IPCC Category	Description	Gas	AD	EF	Combined
			Uncertainty[13] [%]		
1 A 4 solid	Other Sectors	CO_2	0.5	0.5	0.7
2 A 1	Cement Production	CO_2	5	5	7.1
2 A 2	Lime Production	CO_2	5	5	7.1
2 A 3	Limestone and Dolomite Use	CO_2	15	2	15.1
2 A 7 b	Magnesite Sinter Plants	CO_2	5	5	7.1
2 B 1	Ammonia Production	CO_2			5.0
2 B 2	Nitric Acid Production	N_2O			3.0
2 C 1	Iron and Steel Production	CO_2	5	5	7.1
2 C 4	SF6 used in Al and Mg Foundries	SF_6	20	0	20.0
2 C 3	Aluminium production	PFCs	5	2	5.4
2 C 3	Aluminium production	CO_2	5	20	20.6
2 F 6	Semiconductor Manufacture	FCs	5	10	11.2
2 F 1/2/3	ODS Substitutes	HFCs	20	50	53.9
2 F 8	Other Sources of SF6	SF_6	25	50	55.9
3	Solvent and Other Product Use	CO_2	15	10	18.0
3	Solvent and Other Product Use	N_2O	50	0	50.0
4 A 1	Cattle	CH_4			8.0
4 B 1	Cattle	N_2O	10	75	75.7
4 B 1	Cattle	CH_4	10	69	70.1
4 B 8	Swine	CH_4	10	70	70.7
4 D	Agricultural Soils	N_2O			24.0
6 A 1	Managed Waste disposal	CH_4	15	30	33.5

Note: *Uncertainties for activity data for stationary combustion of IPCC Category* 1 A Fuel Combustion *were estimated for gross inland consumption, only random uncertainty was considered.*

No Tier 1 Uncertainty analysis was made with this data, as uncertainties were only available for key sources. Instead National Totals reported for the base year and the year 1995 as reported in the submissions 1998-2005 were compared and the standard deviations were calculated. The following Table presents results from this analysis, giving "uncertainties" as two standard deviations (2σ) relative to the mean value for CO_2, CH_4, N_2O as well as for National Total Emissions (no values for FCs are given, because only two different values were reported during the reporting period 2001-2005, thus no standard deviation could be calculated).

Table 8: Uncertainties for CO_2, CH_4, N_2O as well as for total GHG emissions as derived from reported values for the base year and 1995 in the submissions 1998-2005.

	CO_2	CH_4	N_2O	Total GHG emissions[14]
Base Year	2.5%	19.1%	104.3%	4.1%
1995	2.0%	20.3%	101.2%	5.5%

Note: it was not possible to calculate such "uncertainties" also for the last reporting year (2003) because for this year only one estimate is available. However, it is assumed that for 2003 the uncertainties are in the same range than the given uncertainties for the base year and 1995.

1.7.1 First Comprehensive Uncertainty Analysis

IPCC-GPG requires uncertainty estimates as an essential part of a complete emission inventory. Uncertainty information is not intended to dispute the validity of the inventory as a whole but to help prioritise efforts to improve the accuracy of inventories in the future and guide decisions on methodological choice.

The starting point for any prioritisation of efforts aimed at improving the accuracy of inventories is the identification of key source categories. Based on these categories, the uncertainty is estimated (being itself an input for a possible second step in the identification of key source categories) and as a next step, if required, the methods for emission estimation are adapted.

A first comprehensive uncertainty analysis was performed as a pilot study [WINIWARTER & RYPDAL, 2001] on the greenhouse gases CO_2, CH_4 and N_2O for the years 1990 and 1997. The work was carried out by the *Austrian Research Centres Seibersdorf* to assure independent assessment.

In Table 9 the most important emission sources with respect to uncertainty are listed.

Table 9: Most important emission sources with respect to uncertainty

Emission Source	CO_2	CH_4	N_2O
Energy Conversion	×		×
Industry	×		
Transport	×		×
Energy – Other Sources	×		
Fugitive Emissions – Gas and Liquid Fuels	×		
Industrial Processes – Cement	×		
Metal Industry Processes – Iron and Steel	×		
Enteric Fermentation – Cattle		×	
Agricultural Soils		×	×
Abandonment of Managed Lands	×		
Solid Waste Disposal		×	

[14] including FCs for the reporting years 2001-2005

As regards uncertainty, two aspects were considered: systematic uncertainty and random uncertainty. Random uncertainty covers the fluctuation of a large set of measurements, which may include both the random uncertainty of the measurements and the natural variability of a parameter. A systematic error is the deviation of a result from "reality", a deviation that may be caused by a systematically flawed estimate as well as by the omission or false interpretation of certain data or statistics. The main difficulty in dealing with the systematic error is that it is normally by definition not apparent. Once a systematic error becomes apparent, it can be accounted for and eliminated.

The total uncertainty comprises both systematic and random uncertainty and reflects the current situation, whereas the random uncertainty can be established under ideal conditions with the inventory techniques currently available.

Table 10 shows the estimates for total uncertainty including systematic uncertainty and random uncertainty and Table 11 refers to random uncertainty.

Table 10: Total uncertainty of emission data (emissions given in Tg CO_2 equivalent per year, uncertainties given as a percentage of the mean value)

Total uncertainty		CO_2	CH_4	N_2O	Total GHG emissions
1990	Mean value	63.20	9.48	6.59	79.27
	Standard deviation	0.73	2.29	2.95	3.89
	2σ	**2.3%**	**48.3%**	**89.6%**	**9.8%**
1997	Mean value	67.76	8.34	6.81	82.91
	Standard deviation	0.71	1.98	2.93	3.67
	2σ	**2.1%**	**47.4%**	**85.9%**	**8.9%**

Table 11: Random uncertainty of emission data (emissions given in Tg CO_2 equivalent per year, uncertainties given as a percentage of the mean)

Random uncertainty		CO_2	CH_4	N_2O	Total GHG emissions
1990	Mean value	63.54	11.41	1.99	76.94
	Standard deviation	0.30	1.64	0.26	1.73
	2σ	**1.0%**	**28.7%**	**25.6%**	**4.5%**
1997	Mean value	68.05	10.02	2.27	80.34
	Standard deviation	0.34	1.43	0.27	1.53
	2σ	**1.0%**	**28.5%**	**23.9%**	**3.8%**

Regarding the individual greenhouse gases, the emissions of CO_2 have a low uncertainty whereas the uncertainty for N_2O is high. The overall relative uncertainty calculated for the year 1990 was 9,8%, for the year 1997 it was 8.9%. The reduction is due to the increase in CO_2 emissions caused by the use of fossil fuels. These CO_2 emissions have a very low uncertainty in comparison to other greenhouse gas emissions and as they dominate the total greenhouse gas emissions their uncertainty dominates the overall uncertainty. The random uncertainty calculated for the year 1990 was 4,5%, for the year 1997 it was 3,8%.

Procedure

The uncertainty was determined in four steps:

- Step 1: Compilation of emission sources
- Step 2: Prioritisation and first estimate of uncertainty
- Step 3: Uncertainty assessment for input parameters
- Step 4: Monte Carlo analysis

Step 1: Compilation of emission sources

The emission sources had to be compiled so that it was possible to describe emissions in terms of statistically independent parameters. As the Austrian Air Emission Inventory is based on the CORINAIR SNAP Code, these source categories had to be first transformed into IPCC source categories. Emission source categories that are based on common assumptions and use the same emission factors have been aggregated.

Step 2: Prioritisation and first estimate of uncertainty

A prioritisation of input parameters (emission factors and activities or emission data) was performed using three different approaches in order to determine the emission sources with the highest uncertainty and to provide a focus for further assessment. One approach was based on the results for the UK as described by CHARLES et al. (1998), another approach was based on the results for Norway as described by RYPDAL (1999). In case of qualitative estimates of uncertainty (such as low, medium and high) as in the Norwegian study, these categories were transformed into quantitative values (low = 5%, medium = 30%, high = 80%). Based on the method for the UK and Norway a first estimate of uncertainty was made. The third approach was made according to the IPCC-GPG 2000, Chapter 7 (Methodological Choice and Recalculation).

Step 3: Uncertainty assessment for input parameters

Any emission source category that was relevant in at least one of the approaches described in step 2 was analysed more thoroughly with regard to its uncertainty. A detailed uncertainty analysis was performed by quantitative estimation, by literature research or by expert judgement. In the latter case the experts were asked to provide references from the literature so that their uncertainty estimates could be taken into account.

As already mentioned, two aspects were considered regarding uncertainty: systematic uncertainty and random uncertainty.

Step 4: Monte Carlo analysis

The uncertainty data determined in Step 3 were fed into a Monte Carlo analysis. All input parameters were varied to obtain overall uncertainties for each of the greenhouse gases CO_2, CH_4 and N_2O and for their combination as CO_2 equivalent (using values for greenhouse gas warming potentials). The uncertainties for the underlying data (activities and emission factors) were calculated as well.

1.8 Completeness

CRF–Table 9 (Completeness) has been used in order to describe this issue. 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 covered. 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. Austria has no 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, 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 guidelines on reporting and review (FCCC/CP/2002/8).

Allocation to categories may differ from party to party. The main reasons for different allocation to categories are the allocation in national statistics, insufficient information on the national statistics, national methods, and impossibility to disaggregate emission declarations.

- IE (included elsewhere):

"IE" is used for emissions by sources and removals by sinks of greenhouse gases 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 the emissions or removals from the displaced source/sink category have been included. Such deviation from the expected category is explained. It is planned to further improve the level of disaggregation in order to reduce the number of "IE".

- 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 those emissions by sources and removals by sinks of greenhouse gases marked by "NE" there are checkups in progress if they actually are "NO" (not occurring). As a part of the improvement program of the inventory it is planned that those 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 result in emissions or removals of a specific gas. The increase of this number is due to improved completeness of the CRF- tables.

- 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. Activity data for SF_6 from Aluminium Foundries (cast aluminium – sector *2 C 3*) and semiconductor manufacture are reported as confidential.

Compared to submission 2004, both transparency and completeness have increased in each sector. With respect to land use, land use change and forestry (LULUCF), the use of notation keys NE and IE has increased in number, which does not, however, indicate a decrease in transparency and completeness, but is rather due to the new CRF tables for LULUCF requiring emission estimates to be reported at a more disaggregated level. Subcategories were considered at the most disaggregated level available. Overall transparency increased from 95% to 96%, overall completeness – with exception of LULUCF - increased from 96% to 97%, taking account of notation keys in LULUCF, completeness decreased from 94% to 90%. It should be noted, however, that transparency and completeness values are not related to the respective source's contribution to total emissions. Increased completeness and transparency was accomplished by both advanced completeness of inventory estimates and the proper use of notation keys.

Table 12: Transparency and completeness in submissions 2003 and 2004.

Sector	Submission 2004		Submission 2004		Submission 2005		Submission 2005	
	IE	NE	Transparency	Completeness	IE	NE	Transparency	Completeness
1 Energy	26	16	92%	95%	29	12	91%	96%
2 Industrial processes	2	15	100%	97%	4	10	99%	97%
3 Solvents	0	1	100%	95%	0	1	100%	95%
4 Agriculture	6	2	88%	96%	2	0	96%	100%
5 LUCF	3	15	94%	69%	0	76	100%	60%
6 Waste	2	3	93%	89%	2	0	93%	100%
Total	**39**	**52**	**95%**	**94%**	**37**	**97**	**96%**	**90%**
Total number of estimates*	**916**				**1013**			

** (including IE and NE, also including NO an NA)*

*Transparency was calculated as: [1 - (number of IE / number of estimates)]*100*

*Completeness was calculated as: [1 - (number of NE / number of estimates)]*100*

2 TREND IN TOTAL EMISSIONS

According to the Kyoto Protocol, Austria's greenhouse gas emissions have to be 8% below base year emissions during the five-year commitment period from 2008 to 2012. The European Community and its Member States also have a common reduction target of 8%, which they decided to achieve jointly. In April 2002 the Council of the EC has adopted a decision, the so called "burden sharing agreement"[15] which includes reduction targets for each EC Member State. Austria agreed to reduce its greenhouse gas emissions for 2008–2012 by 13% compared to base year emissions (1990 except for fluorinated gases where the base year is 1995).

For Austria, there is also a CO_2 stabilisation target 2000 according to the UNFCCC, which means that by 2000 CO_2 emissions should have been reduced to 1990 levels. However, the member states of the EC agreed to jointly implement this stabilization target and the EC was successful in fulfilling this goal.

2.1 Emission Trends for Aggregated GHG Emissions

Under the burden sharing agreement of the European Union, Austria is committed to a reduction of its greenhouse gases by 13% below 1990 levels by 2008-2012. Table 13 shows the summary of Austria's anthropogenic greenhouse gas emissions 1990-2003.

For CO_2, CH_4 and N_2O the base year is 1990. For the F-gases the year 1995 has been selected as base year, since the data are considered to be more reliable than those from 1990.

Table 13: Summary of Austria's anthropogenic greenhouse gas emissions from 1990-2003

	Greenhouse gas emissions [Gg CO2 equivalent]										Trend
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	BY*-2003
Total	**78 573**	**80 159**	**83 237**	**83 046**	**82 514**	**80 403**	**81 084**	**84 872**	**86 434**	**91 566**	*16.6%*
CO_2	61 263	63 115	66 562	66 527	66 218	64 614	65 454	69 280	70 994	76 213	*24.4%*
CH_4	9 798	9 143	8 959	8 681	8 557	8 366	8 146	8 021	7 856	7 807	*-20.3%*
N_2O	5 712	6 138	5 795	5 891	5 974	5 808	5 759	5 731	5 636	5 542	*-3.0%*
HFCs	219	555	637	730	813	867	1 019	1 122	1 219	1 308	*135.6%*
PFCs	1 079	69	66	97	45	65	72	82	87	103	*49.2%*
SF6	503	1 139	1 218	1 120	908	684	633	637	641	594	*-47.9%*

Total emissions and CO_2 are without LUCF

**BY= Base Year: 1990 for CO_2, CH_4 and N_2O and 1995 for HFCs, PFCs and SF_6*

Note: Global warming potentials (GWPs) used (100 years time horizon): carbon dioxide (CO_2) = 1; methane (CH_4) = 21; nitrous oxide (N_2O) = 310; sulphur hexafluoride (SF_6) = 23 900; hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances

[15] Council Decision of 25 April 2002 (2002/358/CE) concerning the approval, on behalf of the EC, of the KP to the UNFCCC and the joint fulfilment of commitments thereunder

Austria's total greenhouse gases showed an increase of 16.6% from the base year to 2003 (CO_2: +24.4%).

In the period from 2002 to 2003 Austria's total greenhouse gases increased by 5.9%, CO_2 emissions increased by 7.4%. The following figure presents the trend in total GHG emissions 1990-2003 in comparison to Austria's Kyoto reduction target of 13% from the base year 1990 (BY). This figure excludes emissions and removals from land-use change and forestry (LUCF).

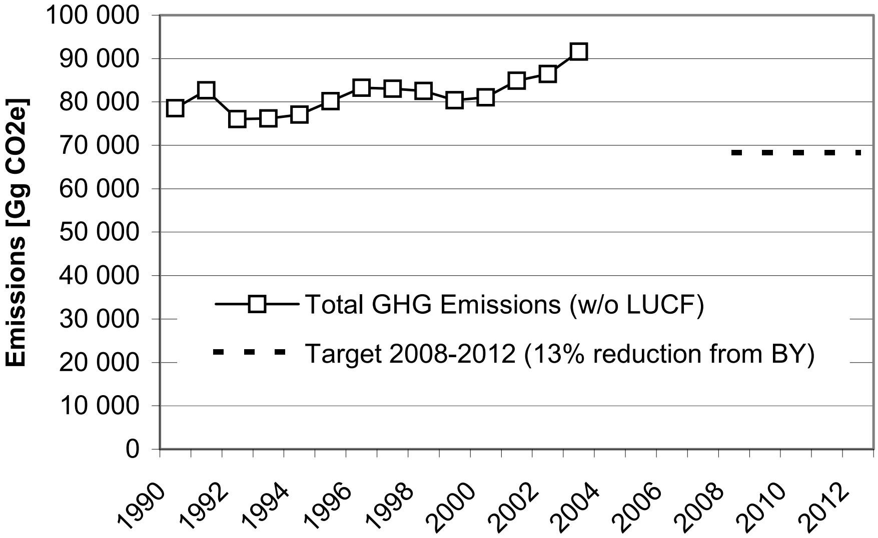


Figure 4: Trend in total GHG emissions 1990-2003

2.2 Emission Trends by Gas

Table 14 presents greenhouse gas emissions of the base year and 2003 as well as their share in total greenhouse gas emissions.

Table 14: Austria's greenhouse gas emissions by gas in the base year and in 2003.

GHG	Base year*	2003	Base year*	2003
	CO_2 equivalent [Gg]		[%]	
Total	**78 535**	**91 566**	***100.0%***	***100.0%***
CO_2	61 263	76 213	*78.0%*	*83.2%*
CH_4	9 798	7 807	*12.5%*	*8.5%*
N_2O	5 712	5 542	*7.3%*	*6.1%*
F-Gases	1 763	2 004	*2.2%*	*2.2%*

Total emissions and CO_2 are without LUCF

**1990 for CO_2, CH_4 and N_2O and 1995 for F-Gases*

The major greenhouse gas in Austria is CO_2, which represented 83.2% of total greenhouse gas emissions in 2003 compared to 78.0% in the base year, followed by CH_4 (8.5% in 2002 respectively 12.5% in the base year), N_2O (6.1% in 2003 and 7.3% in the base year) and finally fluorinated hydrocarbons with a share of 2.2%.

The trend in Austrian greenhouse gas emissions is presented in Figure 5 relative to emissions in the base year (index form: 1990 = 100 for CO_2, CH_4 and N_2O and 1995 = 100 for HFCs, PFCs and SF_6).

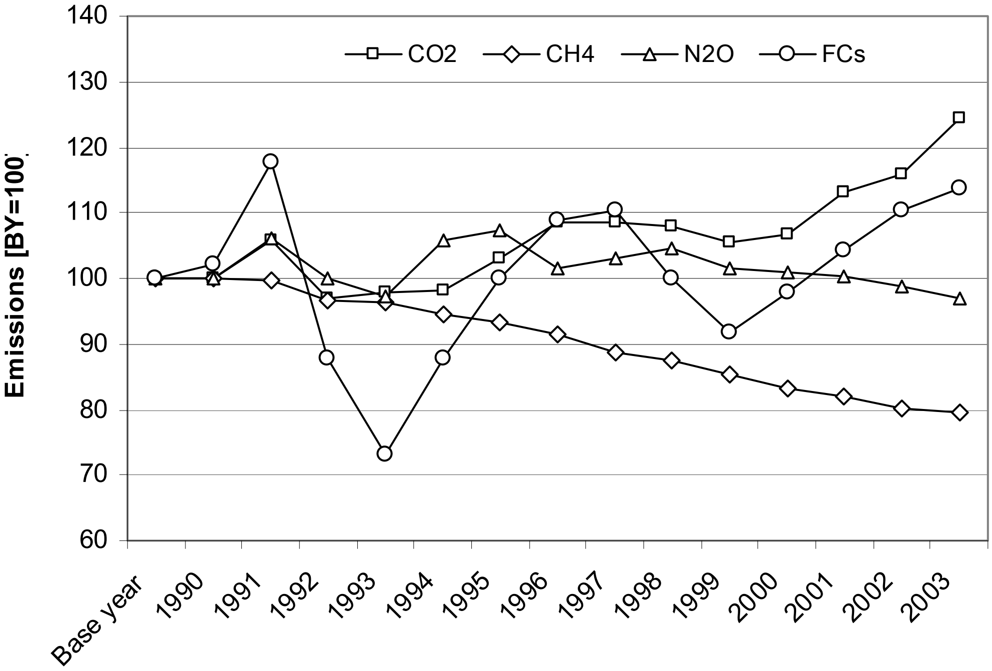


Figure 5: Trend in greenhouse gas emissions 1990-2003by gas in index form (base year = 100)

CO_2

CO_2 emissions have been fluctuating at the beginning of the decade, and after an increase until 1996 followed by a decrease emissions seemed to have stabilized on this level. However, since 2000 emissions are strongly increasing again, from 2000 to 2001 by 6.1%, the next year by 2.5% and again from 2002 to 2003 by 7.4%.

This resulted in a total increase of 24.4% from 1990 to 2003. Quoting in absolute figures, CO_2 emissions increased from 61 263 to 76 213 Gg (see Table 13) during the period from 1990 to 2003 mainly due to higher emissions from transport, which increased by 83%.

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.

According to the Climate Convention Austria's CO_2 emissions should have been reduced to the levels of 1990 by 2000, but the CO_2 stabilisation target for 2000 could not be met. However, the Member States agreed to jointly fulfil this goal and the EC was successful doing so.

CH_4

CH_4 emissions decreased steadily during the period from 1990 to 2003, from 9 798 to 7 807 Gg CO_2 equivalent (see Table 13). In 2003 CH_4 emissions were 20.3% below the level of the base year, mainly due 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 and manure management).

N_2O

N_2O emissions in Austria fluctuated from 1990 to 1995, increasing by 7% over this period. Since then emissions have a moderate decreasing trend, resulting in 5 542 Gg CO_2 equivalent compared to 5 712 in the base year, this is 3% below the level of the base year. The decrease is mainly due lower N_2O emissions from agricultural soils.

The main source of N_2O emissions are agricultural soils with a share of 48% in national total N_2O emissions. Fossil fuel combustion has a share of 15%, nitric acid production which is another important source with regard to national total N_2O emissions had a share of 16%.

HFCs

HFC emissions increased remarkably during the period from 1990 to 2003 from 219 to 1 308 Gg CO_2 equivalent.. In 2000 HFC emissions were 136% above the level of the base year (1995). HFCs are used as substitutes for HCFCs (Hydro Chloro Fluoro Carbons; these are ozone depleting substances), the use of which have been banned for most applications.

PFCs

PFC emissions show the inverse trend as HFC emissions. PFC emissions decreased remarkably during the period from 1990 to 2003, from 1079 to 103 Gg CO_2 equivalent. In 2003 PFC emissions were 49% below the level of the base year (1995).

PFCs are side products of aluminium production, which was terminated in Austria in 1992, since then the main source of PFC emissions is semiconductor manufacture.

SF_6

SF_6 emissions in 1990 amounted to 503 Gg CO_2 equivalent. They increased steadily until 1996 reaching a maximum of 1 218 Gg CO_2 equivalent. Since then they are deceasing, in 2003 SF_6 emissions amounted to 594 Gg CO_2 equivalent, which is 48% below the level of the base year (1995).

The main sources of SF_6 emissions are semiconductor manufacture, magnesium production and filling of noise insulating windows.

2.3 Emission Trends by Source

Table 15 presents a summary of Austria's anthropogenic greenhouse gas emissions by sector for the period from 1990 to 2003:

- Sector 1: Energy
- Sector 2: Industrial Processes
- Sector 3: Solvent and Other Product Use
- Sector 4: Agriculture
- Sector 5: Land-Use Change and Forestry

- Sector 6: Waste

Table 15: Summary of Austria's anthropogenic greenhouse gas emissions from 1990-2003

	Greenhouse gas emissions [Gg CO2 equivalent]									
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total	**78 573**	**80 159**	**83 237**	**83 046**	**82 514**	**80 403**	**81 084**	**84 872**	**86 434**	**91 566**
1	54 946	57 201	61 019	60 283	60 287	58 865	59 015	62 928	64 026	69 331
2	10 153	9 876	9 752	10 345	9 897	9 591	10 329	10 234	10 964	11 046
3	515	422	405	423	405	391	414	426	426	426
4	8 456	8 558	8 089	8 145	8 146	7 860	7 724	7 754	7 553	7 349
5	-9 013	-7 046	-5 192	-11 690	-12 707	-12 637	-13 646	-13 345	-11 311	-12 773
6	4 503	4 102	3 972	3 850	3 778	3 696	3 602	3 530	3 465	3 415

Total emissions are without LUCF

**Base Year: 1990 for CO_2, CH_4 and N_2O and 1995 for HFCs, PFCs and SF_6*

Austria's greenhouse gas emissions by sector in the base year and in 2003 as well as their share and trend are presented in the following table.

Table 16: Austria's greenhouse gas emissions by sector in the base year and in 2003 as well as their share and trend.

GHG	Base year*	2003	Trend BY*-2003	Base year*	2003
	Emissions [Gg CO_2e]			Share [%]	
Total	**78 535**	**91 566**	***16.6%***	***100%***	***100%***
1 Energy	54 946	69 331	*26.2%*	*70%*	*76%*
2 Industry	10 115	11 046	*9.2%*	*13%*	*12%*
3 Solvent	515	426	*-17.3%*	*1%*	*0%*
4 Agriculture	8 456	7 349	*-13.1%*	*11%*	*8%*
5 LUCF	-9 013	-12 773	*41.7%*	*-11%*	*-14%*
6 Waste	4 503	3 415	*-24.2%*	*6%*	*4%*

Total emissions without LUCF

**1990 for CO2, CH4 and N2O and 1995 for HFC, PFC, and SF6*

The dominant sectors are the energy sector, which caused 76% of total greenhouse gas emissions in Austria in 2003 (70% in 1990), followed by the Sector Industrial Processes, which caused 12% of greenhouse gas emissions in 2003 (13% in 1990).

The trend of Austria's greenhouse gas emissions by sector is presented in Figure 6 relative to emissions in the base year 1990.

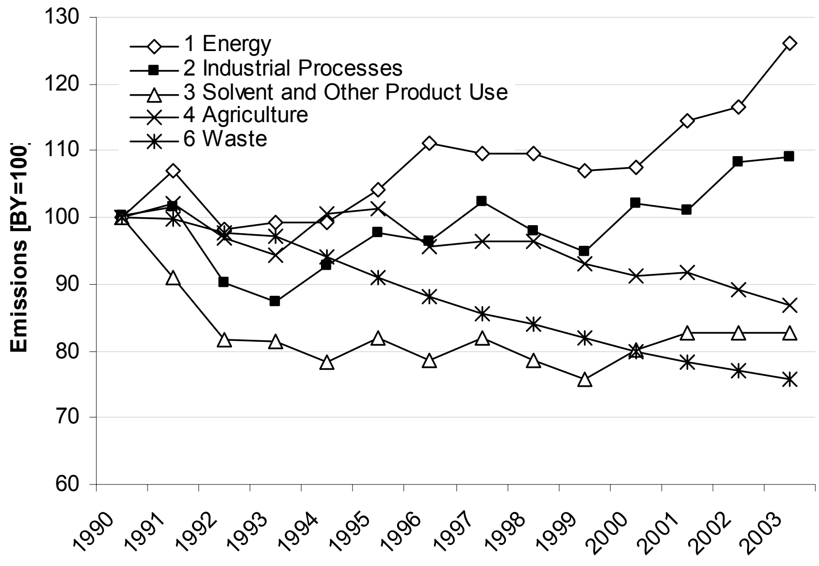


Figure 6: Trend in emissions 1990-2003 by Sector in index form (base year = 100)

2.3.1 Energy (IPCC Category 1)

The trend for greenhouse gas emissions from IPCC category 1 (energy) shows that emissions stabilized between 1996 and 2000, but emissions increased strongly since from 54 946 Gg CO_2 equivalent to 69 331 Gg in 2003, which corresponds to an increase of 26.2%.

99.2% of emissions from this sector in 2003 originated from fossil fuel combustion (Sector *1 A*), fugitive emissions from fuels (Sector *1 B*) are of minor importance.

CO_2 contributes 97.9% to total GHG emissions from *Energy*, N_2O 1.2% and CH_4 0.9%.

The most important energy sub-sectors in 2003 are *1 A 3 Transport* with a share of 33%, followed by *1 A 1 Energy Industries* (23%), *1 A 4 Other Sectors* (22%), and *1 A 2 Manufacturing Industries and Construction* (21%).

The increasing trend from IPCC Category 1 (Energy) is mainly due to a strong increase of emissions from sub-sector *1 A 3 Transport*, which almost doubled from 1990 to 2003 with 82%. Apart from an increase of road performance (miles driven) in Austria, another main reason for this strong increase is tank tourism. In the beginning of the 1990s fuel prices in Austria were higher compared to neighbouring countries, whereas since the middle of the 1990s it is the other way round.

Emissions from sub-sector *1 A 1 Energy* Industries show an increase of 18% from the base year to 2003. The main drivers for emissions from this sector are total electricity production (which increased about 30% from 1990 to 2003; where consumption increased by 40% over this period) and an increase in heat production, which doubled over this period due to an increase of district heating demand in the residential and commercial sector. Furthermore, the share of biomass used as a fuel in this sector and the contribution of hydro plants to total electricity production, which is generally about 75% and varied from 67% to 78% in the observed period (depending on the annual water situation), are important drivers. Also the climatic circumstances influence emissions from this sector: a "cold winter" leads to an increase of heat production.

The increase of heating space, warm water heat demand, climatic circumstances and the change of fuel mix are the most important drivers for emissions from *1 A 4 Other Sectors*. However, the effects compensated each other, and emissions in 2003 are on the level of the base year.

Emissions from *1 A 2 Manufacturing Industries and Construction* increased by 9.1% from 1990 to 2003, mainly due to an increase of natural gas and fuel waste consumption, whereas consumption of solid and liquid fossil fuels is quite stable.

2.3.2 Industrial Processes (IPCC Category 2)

Greenhouse gas emissions from the industrial processes sector fluctuated during the period 1990-2003 and show a minimum in 1993. In 2003 they were 9.2% above the level of the base year. In 2003 greenhouse gas emissions from Category *2 Industrial Processes* amounted to 11 046 Gg CO_2 equivalent.

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Production* and *Mineral Products*, which caused 41% respectively 28% of the emissions from this sector in 2003. The emission trend in this sector follows production figures to a large extent.

The most important GHG of the industry sector was carbon dioxide with 73.8% of emissions from this category, followed by HFCs with 11.8%, N_2O with 8.0%, SF6 with 5.4%, PFCs with 0.9% and finally CH_4 with 0.1%.

2.3.3 Solvent and Other Product Use (IPCC Category 3)

In the year 2003, 0.5% of total GHG emissions in Austria (426 Gg CO_2 equivalent) took place in the Solvent and Other Product Use sector.

Greenhouse gas emissions in this sector decreased by almost 20% from 1990 to 1992 and then remained on that level. In 2002 greenhouse gas emissions from *Solvent and Other product Use* were 17.3% below the level of the base year (emissions for 2002 have been reported as a first estimate of emissions from the year 2003).

55% of these emissions were CO_2 emissions, N_2O emissions contributed 45%.

2.3.4 Agriculture (IPCC Category 4)

Greenhouse gas emissions from the agricultural sector fluctuated at the beginning of the 90ties, since 1995 they show a steady downward trend. In the year 2003 emissions from this category were 13.1% below base year. The decrease is mainly due to decreasing livestock numbers. The fluctuations result from variation of mineral fertilizer sales used as activity data for calculating N_2O emissions from agricultural soils, which is an important sub source.

Emissions from Agriculture amounted to 7 349 Gg CO_2 equivalent in 2003, which corresponds to 8% of national total emissions. In 2003 the most important sub sector *Enteric Fermentation* contributed 42% to total greenhouse gas emissions from the agricultural sector, the second largest sub source *Agricultural Soils* had a share of 36%.

Agriculture is the largest source for both N_2O and CH_4 emissions: 61% of all N_2O emissions and 51% (190.0 Gg CH_4) of all CH_4 emissions in Austria in 2003 originated from this sector. N_2O emissions from *Agriculture* amounted to 10.8 Gg in 2003 (3 360 Gg CO_2 equivalent), which corresponds to 46% of the GHG emissions from this sector, methane contributed 54%.

2.3.5 LULUCF (IPCC Category 5)

Land use change and forestry is a net sink in Austria. CO_2 removals from that category amounted to 9 013 Gg CO_2 in the base year, which corresponds to 11% of national total GHG emissions (without LULUCF) compared to 14% in the year 2003. The trend in net removals from LULUCF is plus 42% over the observed period.

The main sink is subcategory *5 A Forest Land* with net removals of 13 060 Gg CO_2 in 2003. Small emissions arise from the other subcategories, where emissions from all other subcategories together amounted to 287 Gg CO_2 in 2003.

2.3.6 Waste (IPCC Category 6)

Greenhouse gas emissions from Category *6 Waste* decreased steadily during the period, mainly as a result of waste management policies: the amount of land filled waste has decreased as well as methane recovery .

In 2003 the greenhouse gas emissions from the waste sector amounted to 3 415 Gg CO_2 equivalent. This was 24% below the level of the base year. The share of emissions from this category in national total emissions was 4% in the year 2003.

The main source of greenhouse gas emissions in the waste sector is solid waste disposal on land, which caused 83% of the emissions from this sector in 2003.

92.4% of all greenhouse gas emissions in 2003 from *Waste* are CH_4 emissions, 7.2% are N_2O and 0.3% CO_2.

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. The following chapter summarizes the trends for these gases.

A detailed description of the methodology used to estimate these emissions will be provided in *Austria's Informative Inventory Report (IIR) 2005, Submission under the UNECE/CLRTAP Convention*, which will be published by the end of 2005.

Table 17 presents a summary of emission estimates for indirect greenhouse gases and SO_2 for the period from 1990 to 2003. The "National Emission Ceilings" (NEC) as set out in the 1999 *Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone* are also presented in Table 17. These reduction targets should be met by 2010 by parties to the UNECE/CLRTAP convention who signed this protocol.

Table 17: Emissions of indirect GHGs and SO_2 1990-2002

Gas	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	NEC
						[Gg]					
NO_X	210.99	192.13	211.78	199.12	211.13	199.16	204.43	213.67	219.72	229.03	107
CO	1243.6	1018.0	1032.2	962.3	923.4	875.7	810.3	804.0	775.5	801.8	---
NM-VOC	286.02	221.31	216.47	203.72	190.96	180.15	181.01	185.26	181.69	182.30	159
SO_2	76.18	48.21	46.27	42.13	37.25	36.08	33.06	34.22	33.01	34.14	39

NEC: National Emission Ceiling, goal should be met by 2010

Emissions of NMVOCs and CO decreased from the period from 1990 to 2003: for by 36%. SO_2 emissions had a significant negative trend, emissions decreased by 55% compared to 1990 levels. NO_X emissions increased by 9% over this period.

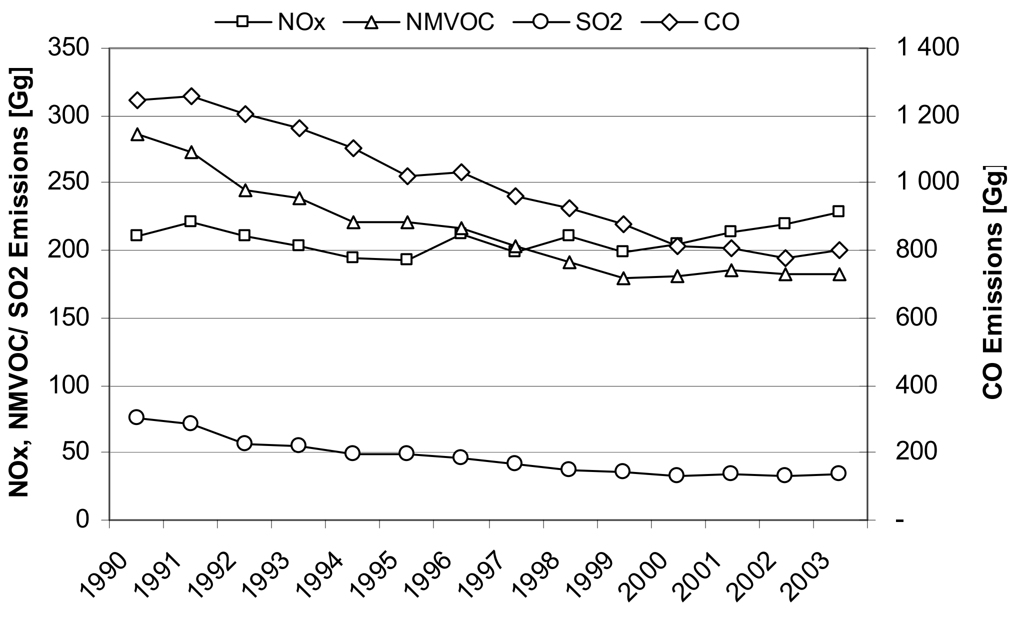


Figure 7: Emissions of indirect GHGs and SO_2 1990-2003

NO_X

NO_X emissions increased from 211 to 229 Gg during the period from 1990 to 2001. In 2001 the NO_X emissions were 9% above the level of 1990.

Over 97% of NO_X emissions in Austria originate from fossil fuel combustion, where the main part originates from mobile combustion.

CO

CO emissions decreased from 1 244 to 802 Gg during the period from 1990 to 2003. In 2003 CO emissions were 36% below the level of 1990.

In the year 2003, 96% of total CO emissions in Austria originated from fuel combustion activities, where the most important sub source regarding CO emissions is the residential and commercial sector.

NMVOC

NMVOC emissions decreased from 286 to 182 g Gg during the period from 1990 to 2003. In 2003 NMVOC emissions were 36% below the level of 1990.

The most important emission sources for NMVOC emissions are *Solvent Use* and fossil fuel combustion, contributing 43% and 46% respectively to national total emissions in 2003.

SO_2

SO_2 emissions decreased from 76 to 34 Gg during the period from 1990 to 2003. In 2003 SO_2 emissions were 55% below the level of 1990.

In the year 2003, 96% of total SO_2 emissions in Austria originated from fuel combustion activities. The decrease is mainly due to lower emissions from residential plants and manufacturing industries and construction.

3 ENERGY (CRF SECTOR 2)

3.1 Sector Overview

In sector *1 Energy* emissions originating from fuel combustion activities (Category *1 A*) as well as fugitive emissions from fuels (Category *1 B*) are considered.

CO_2 emissions from fossil fuel combustion are the main source of GHGs in Austria. In the year 2003 about 75.1% of national total GHGs emissions and 89% of national total anthropogenic CO_2 emissions from Austria were caused by fossil fuel combustion in road traffic, in the energy and manufacturing industry and in the commercial, agricultural and house holding sector.

3.1.1 Emission Trends

Figure 8 presents the trend for emission from IPCC Sector *1 Energy* in Gg CO_2 equivalent. The trend increased by 26.2% from 54.95 Gg CO_2 equivalent in 1990 to 69.33 Gg CO_2 equivalent in 2003 which is mainly caused by increasing emissions from the transport sector.

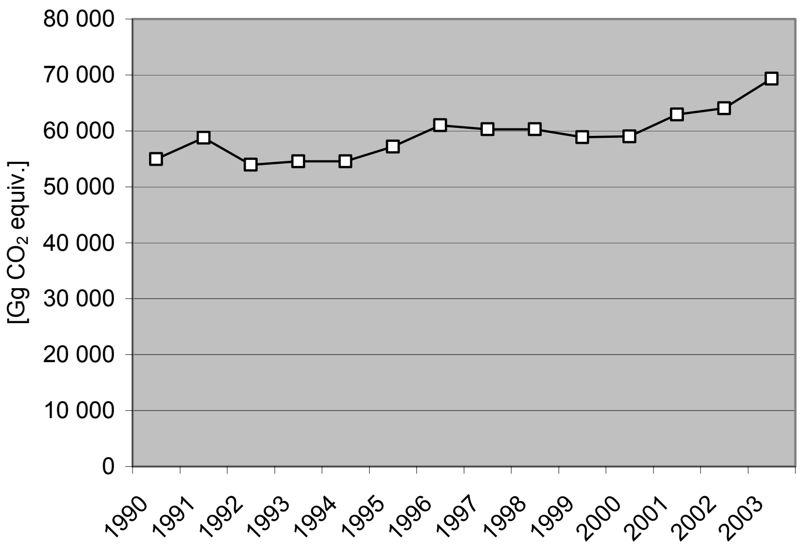


Figure 8: Trend of GHG emissions from 1990-2003 for Sector 1 Energy.

Table 18 presents the emission trend by GHG. The increase of CO_2 and N_2O emissions is mainly caused by the increasing activity in the transport sector. The strong increase of CO_2 emissions from 2002 to 2003 is additionally caused by public electricity plants. The decrease of CH_4 emissions is mainly caused by the decrease of CH_4 emissions from biomass combustion in the residential sector.

Table 18: Emissions of greenhouse gases and their trend from 1990-2003 from category 1 Energy

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1990	53 527	35.56	2.17
1991	57 237	37.09	2.43
1992	52 426	34.97	2.49
1993	53 038	34.65	2.60
1994	53 028	32.43	2.67
1995	55 667	33.46	2.68
1996	59 430	35.35	2.73
1997	58 798	30.76	2.71
1998	58 808	30.15	2.73
1999	57 400	30.32	2.67
2000	57 617	28.89	2.55
2001	61 475	30.27	2.64
2002	62 587	29.70	2.63
2003	67 857	31.11	2.65
Trend 1990-2003	*26.8%*	*-12.5%*	*22.0%*

Emission trends by sectors

Table 19 presents the emission trend by sub category. Emissions from category *1 A 3 Transport* increased very strong since 1990 whereas emissions from stationary combustion do not show such a significant increase. The increase of emissions from category *1 B* is mainly caused by the increase of CH_4 emissions from natural gas distribution.

Table 19: Total GHG emissions in [Gg CO_2 equivalent] from 1990–2003 by sub categories of sector 1 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	54 946	54 566	13 672	13 138	12 637	15 083	36	380	11	369
1991	58 769	58 377	14 474	13 555	14 295	16 015	38	392	9	383
1992	53 932	53 533	11 393	12 449	14 269	15 388	35	400	8	392
1993	54 573	54 174	11 432	12 988	14 473	15 240	40	399	8	391
1994	54 537	54 128	11 694	14 001	14 447	13 943	43	409	6	403
1995	57 201	56 781	12 731	14 085	14 825	15 106	33	420	6	414
1996	61 019	60 635	13 815	13 954	16 392	16 434	40	384	5	379
1997	60 283	59 851	13 422	16 314	15 304	14 774	38	432	5	427
1998	60 287	59 835	12 954	14 777	17 523	14 537	43	453	5	447
1999	58 865	58 380	12 314	13 745	16 909	15 368	43	486	5	481
2000	59 015	58 544	12 334	14 480	18 039	13 645	46	471	6	465
2001	62 928	62 435	13 490	14 245	19 184	15 480	37	492	5	487
2002	64 026	63 546	13 415	14 576	21 280	14 234	42	480	8	471
2003	69 331	68 776	16 105	14 338	22 996	15 300	37	554	8	546
Trend 1990-2003	*26.2%*	*26.0%*	*17.8%*	*9.1%*	*82.0%*	*1.4%*	*3.5%*	*46.0%*	*-26.0%*	*48.1%*

3.2 Fuel Combustion Activities (CRF Source Category 1 A)

This chapter gives an overview of emissions and key sources of category *1 A Fuel Combustion*, includes information on completeness, QA/QC, planned improvements as well as on emissions, emission trends and methodologies applied (including emission factors).

Additionally to information provided in this chapter, Annex 2 includes further information on the underlying activity data used for emissions estimation. The Annex describes the national energy balance (fuels and fuel categories, net calorific values) and the methodology of how activity data is extracted out of the energy balance (correspondence of energy balance to SNAP and IPCC categories). Activity data used for emissions calculation and information on the last revision of the national energy balance is also presented in Annex 2.

For results, methodology and detailed data used for the CO_2 reference approach see Annex 3.

National energy balance data are presented in Annex 4.

3.2.1 Source Category Description

In 2003 the most important source of GHGs is the transport sector (IPCC Category *1 A 3*), with a share of 25.1% in national total GHG emissions. 13.8% of national GHG emissions are released by passenger cars, 1.5% by light duty vehicles, 8.8% by heavy-duty vehicles and 0.02 % 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 0.1% in total GHG emissions. Because Austria is a land locked country, there is no occurrence of maritime activities. About 0.1% of national GHG arise from domestic air traffic.

The second largest GHG source of the energy sector in 2003 is category *1 A 1 Energy Industries*, where fossil fuels are combusted to produce electrical power or district heating. In the year 2003 overall gross public electricity production is 55 977[16] GWh of which 37 304 GWh (66.6%) are generated by hydro plants, 18 292 GWh (32.7%) by thermal power plants and 381 GWh (0,7%) by solar, geothermal and wind plants. Industrial auto producers generate 7 196 GWh of electricity in the year 2003. There are no operating nuclear plants in Austria. Thus, the seasonal water situation in Austria has an important influence on the needs for electric power generation by fossil fuels. In category *1 A 1* biomass is mainly used by smaller district heating plants. The refinery industry which consists of only one plant in Austria is also included in this category (subcategory *1 A 1 b Petroleum refining*).

Fossil fuels, mainly used for space and warm water heating in the commercial, agricultural and house holding sector (Category *1 A 4 Other Sectors* or "small combustion" sector) is the third largest subcategory. Emissions of this category are very dependant on the climatic circumstances and on the economic trend (for example a "cold winter" combined with an economic up trend may influence emissions from this sector significantly). The main share of biomass in Austria is used in the small combustion sector. This sector also includes emissions from off-road mobile sources. In the year 2003 the share in total GHG emissions of category *1 A 4* is 16.7% of which agricultural and forestry off-road machinery has a share of 1.9% in the national total.

[16] Source: IEA Questionnaire dec/2004 by STATISTIC AUSTRIA.

3.2.1.1 Key Sources

The methodology and results of the key source analysis is presented in Chapter 1.5. Table 20 presents the key source categories of category *1 A Fuel Combustion Activities*.

Table 20: Key sources of Category 1 Energy

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
1 A gaseous	Fuel Combustion (stationary)	CO_2	LA; TA
1 A 1 a liquid	Public Electricity and Heat Production	CO_2	LA; TA 1996-1999,2002-2003
1 A 1 a other	Public Electricity and Heat Production	CO_2	LA 1992, 1996-1998, 2000-2003; TA
1 A 1 a solid	Public Electricity and Heat Production	CO_2	LA; TA
1 A 1 b liquid	Petroleum refining	CO_2	LA; TA 1996-2001, 2003
1 A 2 mob-liquid	Manufacturing Industries and Constr.	CO_2	LA
1 A 2 other	Manufacturing Industries and Constr.	CO_2	LA 1990,1992,1999-2003; LA 1996,1998,2001-2002
1 A 2 solid	Manufacturing Industries and Constr.	CO_2	LA; TA
1 A 2 stat-liquid	Manufacturing Industries and Constr.	CO_2	LA; TA
1 A 3 b diesel oil	Road Transportation	CO_2	LA; TA
1 A 3 b gasoline	Road Transportation	CO_2	LA; TA
1 A 3 b gasoline	Road Transportation	N_2O	LA 1993-1995; TA 1996-1998
1 A 4 biomass	Other Sectors	CH_4	LA 1990-1996,1998-1999; TA 1997-2000
1 A 4 mob-diesel	Other Sectors	CO_2	LA; TA 2003
1 A 4 solid	Other Sectors	CO_2	LA; TA
1 A 4 stat-liquid	Other Sectors	CO_2	LA; TA

LA = Level Assessment 1990-2003

TA = Trend Assessment 1996-2003

3.2.1.2 Completeness

Table 21 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 subcategory have been estimated. A "NO" indicates that the Austrian energy balance does not quote an energy consumption for the regarding 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 21: 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		✓	IE(1)	✓
1 A 1 b Solid Fuels		NO	NO	NO
1 A 1 b Gaseous Fuels		✓	IE(1)	✓
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)** **030301 Sinter and palletising plants** **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 Other	**0301 Comb. in boilers, gas turbines and stationary engines (Other Industry+ Electricity and Heat Production in Industry)** **030311 Cement Industry** **030317 Other Glass** **030319 Bricks and Tiles** **0808 Other Mobile Sources and Machinery-Industry**			
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 3 a Civil Aviation	**080501 Domestic airport traffic (LTO cycles - <1000 m)** **080503 Domestic cruise traffic (>1000 m)**			
1 A 3 a Aviation Gasoline		✓	✓	✓
1 A 3 a Jet Kerosene		✓	✓	✓
1 A 3 b Road Transportation	**0701 Passenger cars** **0702 Light duty vehicles < 3.5 t** **0703 Heavy duty vehicles > 3.5 t and buses** **0704 Mopeds and Motorcycles < 50 cm3** **0705 Motorcycles > 50 cm3** **0706 Gasoline evaporation from vehicles**			
1 A 3 b Gasoline		✓	✓	✓
1 A 3 b Diesel Oil		✓	✓	✓
1 A 3 b Natural Gas		NO	NO	NO
1 A 3 b Biomass		NO	NO	NO
1 A 3 b Other Fuels		NO	NO	NO

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
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 Coal		NO	NO	NO
1 A 3 d Residual Oil		NO	NO	NO
1 A 3 d Gas/Diesel oil		✓	✓	✓
1 A 3 d Other Fuels: Gasoline		✓	✓	✓
1 A 3 e Other	**010506 Pipeline Compressors** **0810 Other Mobile Sources and Machinery-Other off-road**			
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 c Agriculture/Forestry/Fisheries	**0203 Plants in agriculture, forestry and aquaculture** **0806 Other Mobile Sources and Machinery-Agriculture** **0807 Other Mobile Sources and Machinery-Forestry**			
1 A 4 c Liquid Fuels		✓	✓	✓
1 A 4 c Solid Fuels		✓	✓	✓
1 A 4 c Gaseous Fuels		✓	✓	✓
1 A 4 c Biomass		✓	✓	✓
1 A 4 c Other Fuels		NO	NO	NO
1 A 5 Other	**0801 Other Mobile Sources and Machinery-Military**			
1 A 5 Liquid Fuels		✓	✓	✓

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
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				
Gasoline		NO	NO	NO
Gas/Diesel oil		NO	NO	NO
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 - <1000 m)** **080504 International cruise traffic (>1000 m)**			
Jet Kerosene		✓	✓	✓
Gasoline		NO	NO	NO
Multilateral Operations		**IE(2)**	**IE(2)**	**IE(2)**

(1) CH_4 emissions from petroleum refining are included in 1 B 2 Fugitive Emissions from Fuels.

(2) Energy consumption and emissions from Multilateral Operations are included in 1 A 4 a Commercial / Institutional.

3.2.2 Methodological Issues

Choice of Methodology

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 Fuls 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 subcategory is multiplied with an emission factor.

Activity data is 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 to the above listed criteria this methodology is equivalent to the IPCC bottom up Tier 2 methodology. See [IPCC 1996 rev. Guidelines] chapter *2.1.1.1 Choice of Method.*

Tier 3 methodology

For the following categories the IPCC Tier 3 methodology is used.

- *1 A 3 a Civil Aviation*
- *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*
- *International Bunkers-Aviation*

Methodology of emission calculation: Each activity (fuel input) of each subcategory is multiplied with 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 is 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. Top down activity data are based on fuel sales taken from the national energy balance.

Consideration of point source emissions

Within the following categories and pollutants plant specific emission declarations are considered.

- *1 A 1 a Public Electricity and Heat Production (42 plants)*: 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 Other – 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 data is used for inventory preparation, if data is not consistent data from the national energy balance is used.

Choice of emission factors for stationary sources

Emission factors for combustion plants are expressed as kg/GJ for CO_2 and 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], [BMWA-EB, 1996], [BMWA-EB, 2003]. 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 t CO_2 / TJ is selected [BMWA-EB, 1996].

Liquid fuels (fossil)

Fuel oil: Depending on the sulfur content three fuel oil categories are considered in the inventory. CO_2 emisson factors are taken from [BMWA-EB, 1996].

Gasoil, Diesel Oil : CO_2 emisson factors are taken from [BMWA-EB, 1996].

Liquid Petroleum Gas, LPG: CO_2 emisson factors are taken from [BMWA-EB, 1996].

Refinery Gas: The CO_2 emission factor is based on plant specific measurements. See chapter 3.2.2.2 1 A 1 b Petroleum Refining.

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, 1994], 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].

Coke Oven Gas: The CO_2 emission factor is a plant specific implied emission factor. Details are provided in chapter 3.2.2.4 1 A 2 a Iron and Steel.

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[17] 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 t 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 2004]. STATISTIK AUSTRIA quotes that the heating value was inquired from plant operator.

Hazardous Waste (partly fossil)

At current the composition and therefore the fossil carbon content of hazardous waste incinerated is widely unknown. However, it is known that at current hazardous waste is incinerated in one waste incineration plant and a couple of public power plants. The selected emission factor of 50 t CO_2 / TJ Waste is based on an expert judgement.

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,1995/1997/2001/2004] which include information about fractions and carbon contents. Details about emissions from cement industry are given in chapter 3.2.2.9 (1 A 2 f Manufacturing Industries and Construction – Other). The fractions and the specific carbon contents of waste incinerated in chemical industry, pulp and paper industry and wood products

[17] Incineration of MSW until 1998 only took place in Vienna 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.

manufacturing industry are unknown. The selected emission factor of 10 t CO_2 / TJ Waste is based on an expert judgement.

Sewage Sludge (non fossil)

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, 2004] 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].

Choice of activity data for stationary sources

For information on the underlying activity data used for estimating emissions see Annex 2. It describes the national energy balance (including fuel and fuel categories, net calorific values) and the methodology applied to extract activity data from the energy balance for the calculation of emissions for *Sector 1 A Fuel Combustion* (such as correspondence of categories of the energy balance to IPCC categories). 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 (see Annex 2).

The national energy balance is provided by STATISTIK AUSTRIA [IEA JQ, 2004] (it is presented in Annex 4). Also net calorific values (NCV) used for converting mass or volume units of the fuel quantities into energy units [TJ], are provided by STATISTIK AUSTRIA (and presented in Annex 4).

In the sectoral approach of Category *1 A* only the fuel quantities that are combusted are relevant and thus considered for emission calculation; 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 other than energy use are considered in other IPCC categories as described in Chapter 3.4 Feedstocks.

3.2.2.1 1 A 1 a Public Electricity and Heat Production

Key Source: Yes (CO_2: gaseous/ liquid/ solid/ other)

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% for the year 1990 and 19.4% for the year 2003. The increase of CH_4 emissions is caused by the increase of natural gas combustion in plants smaller 50 MW_{th} and lack of information on activity data for plants greater than 300 MW_{th} from 2002 onwards which have lower CH_4 emission factors.

Table 22: Greenhouse gas emissions from Category 1 A 1 a.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	10 864	0.14	0.14	10 911
1991	11 622	0.16	0.16	11 676
1992	8 612	0.15	0.13	8 655
1993	8 346	0.16	0.13	8 390
1994	8 635	0.15	0.14	8 680
1995	9 747	0.15	0.15	9 796
1996	10 925	0.18	0.15	10 974
1997	10 497	0.18	0.14	10 544
1998	10 055	0.19	0.16	10 108
1999	9 849	0.15	0.16	9 901
2000	9 880	0.16	0.17	9 935
2001	11 021	0.19	0.19	11 085
2002	10 625	0.21	0.19	10 688
2003	13 292	0.30	0.21	13 363
Trend 1990-2003	22.3%	113.3%	48.3%	22.5%

As can be seen from Table 23 during the last three years solid fossil fuels and natural gas were 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 3% in 2003.

Table 23: Share of fuel types on total CO_2 emissions from Category 1 A 1 a.

	Liquid	Solid	Gaseous	Other
1990	11%	58%	30%	1%
1991	13%	59%	27%	1%
1992	17%	47%	34%	3%
1993	25%	37%	36%	3%
1994	22%	38%	37%	3%
1995	16%	46%	35%	3%
1996	14%	43%	40%	3%
1997	18%	48%	31%	3%
1998	22%	35%	40%	3%
1999	20%	38%	39%	2%
2000	12%	51%	34%	3%
2001	12%	54%	31%	3%
2002	8%	52%	37%	3%
2003	8%	52%	37%	3%

Methodology

The CORINAIR simple methodology is applied.

Emission factors

National emission factors for CO_2 and CH_4 are taken from [BMWA-EB, 1990], [BMWA-EB, 1996] and [UBAVIE, 2001]. N_2O-emission factors are taken from a national study [STANZEL et al., 1995]. The selected emissions factors for 2003 are listed in the following table. The CO_2 emission factor for municipal solid waste is taken from [Abfallwirtschaft, 2003].

Table 24: Emission factors of Category 1 A 1 a for 2003.

Fuel	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}	55.00	0.18	0.50
Natural Gas in district heating plants >= 50 MW_{th}	55.00	1.50	1.00
Natural Gas in plants <= 50 MW_{th}	55.00	1.50	0.10
Fuel Wood	(1)100.00	21.00	3.00
Wood Waste	(1)110.00	2.00	4.00
Sewage Sludge	(1)110.00	12.00	1.40
Biogas, Sewage Sludge Gas, Landfill Gas	(1)112.00	1.50	1.00
Municipal Solid $Waste_{wet}$	(2)48.88	12.00	1.40
Hazardous Waste	(2)50.00	12.00	1.40
Industrial Waste	(2)10.00	12.00	1.40

Reported as CO_2 emissions from biomass.

According to IPCC guidelines non fossil CO_2 emissions of "other fuels" are not reported.

Activity data

Fuel consumption is taken from [IEA JQ 2004] prepared by STATISTIK AUSTRIA (see Annex 4).

In a first step large point sources are considered. UBAVIE is operating a database to store plant specific data, called "*Dampfkesseldatenbank*" (DKDB) which includes fuel consumption, CO,

NO_X, SO_X and dust emissions from boilers with a thermal capacity greater than 3 MW for the years 1990 onwards. These data are used to generate a sectoral split of the categories *Public Power* and *District Heating*, each for the two categories ≥ *300 MW* and ≥ *50 MW to 300 MW* of thermal capacity. Currently 42 plants are considered in this approach.

The remaining fuel consumption (= total consumption minus consumption of large point sources) is the activity data for plants smaller than 50 MW.

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 hydroelectric power plants. If production of electricity by hydropower is low, production from thermal power plants is high and vice versa.

The following Table 25 shows the gross electricity and heat production of public power and district heating plants.

Table 25: Public gross electricity and heat production.

	Gross electricity production [GWh]						Heat Production [TJ] by Combustible Fuels
	Total	Hydro	Combustible Fuels	Geothermal	Solar	Wind	
1990	43 404	30 111	13 293	0	0	0	24 420
1991	43 497	30 268	13 229	0	0	0	29 033
1992	42 838	33 530	9 308	0	0	0	27 600
1993	45 063	35 334	9 729	0	1	0	30 387
1994	44 982	34 243	10 738	0	1	0	30 684
1995	47 944	35 794	12 148	0	1	1	34 350
1996	46 011	32 950	13 055	0	1	5	44 438
1997	47 696	34 701	12 972	0	2	20	40 531
1998	48 250	36 058	12 145	0	2	45	43 343
1999	51 608	39 593	11 963	0	2	51	45 090
2000	53 158	41 410	11 677	0	3	67	42 605
2001	53 656	39 681	13 798	0	4	172	48 820
2002	54 851	40 581	14 060	3	4	203	46 756
2003	55 977	37 304	18 292	3	12	366	50 707

Source: STATISTIK AUSTRIA.

Recalculations

The CO_2 emission factor for municipal solid waste has been revised as data based on a more detailed methodology that is also better documented (it is described in chapter 3.2.2 Methodological Issues) has become available. Total carbon content (fossil and non fossil) is recalculated from 267 t C to 261 t C / t Waste and the fraction of fossil carbon is reduced from 62% to 45%.

In the previous submission activity data from the steam boiler database was taken which was higher than energy statistics, this overhead of plant specific activity data was subtracted from industrial autoproducers. For this submission for the years 1990 and 1991 plant specific data is updated according to a publication from the "Bundeslastverteiler", now PS data is lower and thus the subtraction from industrial autoproducers was not necessary anymore. This results in a shift of CO_2 emissions within these two categories, does however not imply changes in total CO_2 emissions from liquid fuels.

Changes of activity data are based on energy balance recalculation as described in Annex 2.

3.2.2.2 1 A 1 b Petroleum Refining

Key Source: Yes (CO_2: gaseous/ liquid)

Category *1 A 1 b Petroleum Refining* enfolds CO_2 and N_2O emissions from fuel combustion 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*.

The share in total GHG emissions from sector *1 A* is 4.5% for the year 1990 and 3.7% for the year 2003. Crude oil input which was 8 Mio t in 1990 and 9 Mio t in 2003.

Table 26: Greenhouse gas emissions from Category 1 A 1 b.

	CO_2 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	2 456	0.009	2 459
1991	2 488	0.010	2 491
1992	2 444	0.009	2 447
1993	2 732	0.012	2 735
1994	2 709	0.012	2 713
1995	2 591	0.012	2 594
1996	2 646	0.011	2 650
1997	2 640	0.011	2 643
1998	2 642	0.011	2 645
1999	2 271	0.009	2 274
2000	2 199	0.010	2 202
2001	2 216	0.008	2 219
2002	2 551	0.011	2 555
2003	2 526	0.012	2 530
Trend 1990-2003	2.9%	29.0%	2.9%

Table 27 presents the share of CO_2 emissions on the different fuel types.

Table 27: Share of fuel types on total CO_2 emissions from Category 1 A 1 b.

	Liquid	Gaseous
1990	80%	20%
1991	77%	23%
1992	78%	22%
1993	80%	20%
1994	86%	14%
1995	84%	16%

	Liquid	Gaseous
1996	83%	17%
1997	82%	18%
1998	83%	17%
1999	82%	18%
2000	84%	16%
2001	82%	18%
2002	84%	16%
2003	81%	19%

Methodology

The IPCC Tier 2 bottom up methodology is used. Activity data is multiplied with emission factors. For calculation of CO_2 emissions plant specific emission factors are used. For calculation of N_2O emissions country specific default emission factors are used.

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

Table 28: Carbon content per fuel group for petroleum refining

Fuel-Group	PS 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

CO_2 emissions are calculated by multiplying activity data from the energy balance with the emission factors in Table 28.

To reach consistency 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 (they are presented in Table 30, for references see Chapter 3.2.2 Methodological Issues), 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 29.

Table 29: Implied emission factors for refinery gas.

	t CO_2/ TJ
1990	51.7
1991	50.9
1992	51.1
1993	49.2
1994	50.4
1995	52.3

	t CO_2/ TJ
1996	51.8
1997	51.0
1998	51.2
1999	56.8
2000	51.7
2001	52.0
2002	48.6
2003	47.3

N_2O emissions are calculated by multiplying fuel consumption with the emission factors presented in Table 30 (they are selected according to chapter 3.2.2 Methodological Issues).

No combustion specific CH_4 emissions are reported for this category, process-specific CH_4 emissions are reported in Category *1 B 2 a Fugitive Emissions from Fuels – Oil*.

For corresponding crude oil input data which may be used as an indicator over time series refer to Chapter 3.5.2.2 (Table 103).

Table 30: Emission factors of Category 1 A 1 b for 2003.

Fuel	CO_2 [t / TJ]	N_2O [kg / TJ]
Residual Fuel Oil	80.00	0.60
Gas oil	75.00	0.60
Diesel	78.00	0.60
Petroleum	78.00	0.60
Jet Gasoline	78.00	0.60
Other Oil Products	78.00	0.60
LPG	64.00	1.00
Petrol Coke	100.88	-
Natural Gas	55.00	0.10

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

The methodology of calculation of CO_2 emissions has been revised: in the previous submission CO_2 emissions used for the inventory were reported by plant operator but were inconsistent with activity data in the national energy balance that is reported to energy statistics by the *Association of Austrian Petroleum Industry*. For the years 1990 to 1994 emissions had been calculated by using the implied CO_2 emission factor of 1995, expressed as *t CO_2 / Crude Oil Input,* while the applied methodology for the years 1995 to 2002 has not been transparent.

The new methodology for estimating CO_2 emissions is now transparent, more accurate, consistent over time series and consistent with national energy statistics. It uses plant specific emissions factors and data from the national energy balance; the new methodology has been approved by and checked with the plant operator.

Changes in allocation of emissions

Natural Gas: Emissions from electricity autoproduction in petroleum refinery so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category. Due to changes of the energy balance a shift of liquid fuel consumption to industrial autoproducers has been performed. An overview about changes of the energy balance is given in Annex 2.

3.2.2.3 1 A 1 c Manufacture of Solid Fuels and Other Energy Industries

Key Source: Yes (CO_2: gaseous)

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. The share in sector *1 A* overall GHG emissions is 0.6% for the year 1990 and 0.3% for the year 2003.

Table 31: Greenhouse gas emissions from Category 1 A 1 c.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	302	0.008	0.0005	302
1991	307	0.008	0.0006	307
1992	290	0.008	0.0005	291
1993	307	0.008	0.0006	307
1994	300	0.008	0.0005	300
1995	340	0.009	0.0006	340
1996	191	0.005	0.0003	191
1997	234	0.006	0.0004	235
1998	201	0.005	0.0004	201
1999	138	0.004	0.0003	139
2000	196	0.005	0.0004	197
2001	186	0.005	0.0003	186
2002	172	0.005	0.0003	172
2003	212	0.006	0.0005	213
Trend 1990-2003	*-29.7%*	*-29.9%*	*-17.0%*	*-29.7%*

Table 32 shows that except for 2003 all emissions of category *1 A 1 c* originated from natural gas combustion.

Table 32: Share of fuel types on total CO_2 emissions from Category 1 A 1 c.

	Liquid	Gaseous
1990	0%	100%
1991	0%	100%
1992	0%	100%
1993	0%	100%
1994	0%	100%

	Liquid	Gaseous
1995	0%	100%
1996	0%	100%
1997	0%	100%
1998	0%	100%
1999	0%	100%
2000	0%	100%
2001	0%	100%
2002	0%	100%
2003	3%	97%

Methodology

The CORINAIR simple methodology is applied.

Emission factors

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

The N_2O emission factor is taken from a national study [BMUJF, 1994].

The emission factors are presented in Table 33.

Table 33: Emission factors of Category 1 A 1 c.

Fuel	CO_2 [t / TJ]	CH_4 [kg / TJ]	N_2O [kg / TJ]
Natural Gas	55.00	1.50	0.10
Heavy Fuel Oil	78.00	2.00	1.00

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

Natural gas consumption for oil/gas extraction and storage for 2001 an 2002 has been corrected based on improved energy statistics.

Changes in activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

- Emissions of final energy use in coal mining - which is assumed to be needed for space heating purpose only - so far reported under this category is now reported under category *1 A 2 f Manufacturing Industries and Construction-Other.*
- Emissions from electricity autoproducers of oil/gas extraction and gas works so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category.
- In the previous submission emissions from transformation of liquid gas into gas works gas were estimated under this category which was a double counting with emissions from final energy consumption of gaseous fuels in category *1 A 4 - Other*. This double counting has been eliminated.

3.2.2.4 1 A 2 a Iron and Steel

Key Source: Yes (CO_2: 1 A 2 gaseous/ solid/ liquid-stationary)

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*. The share in total GHG emissions from sector 1 A is 9.1% for the year 1990 and 7.5% for the year 2003.

Table 34: Greenhouse gas emissions from Category 1 A 2 a.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	4 945	0.025	0.0434	4 959
1991	4 622	0.023	0.0425	4 636
1992	3 941	0.020	0.0360	3 953
1993	4 221	0.022	0.0374	4 233
1994	4 490	0.026	0.0403	4 503
1995	4 819	0.026	0.0458	4 834
1996	4 690	0.030	0.0425	4 704
1997	5 400	0.037	0.0475	5 415
1998	4 795	0.033	0.0515	4 812
1999	4 886	0.031	0.0482	4 901
2000	5 260	0.038	0.0574	5 279
2001	5 205	0.035	0.0556	5 223
2002	5 489	0.037	0.0573	5 507
2003	5 143	0.035	0.0551	5 161
Trend 1990-2003	*4.0%*	*39.7%*	*26.8%*	*4.1%*

As can be seen from Table 35, CO_2 emissions from category *1 A 2 a* are mainly arising from solid fossil fuels.

Table 35: Share of fuel types in total CO_2 emissions from Category 1 A 2 a.

	Liquid	Solid	Gaseous
1990	9.0%	78.0%	13.0%
1991	9.6%	76.0%	14.4%
1992	11.0%	73.0%	16.1%
1993	10.8%	74.8%	14.4%
1994	10.7%	74.2%	15.0%
1995	11.5%	72.9%	15.6%
1996	9.8%	70.4%	19.8%
1997	9.7%	69.0%	21.3%
1998	14.0%	63.6%	22.4%
1999	13.6%	66.0%	20.4%

	Liquid	Solid	Gaseous
2000	16.0%	65.7%	18.4%
2001	17.0%	64.6%	18.3%
2002	9.7%	71.9%	18.4%
2003	10.9%	71.5%	17.6%

Methodology

Two iron and steel production sites (the only ones operating blast furnaces in Austria) are considered as point sources. For 1990 to 2002 CO_2 emissions and fuel consumption from these two plants are 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. For liquid fuels, natural gas and coke oven coke CO_2 emission factors taken from [BMWA-EB, 1996] are applied. The remaining CO_2 emissions are allocated to the reported coke oven gas consumption. The methodology to divide the reported fuel consumption into energy related and process related consumption is performed with the information provided in [IEA JQ 2004]. The complex carbon fluxes in iron and steel plants can not be well modelled within the energy balance. Thus the resulting implied CO_2 emission factors for solid fuels in CRF-table 1.A(a) for category *1 A 2 a* vary strongly over time and are not reliable.

N_2O emissions of the two iron and steel plants are calculated with the CORINAIR simple methodology.

CH_4 emissions are calculated under the assumption that the ratio of CH_4 emissions to the reported NMVOC emissions is equal to the ratio of CH_4 and NMVOC emissions if calculated with the CORINAIR simple method. For the year 2003 this ratio is 90/322; the plant reported 90 t NMVOC and by applying the ratio obtained from the CORINAIR simple methodology total CH_4 emissions were estimated to be 27 t. In a last step CH_4 emissions were allocated to the different fuel types.

Point source CO_2 emissions 2003

As for the year 2003 no point source CO_2 emissions are reported by plant operators, the Umweltbundesamt performed calculations on the basis of 2000 to 2002 data by means of a simple approach: Activity data taken from [IEA JQ 2004] is multiplied with the average implied emission factors 2000 to 2002.

Emissions

The following table lists the results of the two approaches.

Table 36: Greenhouse gas emissions from Category 1 A 2 a by sub sources.

	area sources			point sources		
	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1990	192	0.005	0.001	4 753	0.020	0.042
1991	256	0.007	0.001	4 366	0.016	0.041
1992	210	0.006	0.001	3 731	0.014	0.035

	area sources			point sources		
	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1993	229	0.006	0.002	3 992	0.016	0.036
1994	248	0.006	0.002	4 242	0.020	0.039
1995	302	0.008	0.002	4 517	0.018	0.044
1996	441	0.012	0.003	4 249	0.019	0.040
1997	541	0.014	0.002	4 859	0.022	0.045
1998	471	0.012	0.002	4 324	0.021	0.050
1999	335	0.009	0.001	4 550	0.022	0.047
2000	420	0.011	0.002	4 840	0.027	0.056
2001	282	0.008	0.001	4 923	0.027	0.054
2002	382	0.010	0.001	5 107	0.027	0.056
2003	314	0.008	0.001	4 829	0.027	0.054

Emission factors

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

N_2O emission factors are taken from the national study [BMUJF, 1994].

The selected and calculated emission factors for 2002 are presented in Table 37 and Table 38.

Table 37: Emission factors of Category 1 A 2 a for 2003, 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	55.00	1.50	0.10
Wood Waste	(1)110.00	2.00	4.00

(1) Reported as CO_2 emissions from biomass.

Table 38: Emission factors of Category 1 A 2 a for 2003, point sources

Fuel	CO_2 [t / TJ]	CH_4 [kg / TJ]	N_2O [kg / TJ]
Heavy Fuel Oil	78.00	0.56	1.00
Coke	104.00	0.56	1.40
Coke Oven Gas	(1)22.44	0.00	0.00
Natural Gas	55.00	0.42	0.10

(1) Implied emission factor of remaining CO_2 emissions.

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Point source activity data reported by plant operators are widely consistent with [IEA JQ 2004].

Recalculations

Activity data is now fully taken from the energy balance which is consistent with plant operators information. In the previous submission information about activity data was partly taken from plant operator. Especially for the year 2002 coke oven coke consumption has been corrected and is now consistent with pig iron production.

Changes in allocation of emissions

Emissions from electricity autoproducers of iron & steel industry so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category.

While total emissions from integrated iron and steel plants were not recalculated a more accurate estimate of process CO_2 emissions from blast furnaces which are reported in category *2 C 1 Iron and Steel Production* leads to the following shifts from or to category *1 A 2 a* :

Table 39: Shift of CO_2 emissions from category 2 C 1 to category 1 A 2 a.

	CO_2 [Gg]
1990	48.7
1991	-29.8
1992	-32.5
1993	-36.1
1994	-28.2
1995	-32.5
1996	8.8
1997	2.4
1998	1.7
1999	-39.5
2000	-37.5
2001	-169.6
2002	587.0

3.2.2.5 1 A 2 b Non-Ferrous Metals

Key Source: Yes (CO_2: 1 A 2 gaseous/ solid/ liquid-stationary)

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 0.2% for the year 1990 and 0.3% for the year 2003.

Table 40: Greenhouse gas emissions from Category 1 A 2 b.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	112	0.003	0.0006	113

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1991	118	0.003	0.0008	118
1992	145	0.003	0.0009	146
1993	153	0.004	0.0008	154
1994	242	0.006	0.0011	242
1995	265	0.007	0.0010	266
1996	165	0.004	0.0008	165
1997	237	0.005	0.0012	238
1998	213	0.004	0.0011	213
1999	199	0.004	0.0011	199
2000	201	0.004	0.0011	201
2001	205	0.005	0.0010	205
2002	211	0.005	0.0011	212
2003	211	0.005	0.0011	211
Trend 1990-2003	*87.3%*	*72.0%*	*63.7%*	*87.3%*

As can be seen from Table 41 the main share in CO_2 emissions arise from combustion of natural gas and heavy fuel oil.

Table 41: Share of fuel types in total CO_2 emissions from Category 1 A 2 b

	Liquid	Solid	Gaseous
1990	30%	3%	66%
1991	28%	16%	56%
1992	21%	19%	60%
1993	21%	10%	69%
1994	16%	10%	74%
1995	15%	4%	81%
1996	29%	3%	68%
1997	32%	8%	60%
1998	31%	8%	61%
1999	30%	11%	59%
2000	26%	11%	63%
2001	24%	6%	69%
2002	23%	8%	69%
2003	31%	2%	66%

Methodology

CORINAIR simple methodology is applied. Fuel consumption is taken from [IEA JQ 2004] as described in Annex 4.

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

N_2O emission factors are taken from a national study [BMUJF, 1994].

The emission factors for 2003 are presented in Table 42.

Table 42: Emission factors of Category 1 A 2 b for 2003.

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	55.00	1.50	0.10

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

Emissions from electricity autoproducers of non-ferrous metals industry so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category.

3.2.2.6 1 A 2 c Chemicals

Key Source: Yes (CO_2: 1 A 2 gaseous/ solid/ liquid-stationary)

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 1.3% for the year 1990 and 1.8% for the year 2003.

Table 43: Greenhouse gas emissions from Category 1 A 2 c.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	705	0.052	0.018	712
1991	696	0.056	0.019	703
1992	784	0.067	0.022	792
1993	866	0.054	0.016	872
1994	835	0.053	0.015	840
1995	889	0.058	0.014	895
1996	856	0.061	0.019	863
1997	1 069	0.060	0.020	1 076
1998	977	0.054	0.017	984

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1999	1 232	0.081	0.023	1 241
2000	1 199	0.068	0.016	1 206
2001	1 252	0.058	0.014	1 257
2002	1 224	0.073	0.018	1 231
2003	1 251	0.089	0.029	1 262
Trend 1990-2003	*77.4%*	*72.0%*	*0.646*	*77.3%*

As can be seen in Table 44, natural gas is still the main source of CO_2 emissions from category *1 A 2 c*. CO_2 emissions from solid fossil fuel combustion increased whereas liquid fossil fuel got less important.

Table 44: Share of fuel types in total CO_2 emissions from Category 1 A 2 c

	Liquid	Solid	Gaseous	Other
1990	11%	10%	75%	3%
1991	12%	18%	66%	4%
1992	7%	26%	63%	4%
1993	8%	20%	69%	2%
1994	11%	21%	66%	3%
1995	10%	17%	71%	3%
1996	10%	20%	67%	3%
1997	13%	24%	61%	2%
1998	12%	26%	60%	2%
1999	8%	25%	65%	3%
2000	5%	22%	71%	2%
2001	6%	21%	72%	1%
2002	5%	21%	72%	2%
2003	9%	20%	68%	2%

Methodology

CORINAIR simple methodology is applied.

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

N_2O emission factors are taken from a national study [BMUJF, 1994].

Emission factors for 2003 are presented in Table 45.

Table 45: Emission factors of Category 1 A 2 c for 2003.

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	55.00	1.50	0.10
Fuel Wood	(1)100.00	2.00	4.00
Wood Waste	(1)110.00	2.00	4.00
Black Liquor	(1)110.00	2.00	1.40
Biogas	(1)112.00	1.50	1.00
Industrial Waste	(2)10.00	12.00	1.40

Reported as CO2 emissions from biomass

According to IPCC guidelines non fossil CO2 emissions of "other fuels" are not reported.

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

Emissions from electricity autoproducers of chemicals industry so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category.

3.2.2.7 1 A 2 d Pulp, Paper and Print

Key Source: Yes (CO_2: 1 A 2 gaseous/ solid/ liquid-stationary)

Category *1 A 2 d Pulp, Paper and Print* enfolds emissions from fuel combustion in pulp, paper and print industry. The share in total GHG emissions from sector *1 A* is 3.9% for the year 1990 and 12.7% for the year 2003.

Table 46: Greenhouse gas emissions from Category 1 A 2 d.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	2 124	0.120	0.059	2 145
1991	2 566	0.132	0.065	2 589
1992	2 124	0.125	0.062	2 146
1993	2 165	0.131	0.077	2 191
1994	2 620	0.146	0.080	2 648
1995	2 231	0.138	0.079	2 258
1996	2 148	0.131	0.065	2 170
1997	2 925	0.152	0.081	2 953
1998	2 677	0.141	0.068	2 701

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1999	2 025	0.124	0.065	2 048
2000	2 176	0.127	0.057	2 196
2001	2 012	0.117	0.052	2 030
2002	1 917	0.121	0.063	1 939
2003	1 857	0.111	0.065	1 879
Trend 1990-2003	*-12.6%*	*-7.0%*	*0.099*	*-12.4%*

As can be seen in Table 47, 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 47: Share of fuel types in total CO_2 emissions from Category 1 A 2 d.

	Liquid	Solid	Gaseous
1990	39%	17%	44%
1991	42%	19%	39%
1992	30%	20%	50%
1993	31%	19%	50%
1994	24%	14%	61%
1995	23%	17%	60%
1996	18%	17%	65%
1997	19%	15%	66%
1998	18%	16%	66%
1999	13%	17%	70%
2000	9%	19%	72%
2001	10%	18%	72%
2002	8%	22%	70%
2003	10%	17%	73%

Methodology

The CORINAIR simple methodology is applied.

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

N_2O emission factors are taken from a national study [BMUJF, 1994].

Emission factors for 2002 are presented in Table 48.

Table 48: Emission factors of Category 1 A 2 d for 2003.

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	55.00	1.50	0.10
Fuel Wood	(1)100.00	2.00	4.00
Wood Waste(2)	(1)110.00	2.00	4.00
Black Liquor	(1)110.00	2.00	1.40
Biogas	(1)112.00	1.50	1.00
Landfill Gas	(1)112.00	1.50	1.00
Industrial Waste	(3)10.00	12.00	1.40

(1) Reported as CO2 emissions from biomass

(2) Including sewage sludge from paper mills

(3) According to IPCC guidelines non fossil CO2 emissions of "other fuels" are not reported.

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

Emissions from electricity autoproducers of pulp, paper and print industry so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category.

3.2.2.8 1 A 2 e Food Processing, Beverages and Tobacco

Key Source: Yes (CO_2: 1 A 2 gaseous/ solid/ liquid-stationary)

Category *1 A 2 e Food Processing, Beverages and Tobacco* enfolds emissions from fuel combustion in food processing, beverages and tobacco industry. The share in total GHG emissions from sector *1 A* is 1.5% for the year 1990 and 1.8% for the year 2003.

Table 49: Greenhouse gas emissions from Category 1 A 2 e.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	834	0.018	0.005	836
1991	906	0.020	0.005	908
1992	848	0.018	0.005	850
1993	863	0.016	0.005	864
1994	916	0.019	0.005	918
1995	925	0.019	0.005	927

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1996	870	0.019	0.003	872
1997	1 104	0.023	0.004	1 106
1998	971	0.021	0.004	973
1999	930	0.024	0.009	934
2000	1 153	0.028	0.005	1 155
2001	1 072	0.026	0.005	1 074
2002	1 241	0.031	0.005	1 243
2003	1 262	0.030	0.005	1 264
Trend 1990-2003	*51.3%*	*67.3%*	*12.1%*	*51.2%*

As can be seen in Table 50, natural gas combustion 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 50: Share of fuel types in total CO_2 emissions from Category 1 A 2 e.

	Liquid	Solid	Gaseous
1990	39%	1%	60%
1991	42%	2%	56%
1992	38%	4%	58%
1993	43%	2%	55%
1994	38%	3%	59%
1995	36%	1%	64%
1996	28%	0%	71%
1997	30%	1%	69%
1998	28%	1%	71%
1999	22%	1%	77%
2000	17%	4%	79%
2001	20%	3%	77%
2002	14%	3%	83%
2003	20%	1%	79%

Methodology

CORINAIR simple methodology is applied.

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

N_2O emission factors are taken from a national study [BMUJF, 1994].

Emission factors for 2003 are presented in Table 51.

Table 51: Emission factors of Category 1 A 2 e for 2003.

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	55.00	1.50	0.10
Fuel Wood	(1)100.00	2.00	4.00
Wood Waste	(1)110.00	2.00	4.00
Biogas	(1)112.00	1.50	1.00
Industrial Waste	(2)10.00	12.00	1.40

(1) Reported as CO2 emissions from biomass

(2) According to IPCC guidelines non fossil CO2 emissions of "other fuels" are not reported.

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

Emissions from electricity autoproducers of food processing, beverages and tobacco industry so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under this category.

3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other

Key Source: Yes (CO_2: 1 A 2 gaseous/ solid/ liquid-stationary)

Category *1 A 2 f Other* enfolds emissions from fuel combustion in industry which are not reported under categories *1 A 2 a, 1 A 2 b, 1 A 2 c, 1 A 2 d* and *1 A 2 e*. It also includes emissions from mobile sources (off road machinery) of total industry. For the stationary sources cement industry is considered separately.

The share in total GHG emissions from sector *1 A* is 8% for the year 1990 and 6.6% for the year 2003. N_2O emissions mainly arise from off road activity.

Table 52: Greenhouse gas emissions from Category 1 A 2 f.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	4 249	0.177	0.389	4 374
1991	4 471	0.196	0.407	4 601
1992	4 432	0.199	0.408	4 563
1993	4 545	0.198	0.399	4 673
1994	4 715	0.204	0.419	4 849
1995	4 775	0.206	0.407	4 905
1996	5 049	0.217	0.408	5 180
1997	5 388	0.222	0.431	5 526
1998	4 957	0.218	0.433	5 095
1999	4 285	0.197	0.430	4 422
2000	4 311	0.209	0.418	4 445
2001	4 319	0.225	0.425	4 455
2002	4 313	0.219	0.409	4 444
2003	4 439	0.203	0.377	4 560
Trend 1990-2003	*4.5%*	*15.1%*	*-3.1%*	*4.3%*

As can be seen from Table 53, natural gas and liquid fossil fuel combustion is the main source of CO_2 emissions from category *1 A 2 f*. The share of fossil fuel types on total CO_2 emissions is quite constant over the years.

Table 53: Share of fuel types in total CO_2 emissions from Category 1 A 2 f.

	Liquid	Solid	Gaseous	Other
1990	49%	10%	37%	5%
1991	49%	11%	36%	4%
1992	45%	13%	36%	6%
1993	52%	11%	35%	2%
1994	49%	9%	39%	3%
1995	45%	9%	43%	3%
1996	44%	11%	43%	2%
1997	52%	11%	34%	3%
1998	52%	12%	34%	3%
1999	51%	11%	33%	6%
2000	47%	12%	35%	7%
2001	45%	10%	36%	9%
2002	46%	7%	37%	9%
2003	51%	6%	35%	7%

1 A 2 f Manufacturing Industries and Construction - Other - stationary sources

In the following the methodology of estimating emissions from stationary sources of category *1 a 2 f Other* is described. The share in total GHG emissions from sector *1 A* is 5.9% for the year 1990 and 4.9% for the year 2003.

Table 54: Greenhouse gas emissions from Category 1 A 2 f stationary sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	3 234	0.10	0.03	3 246
1991	3 414	0.12	0.04	3 428
1992	3 364	0.12	0.04	3 378
1993	3 511	0.12	0.04	3 526
1994	3 654	0.13	0.04	3 668
1995	3 738	0.13	0.03	3 752
1996	4 041	0.15	0.04	4 057
1997	4 363	0.15	0.05	4 381
1998	3 916	0.15	0.04	3 932
1999	3 238	0.13	0.06	3 259
2000	3 250	0.15	0.06	3 271
2001	3 243	0.17	0.07	3 269
2002	3 221	0.16	0.06	3 244
2003	3 334	0.15	0.06	3 357
Trend 1990-2003	*3.1%*	*47.8%*	*81.0%*	*3.4%*

As can be seen in Table 55, natural gas and liquid fossil fuel combustion is the main stationary source of CO_2 emissions from category *1 A 2 f*. The share of natural gas and liquid fuels in total CO_2 emissions is still at the level of 1990. Solid fuels got less important but CO_2 emissions from combustion of industrial waste are increasing.

Table 55: Share of fuel types on total CO_2 emissions from Category 1 A 2 f stationary sources.

	Liquid	Solid	Gaseous	Other
1990	33%	13%	48%	6%
1991	33%	14%	48%	5%
1992	28%	17%	48%	8%
1993	37%	14%	46%	3%
1994	34%	12%	51%	4%
1995	30%	12%	55%	4%
1996	30%	13%	54%	3%
1997	41%	14%	41%	4%
1998	40%	15%	43%	3%
1999	35%	14%	44%	7%
2000	29%	16%	46%	9%
2001	26%	14%	48%	12%

	Liquid	Solid	Gaseous	Other
2002	28%	10%	50%	12%
2003	35%	8%	47%	9%

1 A 2 f Manufacturing Industries and Construction - Cement Clinker Production (NACE 26.51)

This category enfolds emissions from fuel combustion in cement clinker kilns. The capacity of the 10 Austrian plants is about 4 mio t cement clinker / year. Yearly clinker production is about 80% of total capacity. Further information about yearly clinker production is provided in the methodology chapter of category *2 A 1 cement production*.

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 and 2003]. 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 2002.

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 1990 to 2002

Emissions for the years 1990 to 2002 are taken from industry [HACKL, MAUSCHITZ, 1995, 1997, 2001 and 2003].

For solid, liquid and gaseous fuels CO_2 emissions are calculated by multiplying activity data with national default emission factors (for sources of emission factors see relating chapter). The remaining CO_2 emissions are allocated to industrial waste, which does not always lead to an reliable implied emission factor. Rationales are given in the following chapter *Activity data.*

CO_2 emissions 2003

For the year 2003 CO_2 emissions from coal, fuel oil and natural gas are calculated by multiplying activity data with national default emission factors, whereas for industrial waste the implied emission factor the averaged implied emission factor of 2000 to 2002 is used.

CH_4 and N_2O emissions

Are calculated with the simple CORINAIR methodology.

Emissions

The following table present greenhouse gas emissions from fuel combustion for cement clinker production.

Table 56: Greenhouse gas emissions from Category 1 A 2 f - cement clinker production.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	1 055	0.05	0.01	1 059
1991	1 038	0.05	0.01	1 043
1992	1 107	0.05	0.01	1 112
1993	1 038	0.06	0.01	1 044
1994	1 089	0.06	0.01	1 095
1995	867	0.05	0.01	872
1996	861	0.06	0.01	867
1997	958	0.06	0.01	963
1998	888	0.06	0.01	894
1999	871	0.06	0.01	876
2000	938	0.07	0.01	944
2001	954	0.08	0.01	959
2002	976	0.08	0.01	982
2003	878	0.06	0.01	882
Trend 1990-2003	-16.8%	36.0%	-14.5%	-16.7%

Activity data

Hard Coal, Brown Coal, Petrol Coke and Industrial Waste

In [IEA JQ 2004] 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, petrol coke and industrial waste for fuel combustion, 100% of those fuels are allocated to the cement industry. It has to be noted that for industrial waste [IEA JQ 2004] uses about 25% lower calorific values than [HACKL, MAUSCHITZ, 1995, 1997, 2001 and 2003]. By keeping activity data consistent with [IEA JQ 2004] this leads to a rather high implied emission factor for CO_2.

Natural Gas

For the period 1990 to 2002 natural gas consumption is taken from [HACKL, MAUSCHITZ, 1995, 1997, 2001 and 2003] and converted into the unit TJ by applying the calorific values reported in [IEA JQ 2004].

For the year 2003 the natural gas consumption of 2002 is used.

Fuel Oil

For the period 1990 to 2002 fuel oil consumption is taken from [HACKL, MAUSCHITZ, 1995, 1997, 2001 and 2003] and converted into the unit TJ by applying the calorific values reported in [IEA JQ 2004].

For the year 2003 30% of fuel oil consumption of NACE Division 26 as reported in [IEA JQ 2004] is selected which is the same ratio as for the year 2002.

Emission factors

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

N_2O emission factors are taken from a national study [BMUJF, 1994].

Recalculations

CO_2 emissions 2000 to 2002: Emission factors and activity data are now taken from [HACKL & MAUSCHITZ, 2003] whereas in the previous submission CO_2 emissions were estimated using the 1999 emission factors and activity data from [HACKL & MAUSCHITZ, 2001].

From 1990 on the energy balance is updated according to information from [HACKL & MAUSCHITZ, 1995, 1997, 2001 and 2003], especially for industrial waste.

1 A 2 f Manufacturing Industries and Construction - Other (NACE 17, 18, 19, 20, 25, 26.1, 26.2, 26.3 , 26.4, 26.6, 26.7, 26.8, 33, 34, 35, 36, 37, 45)

This category enfolds emissions due to fuel combustion of the industrial branches as specified in NACE 17, 18, 19, 20, 25, 26.1, 26.2, 26.3 , 26.4, 26.6, 26.7, 26.8, 33, 34, 35, 36, 37, 45.

Methodology

The CORINAIR simple methodology is applied.

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4, fuel consumption of cement industry is subtracted as it is considered separately (see above).

Emission factors

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

N_2O emission factors are taken from a national study [BMUJF, 1994].

The emission factors for 2003 are presented in Table 51.

Table 57: Emission factors of Category 1 A 2 f stationary sources for 2003.

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
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
Petrol Coke	100.88	0.00	0.00
Natural Gas	55.00	1.50	0.10
Fuel Wood	(1)100.00	2.00	4.00
Wood Waste	(1)110.00	2.00	4.00
Black Liquor	(1)110.00	2.00	1.40
Biogas	(1)112.00	1.50	1.00
Sewage Sludge Gas	(1)112.00	1.50	1.00
Landfill Gas	(1)112.00	1.50	1.00
Industrial Waste-unspecified	(2)10.00	12.00	1.40
Industrial Waste-Cement industry	(3)81.15	12.00	1.40

(1) Reported as CO2 emissions from biomass

(2) According to IPCC guidelines non fossil CO2 emissions of "other fuels" are not reported.

(3) Implied emission factor as cited in chapter *methodology,* see Page 87

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

Emissions from electricity autoproducers other than NACE 17, 18, 19, 20, 25, 26.1, 26.2, 26.3, 26.4, 26.6, 26.7, 26.8, 33, 34, 35, 36, 37 and 45 so far reported under this category are now reported under the respective IPCC categories *1 A 1 b, 1 A 1 c, 1 A 2 a, 1 A 2 b, 1 A 2 c, 1 A 2 d, 1 A 2 e, 1 A 4 a*.

1 A 2 f Manufacturing Industries and Construction - Other - mobile sources

In the following the methodology of estimating emissions from mobile sources of category *1 A 2 f Other* is described. The share in total GHG emissions from sector *1 A* is 1.4% for the year 1990 and 1.3% for the year 2003. All GHGs emissions originate from liquid fossil fuel combustion.

Table 58: Greenhouse gas emissions from Category 1 A 2 f mobile sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO2-equ [Gg]
1990	1 015.95	0.07	0.35	1 126.13
1991	1 056.85	0.08	0.37	1 171.44
1992	1 068.10	0.08	0.37	1 183.89
1993	1 034.04	0.08	0.36	1 146.16
1994	1 061.28	0.08	0.38	1 180.05
1995	1 036.24	0.07	0.37	1 152.30
1996	1 007.95	0.07	0.37	1 121.98
1997	1 024.94	0.07	0.38	1 143.72
1998	1 040.13	0.07	0.39	1 162.58
1999	1 046.85	0.06	0.37	1 162.39
2000	1 060.59	0.06	0.36	1 173.27
2001	1 075.61	0.06	0.35	1 186.00
2002	1 091.70	0.06	0.35	1 200.13
2003	1 104.68	0.05	0.31	1 202.66
Trend 1990 - 2003	9%	-30%	-11%	7%

Combustion of liquid fossil fuels is the only mobile source of CO_2 emissions from category *1 A 2 f*.

Methodology

In 2001 a study on off road emissions in Austria was finished [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 f 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 Activities

Depending on the fuel consumption of the engine the ratio power of the engine was calculated, emissions were calculated by multiplying ratio power and emission factors. To improve data quality the influence of the vehicle age on the operating time was taken into account.

With this method all relevant effects on engine emissions could be covered:

- Emissions according to the engine type
- Emissions according to the effective engine performance
- Emissions according to the engine age
- Emissions depending on the engine operating time
- Engine operating time according to the engine age

The used methodology conforms to the requirements of the IPCC tier 3 methodology.

Emission factors

Emission factors were defined for four categories of engine type depending on the year of construction. Emission factors are listed in Table 59 to Table 62. The emission factors present fuel consumption and emissions according to the engine power output. Total emissions are calculated by multiplying emission factors with average motor capacity and activity data. With this method national total fuel consumption and total emissions are calculated with a bottom-up method. Calculated total fuel consumption of off-road traffic is summed up with total fuel consumption of road transport and is compared with national total sold fuel: due to uncertainties of the bottom-up method the values differ by about 5%. To be consistent with the national energy balance, activity data in the bottom-up approaches for both road transport and off-road transport is adjusted so that finally the calculated total fuel consumption equals the figure of fuel sold in the national energy balance.

Table 59: Emission Factors for diesel engines > 80 kW

Year	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
1993	247.2	13.89	88.89
1997	239.2	11.11	97.22
2000	231.7	8.33	61.11

Table 60: Emission Factors for diesel engines < 80 kW

Year	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
1993	259.7	27.78	88.89
1997	251.1	19.44	97.22
2000	243.3	16.67	61.11

Table 61: Emission Factors for 4-stroke-petrol engines

Year	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
1993	481.7	600.00	11.11
1997	455.6	533.33	11.11
2000	438.1	494.44	11.11

Table 62: Emission Factors for 2-stroke-petrol engines

Year	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O
1993	613.1	833.33	2.78
1997	591.1	750.00	2.78
2000	573.6	666.67	2.78

Activity data

Activity data, vehicle stock and specific fuel consumption for vehicles and machinery (e.g. leader, digger, …) were taken from:

- STATISTIK AUSTRIA
- Questionnaire to vehicle and machinery user
- Information from vehicle and machinery manufacturer
- Interviews with experts
- Expert judgment

Activities used for estimating emissions of *1 A 2 f* as well as the implied emission factors (national total emissions divided by total fuel consumption in TJ) are presented in the following table.

Table 63: Implied emission factors and activities for industrial off-road traffic 1990–2003

		Implied Emission Factors		
	Activity	CO_2	CH_4	N_2O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	13 724	74.02	5.4	25.8
1991	14 277	74.03	5.5	25.8
1992	14 429	74.03	5.5	25.8
1993	13 971	74.02	5.5	25.8
1994	14 339	74.02	5.3	26.6
1995	14 033	73.84	5.3	26.6
1996	13 650	73.84	5.2	26.8
1997	13 880	73.84	5.0	27.5
1998	14 086	73.84	4.9	27.9
1999	14 210	73.67	4.4	26.1
2000	14 396	73.67	4.2	25.1
2001	14 600	73.67	4.0	24.3
2002	14 819	73.67	3.7	23.5
2003	14 995	73.67	3.5	21.0
Trend 1990 - 2003	*9%*	*-0.5%*	*-35%*	*-19%*

Recalculation

Due to results from a new study on tank tourism (which has not been published yet), the split of diesel consumption into road and off-road traffic has been recalculated; as the study shows, in the past years more diesel flow in the road traffic than in the off-road sector (and vice versa in the early 90-ties): for the base year about 7% more fuel has been allocated to road transport, and for the year 2002 it was about 2% less diesel that has been reallocated from road transport to off-road transport in forestry (*1 A 4 mobile* – agriculture and forestry) and industry (*1 A 2 f*).

3.2.2.10 1 A 3 a Civil Aviation

Key Source: No

Greenhouse gas emissions from aviation are low in comparison to emissions from the transport sector but show a strong increase from 1990 to 2003. However, the trend for the different GHGs varies due to different methodologies of emission estimation.

The category *1 A 3 a Civil Aviation* contains flights according to Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) for national LTO and national cruise. International LTO and international cruise is considered in *I B Av International Bunkers Aviation*. Military Aviation is allocated in *1 A 3 e Other.* For VFR only CO_2 emissions were considered.

Table 64: CO_2 and N_2O emissions from 1 A 3 a Civil Aviation by subcategories 1990-2003

	CO_2			N_2O		CH_4
	nat. LTO	VFR	nat. cruise	nat. LTO	nat. cruise	nat. LTO
	[Gg]	[Gg]	[Gg]	[Gg]	[Gg]	[Gg]
1990	10.0	7.8	14.2	0.0006	0.0005	0.0022
1991	10.8	8.1	18.7	0.0007	0.0006	0.0021
1992	11.6	8.3	23.2	0.0007	0.0007	0.0021
1993	12.4	8.6	27.6	0.0008	0.0009	0.0020
1994	13.2	8.8	32.1	0.0008	0.0010	0.0019
1995	14.0	7.1	36.6	0.0009	0.0012	0.0018
1996	16.2	6.8	40.6	0.0010	0.0013	0.0029
1997	18.4	7.6	44.5	0.0011	0.0014	0.0039
1998	20.6	8.2	48.5	0.0012	0.0015	0.0050
1999	21.1	8.7	51.3	0.0012	0.0016	0.0052
2000	21.6	6.4	54.1	0.0014	0.0017	0.0054
2001	17.2	6.4	43.1	0.0011	0.0014	0.0043
2002	19.7	6.4	49.1	0.0013	0.0016	0.0049
2003	17.2	6.4	43.1	0.0013	0.0014	0.0043
Trend 1990 – 2003	*72%*	*-18%*	*204%*	*117%*	*180%*	*95%*

Methodological Issues

A country-specific methodology was applied.

The calculations are based on a study commissioned by the Umweltbundesamt finished in 2002 [KALIVODA et. al, 2002].

For the air transport class IFR (Instrument Flight Rules) the very detailed methodology from the CORINAIR guidebook in an advanced version (based on the [MEET, 1999] model) has been used. It is based on air traffic movement data[18] (flight distance and destination per aircraft type), aircraft/ engine performance data and emission factors.

Activity Data

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 were summed up to a total fuel consumption figure. This value was compared by the Umweltbundesamt with the total amount of kerosene sold in Austria of the national energy balance: a difference was observed (lower fuel consumption in the energy balance). Therefore 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.

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 number of LTO cycles performed was obtained by disaggregating total LTOs obtained from STATISTIK AUSTRIA according to the ratio of fuel used for IFR domestic LTO and IFR international LTO respectively as obtained from the study (assuming equal fuel consumption for domestic and international LTO).

The study only delivers values until 2000, for the years 2001 to 2003 the fuel allocation was based on the values and shares for 2000. The splitting of the energy data of 2003 into national and international aviation has been done according to the flight numbers of arrival and departure flights (Statistic Austria).

Fuel consumption in [t] was transformed into [GJ] using the heating values as presented in Annex 4.

Table 65: Number of national LTO cycles and fuel consumptions as obtained from the MEET model 1990-2003

	Activity			
	nat. LTO Kerosene [Mg]	VFR Gasoline [Mg]	nat. cruise Kerosene [Mg]	national LTO [-]
1990	3 164	2 487	4 508	6 220
1991	3 417	2 563	5 929	6 644
1992	3 670	2 641	7 351	7 450
1993	3 924	2 722	8 773	7 947
1994	4 177	2 805	10 195	8 219
1995	4 430	2 241	11 616	8 923
1996	5 128	2 153	12 877	10 233
1997	5 827	2 417	14 137	11 013
1998	6 525	2 602	15 398	12 025

[18] This data is also used for the split national/ international aviation.

1999	6 697	2 771	16 279	12 210
2000	6 868	2 039	17 161	13 551
2001	5 474	2 039	13 677	13 045
2002	6 242	2 039	15 596	13 084
2003	5 474	2 040	13 677	13 652
Trend 1990 - 2003	*73%*	*-18%*	*203%*	*119%*

CO_2

CO_2 emissions covered in this subcategory were calculated separately for VFR-flights and IFR-flights, for national LTO and national cruise.

For calculation of CO_2 emissions an emission factor of 3 150 kg CO_2/ Mg fuel has been used for all subcategories (IFR and VFR), was taken from the study [KALIVODA et. al, 2002].

N_2O

CORINAIR simple methodology was used.

For N_2O emissions VFR flights are not considered as the applied emission factors only refers to an "average international fleet with large aircraft" which is not true for this subcategory.

The applied emission factors for national/international cruse and national/international LTO were taken from the 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).

CH_4

Following the simple methodology of the CORINAIR Guidebook, CH_4 emissions for national and international cruise are assumed to be Zero. Furthermore, for calculating CH_4 emissions VFR aviation was not considered.

For calculation of CH_4 emissions an emission factor of 0.53 g/GJ kerosene (IFR national/ international LTO) taken from the study [KALIVODA et. al, 2002] has been applied.

Recalculations

The splitting of the energy data into national and international aviation of 2001 and 2002 has been updated according to the energy balance.

3.2.2.11 1 A 3 b Road Transport

Key Source: Yes (CO_2: diesel/ gasoline; N_2O: gasoline)

Emissions from road transportation are covered in this category.

Table 66: Greenhouse gas emissions from Category 1 A3 b Road Transport

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Total GHG [Gg CO2e]
1990	11 924	2.88	0.52	12 144
1991	13 509	2.85	0.73	13 794
1992	13 454	2.58	0.84	13 770
1993	13 636	2.37	0.95	13 979

1994	13 588	2.16	0.99	13 941
1995	13 965	1.97	0.99	14 312
1996	15 544	1.79	0.97	15 883
1997	14 466	1.60	0.91	14 781
1998	16 548	1.53	0.96	16 877
1999	15 843	1.36	0.88	16 143
2000	16 879	1.25	0.85	17 171
2001	18 114	1.16	0.84	18 399
2002	20 138	1.10	0.87	20 430
2003	21 883	1.04	0.87	22 173
Trend 1990 -2003	*83.5%*	*-64.0%*	*68.0%*	*82.6%*

Table 67: GHG emissions from Road Transport, differentiated by means of transportation

	Passenger cars		light duty vehicles	heavy duty vehicles	moped	motorcycle
	petrol	diesel				
	[Gg CO_2e]	[Gg CO_2e]	[Gg CO_2e]	[Gg CO_2e]	[Gg CO_2e]	[Gg CO_2e]
1990	7 514	1 471	1 135	1 970	22	34
1991	8 372	1 685	1 172	2 509	21	35
1992	8 047	1 803	1 207	2 655	20	37
1993	7 761	1 948	1 224	2 987	19	39
1994	7 505	2 202	1 269	2 904	19	42
1995	7 262	2 427	1 283	3 275	18	46
1996	6 707	2 678	1 304	5 123	19	50
1997	6 355	2 938	1 327	4 088	18	54
1998	6 690	3 404	1 364	5 341	18	59
1999	6 189	3 610	1 409	4 853	17	65
2000	5 986	3 941	1 423	5 734	17	68
2001	6 043	4 353	1 408	6 505	17	72
2002	6 531	5 183	1 404	7 220	17	75
2003	6 697	5 933	1 400	8 047	17	79
Trend 1990 - 2003	*-10.9%*	*303.4%*	*23.4%*	*308.5%*	*-23.6%*	*133.0%*

Even more than a third of the greenhouse gas emissions of the road sector are caused by heavy duty vehicles. In comparison with the emissions of 1990 the emissions of diesel cars and heavy duty vehicles tripled.

Methodology

Mobile combustion is differentiated into the categories *Passenger Cars*, *Light Duty Vehicles*, *Heavy Duty Vehicles* and *Buses, Mopeds and Motorcycles*.

In order to apply the CORINAIR methodology a split of the fuel consumption of different vehicle categories is needed. Calculations of emissions from *Mobile Combustion* are based on the GLOBEMI study [HAUSBERGER, 1998].

For road transportation, energy consumption and emissions of the different categories are calculated by multiplying the yearly road performance (km/vehicle and year) and the specific energy use with emission factors. The emissions from cold starts are calculated separately – taking into account temperature, interception periods and driving distances.

Emission factors

Implied emission factors for the different means of road transportation are listed in the following tables. The IEFs change over time due to new technologies and changes in the fleet composition.

Table 68: Implied emission factors of passenger cars 1990 - 2003

		Implied Emission Factors		
	Activity [TJ]	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
1990	135 720	87.86	21.2	3.8
1991	151 924	88.92	18.8	4.8
1992	150 382	89.47	17.2	5.6
1993	152 804	89.24	15.5	6.2
1994	156 013	87.09	13.8	6.4
1995	158 961	87.85	12.4	6.2
1996	158 512	98.06	11.3	6.1
1997	160 981	89.86	9.9	5.6
1998	177 926	93.01	8.6	5.4
1999	177 158	89.43	7.7	5.0
2000	183 537	91.97	6.8	4.7
2001	195 568	92.62	5.9	4.3
2002	224 320	89.77	4.9	3.9
2003	246 813	88.66	4.2	3.5
Trend 1990 - 2003	*82%*	*1%*	*-80%*	*-8%*

The increase of the implied emission factor of N_2O is due to the implementation of three-way-catalytic converters in petrol passenger cars in the year 1987, because since then the share of vehicles with these converters increased. As N_2O is produced within the catalytic converter at adequate temperature, the implied emission factors of N_2O (and the sum of emissions of petrol cars) increased too.

The catalytic converter of former generation (EURO 1) had an higher N_2O-niveau than the catalysts of the newer generation (as of EURO 2). Therefore, since 1996 (implementation of EURO 2) the implied emission factor of N_2O is decreasing steadily.

The decrease of the IEF for CH_4 is also due to the increasing share of vehicles with catalytic converters and improved combustion technologies.

The change of the implied emission factors of CO_2 over time is caused by the different split of diesel and petrol. The implied emission factors of light duty vehicles show the same effect.

Table 69: Implied emission factors of light duty vehicles 1990 - 2003

		Implied Emission Factors		
	Activity	CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	15 079	74.73	7.9	1.6
1991	15 596	74.67	7.0	1.6
1992	16 078	74.61	6.1	1.6
1993	16 425	74.07	5.4	1.6
1994	17 026	74.06	4.7	1.5
1995	17 242	73.93	4.1	1.5
1996	17 535	73.92	3.6	1.5
1997	17 843	73.92	3.1	1.5
1998	18 339	73.91	2.7	1.5
1999	18 981	73.76	2.3	1.5
2000	19 180	73.75	2.0	1.5
2001	18 985	73.74	1.8	1.5
2002	18 927	73.74	1.5	1.4
2003	18 874	73.73	1.3	1.4
Trend 1990 - 2003	*25%*	*-1%*	*-83%*	*-16%*

Table 70: Implied emission factors of heavy duty vehicles 1990 - 2003

		Implied Emission Factors		
	Activity	CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	26 409	74.01	2.5	1.5
1991	33 653	74.01	2.2	1.5
1992	35 617	74.01	2.1	1.5
1993	40 078	74.01	2.0	1.5
1994	38 972	74.01	1.9	1.5

1995	44 073	73.84	1.9	1.4
1996	68 959	73.84	1.7	1.4
1997	55 025	73.84	1.6	1.4
1998	71 910	73.84	1.4	1.4
1999	65 496	73.67	1.4	1.3
2000	77 387	73.67	1.3	1.3
2001	87 817	73.67	1.2	1.3
2002	97 488	73.67	1.2	1.2
2003	108 680	73.67	1.1	1.2
Trend 1990 - 2003	*312%*	*0%*	*-56%*	*-20%*

Table 71: Implied emission factors of Mopeds 1990 - 2003

		Implied Emission Factors		
	Activity	CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	271	75.75	1 790.5	0.4
1991	254	75.74	1 771.0	0.4
1992	243	75.78	1 717.3	0.4
1993	238	74.16	1 632.3	0.4
1994	230	74.14	1 571.4	0.4
1995	224	74.15	1 506.9	0.4
1996	219	74.21	1 444.2	0.5
1997	215	74.15	1 378.3	0.5
1998	213	74.18	1 308.0	0.5
1999	210	74.12	1 249.0	0.5
2000	204	74.23	1 204.5	0.5
2001	199	74.09	1 157.0	0.5
2002	195	74.18	1 112.5	0.5
2003	192	74.24	1 061.4	0.5
Trend 1990 - 2003	*-29%*	*-2%*	*-41%*	*-20%*

Table 72: Implied emission factors of Motorcycles 1990 - 2003

	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	310	75.83	67.2	0.6
1991	330	75.83	66.3	0.6
1992	368	75.82	62.5	0.8
1993	416	74.21	57.7	0.7
1994	465	74.16	54.4	0.6
1995	528	74.17	50.7	0.8
1996	587	74.19	47.9	0.7
1997	645	74.18	45.8	0.8
1998	721	74.20	43.3	0.7
1999	799	74.18	41.3	0.8
2000	849	74.19	40.0	0.7
2001	896	74.15	38.3	0.8
2002	945	74.19	36.7	0.7
2003	998	74.19	35.1	0.8
Trend 1990 - 2003	*222%*	*-2%*	*-48%*	*33%*

Activity data

Calculation of the activity data is based on the GLOBEMI study [HAUSBERGER, 1998]. Information on the number of new vehicles is published yearly by STATISTIK AUSTRIA. Information on the yearly road performance of the vehicles is supplied by the Austrian automobile clubs throughout the annual vehicle inspection system.

The yearly road performance of the vehicle categories for different street categories is calculated as a function of vehicle size and vehicle age. The extrapolation of the yearly vehicle stock- and performance share (by vehicle age, motor type and vehicle size) is based on a dynamic, vehicle specific drop out- and road performance function.

Based on the GLOBEMI model total fuel consumption and total emissions for road transport are calculated with a bottom-up approach. Calculated total fuel consumption of road transport is summed up with total fuel consumption of off road traffic and is compared with national total sold fuel: to be consistent with the national energy balance, activity data in the bottom-up approach is adjusted so that finally the calculated total fuel consumption equals the figure of fuel sold in the national energy balance.

Uncertainties

Uncertainty estimates are based on [Winiwarter & Rypdal, 2001]:

- the uncertainty of activity data (total fuel sold) for road transport is considered to be low (0.5%), and also the uncertainty of CO_2 emission factors is estimated to be 0.5%.
- N_2O emissions are calculated not only on the basis of the amount of total fuel sold but also on vehicle km per vehicle type, that's why the uncertainty of activity data for N_2O emissions is estimated to be higher than for CO_2 (10%).

- 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 50%.

Recalculation

As already mentioned under "recalculations" in Chapter *1 A 2 f Manufacturing industries and construction - mobile sources*, the split of diesel allocated to the road and off-road sector respectively has been recalculated;

Furthermore, emission factors for CH_4 and N_2O used in the inventory for the whole time series have been updated using the updated handbook of emission factors (version 2.1). The handbook is the result of new measurements.

3.2.2.12 1 A 3 c Railways

Key Source: No

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

Table 73: Greenhouse gas emissions from Category 1 A 3 c Railways.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1990	173.91	0.007	0.022
1991	180.21	0.007	0.023
1992	179.83	0.007	0.022
1993	175.24	0.007	0.021
1994	176.77	0.007	0.021
1995	165.03	0.006	0.019
1996	149.27	0.006	0.017
1997	148.24	0.005	0.017
1998	145.98	0.005	0.017
1999	179.92	0.006	0.020
2000	179.41	0.006	0.020
2001	178.88	0.006	0.019
2002	176.54	0.006	0.019
2003	174.05	0.005	0.018
Trend 1990 - 2003	*0.1%*	*-27.2%*	*-15.4%*

The applied methodology is described in the subchapter on mobile sources of *1 A 2 f* (see Chapter 3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other). Activities used for estimating the emissions and the implied emission factors are presented in the following table.

Table 74: Emission factors and activity data for railway 1990–2003

	Activity	Implied Emission Factors CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	2 330	74.6	3.1	9.3
1991	2 417	74.6	3.1	9.3
1992	2 411	74.6	3.0	9.2
1993	2 351	74.5	3.0	9.1
1994	2 372	74.5	2.9	8.9
1995	2 217	74.4	2.8	8.8
1996	2 004	74.5	2.8	8.6
1997	1 998	74.2	2.7	8.5
1998	1 968	74.2	2.6	8.4
1999	2 433	73.9	2.5	8.3
2000	2 428	73.9	2.4	8.1
2001	2 421	73.9	2.4	8.0
2002	2 389	73.9	2.3	7.9
2003	2 355	73.9	2.3	7.8
Trend 1990 - 2003	*1%*	*-1%*	*-26%*	*-16%*

3.2.2.13 1 A 3 d Navigation

Key Source: No

In this category emissions from diesel and gas fuelled ships are considered.

Table 75: Greenhouse gas emissions from Category 1 A 3 d Navigation.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1990	52.07	0.013	0.012
1991	47.26	0.013	0.011
1992	46.28	0.013	0.011
1993	46.64	0.013	0.011
1994	55.56	0.013	0.013
1995	53.91	0.013	0.012
1996	53.97	0.013	0.012
1997	61.81	0.013	0.014
1998	62.42	0.013	0.014
1999	63.03	0.012	0.014

2000	63.63	0.012	0.014
2001	72.73	0.012	0.016
2002	79.57	0.012	0.017
2003	84.25	0.012	0.018
Trend 1990 - 2003	*61.8%*	*-4.9%*	*44.8%*

The applied methodology is described in the subchapter on mobile sources of *1 A 2 f* (see Chapter 3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other). Activities used for estimating the emissions and the implied emission factors are presented in the following table.

Table 76: Emission factors and activity data for the sector Navigation 1990–2003

		Implied Emission Factors		
	Activity	CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	701	74.33	18.44	17.76
1991	636	74.36	20.10	17.52
1992	622	74.37	20.45	17.19
1993	630	74.05	20.18	16.89
1994	750	74.04	17.17	17.19
1995	730	73.90	17.46	16.84
1996	730	73.90	17.31	16.60
1997	836	73.89	15.21	16.71
1998	845	73.89	14.91	16.49
1999	855	73.74	14.57	16.22
2000	863	73.74	14.25	16.00
2001	986	73.73	12.50	16.02
2002	1 079	73.73	11.42	15.93
2003	1 143	73.72	10.75	15.77
Trend 1990 - 2003	***63%***	***-1%***	***-42%***	***-11%***

3.2.2.14 1 A 3 e Other Transportation

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 2003. The increase of emissions is caused by the increase of natural gas transfer through Austria.

Table 77: Greenhouse gas emissions from Category 1 A 3 e.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	223	0.006	0.0004	223
1991	224	0.006	0.0004	224
1992	218	0.006	0.0004	219
1993	213	0.006	0.0004	213
1994	208	0.006	0.0004	208
1995	225	0.006	0.0004	225
1996	232	0.006	0.0004	232
1997	231	0.006	0.0004	231
1998	349	0.010	0.0006	349
1999	429	0.012	0.0008	430
2000	531	0.014	0.0010	531
2001	454	0.012	0.0008	455
2002	505	0.014	0.0009	505
2003	484	0.013	0.0009	485
Trend 1990-2003	*117.5%*	*117.5%*	*117.5%*	*117.5%*

Combustion of natural gas is the only source of CO_2 emissions from category *1 A 2 e*.

Methodology

The CORINAIR simple methodology is applied.

Activity data (fuel consumption) is taken from [IEA JQ 2004] as presented in Annex 4.

CO_2 and CH_4 emission factors are taken from studies [BMWA-EB, 1996].

N_2O emission factors are taken from a national study [BMUJF, 1994].

Emission factors for 2002 are presented in Table 78.

Table 78: Emission factors of Category 1 A 2 e for all years.

Fuel	CO_2 [t / TJ]	CH_4 [kg / TJ]	N_2O [kg / TJ]
Natural Gas	55.00	1.50	0.10

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

3.2.2.15 1 A 4 Other sectors

Category *1 A 4 Other sectors* enfolds emissions from stationary fuel combustion in the small combustion sector. It also includes emissions from mobile sources in households and gardening including snow cats and skidoos as well as from agriculture and forestry.

The share in total GHG emissions from sector *1 A* is 27.6% for the year 1990 and 22.2% for the year 2003.

Table 79: Greenhouse gas emissions from Category 1 A 4.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	14 392	18.88	0.95	15 083
1991	15 296	20.21	0.95	16 015
1992	14 710	18.45	0.94	15 388
1993	14 569	18.00	0.94	15 240
1994	13 314	16.21	0.93	13 943
1995	14 459	16.90	0.94	15 106
1996	15 738	17.96	1.03	16 434
1997	14 170	13.63	1.03	14 774
1998	13 953	13.13	0.99	14 537
1999	14 776	13.30	1.01	15 368
2000	13 097	12.38	0.93	13 645
2001	14 883	13.68	1.00	15 480
2002	13 663	12.98	0.96	14 234
2003	14 702	13.96	0.98	15 300
Trend 1990-2003	*2.2%*	*-26.1%*	*3.6%*	*1.4%*

As can be seen from Table 80, 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 CO_2 emissions from natural gas combustion increased.

Table 80: Share of fuel types on total CO_2 emissions from Category 1 A 4.

	Liquid	Solid	Gaseous
1990	62%	20%	18%
1991	60%	20%	20%
1992	59%	17%	23%
1993	59%	15%	26%
1994	61%	14%	25%
1995	60%	12%	28%
1996	63%	11%	26%
1997	63%	10%	28%
1998	63%	8%	28%
1999	60%	8%	32%
2000	61%	7%	31%
2001	60%	6%	35%
2002	63%	6%	32%
2003	63%	5%	32%

<u>1 A 4 Other sectors - stationary sources</u>

Key Source: Yes (CO_2: gaseous/ liquid/ solid; CH_4: biomass)

Category *1 A 4 Other sectors stationary* enfolds emissions from stationary fuel combustion in the small combustion sector.

The share in total GHG emissions from sector *1 A* is 24.6% for the year 1990 and 19.7% for the year 2003.

Table 81: Greenhouse gas emissions from Category 1 A 4 stationary sources.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	12 893	18.59	0.48	13 433
1991	13 937	19.94	0.53	14 520
1992	13 307	18.16	0.50	13 844
1993	13 154	17.71	0.50	13 682
1994	11 818	15.92	0.46	12 294
1995	13 054	16.62	0.50	13 556
1996	14 214	17.67	0.54	14 751
1997	12 553	13.33	0.49	12 986
1998	12 391	12.85	0.48	12 809
1999	13 191	13.02	0.50	13 620
2000	11 599	12.13	0.46	11 995
2001	13 317	13.44	0.52	13 759
2002	12 057	12.75	0.48	12 473
2003	13 100	13.75	0.52	13 550
Trend 1990-2003	*1.6%*	*-26.0%*	*8.4%*	*0.9%*

As can be seen in Table 82, liquid fossil fuels are the main stationary source of CO_2 emissions from category *1 A 4* with quite constant share over the total time series. Since 1990 solid fossil fuels became less important whereas CO_2 emissions from natural gas combustion increased.

Table 82: Share of fuel types in total CO_2 emissions from Category 1 A 4 stationary sources.

	Liquid	Solid	Gaseous	Other
1990	57%	23%	20%	0.2%
1991	56%	22%	22%	0.1%
1992	55%	19%	26%	0.2%
1993	55%	17%	29%	0.1%
1994	56%	16%	28%	0.1%
1995	56%	14%	31%	0.1%
1996	59%	12%	28%	0.2%
1997	58%	11%	31%	0.2%
1998	59%	10%	32%	0.1%
1999	55%	9%	36%	0.2%
2000	56%	8%	35%	0.1%
2001	55%	6%	39%	0.0%

	Liquid	Solid	Gaseous	Other
2002	58%	6%	36%	0.1%
2003	59%	5%	36%	0.1%

Methodology

The CORINAIR simple methodology is applied.

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

1. Central Heatings (CH)
2. Apartment Heatings (AH)
3. Stoves (ST)

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

There is no information about the structure of devices within this categories. Therefore it is assumed that the whole fuel consumption reported in [IEA JQ 2004] is combusted in devices similar to central heatings.

1 A 4 b Residential

For category *1 A 4 b Residential* the disaggregation of the fuel consumption to each of the heating types is performed by the means of building- and habitation-statistics which were surveyed for the years 1991 and 2000 by STATISTIK AUSTRIA.

Emission factors

CO_2, CH_4 and VOC emission factors are taken from studies [BMWA-EB, 1990], [BMWA-EB, 1996]. 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 as listed in Table 83. The split follows closely [STANZEL et. al, 1995].

Table 83: 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%
Natural Gas; LPG	80%	20%	100%
Biomass	25%	75%	100%

The selected emission factors for 2003 are presented in Table 84.

Table 84: Emission factors of Category 1 A 4 for the year 2003.

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	-	0.10	-
Natural Gas	55.00	0.80	0.80	1.00	1.00
Fuel Wood	(1)100.00	150.00	220.00	3.00	7.00
Wood Waste	(1)110.00	150.00	220.00	3.00	7.00
Landfill Gas	(1)112.00	1.50	-	1.00	-
Industrial Waste	(2)10.00	12.00	-	1.40	-

(1) Reported as CO2 emissions from biomass.

(2) According to IPCC guidelines non fossil CO2 emissions of "other fuels" are not reported.

Activity data

Fuel consumption is taken from [IEA JQ 2004] as presented in Annex 4.

Recalculations

Changes of activity data are based on energy balance recalculation as described in Annex 2.

Changes in allocation of emissions

Emissions from electricity autoproducers in the commercial sector so far reported under category *1 A 2 f Manufacturing Industries and Construction-Other* are now reported under category *1 A 4 a Commercial/Institutional*.

1 A 4 Other sectors - mobile sources

1 A 4 b Household and Gardening

Key Source: No

The applied methodology is described in the subchapter on mobile sources of 1 A 2 f (see Chapter 3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other). Activities used for estimating the emissions and the implied emission factors are presented in the following table.

Table 85: Greenhouse gas emissions from mobile sources of household and gardening 1990–2003

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1990	141.81	0.11	0.02
1991	142.23	0.11	0.02
1992	143.63	0.11	0.02
1993	144.52	0.11	0.02
1994	143.47	0.11	0.03
1995	144.26	0.10	0.03
1996	143.31	0.10	0.03
1997	142.30	0.10	0.03
1998	141.40	0.10	0.03
1999	140.62	0.10	0.02
2000	140.45	0.09	0.02
2001	140.42	0.08	0.02
2002	140.49	0.07	0.02
2003	140.22	0.06	0.02
Trend 1990 - 2003	*-1%*	*-40%*	*-21%*

Table 86: Emission factors and activity data for mobile sources of household and gardening 1990–2003

	Activity	Implied Emission Factors		
		CO_2	CH_4	N_2O
	[TJ]	[t/TJ]	[kg/TJ]	[kg/TJ]
1990	1 891.2	74.98	0.056	0.013
1991	1 896.8	74.98	0.056	0.013
1992	1 915.6	74.98	0.055	0.013
1993	1 950.0	74.11	0.055	0.013
1994	1 935.9	74.11	0.055	0.013
1995	1 948.7	74.03	0.054	0.013
1996	1 935.8	74.03	0.053	0.013
1997	1 922.1	74.03	0.053	0.013
1998	1 910.0	74.03	0.053	0.013
1999	1 901.5	73.95	0.051	0.012
2000	1 899.1	73.96	0.046	0.012
2001	1 899.1	73.94	0.042	0.012
2002	1 899.3	73.97	0.037	0.011
2003	1 895.7	73.97	0.033	0.010
Trend 1990 - 2003	*0.2%*	*-1.3%*	*-41%*	*-23%*

1 A 4 c Agriculture and Forestry

Key Source: Yes (CO_2: mobile-diesel)

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

The applied methodology is described in the subchapter on mobile sources of *1 A 2 f* (see Chapter 3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other). Activities used for estimating the emissions and the implied emission factors are presented in the following tables.

Table 87: Greenhouse gas emissions for mobile sources of Agriculture and Forestry

	Agriculture			Forestry		
	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]
1990	821.35	0.12	0.27	536	0.08	0.18
1991	822.87	0.12	0.27	394	0.06	0.13
1992	832.86	0.12	0.27	426	0.06	0.14
1993	839.26	0.12	0.28	431	0.06	0.14
1994	843.89	0.12	0.28	509	0.07	0.17
1995	767.93	0.11	0.26	493	0.07	0.17
1996	836.50	0.11	0.28	544	0.07	0.19
1997	932.84	0.12	0.32	542	0.07	0.19
1998	898.22	0.12	0.31	523	0.07	0.18
1999	915.48	0.11	0.31	529	0.06	0.18
2000	857.65	0.10	0.28	500	0.06	0.17
2001	917.18	0.10	0.29	509	0.06	0.17
2002	902.51	0.10	0.28	563	0.06	0.18
2003	813.77	0.09	0.24	648	0.06	0.21
Trend 1990 - 2003	*-1%*	*-25%*	*-11%*	*21%*	*-16%*	*17%*

Table 88: Emission factors and activity data for mobile sources of Agriculture and Forestry 1990–2003

	Agriculture				Forestry			
		Implied Emission Factors				Implied Emission Factors		
	Activity [TJ]	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]	Activity [TJ]	CO_2 [t/TJ]	CH_4 [kg/TJ]	N_2O [kg/TJ]
1990	11 088	74.1	10.5	24.3	7 234	74.1	10.4	24.3
1991	11 108	74.1	10.5	24.3	5 318	74.1	10.4	24.3
1992	11 243	74.1	10.5	24.3	5 758	74.1	10.3	24.3
1993	11 338	74.0	10.5	24.3	5 826	74.0	10.3	24.3
1994	11 401	74.0	10.4	24.4	6 883	74.0	10.2	24.6
1995	10 398	73.9	10.5	24.5	6 678	73.9	10.0	24.8
1996	11 327	73.9	10.1	24.9	7 371	73.9	9.7	25.1
1997	12 631	73.9	9.6	25.3	7 340	73.9	9.5	25.4

1998	12 162	73.9	9.5	25.2	7 076	73.9	9.4	25.7
1999	12 424	73.7	9.0	24.7	7 174	73.7	8.9	25.3
2000	11 639	73.7	8.8	24.2	6 784	73.7	8.5	24.8
2001	12 448	73.7	8.2	23.5	6 905	73.7	8.0	24.4
2002	12 248	73.7	7.9	22.6	7 642	73.7	7.6	24.0
2003	11 043	73.7	7.9	21.6	8 801	73.7	7.2	23.3
Trend 1990 - 2003	-0.4%	-0.5%	-25%	-11%	22%	-0.5%	-31%	-4%

Recalculation

Activity data for agriculture and forestry have been recalculated based on results from a new study, which estimates the usage of diesel in the Austrian agriculture [Handler, 2003]; furthermore, as already mentioned under "recalculations" in Chapter *1 A 2 f Manufacturing industries and construction - mobile sources*, the split of diesel allocated to the road and off-road sector respectively has been recalculated.

Activity decreased by about 13% in 1990 and decreased by 14% in 2002, compared to the previous submission.

3.2.2.16 1 A 5 Other

In this category emissions of military transport (road and aviation) are reported.

Military Aviation

The following table presents GHG emissions from military aviation.

Table 89: Greenhouse gas emissions from military aviation

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Activity [TJ]
1990	32.9	0.0021	0.0011	455.1
1991	35.0	0.0022	0.0011	484.0
1992	31.6	0.0020	0.0010	436.8
1993	37.3	0.0024	0.0012	516.2
1994	39.5	0.0025	0.0013	546.2
1995	30.5	0.0019	0.0010	418.8
1996	36.8	0.0023	0.0012	507.1
1997	35.0	0.0021	0.0011	482.6
1998	40.3	0.0024	0.0013	556.0
1999	39.5	0.0023	0.0013	543.6
2000	42.9	0.0027	0.0014	589.5
2001	34.2	0.0021	0.0011	469.8
2002	39.0	0.0026	0.0013	535.7
2003	34.2	0.0025	0.0011	469.7
Trend 1990 - 2003	*4.0%*	*19.0%*	*0%*	*3%*

Methodological Issues

Fuel consumption for military flights were reported by the Ministry of Defence. Calculation of emissions from military aviation did not distinguish between LTO and cruise.

For calculation of 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 emissions have been calculated with an emission factor of 0.53 g/GJ. The emission factor is assumed to be the same as the emission factor of national LTO.

As recommended in the IPCC GPG, for calculation of N_2O emissions of military flights the IEF of civil aviation domestic LTO was applied as no military specific emission factor was available.

Military Off-Road (without aviation)

The applied methodology is described in the subchapter on mobile sources of 1 A 2 f (see Chapter 3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other).

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. 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. For tanks and other special military vehicles the emission factors for diesel engines > 80kW was used (see Table 59; for these vehicles an power of 300kW was assumed). 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 are presented in the following table.

Table 90: Greenhouse gas emissions from Military (Off-Road without Aviation)

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Activity [TJ]
1990	2.14	0.0001	0.0008	1 990.0
1991	2.14	0.0001	0.0008	1 991.0
1992	2.14	0.0001	0.0008	1 992.0
1993	2.14	0.0001	0.0008	1 993.0
1994	2.14	0.0001	0.0008	1 994.0
1995	2.13	0.0001	0.0008	1 995.0
1996	2.12	0.0001	0.0008	1 996.0
1997	2.11	0.0001	0.0008	1 997.0
1998	2.10	0.0001	0.0008	1 998.0
1999	2.08	0.0001	0.0008	1 999.0
2000	2.07	0.0001	0.0007	2 000.0
2001	2.06	0.0001	0.0007	2 001.0
2002	2.03	0.0001	0.0006	2 002.0
2003	2.01	0.0001	0.0006	2 003.0

Trend 1990 - 2003	*-6%*	*-33%*	*-24%*	*1%*

3.2.2.17 International Bunkers - Aviation

Emissions from aviation assigned to international bunkers include the transport modes international LTO and international cruise for IFR-flights (International Flight Rules).

Table 91: Emissions and Activity from International Aviation 1990-2003

Year	CO_2		N_2O		CH_4	Activity	
	int. LTO Kerosene [Gg]	int. cruise Kerosene [Gg]	int. LTO Kerosene [Gg]	int. cruise Kerosene [Gg]	int. LTO Kerosene [Gg]	int. LTO Kerosene TJ	int. cruise Kerosene TJ
1990	90.3	795.7	0.006	0.025	0.015	1 249	11 014
1991	103.0	890.8	0.006	0.028	0.016	1 426	12 330
1992	115.8	961.6	0.007	0.031	0.017	1 603	13 310
1993	128.6	1 011.4	0.008	0.032	0.018	1 780	13 998
1994	141.4	1 044.2	0.009	0.033	0.019	1 957	14 453
1995	154.2	1 173.2	0.010	0.037	0.020	2 120	16 127
1996	164.8	1 301.6	0.010	0.041	0.023	2 270	17 927
1997	175.4	1 350.2	0.011	0.043	0.027	2 417	18 605
1998	186.0	1 392.3	0.011	0.044	0.030	2 563	19 187
1999	190.1	1 351.6	0.011	0.043	0.029	2 613	18 583
2000	194.2	1 480.8	0.012	0.047	0.029	2 669	20 356
2001	191.0	1 456.5	0.012	0.046	0.028	2 625	20 021
2002	176.9	1 349.2	0.012	0.043	0.026	2 432	18 548
2003	168.3	1 283.6	0.012	0.041	0.025	2 313	17 643
Trend 1990 - 2003	*86.4%*	*61.3%*	*100%*	*64%*	*67%*	*85.2%*	*60%*

Methodological Issues

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

3.2.3 Quality Assurance and Quality Control and Verification

For general QA/QC see Chapter 1.6.

At present STATISTIK AUSTRIA works on a written documentation for the national energy balance. Additionally a document which covers a more actual quantification of uncertainty is expected. Both documents will be presented to the Umweltbundesamt in 2005.

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

- BGBl II 1997/ 331 Feuerungsanlagen-Verordnung

- BGBl 1989/ 19 Luftreinhalteverordnung für Kesselanlagen
- BGBl 1988/ 380 Luftreinhaltegesetz für Kesselanlagen

Extracts of the relevant paragraphs are provided in Annex 6.

As already mentioned in the sub chapter on road transport, total calculated fuel consumption is adjusted to equal total fuel sold in Austria. The difference between calculated fuel consumption and observed fuel consumption is mainly due to tank tourism as in Austria fuel prices are lower than in most neighbouring countries[19].

3.2.4 Recalculations of Category 1 A

The revision of the national energy statistics for the time series 1990-2002 by STATISTIC AUSTRIA results changes for category *1 A* for all GHGs from 1990 onwards. For details see Annex 2 and the respective chapters of the subsectors of *1 A*.

Description of reasons for recalculation for each GHG is given in the relevant subchapters. The tables below show the recalculation difference of emissions from Sector *1 A Fuel Combustion* and its sub categories with respect to the previous submission.

CO_2 emissions

Table 92 shows the recalculations of CO_2 emissions for the subcategories of sector *1 A Fuel Combustion.*

Table 92: Recalculation difference of CO_2 emissions in [Gg] for Category 1 A Fuel Combustion with respect to previous submission.

	1 A	1 A 1	1 A 2	1 A 3	1 A 4	1 A 5
1990	308.22	147.28	-61.92	-354.33	577.18	0.00
1991	236.50	150.01	-9.34	-174.65	270.48	0.00
1992	282.15	201.71	-123.10	-156.98	360.52	0.00
1993	615.45	459.62	-199.22	-105.57	460.61	0.00
1994	528.97	365.53	63.48	-245.56	345.52	0.00
1995	674.11	239.37	99.24	47.82	287.68	0.00
1996	406.49	66.38	253.34	-21.40	108.17	0.00
1997	814.11	-303.76	1 110.21	-36.43	44.08	0.00
1998	393.48	50.34	428.15	88.97	-173.99	0.00
1999	301.66	-538.35	238.00	44.69	557.31	0.00
2000	310.15	-225.05	592.15	298.10	-355.05	0.00
2001	286.59	-1 088.93	1 143.94	180.52	58.23	-7.16
2002	605.03	-1 665.31	1 890.65	367.36	12.07	0.26

CH_4 emissions

[19] Results from a recent study on tank tourism [BMLFUW, 2004] show that for 2003 about 30% of total fuel sold in Austria was not driven in Austria; the share of fuel sold abroad increased since 1997, where it was negligible. In 1990 it was the other way round: about 4% of the fuel used in Austria was bought abroad.

Table 93 shows the recalculations of CH_4 emissions for the subcategories of sector *1 A Fuel Combustion.*

Table 93: Recalculation difference of CH_4 emissions in [Gg] for Category 1 A Fuel Combustion with respect to previous submission.

	1 A	1 A 1	1 A 2	1 A 3	1 A 4	1 A 5
1990	0.10	0.00	-0.01	0.05	0.06	0.00
1991	-0.05	0.00	0.00	-0.08	0.02	0.00
1992	-0.12	0.00	0.01	-0.16	0.02	0.00
1993	-0.19	0.00	0.02	-0.22	0.02	0.00
1994	-0.28	0.00	0.02	-0.31	0.02	0.00
1995	-0.27	0.00	0.02	-0.30	0.00	0.00
1996	-0.20	0.01	0.02	-0.26	0.03	0.00
1997	-0.29	-0.01	0.02	-0.28	-0.03	0.00
1998	-0.30	0.01	0.03	-0.35	0.01	0.00
1999	-0.04	-0.01	0.00	-0.32	0.29	0.00
2000	-0.02	0.00	0.03	-0.32	0.27	0.00
2001	-0.30	-0.01	0.03	-0.35	0.03	0.00
2002	-0.42	-0.05	0.12	-0.42	-0.06	0.00

N_2O emissions

Table 94 shows the recalculations of N_2O emissions for the subcategories of sector *1 A Fuel Combustion.*

Table 94: Recalculation difference of N_2O emissions in [Gg] for Category 1 A Fuel Combustion with respect to previous submission.

	1 A	1 A 1	1 A 2	1 A 3	1 A 4	1 A 5
1990	-0.88	0.00	0.07	-1.02	0.06	0.00
1991	-1.26	0.00	0.07	-1.33	0.01	0.00
1992	-1.45	0.00	0.06	-1.52	0.01	0.00
1993	-1.61	0.00	0.06	-1.67	0.00	0.00
1994	-1.71	0.00	0.06	-1.78	0.01	0.00
1995	-1.68	0.00	0.05	-1.70	-0.03	0.00
1996	-1.56	0.00	0.04	-1.59	-0.01	0.00
1997	-1.43	0.00	0.04	-1.45	0.00	0.00
1998	-1.51	0.00	0.03	-1.49	-0.05	0.00
1999	-1.33	0.00	0.04	-1.32	-0.04	0.00
2000	-1.32	0.00	0.01	-1.25	-0.09	0.00
2001	-1.26	0.00	0.01	-1.20	-0.07	0.00
2002	-1.36	0.00	0.03	-1.33	-0.07	0.00

Emissions in Gg CO_2 equivalent

Table 95 shows the recalculations in [Gg CO_2 equivalent] for the subcategories of sector *1 A Fuel Combustion.*

Table 95: Recalculation difference of GHG emissions in [Gg CO_2 equivalent] for Category 1 Energy *with respect to previous submission.*

	1 A	1 A 1	1 A 2	1 A 3	1 A 4	1 A 5
1990	36.21	146.57	-40.68	-668.03	598.35	0.00
1991	-154.88	149.53	12.02	-589.23	272.80	0.00
1992	-170.18	201.79	-103.55	-631.79	363.38	0.00
1993	111.21	459.70	-180.87	-628.60	460.99	0.00
1994	-6.92	365.79	81.44	-803.82	349.67	0.00
1995	148.47	239.71	114.76	-484.24	278.24	0.00
1996	-81.92	66.44	266.71	-519.45	104.38	0.00
1997	366.18	-304.91	1 122.17	-493.11	42.03	0.00
1998	-80.36	51.21	436.49	-380.25	-187.80	0.00
1999	-110.12	-538.92	248.98	-372.63	552.44	0.00
2000	-100.67	-223.83	596.80	-94.98	-378.66	0.00
2001	-111.21	-1 088.37	1 147.59	-199.75	36.62	-7.31
2002	174.45	-1 665.27	1 902.47	-53.57	-9.44	0.25

3.2.5 Planned Improvements

Energy Balance

A new inquiry of energy demand in the commercial sector and housholds (Mikrozenzus) was performed by STATISTIK in 2004 and will be considered in future energy statistics.

3.3 Comparison of the Sectoral Approach with the Reference Approach

3.3.1 Comparison of CO_2 emissions

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

Table 96 compares the results of the two approaches.

Table 96: Comparison of CO_2 emissions of the two approaches

Year	Reference Approach				Sectoral Approach				
	Liquid [Gg CO_2]	Solid [Gg CO_2]	Gaseous [Gg CO_2]	Total [Gg CO_2]	Liquid [Gg CO_2]	Solid [Gg CO_2]	Gaseous [Gg CO_2]	Other [Gg CO_2]	Total [Gg CO_2]
1990	28 565	15 914	12 238	56 716	28 051	13 907	11 088	379	53 425
1991	30 984	16 770	12 939	60 693	30 551	14 515	11 686	373	57 126
1992	30 072	12 952	12 705	55 729	29 323	10 683	11 749	551	52 306
1993	31 114	11 649	13 399	56 163	30 742	9 563	12 250	371	52 926
1994	30 359	11 808	13 782	55 950	30 114	9 488	12 868	430	52 900
1995	30 919	13 496	15 048	59 463	30 315	10 844	13 957	423	55 540
1996	33 392	13 665	16 017	63 073	32 941	10 827	15 109	482	59 359
1997	32 869	14 446	15 437	62 752	32 147	11 416	14 573	542	58 677
1998	35 144	12 634	15 848	63 626	34 290	9 022	14 887	467	58 666
1999	33 179	12 678	16 125	61 982	32 332	9 325	15 038	535	57 229
2000	32 305	14 240	15 388	61 934	31 689	10 685	14 461	617	57 452
2001	34 704	14 765	16 309	65 778	33 863	11 305	15 371	754	61 292
2002	35 534	15 048	16 494	67 076	35 013	11 272	15 340	754	62 420
2003	38 645	15 684	17 834	72 163	38 166	12 131	16 569	754	67 624

Table 97 presents the percentual difference of the two approaches.

Table 97: Difference of CO_2 emissions of the two approaches.

Year	Liquid	Solid	Gaseous	Total
1990	1.8%	14.%	10.4%	6.2%
1991	1.4%	15.5%	10.7%	6.2%
1992	2.6%	21.2%	8.1%	6.5%
1993	1.2%	21.8%	9.4%	6.1%
1994	0.8%	24.5%	7.1%	5.8%
1995	2.0%	24.5%	7.8%	7.1%
1996	1.4%	26.2%	6.0%	6.5%
1997	2.3%	26.6%	5.9%	6.9%
1998	2.5%	40.0%	6.5%	8.5%
1999	2.6%	36.0%	7.2%	8.3%
2000	1.9%	33.3%	6.4%	7.8%
2001	2.5%	30.6%	6.1%	7.3%

2002	1.5%	33.5%	7.5%	7.5%
2003	1.3%	29.3%	7.6%	6.7%

Reasons for deviation of CO_2 emissions:

- In the reference approach the IPCC default net calorific values are used. In the sectoral approach country specific net calorific values are taken to calculate the energy consumption.
- The selected emission factors (carbon content) of the two approaches are different.
- Liquid Fuels: 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 considers a share of feed stocks used for plastics production and solvent production as non-carbon-stored. In the sectoral approach a share of emissions from waste incineration of plastics is included in category *1 A 1 a Public Electricity and Heat Production*. Emissions from solvents use are included in category *3 Solvent an Other Products Use*. In the sectoral approach a share of municipal solid waste without energy recovery is considered in category 6C for the years 1990 and1991.
- Solid fuels: 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 carbide production which are included in category *2 B 4 Carbide Production*.
- Gaseous fuels: National approach uses sector specific carbon contents and heating values different to IPCC default factors. Process emissions from ammonia-production are included in category *2 B 1 Ammonia Production*.
- Other fuels: The sectoral approach considers waste as an additional fuel type (e.g. municipal solid waste, hazardous waste and industrial fuel waste)

Simple approach of quantifying the deviation:

By quantifying the deviation between the two approaches with a simple approach it can be seen that the resulting remaining difference of total CO_2 emissions is less than -3 % for all years (see Table 98). Note that this may be interpreted that the sectoral approach plus process emission would be even higher than the reference approach.

At the moment is not possible to quantify the amount of solvents and plastics products which are imported or exported by products, bulk or waste. Furthermore it is known that petrol coke is imported and used for carbide production but not considered in the energy balance.

Table 98: Quantification of deviation between the two approaches

Year	Natural Gas (1)	2 B Chemical Industry(3)	2 C Metal Production	3 Solvent Use	Total	Remaining total deviation(2)
1990	376	427	3 725	283	4 811	-2.7%
1991	422	436	3 688	237	4 783	-2.0%
1992	418	409	3 158	188	4 173	-1.3%
1993	374	437	3 143	187	4 141	-1.6%
1994	420	404	3 398	172	4 394	-2.4%

1995	576	489	3 908	190	5 163	-2.1%
1996	383	484	3 694	173	4 734	-1.6%
1997	343	475	4 083	190	5 091	-1.6%
1998	449	521	3 887	172	5 029	-0.1%
1999	571	492	3 749	158	4 970	-0.4%
2000	416	484	4 185	181	5 266	-1.3%
2001	154	462	4 144	194	4 954	-0.7%
2002	350	469	4 637	194	5 650	-1.5%
2003	390	518	4 532	194	5 634	-1.5%

(1) Deviation due to the use of different carbon emissions factors, losses and statistical differences.

(2) Negative numbers indicate that CO_2 emissions from the reference approach are lower than emissions from the sectoral approach.

(3) Excluding carbide production.

3.3.2 Comparison of energy consumption

Table 99 compares the energy consumption of the two approaches.

Table 99: Comparison of Energy Consumption of the two approaches

Year	Reference Approach				Sectoral Approach				
	Liquid [TJ]	Solid [TJ]	Gaseous [TJ]	Total [TJ]	Liquid [TJ]	Solid [TJ]	Gaseous [TJ]	Other [TJ]	Total [TJ]
1990	432 880	168 733	219 239	820 853	376 785	140 856	201 600	8 990	728 231
1991	467 037	177 293	231 794	876 124	409 455	149 226	212 477	10 079	781 237
1992	457 286	137 560	227 610	822 456	393 684	112 099	213 616	13 270	732 669
1993	465 569	123 581	240 044	829 194	414 609	98 208	222 735	10 917	746 469
1994	457 133	125 300	246 908	829 341	406 726	97 604	233 968	11 709	750 007
1995	462 169	142 849	269 583	874 601	409 130	112 752	253 772	12 040	787 693
1996	501 056	145 218	286 941	933 215	445 358	113 817	274 712	15 209	849 095
1997	500 301	153 621	276 551	930 474	433 886	118 589	264 963	14 624	832 062
1998	529 927	134 632	283 920	948 478	462 594	103 398	270 664	13 641	850 297
1999	502 235	134 660	288 876	925 770	435 357	101 521	273 414	14 445	824 736
2000	490 877	150 904	275 681	917 462	428 967	117 085	262 921	14 171	823 143
2001	526 665	156 589	292 169	975 423	458 103	121 866	279 473	15 457	874 900
2002	537 421	159 232	295 485	992 138	474 081	119 650	278 905	18 380	891 017
2003	580 291	166 443	319 491	1 066 225	516 004	131 134	301 261	18 855	967 253

Energy consumptions are lower in the sectoral approach because

(i) non–energy use of fuels is not considered in the sectoral approach except the share that is considered in fuel waste and reported as "Other Fuels",

(ii) transformation and distribution losses are not considered in the sectoral approach and

(iii) net calorific values for the different fuel types in the two approaches are different.

For solid fuels the difference is additionally caused by transformation losses from coking coal to coke oven coke and from coke oven coke and fuel oil to blast furnace gas which are not considered in the sectoral approach.

3.4 Feedstocks

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.

For fraction of carbon stored the IPCC default values are applied for all fuels except for coke oven coke, of which the amount carbon stored in steel was calculated. Efforts are still ongoing to ensure completeness, to avoid double counting in the national inventory and to ensure consistency with the national energy balance.

Lubricants:

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

use: emissions from the use of motor oil are included in CO_2 emissions from transport. 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: CO_2 emissions from the use of bitumen for road paving and roofing are currently not estimated (categories *2 A 5*, *2 A 6*). However, VOC emissions are estimated.

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

Natural Gas:

manufacture: 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*).

use/disposal: not applicable, no CO_2 emissions result from the use or disposal of ammonia.

Coke oven coke:

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

use: CO_2 emissions from coke used in iron and steel industry are reported under *2 C*.

disposal: not applicable.

Other bituminous coal:

In [IEA JQ 2004] 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.

disposal: not applicable.

Other oil products:

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 *3*.

disposal: emissions from the disposal of plastics in landfills are considered in *6 A* and from the use of plastic waste as a fuel in *1 A 2*; emissions from the incineration of plastic in waste without energy recovery is included in *6 C*; emissions from incineration of plastics in waste with energy recovery are considered in *1 A 1 a*.

3.5 Fugitive Emissions (CRF Source Category 1 B)

3.5.1 Source Category Description

In the year 2003 0.6% of national total emissions arose from IPCC Category *1 B Fugitive Emissions*. No key sources have been identified within this category.

3.5.1.1 Emission Trends

Table 100 presents GHG emissions arising from this category, their share and trend from 1990 to 2003.

Table 100: Greenhouse gas emissions from Category 1 B Fugitive Emissions

Sector/ Gas	GHG emissions [Gg CO_2 equivalent]										Share 2003	Trend 1990-2003
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003		
TOTAL	379.69	420.15	384.32	431.72	452.56	485.67	470.76	492.36	479.55	554.22	***100%***	***+46%***
CO_2	102.03	127.03	71.03	120.51	141.83	170.53	164.53	182.73	167.03	233.04	*36%*	*+128%*
CH_4	277.67	293.13	313.29	311.21	310.73	315.13	306.23	309.62	312.51	321.19	*64%*	*+16%*

3.5.1.2 Completeness

Table 101 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 subcategory 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 occurring in Austria is one coking plant as part of an integrated iron and steel site.

Furthermore, emissions from oil and from gas exploration and production are reported together under oil production (as oil and gas are extracted together at most sites) except CO_2 emissions from sour gas processing, which is reported separately under gas extraction.

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 101: 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	050102 Underground mining	NO	NO
ii Surface Mines	050101 Open cast mining	NA	✓
1 B 1 b Solid Fuel Transformation		IE(1)	IE(1)

IPCC Category	SNAP	Status	
		CO_2	CH_4
1 B 2 a Oil			
i Exploration	0502 Extraction, 1st treatment and loading of liquid fossil fuels	IE(2)	IE(2)
ii Production		✓	✓
iii Transport	050502 Transports and Depots	NE	NE
vi Refining/ Storage	0401 Processes in Petroleum Industries	NA(3)	✓
v Distribution of oil products	0504 Liquid fuel distribution 0505 Petrol distribution	NA	NA(4)
1 B 2 b Natural Gas			
Exploration	0503 Extraction, 1st treatment and loading of gaseous fossil fuels	✓(2)	IE(2)
i Production/Processing			
ii Transmission	050601 Pipelines	✓	✓
Distribution	050602 Distribution Networks	✓	✓
iii Other Leakage		NE	NE
1 B 2 c Venting/Flaring		IE(5)	IE(6)

(1) included in 1 A 2 a Iron and Steel

(2) 1 B 2 a i Oil Exploration, 1 B 2 b Natural Gas Exploration and 1 B 2 b I Natural Gas Production/Processing, except CO2 emissions from processing of sour gas, are included in 1 B 2 a ii.

(3) CO_2 emissions due to combustion are included in 1 A 1 b Petroleum Refining, fugitive CO_2 emissions are assumed to be negligible.

(4) also includes storage in storage tanks and refinery dispatch station - only NMVOC emissions are estimated as CH_4 emissions are assumed to be negligible.

(5) included in 1 A 1 b Petroleum Refining

(6) included in 1 B 2 a vi Petroleum Refining

3.5.2 Methodological issues

3.5.2.1 1 B 1 a Fugitive Emissions from Fuels – Coal Mining

This category covers 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, in the last years coal mining increased again (see Table 102). The overall trend from the base year to 2003 is plus 25%.

Emissions are calculated by multiplying the amount of brown coal produced (= activity data) with the CORINAIR default emission factor of 214 g CH_4/ Mg coal (Emission Factor Data Base #11378[20]). Activity data are taken from the national energy balance, for 2003 no up-to-date activity data was available, that's why the value of 2002 was also used for 2003.

[20] http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Table 102: Activity data (brown coal produced) and CH_4 emissions for Fugitive Emissions from Fuels- Coal Mining 1990-2003

Year	Coal Mined [Mg]	CH_4 emissions [Gg]
1990	2 447 710	0.52
1991	2 080 726	0.52
1992	1 746 756	0.45
1993	1 691 675	0.37
1994	1 369 217	0.36
1995	1 297 919	0.29
1996	1 108 558	0.28
1997	1 130 839	0.24
1998	1 140 651	0.24
1999	1 137 888	0.24
2000	1 254 605	0.27
2001	1 193 970	0.26
2002	1 811 824	0.39
2003	1 811 824	0.39

3.5.2.2 1 B 2 a Fugitive Emissions from Fuels – Oil

In this category fugitive emissions from oil refining (CH_4) and CO_2 and CH_4 emissions from combined oil and gas production are considered. CO_2 emissions from the refinery resulting from combustion processes (including flaring) are included in *1 A 1 b Petroleum Refining*.

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

Refining

Methane emissions from refining are calculated using IPCC Tier 1 methodology (reference manual chapter 1.8).

Emissions are calculated by multiplying the amount of crude oil input (= activity data) with an emission factor. Activity data are taken from the national energy balance (see Table 103).

The implied emission factor of 31.66 CH_4 g/ t crude oil resulted from multiplying an average value of 745 kg CH_4/PJ crude oil input for methane emissions from this category (selected from table 1-58 of the IPCC Reference Manual) with the net calorific value of 42.5 GJ/t oil (taken from the national energy balance).

Production

The amount of gas produced was reported by the *Association of the Austrian Petroleum Industry* (see Table 103).

Methane emissions for the years 1992 to 2003 from combined oil and gas production was also reported by the *Association of the Austrian Petroleum Industry*, they were calculated according to „SHELL Paper Environment / Storage - References 1) USA EPA1986, AP-42 and 2) E&P Forum 1994, Report 2.59/197".

As can be seen in the table, the implied emission factor decreased by about 45% for the period from 1990 to 2003 due to improved production techniques resulting in lower production losses.

CO_2 emissions from production were also reported by the *Association of the Austrian Petroleum Industry*, they have been calculated according to the composition of the raw gas (the reported CO_2 emissions refer to CO_2 that has been separated from the raw gas).

Table 103: Activity data (Crude Oil Refined and Gas Produced, respectively) and emissions for Fugitive Emissions from Fuels- Oil Refining and Production 1990-2002

	Refining		Production				
Year	Crude Oil Refined [Gg]	CH_4 [Gg]	Gas Produced [Mio m³]	CH_4 [Gg]	IEF CH_4 [kg/ 1000m³]	CO_2 [Gg]	IEF CO_2 [kg/ 1000m³]
1990	7 952	0.25	1 288	4.56	3.54	43	33.39
1991	8 273	0.26	1 326	4.56	3.44	43	32.43
1992	8 732	0.28	1 437	4.56	3.17	40	27.84
1993	8 522	0.27	1 488	4.54	3.05	37	24.87
1994	8 898	0.28	1 355	4.50	3.32	48	35.06
1995	8 619	0.27	1 482	4.41	2.97	38	25.64
1996	8 754	0.28	1 492	4.47	3.00	41	27.48
1997	9 374	0.30	1 428	4.55	3.18	31	21.76
1998	9 190	0.29	1 568	4.39	2.80	61	38.90
1999	8 635	0.27	1 741	4.15	2.38	90	51.69
2000	8 240	0.26	1 805	4.03	2.23	72	39.89
2001	8 799	0.28	1 954	4.10	2.10	88	45.04
2002	8 945	0.28	2 014	4.18	2.08	84	41.71
2003	8 874	0.28	2 030	3.92	1.93	133	65.52

3.5.2.3 1 B 2 b Fugitive Emissions from Fuels – Natural Gas

In this category CO_2 emissions from sour gas processing, CH_4 emissions from gas distribution and CO_2 and CH_4 emissions from gas transmission and storage are reported.

CO_2 emissions from this category mainly arise from sour gas processing, the trend is increasing emissions due to increasing gas production. Gas transmission is only a minor source of CO_2 emissions.

Sour Gas Processing

CO_2 emissions from natural gas production (sour gas processing) are reported by the *Association of the Austrian Petroleum Industry* (see Table 104) and were calculated from sour gas composition. Activity data for natural gas production are reported by the *Association of the Austrian Petroleum Industry* (see Table 104).

Distribution

Emissions from natural gas distribution are calculated using an average of the CORINAIR default emission factor for the CORINAIR simpler method (20.9 t/ PJ), the heat calorific value for natural gas (35.85 GJ/m³) was taken from the national energy balance[21].

Activity data for natural gas distribution corresponds to the gross inland consumption taken from the energy balance.

Transmission, Storage

Pipeline lengths and natural gas stored were taken from annual reports of the *Association of the Austrian Petroleum Industry* (if no value was available for a certain year, the value of the year before or after was used).

Emission factors were taken from the IPCC GPG Table 2.16 (for transmission sum of lower values for venting and fugitives).

Table 104: Activity data and emissions for Fugitive Emissions from Fuels – Natural Gas Distribution and Sour Gas Processing 1990-2003

Year	Natural Gas Distribution		Sour Gas Processing	
	Gas Consumption [Mm³]	CH_4 Emissions [Gg]	Sour Gas Prod. [1000m³]	CO_2 Emissions [Gg]
1990	6 090	4.25	248 090	59
1991	6 439	4.49	285 901	68
1992	6 323	4.41	357 135	80
1993	6 668	4.65	321 653	75
1994	6 859	4.79	363 582	80
1995	7 488	5.23	405 638	89
1996	7 971	5.56	136 737	30
1997	7 682	5.36	406 177	89
1998	7 887	5.50	367 195	81
1999	8 058	5.62	352 318	81
2000	7 690	5.37	358 357	93
2001	8 150	5.69	393 492	95
2002	8 242	5.75	347 513	83
2003	8 912	6.22	408 198	100

Table 105: Activity data and emissions for Fugitive Emissions from Fuels – Natural Gas Transmission and Storage 1990-2003

Year	Natural Gas Transmission (Pipelines Fugitive & Venting)			Natural Gas Storage	
	Pipelines [km]	CH_4 Emissions [Gg]	CO_2 Emissions [Gg]	Natural Gas Stored [Mm³]	CH_4 Emissions [Gg]
1990	1 032	2.99	0.03	1 500	0.65

[21] Due to an error in the calculation sheet, the IEF now corresponds to about 19.5 t/ PJ, this will be corrected for the next submission.

Year	Natural Gas Transmission (Pipelines Fugitive & Venting)			Natural Gas Storage	
	Pipelines [km]	CH_4 Emissions [Gg]	CO_2 Emissions [Gg]	Natural Gas Stored [Mm³]	CH_4 Emissions [Gg]
1991	1 032	2.99	0.03	1 500	0.65
1992	1 032	2.99	0.03	1 625	0.70
1993	1 032	2.99	0.03	1 980	0.85
1994	1 032	2.99	0.03	1 329	0.57
1995	1 032	2.99	0.03	1 820	0.78
1996	1 238	3.59	0.03	1 820	0.78
1997	1 238	3.59	0.03	1 820	0.78
1998	1 238	3.59	0.03	1 820	0.78
1999	1 358	3.94	0.03	1 820	0.78
2000	1 358	3.94	0.03	1 665	0.72
2001	1 358	3.94	0.03	1 132	0.49
2002	1 358	3.94	0.03	789	0.34
2003	1 430	4.15	0.04	789	0.34

3.5.3 Recalculations

Activity data for *1 B 1 a Coal Mining* and *1 B 2 b ii Natural Gas Distribution* for 2002 have been updated.

For *1 B 2 a Refining/ Storage* and *1 B 2 b Distribution* activity data have been updated for the whole time series, data is now consistent with the national energy balance.

The recalculations only affected CH4 emissions, the resulting difference with respect to values reported last year is presented in Table 106.

Table 106: Recalculation difference of emissions in [Gg] for Category 1 B Fugitive Emissions with respect to the previous submission.

	CH_4
1990	-0.001
1991	-0.006
1992	-0.004
1993	-0.004
1994	-0.002
1995	-0.004
1996	-0.011
1997	-0.009
1998	-0.016
1999	-0.015
2000	-0.015
2001	-0.027
2002	0.431

4 INDUSTRIAL PROCESSES (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 Category *2 Industrial Processes* for the period from 1990 to 2003.

Emissions from this category comprise emissions from the following sub categories: *Mineral Products*, *Chemical Industry*, *Metal Production* and *Consumption of Halocarbons and* SF_6.

Only process related emissions are considered in this Sector; emissions due to fuel combustion in manufacturing industries are allocated in 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 115.

4.1.1 Emission Trends

In the year 2003, 12.1% of national total greenhouse gas emissions (without LULUCF) originated from industrial processes, compared to 12.9% in the base year (for CO_2, CH_4 and N_2O the base year is 1990; for HFCs, PFCs and SF_6 the year 1995 has been selected as base year, since the data are considered to be more reliable than those of 1990).

Greenhouse gas emissions from the industrial processes sector fluctuated during the period, they reached a minimum in 1993 which was mainly due to termination of primary aluminium production in Austria in 1992 which was an important source for PFC emissions. Since then emissions are increasing again, mainly due to increasing emissions from consumption of fluorinated compounds.

In 2003, greenhouse gas emissions from Category *2 Industrial Processes* amounted to 11 046 Gg CO_2 equivalent compared to 10 115 Gg in the base year. Figure 9 shows the trend of GHG emissions from this category for 1990-2003.

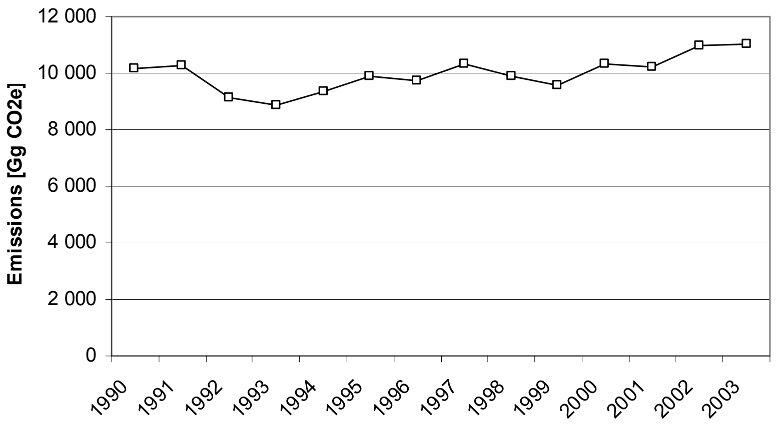


Figure 9: GHG emissions from IPCC Sector 2 Industrial Processes 1990-2002

Emission trends by gas

Table 107 presents greenhouse gas emissions of the industrial processes sector as well as their share in total greenhouse gas emissions from that sector in the base year and in 2003.

Table 107: Greenhouse gas emissions from 2 Industrial Processes by gas in the base year and in 2003.

GHG	Base year*	2003	Base year*	2003
	CO_2 equivalent [Gg CO_2e]		[%]	
Total	**10 114.82**	**11 046.05**	***100.00%***	***100.00%***
CO_2	7 432.16	8 151.09	*73.5%*	*73.8%*
CH_4	7.48	7.30	*0.1%*	*0.1%*
N_2O	912.02	883.38	*9.0%*	*8.0%*
HFCs	555.26	1 308.22	*5.5%*	*11.8%*
PFCs	68.74	102.54	*0.7%*	*0.9%*
SF_6	1 139.16	593.52	*11.3%*	*5.4%*

**1990 for CO_2, CH_4 and N_2O and 1995 for F-Gases*

The major GHG of the industrial processes sector is carbon dioxide with 73.8% of emissions from this category in 2003, followed by HFCs with 11.8%, N_2O with 8.0%, SF_6 with 5.4%, PFCs with 0.9% and finally CH_4 with 0.1%. Emissions by gas and their trends are presented in Table 108.

Table 108: Emissions from IPCC Category 2 Industrial Processes by gas from 1990-2003 and their trend

Gas	GHG emissions [Gg CO2e]										Trend
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	BY*-2003
Total	10 153	9 876	9 752	10 345	9 897	9 591	10 329	10 234	10 964	11 046	***9.2%***
CO_2	7 432	7 248	6 949	7 529	7 227	7 045	7 645	7 600	8 203	8 151	*9.7%*
CH_4	7.48	7.06	7.27	7.49	8.11	7.25	7.32	6.77	7.47	7.30	*-2.4%*
N_2O	912	857	874	863	897	923	952	786	807	883	*-3.1%*
HFCs	219	555	637	730	813	867	1 019	1 122	1 219	1 308	*135.6%*
PFCs	1 079	69	66	97	45	65	72	82	87	103	*49.2%*
SF_6	503	1 139	1 218	1 120	908	684	633	637	641	594	*-47.9%*

** BY: 1990 for CO_2, CH_4 and N_2O and 1995 for F-Gases*

CO' emissions

As can be seen in Figure 10, CO_2 emissions from the industrial processes sector fluctuated during the period from 1990 to 2003, showing no clear trend. In 2003 CO_2 emissions from Industrial Processes amounted to 8 151 Gg CO_2 equivalent, which corresponds to an increase of 9.7% compared to base year emissions (7 248 Gg).

About 50% of CO_2 emissions originate from *Metal Production (mainly Iron and Steel Production)* and about 40% from *Mineral Products (Cement Production)*. The rest originates from *Chemical Industry (mainly Ammonia Production)*.

CH_4 emissions

As can be seen in Figure 10, CH_4 emissions from Industrial Processes fluctuated over the period from 1990 to 2003, they reached a maximum in 1998 and now are 2.3% below the level of the base year.

CH_4 emissions from this sector mainly arise from *Chemical Industry (Ammonia Production and Production of Urea and Fertilizers),* a minor source for CH_4 emissions is *Metal Production (Electric Furnace Steel Plants, Rolling Mills)*.

N_2O emissions

N_2O emissions from this sector arise from *Nitric Acid Production (Chemical Industry)*. As can be seen in Figure 10, N_2O emissions from the industrial processes sector first showed a decreasing trend, and then increased until 2001. From 2000 to 2001 emissions dropped by 17%, which is due to the introduction of a new catalyst in the nitric acid plant. Since 2001 emissions increased again due to an increase of nitric acid production.

In 2003, N_2O emissions from *Industrial Processes* were 3.1% below the level of the base year.

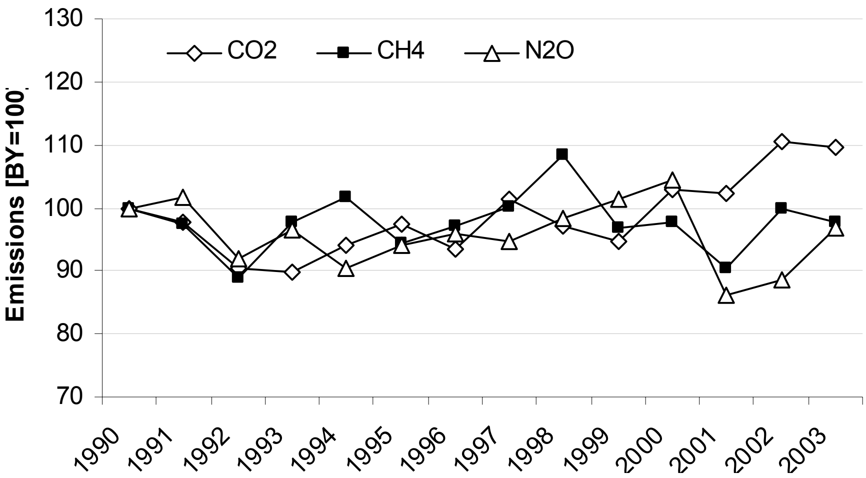


Figure 10: CO_2, CH_4 and N_2O emissions from Industrial Processes 1990-2002 in index form (base year = 100)

HFC emissions

As can be seen in Figure 11, HFC emissions increased remarkably during the period from 1990 to 2003. In 2003 HFC emissions amounted to 1 308 Gg CO_2 equivalent. This was 136% above the level of the base year (1995).

HFC emissions arise from *Refrigeration and Air Conditioning Equipment*, *Foam Blowing* and *XPS/ PU plates*.

PFC emissions

As can be seen in Figure 11, PFC emissions decreased remarkably during the period from 1990 to 2003. In 1990 PFC emissions amounted to 1 079 Gg CO_2 equivalent, they decreased until 1993 to around 50 Gg CO_2 equivalent due to the termination of primary aluminium production in 1993 which was the major source for PFC emissions. Since then PFC emissions increased, in the year 2003 they amounted to 103 Gg CO_2 equivalent, this was 49.2% above the level of the base year (1995).

PFC emissions now only arise from semiconductor manufacture.

SF6 emissions

As can be seen in Figure 11, SF_6 emissions increased at the beginning of the period and reached a maximum in 1996, since then SF_6 emissions are decreasing again. In 2003 SF_6 emissions amounted to 594 Gg CO_2 equivalent. This was 47.9% below the level of the base year (1995).

SF_6 emissions arise mainly from semiconductor manufacture, magnesium production and filling of noise insulate glasses.

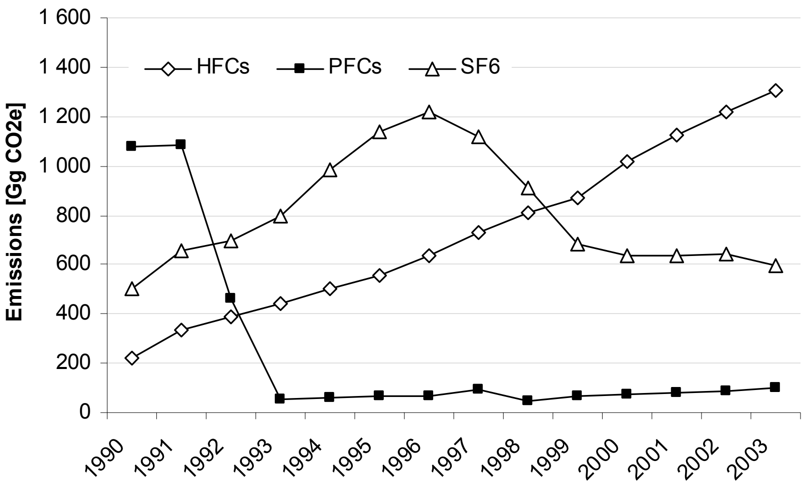


Figure 11: HFC, PFC and SF_6 emissions from Industrial Processes 1990-2003

Emission trends by sources

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Production* and *Mineral Products*, which caused 41.0% and 27.7% of emissions from this sector in 2003 (see Table 109).

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 1.5.1 Austria's Key Source Categories).

Table 109: Greenhouse gas emissions from IPCC Category 2 Industrial Processes by sector, their share and trend for the base year and 2002.

	Emissions [Gg CO2e]		Share [%]		Trend BY - 2003
	BY*	2003	BY*	2003	
2 Industrial Processes	**10 114.82**	**11 046.05**	***100%***	***100%***	***+0%***
A Mineral Products	3 242.73	3 060.20	*32.1%*	*27.7%*	*-5.6%*
B Chemical Industry	1 383.92	1 449.49	*13.7%*	*13.1%*	*+4.7%*
C Metal Production	4 168.12	4 532.08	*41.2%*	*41.0%*	*+8.7%*
F Consumption of Halocarbons and SF6	1 320.05	2 004.28	*13.1%*	*18.1%*	*+51.8%*

**1990 for CO_2, CH_4 and N_2O and 1995 for F-Gases*

Figure 12 and Table 110 present greenhouse gas emissions from IPCC Category *2 Industrial Processes* by sub category for the years 1990 to 2003.

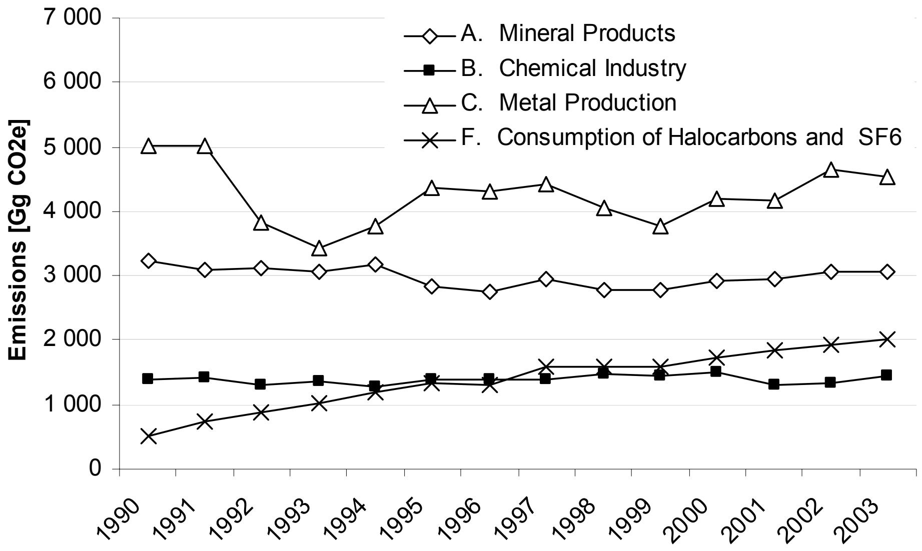


Figure 12: Emissions from IPCC Category 2 Industrial Processes per sub sector 1990-2003

Table 110: Total greenhouse gas emissions from 1990–2003 by subcategories of Category 2 Industrial Processes

	GHG emissions [Gg CO_2 equivalent]										
	BY	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
2	**10 115**	**10 153**	**9 876**	**9 752**	**10 345**	**9 897**	**9 591**	**10 329**	**10 234**	**10 964**	**11 046**
2 A	3 243	3 243	2 826	2 738	2 938	2 785	2 771	2 928	2 947	3 055	3 060
2 B	1 384	1 384	1 379	1 398	1 378	1 460	1 456	1 491	1 302	1 325	1 449
2 C	4 168	5 029	4 351	4 304	4 432	4 051	3 772	4 192	4 152	4 645	4 532
2 F	1 320	497	1 320	1 311	1 597	1 601	1 593	1 717	1 833	1 939	2 004

**1990 for CO_2, CH_4 and N_2O and 1995 for F-Gases*

2 A Mineral Products

For the source *Mineral Products* greenhouse gas emissions decreased by 5.6% from 1990 to 2003. This was mainly due to decreasing CO_2 emissions from cement production due to a decrease in cement production.

Only CO_2 emissions arise from this source category.

2 B Chemical Industry

For the source *Chemical Industry* greenhouse gas emissions remained quite stable over the period from 1990 to 2003, in 2003 emissions were 4.7% above the level of the base year.

The main sources of this sub sector are N_2O emissions from nitric acid production and CO_2 emissions from ammonia production.

2 C Metal Production

Greenhouse gas emissions from *Metal Production* fluctuated over the period, which is mainly a result of a drop in PFC emissions from primary aluminium production which was terminated in 1993 and an increase in CO_2 emissions from *Iron and Steel Production.* The overall trend is a decrease by 9.9% related to emissions of the year 1990. Related to emissions of the base year, emissions increased by 8.7%.

The main source of this sector are CO_2 emissions from pig iron production.

2 F Consumption of Halocarbons and SF_6

For the source *Consumption of Halocarbons and SF_6* greenhouse gas emissions increased by 51.8% compared to base year emissions (1995 for PFCs, HFCs and SF_6). In 2003 emissions were about four times higher than in 1990. This was mainly due to strongly increasing emissions from the use of HFCs as substitutes for ozone depleting substances (*ODS Substitutes*).

4.1.2 Key Sources

The methodology and results of the key source analysis is presented in Chapter 1.5, below the key sources in the IPCC Sector *2 Industrial Processes* are presented (see Table 111).

Table 111: Key categories of Sector 2 Industrial Processes

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
2 A 1	Cement Production	CO_2	All
2 A 2	Lime Production	CO_2	All LA, TA00
2 A 7 b	Magnesia Sinter Plants	CO_2	All
2 B 1	Ammonia Production	CO_2	All LA
2 B 2	Nitric Acid Production	N_2O	All LA, TA96-97, TA01-03
2 C 1	Iron and Steel Production	CO_2	All

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
2 C 3	Aluminium production	PFCs	LA90-92
2 C 4	SF_6 used in Al and Mg Foundries	SF_6	LABY-97, TA96-02
2 F 1/2/3	ODS Substitutes	PFCs	All LA except LA90, TA97-03
2 F 6	Semiconductor Manufacture	FCs	LABY, LA92-03, TA96, TA00-01
2 F 8	Other Sources of SF6	SF_6	LA97-01

LA90 = Level Assessment 1990

LA00 = Level Assessment 2000

TA91 = Trend Assessment BY-1991

TA00 = Trend Assessment BY-2000

In the base year, 12.1% of total greenhouse gas emissions in Austria originated from the 11 key sources of the industrial processes sector compared to 11.5% in 2002. The most important key source is *Iron and Steel Production* which had a share of 4.9% in total emissions in 2003. The second important is *Cement Production*: 1.9% of total emissions 2003 originated from this category. Another 1.4% of total emissions originated from *ODS Substitutes*. All other key sources of the industrial processes sector had a share of less than 1% in national total greenhouse gas emissions in 2003 (see Table 112).

Table 112: Level Assessment for the base year and 2003 for the key sources of Category 2 Industrial Processes

IPCC Category	Source Categories	GHG	Level Assessment	
			BY	2003
2 A 1	Cement Production	CO_2	2.6%	1.9%
2 A 2	Lime Production	CO_2	0.5%	0.6%
2 A 7 b	Magnesia Sinter Plants	CO_2	0.6%	0.4%
2 B 1	Ammonia Production	CO_2	0.5%	0.5%
2 B 2	Nitric Acid Production	N_2O	1.2%	1.0%
2 C 1	Iron and Steel Production	CO_2	4.5%	4.9%
2 C 3	Aluminium production	PFCs	NO	NO
2 C 4	SF_6 used in Al and Mg Foundries	SF_6	0.6%	NO
2 F 1/2/3	ODS Substitutes	PFCs	0.7%	1.4%
2 F 6	Semiconductor Manufacture	FCs	0.6%	0.5%
2 F 8	Other Sources of SF_6	SF_6	0.3%*	0.2%*

**Level Assessment does not meet the 95% threshold of that year*

4.1.3 Methodology

The general method for estimating emissions for the industrial processes 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. For IPCC key source categories, methodologies are described in more detail.

4.1.4 Uncertainty Assessment

In this year's submissions uncertainty estimates for all key sources based on the IPCC GPG, on the uncertainty study cited in Chapter 1.7 Uncertainty Assessment and on expert judgement by Umweltbundesamt are provided (see Table 112, explanations see respective subchapters).

Table 113: Uncertainty assessment for key sources of Sector 2 Industrial Processes

IPCC Category	Source Categories	Uncertainty [%]		
		Activity data	Emission factor	Emission estimate
2 A 1	Cement Production	5	5	7
2 A 2	Lime Production	5	5	7
2 A 7 b	Magnesia Sinter Plants	5	5	7
2 B 1	Ammonia Production	-	-	5
2 B 2	Nitric Acid Production	-	-	3
2 C 1	Iron and Steel Production	5	5	7
2 C 3	Aluminium production	5	2	5
2 C 4	SF_6 used in Al and Mg Foundries	20	0	20
2 F 1/2/3	ODS Substitutes	20	50	54
2 F 6	Semiconductor Manufacture	5	10	11
2 F 8	Other Sources of SF_6	25	50	56

4.1.5 Quality Assurance and Quality Control (QA/ QC)

For the Austrian Inventory an internal quality management system has been established, for further information see Chapter 1.6.

Concerning measurement and documentation of emission data there are also specific regulations in the Austrian legislation as presented in Table 114. This legislation also addresses verification. Some plants that are reporting emission data have quality management systems according to the ISO 9000–series or according similar systems.

Table 114: Austrian legislation with specific regulations concerning measurement and documentation of emission data

IPCC Source Category	Austrian legislation
2 A 1	BGBl 1993/ 63 Verordnung für Anlagen zur Zementerzeugung
2 A 7	BGBl 1994/ 498 Verordnung für Anlagen zur Glaserzeugung
2 C 1	BGBl 1994/ 447 Verordnung für Gießereien

2 C 1	BGBl II 1997/ 160 Verordnung für Anlagen zur Erzeugung von Eisen und Stahl
2 C 1	BGBl II 1997/ 163 Verordnung für Anlagen zum Sintern von Eisenerzen
2 A / 2 B /2 C / 2 D	BGBl II 1997/ 331 Feuerungsanlagen-Verordnung
2 C 2 / 2 C 3 / 2 C 5	BGBl II 1998/ 1 Verordnung zur Erzeugung von Nichteisenmetallen
2 A / 2 B /2 C / 2 D	BGBl 1988/ 380 Luftreinhaltegesetz für Kesselanlagen
2 A / 2 B /2 C / 2 D	BGBl 1989/ 19 Luftreinhalteverordnung für Kesselanlagen

Extracts of the applicable paragraphs are provided in Annex 6.

4.1.6 Recalculations

Compared to last year's inventory one source has been added, emissions from two sources have not been reported anymore because they have been double counted, and data for several sources have been updated. A summary of the changes made since the last submission is presented below:

Addition of source categories:

2 C 2 Ferroalloys (CO_2) has been added to the inventory.

Changes in the use of Notation Keys:

2 A 5 Asphalt Roofing and *2 A 6 Road Paving with Asphalt:*

emissions are now reported as "IE", as emissions are already included in the Solvents Sector.

2 A 4 Soda Ash Production and Use:

CO_2 Emissions from Soda Ash Production are now reported as "IE", as coke used in the process is already considered as fuel in the Energy Sector (*1 A 2 c Chemical Industries*).

Update of activity data:

2 B 5 Chemical Industries - Other:

CO_2 emissions from fertilizer production for 1992-1994 have been updated using information from Industry. Emissions from 1990-1991 were recalculated using the average EF from 1993-2003.

2 A 1 Cement Production:

activity and emission data for CO2 emissions from *Cement Production* 1998-2002 have been updated using data from a study based on plant specific data.

2 A 7 a Bricks:

activity data for 2002 has been updated.

2 C 1 Iron and Steel:

Activity data for 2002 has been updated.

Improvements of methodologies and emission factors:

2 B 5 Chemical Industries - Other:

As indicated in the NIR 2004, there had been an inconsistency of the time series for CH_4 emissions from urea production; now the time series has been recalculated to improve time series consistency.

2 C 1 Iron and Steel:

For calculating CO_2 emissions electric arc furnaces now a country specific emission factor is used (previously an emission factor taken from a Swiss publication was applied).

Process specific CO_2 emissions from pig iron production have been recalculated as the underlying activity data used for the calculation (non-energy use of coke) has been updated in the national energy balance.

2 C 3 Aluminium Production:

Activity data used for calculation of PFC and CO_2 emissions from *Aluminium Production* has been harmonized.

2 F Consumption of Halocarbons and SF_6:

During an internal audit several mistakes and inconsistencies were identified and corrected and the data quality could be improved for some sub-sectors using information from industry. Furthermore emissions from 2001 and 2002 were updated using extrapolation techniques (following recommendations from the ERT) and data from industries, previously the same estimated as for 2000 was used for these years.

For further information see the recalculation sections of the respective subchapters of this chapter and the tables presented in Chapter 8.

4.1.7 Completeness

Table 115 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 subcategory have been estimated, the grey shaded cells are those also shaded in the CRF.

Table 115: Overview of subcategories of Category 2 Industrial Processes: 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)	✓		
2 A 2	Lime Production	040614	Lime (decarbonising)	✓		
2 A 3	Limestone and Dolomite Use	040618	Limestone and Dolomite Use	✓		
2 A 4	Soda Ash Production and Use	040619	Soda Ash Production and Use	✓		
2 A 5	Asphalt Roofing	040610	Roof covering with asphalt materials	IE(1)		
2 A 6	Road Paving with Asphalt	040611	Road paving with asphalt	IE(1)		
2 A 7	*Other*					

	2 A 7 a Bricks	040613	Bricks (decarbonising)	✓		
	2 A 7 b Magnesit Sinter	040617	Other - Magnesia Sinter Plants	✓		
2 B	**CHEMICAL INDUSTRY**					
2 B 1	Ammonia Production	040403	Ammonia	✓	✓	
2 B 2	Nitric Acid Production	040402	Nitric acid	✓		✓
2 B 3	Adipic Acid Production	040521	Adipic acid			NO(2)
2 B 4	Carbide Production	040412	Calcium carbide production	✓	NE	
2 B 5	Other	040407 040408	NPK fertilisers Urea	✓	✓	
2 C	**METAL PRODUCTION**					
2 C 1	Iron and Steel Production(3)	040202 040206 040207 040208	Blast furnace charging Basic oxygen furnace steel plant Electric furnace steel plant Rolling mills	✓	✓	
2 C 2	Ferroalloys Production	040302	Ferro alloys	✓	NE	
2 C 3	Aluminium Production	040301	Aluminium production (electrolysis) – except SF_6	✓ / NO(3)	✓ / NO(3)	
2 C 4	SF_6 Used in Aluminium and Magnesium Foundries	030310 040301 040304	Secondary Aluminium Production Aluminium Production – SF_6 only Magnesium Production – SF_6 only		SF_6 ✓	
2 C 5	*Other*					
2 D	**OTHER PRODUCTION**					
2 D 1	*Pulp and Paper*					
2 D 1	*Food and Drink*			NA(4)		
					HFCs, PFCs, SF_6	
2 E	**PRODUCTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE**	0408	Production of halocarbons and sulphur hexaflouride		NO(5)	
2 F	**CONSUMPTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE** (6)					
2 F 1	Refrigeration and Air Conditioning Equipment				✓	
2 F 2	Foam Blowing				✓	
2 F 3	Fire Extinguishers				✓	
2 F 4	Aerosols				✓	
2 F 5	Solvents				✓	
2 F 6	Semiconductor Manufacture				✓	
2 F 7	Electrical Equipment				✓	
2 F 8	*Other*				✓	

(1) *Emissions are included in Sector* 3 Solvent and Other Product Use

(2) *There is no adipic acid production in Austria.*

(3) *Primary aluminium production was terminated in 1992.*

(4) *CO_2 emissions from this source are of biogenic origin.*

(5) There is no production of halocarbons or SF_6 in Austria.

(6) No corresponding SNAP category is presented here as the actual estimation is based on IPCC Categories.

4.1.8 Planned Improvements

For the last year of the inventory, no data was available for some important sub-categories of this Sector. One reason is that national statistical data are not available in time to be considered in the inventory. On the other hand, industry is not obliged to report data for the national inventory.

The data availability problem will be solved for most key sources of this Sector from the years 2005 onwards, because the ordinance that regulates monitoring and reporting in the context of the EU Emissions Trading scheme in Austria also regulates that data reported from the plant operators can be used for the inventory (see Chapter 1.2).

This ensures data availability for the following key sources:

- 2 A 1 Cement Production
- 2 A 2 Lime Production
- 2 A 7 b Magnesia Sinter Plants
- 2 C 1 Iron and Steel,

and the non-key sources

- 2 A 3 Limestone and Dolomite Use
- 2 A 4 Soda Ash Use
- 2 A 7 a Bricks production
- 2 B 4 Carbide Production.

Until data is available from the EU Emissions Trading scheme[22], mainly national statistical data will be used to estimate emissions where data from plant operators is not available.

Furthermore, it is planned to incorporate results from a new study concerning emissions from ODS Substitutes for the next submission.

4.2 Mineral Products (CRF Source 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 production of cement are a key source because of the contribution both to the level of all years of the greenhouse gas inventory and to the trend from the base year to all

[22] the first year for which data will be available is 2005, this data will be reported in the submission 2007

years. In 2003 CO_2 emissions from cement production contributed 1.9% to total greenhouse gas emissions in Austria (see Table 112).

In this category process specific CO2 emissions are reported, 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 calcium carbonate ($CaCO_3$) 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 116 presents the process-related CO_2 emissions from the production of cement for the period from 1990 to 2003.

Table 116: CO_2 emissions from decarbonising from cement production 1990–2003

Year	Process specific CO_2 emissions [Gg]	Clinker [t/a]	IEF [kg/t_{Cl}]
1990	2 033	3 693 539	550.53
1991	2 005	3 635 462	551.51
1992	2 105	3 820 397	550.99
1993	2 032	3 678 293	552.39
1994	2 102	3 791 131	554.52
1995	1 631	2 929 973	556.77
1996	1 634	2 915 956	560.45
1997	1 761	3 103 312	567.43
1998	1 599	2 869 035	557.22
1999	1 607	2 891 785	555.84
2000	1 712	3 052 974	560.62
2001	1 720	3 061 338	561.82
2002	1 736	3 118 227	556.62
2003	1 736	3 118 227	556.62

CO_2 emissions (see Table 116) have been quite constant from 1990 to 1994, then dropped by 21.7% compared to the previous year, due to a drop in cement production of almost 20%. Since then emissions as well as production of cement remained on this lower level with only minor fluctuations. The overall trend from 1990 to 2002 was minus 15%. For the year 2003 the value of 2002 was used, as no up to date value was available.

4.2.1.2 Methodological Issues

Emissions were estimated using the IPCC Tier 2 methodology.

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 and 2004]. The studies cover the years 1988 to 2002. As data for 2003 was not available in time, the value of 2002 was used for 2003 as a first estimate.

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.

CO_2 emissions from the raw meal calcination (decarbonising) were calculated from the raw meal composition:

$$M_{(CO2\ calc)} = \sum_k (m_{(raw\ meal)})_k \bullet x_{(CaCO3)k} \bullet (44.0088/100.0892)$$

Whereas:

m mass stream [kg/a]

x mass portion

k for the k^{th} cement plant

The raw meal composition was determined at every Austrian plant, based on this data and plant specific production data total emissions from this source were calculated.

No cement kiln dust (CKD) correction factor was considered because cement kiln dust is returned back into the raw material.

Table 116 presents activity data and implied emission factors for process-specific CO_2 emissions from cement production as reported in the studies [HACKL, MAUSCHITZ, 1995, 1997, 2001 and 2004].

4.2.1.3 Uncertainty Assessment

As the applied methodology is based on plant specific data, the uncertainty of both activity data and emission factors (basically the raw meal composition as the uncertainty for the stochiometric emission factor is negligible) is assumed to be low (5%). This results in a combined uncertainty of 7% (according to the IPCC GPG Table 3.2, the uncertainty for emissions using Tier 2 methodology (based on clinker production data) is 5-10%).

4.2.1.4 Recalculations

Activity data and emission data for 1998 onwards have been updated (previously the estimate of 1998 was used for the years after). The recalculation difference resulting from the update of data is presented in the following table.

Table 117: Recalculation difference for CO2 emissions from Cement Production with respect to submission 2004

	1998	1999	2000	2001	2002
Recalculation Difference [Gg]	19.06	19.80	124.00	132.36	148.10

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 was a key source because of its contribution to the total inventory's level in all inventory years and to the trend of emissions of the total greenhouse gas inventory from the base year to 2000. In the year 2003 emissions from this category contributed 0.6% to the total amount of greenhouse gas emissions in Austria (see Table 112).

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 118 presents activity data for this category (lime produced) as well as CO_2 emissions from lime production for the period from 1990 to 2002.

Table 118: Activity data and CO_2 emissions for Lime production 1990–2002

Year	Lime Produced [t/a]	CO_2 emissions [Gg]	CO_2 IEF [kg/Mg]
1990	512 610	396	772.84
1991	477 135	361	757.16
1992	462 392	355	768.00
1993	479 883	365	760.96
1994	518 544	390	753.06
1995	522 934	395	754.60
1996	505 189	383	757.59
1997	549 952	412	749.99
1998	594 695	454	763.03
1999	595 978	453	760.34
2000	654 437	498	760.26
2001	666 633	507	759.97
2002	719 246	547	759.97

The overall trend for CO_2 emissions from this category was increasing emissions, in the year 2002 emissions were 38% higher than 1990 (see Table 118).

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*, except the emission value for 2002, which was calculated using the IEF of 2001.

The reported CO_2 emission data is based data of each lime production plant in Austria, considering the CaO and MgO content of limestone used at the different plants and calculating CO2 emissions from the stoichiometric ratios (using IPCC default emission factors).

Activity data for lime production for the period from 1990 to 2002 is presented in Table 118.

For 2003 no data were available, that's why the data of 2002 was reported for 2003 also.

4.2.2.3 Uncertainty Assessment

Uncertainties for activity data are considered to be low as it is based on plant specific data of all Austrian plants and is therefore considered the same as for cement production (5%). The uncertainty of the emission factor is assumed to be 5% based on the same assumptions as for cement production.

4.2.3 Limestone and Dolomite Use (2 A 3)

4.2.3.1 Source Category Description

Emissions: CO_2

Key Source: *No*

In this category CO_2 emissions from decarbonising of limestone and dolomite in the glass industry and in the iron and steel industry is considered. This category was not rated a key source in the key source analysis of the submission 2005. In 2003 emissions from this category contributed 0.3% to national total emissions.

Emissions from this category increased by 35% mainly due to increased limestone use in iron and steel industries.

Table 119: Activity data and CO_2 emissions for Limestone and Dolomite Use 1990–2003

Year	Limestone Used [t/a]	Dolomite Used [t/a]	CO_2 emissions [Gg]
1990	430 729	24 020	200
1991	433 122	27 646	203
1992	386 650	24 463	181
1993	386 186	24 485	181
1994	417 440	26 212	195
1995	485 610	26 225	225
1996	430 890	26 225	201
1997	494 406	24 457	228
1998	516 957	24 457	238
1999	476 446	26 826	222
2000	545 077	22 624	250
2001	530 453	26 573	245
2002	577 853	23 477	265
2003	582 132	30 368	270

4.2.3.2 Methodological Issues

Emissions were estimated using the methodology and the default emission factor of the IPCC guidelines.

Activity data for limestone and dolomite used in glass industry were reported by the *Association of Glass Industry* for the year 2002 and 2003, for the years before activity data was estimated using a constant ratio of limestone and dolomite used per ton of glass produced (glass production was reported by the *Association of Glass Industry* for all years).

Activity data for limestone used in blast furnaces for the years 1998 to 2002 was reported directly by the plant operator of the two integrated iron and steel production sites that operate blast furnaces. For the years before and after activity data was estimated using the average ratio of limestone used per ton of pig iron produced of the years 1998-2002.

For calculation of CO_2 emissions the IPCC default emission factors of 440 kg CO_2/ t limestone and 447 kg CO_2/ t dolomite were used.

4.2.4 Soda Ash Use (2 A 4)

4.2.4.1 Source Category Description

Emissions: *CO_2*

Key Source: *No*

In this category CO_2 emissions from decarbonising of soda used in glass industry is considered. In 2003 emissions from this category contributed 0.02% to total emissions in Austria. The following table presents CO_2 emissions from this category.

Table 120: Activity data and CO_2 emissions for Soda Use 1990–2003

Year	Soda Used [t/a]	CO_2 emissions [Gg]
1990	46 690	19
1991	53 737	22
1992	47 551	20
1993	47 593	20
1994	50 950	21
1995	50 975	21
1996	50 975	21
1997	47 539	20
1998	47 539	20
1999	52 144	22
2000	43 976	18
2001	51 652	21
2002	45 633	19
2003	45 263	19

4.2.4.2 Methodological Issues

Emissions were estimated using the methodology and the default emission factor of the IPCC guidelines.

Activity data for soda used in glass industry were reported from the *Association of Glass Industry* for the year 2002 and 2003, for the years before activity data was estimated using a constant ratio of soda used per ton of glass produced, taken from the data reported for 2002 (glass production was reported by the *Association of Glass Industry* for all years). Activity data is presented in Table 120.

For calculation of CO_2 emissions the IPCC default emission factor of 415 kg CO_2/ t soda was used.

4.2.5 Asphalt Roofing (2 A 5) and Road Paving with Asphalt (2 A 6)

Emissions previously reported under these categories resulted from asphalt roofing production and bitumen production as well as pre-painting before the asphalt roofing or road paving. However, these emissions are already accounted for in the solvents sector, that's why emissions are now reported as "IE".

4.2.6 Mineral Products – Other (2 A 7)

4.2.6.1 Source Category Description

In this category bricks (decarbonising) and magnesia sinter production are addressed.

4.2.6.2 Bricks Production

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 121 presents CO_2 emissions from bricks production for the period from 1990 to 2003. CO_2 emissions from bricks production had a maximum in 1995/1996, following brick production. In 2003 emissions from this category were 6% above the level of 1990.

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, considering the carbonate contents of raw materials used for bricks production at the different plants and calculating CO_2 emissions from the stoichiometric ratios (using IPCC default emission factors).

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 before 1998 were calculated. For 2003 the value of 2002 was used.

Table 121 presents activity data for production of bricks and CO_2 emissions for this category for the period from 1990 to 2003.

Table 121: Activity data and CO_2 emissions for Bricks Production 1990-2003

Year	Bricks [t/a]	CO_2 emissions [Gg]	CO_2 IEF
1990	2 230 000	112	50.35
1991	2 333 852	118	50.35
1992	2 412 902	121	50.35
1993	2 593 236	131	50.35
1994	2 675 473	135	50.35

Year	Bricks [t/a]	CO_2 emissions [Gg]	CO_2 IEF
1995	2 848 716	143	50.35
1996	2 848 716	143	50.35
1997	2 625 046	132	50.35
1998	2 557 448	129	50.35
1999	2 184 773	117	53.43
2000	1 954 855	112	57.16
2001	1 959 395	119	60.88
2002	1 904 142	116	60.88
2003	1 904 142	116	60.88

Recalculations

Activity data for 2002 has been updated with national statistical data.

4.2.6.3 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 emission from magnesia sinter production is a key source both due to the contribution to total emissions of all inventory years and also with regard to all trend assessments. In 2003 it contributed 0.41% to the total amount of greenhouse gas emissions in Austria (see Table 112).

During production of magnesia sinter CO_2 is generated during the calcination step, when magnesia ($MgCO_3$) is roasted at high temperatures in a kiln to produce MgO. Magnesia sinter is processed in the refractory industry.

Table 122 presents CO_2 emissions from production of magnesia sinter for the period from 1990 to 2002.

CO_2 emissions from magnesia sinter plants varied over the period from 1990 to 2002 with an overall decreasing trend. In 2002 emissions were 22% less than in 1990. For 2003 no data was available.

Methodological Issues

No IPCC methodology is available for this source.

Emission values were directly reported by the only company in Austria sintering magnesia. Emissions have been calculated based on the carbonate content of the raw material.

Table 122 presents CO_2 emissions from this category for the period from 1990 to 2002. For 2003 no data was available.

Table 122: CO_2 emissions from Magnesia Sinter Production 1990-2002

Year	CO_2 Emissions [Gg]
1990	481
1991	392
1992	336

1993	325
1994	323
1995	410
1996	355
1997	384
1998	345
1999	350
2000	339
2001	334
2002	374

Uncertainty Assessment

Emissions were calculated based on stochiometric ratios and this is a fixed number, therefore the uncertainty of the emission factor is the uncertainty of raw material composition which is estimated to be about 5%. The uncertainty of activity data is assumed to be low (5%) as there is only one plant in Austria and data is obtained from this plant.

4.3 Chemical Industry (CRF Source 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 source due to the contribution to the level of total emissions of the Austrian greenhouse gas inventory of all years from 1990 to 2003. In 2003 it contributed 0.54% to the total amount of greenhouse gas emissions in Austria (see Table 112).

Ammonia (NH_3) is produced by catalytic steam reforming of natural gas or other light hydrocarbons (e.g. liquefied petroleum gas, naphtha). CO_2 is produced by stoichiometric conversion and is mainly emitted during the primary reforming step.

One 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 poisonous for the ammonia synthesis catalyst and have to be removed by conversion to CH_4 in the methanator. The other half is recycled methane that has not been converted in the reforming step. Only a small part of the methane is actually emitted, the main part is used as a fuel in the primary reformer.

Table 123 presents CO_2 and CH_4 emissions from ammonia production as well as production of ammonia for the period from 1990 to 2003.

Emissions varied during the period and followed closely the trend in ammonia production. From 1990 to 1994 emissions remained quite stable and then increased and reached a maximum in 1998. Since then emissions were decreasing again. In 2003 CO_2 emissions increased by 12%, CH_4 emissions by 31%. The implied emission factors vary depending on the plant utilization and on how often the production process was interrupted, e.g. because of change of the catalyst.

4.3.1.2 Methodological Issues

Following the IPCC Guidelines plant specific measurement data was collected.

Activity data since 1990 and emission data from 1994 onwards were reported directly to the UMWELTBUNDESAMT by the only ammonia producer in Austria and thus represent plant specific data. From emission and activity data an implied emission factor was calculated (see Table 123). The implied emission factor 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.

Emissions are measured regularly at the only ammonia producer in Austria, using spot sampling and extrapolation to annual loads. The measurements are performed 2 to 12 times per year for both CO_2 and CH_4.

CO_2 and CH_4 emission factors of ammonia plants depend largely 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 (as in 1998) needs a prolonged start up procedure. This causes an increase of emissions without production of ammonia.

Table 123: Activity data, emissions and implied emission factors for CO_2 and CH_4 emissions from ammonia production 1990–2003

Year	Ammonia Produced [t]	CO_2 Emissions [Gg]	CH_4 Emissions [Gg]	IEF CO_2 [kg/t]	IEF CH_4 [g/t]
1990	461 000	396	0.062	859	135
1991	475 000	408	0.064	859	135
1992	432 000	371	0.058	859	135
1993	469 000	403	0.063	859	135
1994	444 000	381	0.060	859	135
1995	473 000	468	0.061	990	129
1996	484 772	465	0.059	960	122
1997	479 698	457	0.081	953	169
1998	484 449	501	0.102	1 035	211
1999	490 493	472	0.055	963	112
2000	482 333	463	0.060	960	124
2001	448 176	442	0.051	986	114
2002	464 028	445	0.069	959	148
2003	510 887	494	0.047	966	93

4.3.1.3 Uncertainty assessment

As data was obtained from the only ammonia plant in Austria and data is based on actual measurement data the quality of emission estimates is rated as "high" (5% uncertainty).

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)

Nitric acid (HNO_3) is manufactured via the reaction of ammonia (NH_3) whereas 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 contain a small amount of methane, which is solved in the ammonia and is a byproduct. 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 a CO_2 emission in the tail gas.

In Austria there is only one producer of HNO_3.

Table 124 presents N_2O and CO_2 emissions from production of nitric acid for the period from 1990 to 2003.

N_2O emissions fluctuated during the period from 1990 to 2003, they increased from 1993 to 2000 and then decreased. This drop in emissions since 2001 was due to efforts made by the company to reduce their N_2O emissions, the IEF decreased from an average of 5.7 kg N_2O / t nitric acid, to about 5.0 kg N_2O / t nitric acid.

CO_2 emissions also varied over the period from 1990-2002 following the trend of nitric acid production closely until 1999. Specific emissions decreased since 2000 due to efforts made by the plant owner to reduce greenhouse gas emissions (also see implied emission factors in Table 124). In 2003 emissions were 7% lower than in 1990.

4.3.2.2 Methodological Issues

Following the IPCC Guidelines plant specific measurement data was collected.

Activity and emission data of N_2O emissions was obtained directly from the plant operator. Since 1998, emissions are measured continuously. 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 ton of product were calculated for the used technologies (nitric acid is produced at one site in up to five plants with different technologies; some of the plants where closed since 1990, two are still in operation). With these (conservative) estimate of emission factors and the production volume of the individual plants the total emission of N_2O per year was calculated.

Activity and emission data of CO_2 emissions from the years 1994 onwards have been reported directly to the UMWELTBUNDESAMT by the plant operator and thus represent plant specific data. 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 124: Activity data, emissions and implied emission factors for CO_2 and CH_4 emissions from Nitric Acid Production 1990-2003

Year	Nitric Acid Produced [t]	CO_2 Emissions [Gg]	N_2O Emissions [Gg]	IEF CO_2 [kg/t]	IEF N_2O [kg/t]
1990	529 998	0.41	2 942	0.78	5.55
1991	534 910	0.42	2 991	0.78	5.59
1992	484 731	0.38	2 702	0.78	5.57
1993	513 224	0.40	2 835	0.78	5.52
1994	467 391	0.36	2 662	0.78	5.70
1995	484 016	0.37	2 765	0.76	5.71
1996	495 738	0.38	2 820	0.76	5.69
1997	489 376	0.36	2 783	0.73	5.69
1998	504 977	0.38	2 893	0.75	5.73
1999	512 797	0.40	2 979	0.78	5.81
2000	533 715	0.37	3 070	0.69	5.75
2001	510 800	0.36	2 537	0.71	4.97
2002	522 410	0.37	2 604	0.70	4.98
2003	558 226	0.41	2 850	0.73	5.10

4.3.2.3 Uncertainty assessment

As data was obtained from the only nitric acid plant in Austria where emissions are measured continuously the quality of emission estimates was rated as "high" (5% uncertainty).

4.3.3 Calcium Carbide Production (2 B 4)

4.3.3.1 Source Category Description

Emission: CO_2

Key Source: No

Calcium carbide is made by heating calcium carbonate and subsequently reducing CaO with carbon – both steps lead to emissions of CO_2.

This source is only a minor source of CO_2 emissions in Austria: in 2003, emissions from this source contributed 0.04% to national total emissions.

4.3.3.2 Methodological Issues

Emissions were estimated using a country specific methodology.

Activity data was directly reported by the plant operator of the only carbide production plant in Austria. For 2003 no data was available, that's why the value of 2002 was used as a first estimate.

An emission factor of 1.2957 t / t carbide obtained from industry was applied. It was obtained by summing the emission factors for the carbonate and coke step up:

production of lime needed for calcium carbide production: 0.7153 t / t carbide calcium carbide production: 0.5804 t / t carbide

Table 125: Activity data and emissions for CO_2 emissions from Calcium Carbide Production 1990-2002

Year	Calcium Carbide [t]	CO_2 Emissions [Gg]
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

4.3.4 Chemical Industry – Other: Production of Fertilizers and Urea (2 B 5)

4.3.4.1 Source Category Description

Emission: *CH_4, CO_2*

Key Source: No

This category includes CH_4 emissions from the production of urea (CO_2 emissions are negligible) and CH_4 and CO_2 emissions 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.

CO_2 emissions from the production of fertilizers varied over the period following closely the trend of fertilizer production. They first decreased, reaching a minimum in 1998 and since then increased again. In 2003 emissions from this category were 13% lower than in 1990 (see Table 126).

4.3.4.2 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.

Data for fertilizer production for 1990 to 1994 were taken from national statistics (STATISTIK AUSTRIA), for 1995 to 2003 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 2003 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 for the years 1993 to 1990. However, there is an inconsistency in the time series (see subchapter on time series consistency below).

CO_2 emissions from fertilizer production were calculated by industry using a mass balance approach.

CH_4 emissions from the production of fertilizers and urea were reported for the years 2002 and 2003, this data became available due to a measurement program for CH_4 at the plant starting in 2002. For the years before no data is available, that's why the implied emission factor for the year 2002 was used for all years.

Table 126 presents activity data, emissions and implied emission factors for CH_4 and CO_2 emissions from *Fertilizer Production* and CH_4 emissions from *Urea Production* for the period from 1990 to 2003.

Table 126: Activity data, emissions and implied emission factors for CO_2 and CH_4 emissions from NPK-fertilizer Production and Urea Production 1990-2003

Year	Urea Production			Fertilizer Production			
	Urea Production [t]	CO_2 [Gg]	CH_4 [Gg]	Fertilizer Production [t]	CO_2 [Gg]	IEF CO_2 [kg/t]	CH_4 [Gg]
1990	282 000	0.27	0.11	1 388 621	27.14	19.55	0.184
1991	295 000	0.29	0.11	1 273 467	24.89	19.55	0.168
1992	259 000	0.25	0.10	1 182 595	23.12	19.55	0.156
1993	305 000	0.30	0.12	1 250 804	24.45	19.55	0.165
1994	360 000	0.35	0.14	1 222 578	23.90	19.55	0.162
1995	393 000	0.40	0.15	916 265	19.55	21.34	0.121
1996	417 705	0.30	0.16	940 313	18.07	19.22	0.124
1997	392 017	0.35	0.15	924 856	17.22	18.62	0.122
1998	395 288	0.29	0.15	977 212	18.68	19.12	0.129
1999	408 386	0.24	0.16	988 662	19.65	19.88	0.131
2000	390 185	0.22	0.15	1 022 983	20.59	20.13	0.135
2001	367 218	0.26	0.14	959 698	19.75	20.58	0.127
2002	389 574	0.35	0.15	1 013 767	23.61	23.29	0.134
2003	447 450	0.18	0.16	1 073 040	24.07	22.41	0.134

4.3.4.3 Recalculation

As indicated in the previous NIR, there had been a time series inconsistency for CH_4 emissions from urea production, this was corrected in this submission.

4.3.4.4 Time Series Consistency / Planned Improvements

The time series of fertilizer production is not consistent with respect to activity data. Whereas the date obtained from STATISTIK AUSTRIA for the period from 1990 to 1994 cover data for the total production in Austria the data for the period 1995 to 2002 reflect only the production of the largest Austrian producer. It is planned to prepare a consistent time series.

4.4 Metal Production (CRF Source 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)

In Austria iron and steel production is concentrated mainly at two integrated sites operated by the same company. This company is the only company operating blast furnaces in Austria. Additionally there are some companies operating electric arc furnaces, contributing about 10% to total steel production in Austria.

In this category only process specific CO_2 emissions are reported, emissions due to combustion in iron and steel industry are reported in the energy sector (Category *1 A 2 a*).

Process specific CO_2 emissions result from the use of reducing agent in pig iron production in blast furnaces and steel production in electric arc furnaces (use of electrodes) as well as from steel production (lowering the carbon content of steel compared to pig iron in electric arc furnaces and basic oxygen furnaces respectively).

Also CH_4 emissions from rolling mills and from electric arc furnaces are reported in this category.

CO_2 emissions from iron and steel production is an important key category of the Austrian greenhouse gas inventory because of its contribution to the total inventory level for all years of the inventory (ranking between seven to nine) and because of its contribution to the trend.

In the year 2003, CO_2 emissions from production of iron and steel contributed 4.9% to total greenhouse gas emissions in Austria (see Chapter 1.5.1).

CH_4 emissions from this category are negligible, the contribution to national total emissions in 2003 was 0.0001%.

Table 128 presents total CO_2 and CH_4 emissions from the production of iron and steel for the period from 1990 to 2003. CO_2 emissions from *Iron and Steel Production* decreased from 1990 to 1993 and then increased steadily following the trend of steel production. In 2003 emissions were 27% above the level of 1990.

4.4.1.2 Methodological Issues

General Remark

Total CO_2 emissions from the two main integrated iron and steel production sites in Austria are reported directly by industry until 2002. They are calculated by applying a very detailed mass balance approach for carbon. Process specific emissions[23] are calculated by the Umweltbundesamt according to the IPCC good practice guidance, these emissions are subtracted from total CO_2 emissions reported by the company. The remaining emissions are

[23] Process specific emissions considered are CO2 emissions resulting from the use of reducing agent in pig iron production in blast furnaces and CO2 emissions from steel production resulting from the lowering of the carbon content of steel compared to pig iron in basic oxygen furnaces as well as CO2 emissions from limestone use in blast furnaces.

reported in the energy sector as emissions due to combustion in category *1 A 2 a Iron and Steel*.

Thus some shortcomings of the methodology applied for calculating process specific CO_2 emissions do not have an effect on national total emissions but only on the split between process specific and combustion specific emissions (for example only carbonatious ore was considered for calculating the split of process specific and combustion specific CO_2 emissions from blast furnaces whereas the carbon content of other ore used was not considered; however, the detailed mass balance approach used by the operator does consider all carbon introduced to the process, thus also considering ore other than carbonatious ore).

For the year 2003 total CO_2 emissions were not reported by industry, thus they were estimated using information from the national energy balance and from the years before (see below and description of category *1 A 2 a*).

CO_2 emissions from pig iron production

CO_2 emissions were calculated following closely the IPCC GPG guidelines Tier 2 approach, applying the default emission factor of table 3.6 of the IPCC GPG:

*CO_2 Emissions = Mass of reducing agent * 3.1 t CO_2/ t reducing agent + (Mass of Carbon in the Ore – Mass of Carbon in the Crude Iron) * 44/12*

The mass of reducing agent (coke) was taken from the national energy balance (see Annex 4). According to a national study [Hiebler/Gamsjäger/God] 56.3% of coke used in blast furnaces is actually needed as reducing agent, this part is reported as non-energy use in the national energy balance[24].

This non-energy use is used for calculating CO_2 emissions from pig iron production in blast furnaces with the equation presented above, as this is assumed to be more accurate than the approach of the GPG where total mass of reducing agent is considered as non-energy use and the resulting emissions as process specific emissions.

Only carbonatious ore was considered for the calculation as no statistical data was available for the amount of other ore[25] (however, the carbon content of iron oxide is only small). Carbon content of the ore was calculated assuming pure ore, thus the factor used for calculating the mass of carbon in the ore was based on the stochiometric ratio of carbon in $FeCO_3$:

*Mass of Carbon in the Ore = Mass of ore * 12/ 116*

Mass of ore used in pig iron production for the years 1990 to 1995 was taken from national statistics (statistical yearbook of STATISTIK AUSTRIA), the value of 1995 was also used for 1996 and 1997. From 1998 –2002 the mass of ore was directly reported by industry, for 2003 the value of 2002 was used.

Mass of carbon in pig iron was calculated by applying the IPCC default value of 4% carbon in crude steel.

Pig iron production data for 1990 and 1995 to 2001 was taken from national statistics (statistical yearbook of STATISTIK AUSTRIA), data for 1991 to 1994 was taken from www.worldsteel.org , for 2002 and 2003 it was directly reported by industry.

24 Because of the methodology of the energy balance, the reported amount of non-energy use is not always exactly 56.3%, that's why for calculating emissions total coke use in blast furnaces was taken from the energy balance and from this amount 56.3% was considered as non-energy use.

25 Carbonatious ore is mined in Austria, thus it is reported in the statistical yearbook.

For the year 2003 total emissions were not reported by industry. To calculate process specific CO_2 emissions from pig iron production for the year 2003, the average IEF of the three years before was used.

Activity data, calculated CO_2 emission data as well as the implied emission factor for CO_2 emissions from pig iron production are presented in Table 127.

Table 127: Activity data, emissions and implied emission factors for CO_2 emissions from pig iron production 1990–2003

Year	Coke [kt]	Ore [kt]	Pig Iron [kt]	CO_2 [Gg]	IEF CO_2 [t/t Pig Iron]
1990	872	2 225	3 444	3 043	883
1991	878	2 092	3 442	3 010	874
1992	792	1 629	3 074	2 624	854
1993	808	1 627	3 070	2 671	870
1994	882	1 695	3 320	2 889	870
1995	1 001	2 071	3 888	3 318	853
1996	932	2 071	3 432	3 173	924
1997	1 058	2 071	3 972	3 482	877
1998	1 026	1 810	4 032	3 276	812
1999	991	1 734	3 912	3 157	807
2000	1 114	1 879	4 320	3 532	818
2001	1 101	1 875	4 380	3 483	795
2002	1 255	1 925	4 669	3 936	843
2003	1 142	1 925	4 677	3 828	819

CO_2 emissions from steel production

CO_2 emissions from steel production (which corresponds to steel production at the two integrated sites operating blast furnaces) were calculated following the IPCC GPG guidelines Tier 2 approach:

*CO2 Emissions = (Mass of Carbon in the Crude Iron used for Crude Steel – Mass of Carbon in the Crude Steel) * 44/12*

For the years 1990 to 2001 activity data for electric steel production was subtracted from total steel production in Austria taken from national statistics (statistical yearbook of STATISTIK AUSTRIA) to obtain steel production of the two integrated sites operating blast furnaces. For 2002 and 2003 steel production of the two integrated sites operating blast furnaces was directly reported by industry.

The average carbon content of 0.15% for steel was obtained from the operator of the two integrated sites; as mentioned above, the IPCC default value was used for the carbon content of pig iron (4%).

CO_2 and CH_4 emissions from electric 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 from the years before.

For calculating CH_4 emissions an emission factor of 5 g CH_4 /Mg electric steel was applied. An emission factor for VOC emissions from production of steel in Austria was taken from a study published by the Austrian chamber of commerce, section industry [WINDSPERGER & TURI, 1997]. It was assumed that total VOC emissions are composed of 10% CH_4 and 90% NMVOC (expert judgement UMWELTBUNDESAMT).

Activity data were obtained from the *Association of Mining and Steel* and thus represent plant specific data.

CH_4 emissions from rolling mills

Emissions were estimated using a country specific methodology.

The emission factor for VOC emissions from rolling mills (1 g VOC/ Mg steel) was reported directly by industry and thus represents plant specific data. It was assumed that VOC emissions are composed of 10% CH_4 and 90% NMVOC (expert judgement UMWELTBUNDESAMT).

Activity data as used for calculating CO_2 emissions from steel production (see above) was applied.

Table 128 presents pig iron, steel and electric steel production, CO_2 and CH_4 emissions and implied emission factors as well as total CO_2 emissions from this sector.

Table 128: Activity data, emissions and implied emission factors for CO_2 and CH_4 emissions from Iron and Steel Production 1990–2003

Year	Steel Production				Electric Steel Production			**Total CH_4 [Gg]**	**Total CO_2 [Gg]**
	Steel [kt]	CO_2 [Gg]	IEF CO_2 [t/t]	CH_4 [Gg]	Electric Steel [kt]	CO_2 [Gg]	CH_4 [Gg]		
1990	3 921	484	123	0.0004	370	19.56	0.002	**0.0022**	**503**
1991	3 896	483	124	0.0004	290	15.34	0.001	**0.0018**	**499**
1992	3 592	431	120	0.0004	361	19.06	0.002	**0.0022**	**450**
1993	3 738	430	115	0.0004	411	21.71	0.002	**0.0024**	**451**
1994	3 968	465	117	0.0004	431	22.78	0.002	**0.0026**	**488**
1995	4 538	545	120	0.0005	454	23.98	0.002	**0.0027**	**569**
1996	4 032	481	119	0.0004	396	20.94	0.002	**0.0024**	**502**
1997	4 718	557	118	0.0005	466	24.61	0.002	**0.0028**	**581**
1998	4 801	565	118	0.0005	503	26.58	0.003	**0.0030**	**592**
1999	4 722	548	116	0.0005	486	25.68	0.002	**0.0029**	**573**
2000	5 183	605	117	0.0005	541	28.57	0.003	**0.0032**	**634**
2001	5 346	613	115	0.0005	546	28.84	0.003	**0.0033**	**642**
2002	5 647	654	116	0.0006	538	28.45	0.003	**0.0033**	**682**
2003	5 707	655	115	0.0006	568	30.05	0.003	**0.0034**	**685**

4.4.1.3 Uncertainty Assessment

According to the IPCC GPG the uncertainty of the CO_2 emission factor for coke and the carbon content of iron and steel is 5%.

The uncertainty of activity data is assumed to be low (5%) because there are only five production sites with two sites dominating.

However, in the case of CO_2 emissions from iron and steel production (not including electric steel production) the uncertainty of total emissions from the two production sites is relevant (see general remark in Chapter 4.4.1.2). According to the Monitoring and Reporting Guidelines[26], uncertainties of emission estimates for process emissions from solid raw materials is 5%.

4.4.1.4 Recalculation

The amount of coke used in blast furnaces has been recalculated, based on the assumption that 56.3% is non-energy use. However, this does not effect national total emissions, as total emissions from the two integrated iron and steel sites were reported from industry and used for preparation of the inventory (see general remark above), only the separation into process-specific and combustion-related emissions has slightly changed.

Previously an emission factor from a swiss study was used to calculate CO_2 emissions from electric arc furnaces, now PS data from all Austrian plants became available, and this information was used to recalculate emissions (see Table 129).

Table 129: Recalculation difference of CO_2 emissions from electric arc furnaces 1990–2002

Year	CO_2 emissions [Gg]
1990	-17.45
1991	-13.69
1992	-17.00
1993	-19.37
1994	-20.32
1995	-21.39
1996	-18.68
1997	-21.95
1998	-23.71
1999	-22.91
2000	-25.48
2001	-25.73
2002	-26.11

26 COMMISSION DECISION of 29/01/2004 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

4.4.2 Aluminium Production (2 C 3)

4.4.2.1 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.

The 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 source for PFC emissions because of the contribution to the total level of greenhouse gas emissions in the years 1990 to 1992 and because of its contribution to the trend from the base year to 1991 and 1992. In the trend assessment for the base year to 1992 also this source was also identified a key category with respect to CO_2 emissions.

Table 130 presents PFC and CO_2 emissions from primary aluminium production for the period from 1990 to 1992.

Table 130: PFC emissions from primary aluminium production from 1990 to 1992

	1990	1991	1992
PFC emission [Gg CO_2-equivalent]	1050	1050	418
CO_2 emissions [Gg]	158	158	63

4.4.2.2 Methodological Issues

CO_2 emissions were calculated by applying the IPCC default emission factor of 1.8 t CO_2 / t aluminium produced taken from the IPCC guidelines (Table 2.16).

PFC emissions were estimated using the IPCC Tier 1b 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, 1996], [TABERAUX, 1996]:

$$kg\ CF_4/t_{Al} = (1.7 \times AE/pot/day \times F \times AE_{min})/CE$$

Where:

AE/pot/day	=	frequency of occurrence of the anode effect (dependent on type of oxide supply (1,2 / day)
t_{Al}	=	effective production capacity per year [t]
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 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 – value was also used for 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.

4.4.2.3 Recalculations

Previously the activity data used for calculating PFC and CO_2 emissions were not consistent, this has been corrected.

4.4.3 SF_6 Used in Aluminium and Magnesium Foundries (2 C 4)

4.4.3.1 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 source because of its contribution to total emissions in the years 1990 to 1997 and to the trend of emissions in the trend assessment of the years 1996 to 2002.

In the base year, SF_6 emission from aluminium and magnesium foundries contributed 0.6% to the total amount of greenhouse gas emissions in Austria, in the year 2003 no emissions arose from this category (see Table 112).

Table 131 presents SF_6 emissions from magnesium and aluminium foundries for the period from 1990 to 2003.

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 2000 they decreased by 97%. For the years 2001 and 2002 the value of 2000 was used due to lack of more up to date data; since 2003 the use of SF_6 in foundries is prohibited in Austria.

Table 131: SF_6 emissions from magnesium and aluminium foundries 1990–2003

Year	SF_6 emissions [Gg]
1990	0.0106
1991	0.0116
1992	0.0106
1993	0.0116
1994	0.0156
1995	0.0185
1996	0.0256

Year	SF_6 emissions [Gg]
1997	0.0146
1998	0.0069
1999	0.0009
2000	0.0003
2001	0.0003
2002	0.0003
2003	0

4.4.3.2 Methodological Issues

Emissions were estimated following the IPCC methodology.

Information about the amount of SF_6 used was obtained directly from the aluminium producers in Austria and thus represent plant-specific data (for verification data was checked against data from SF_6 suppliers). Actual emissions of SF_6 equal potential emissions and correspond to the annual consumption of SF_6.

4.5 Consumption of Halocarbons and SF_6 (CRF Source Category 2 F)

4.5.1 Source Category Description

This category includes the following emission sources: refrigeration and air conditioning equipment, foam blowing, fire extinguishers, semiconductor manufacture, electrical equipment and other sources (noise insulation windows, tyres and research). The subcategories aerosols and solvents have not been estimated because no data was available (however, it is considered in the improvement plan to try to obtain data).

There is no production of Halocarbons in Austria.

Potential emissions are reported as sums under category *2 F*, for estimates of actual emissions please refer to the respective sub-categories.

Emission Trends

For the source *Consumption of Halocarbons and SF_6* greenhouse gas emissions increased by 52% compared to base year emissions (1995 for PFCs, HFCs and SF_6). In 2003, emissions were four times higher than in 1990. This was mainly due to strongly increasing emissions from the use of HFCs as substitutes for ozone depleting substance (*ODS Substitutes*).

Potential and actual emissions per substance group is presented in Table 132, emissions by sub sector and gas are presented in Table 133.

Table 132: Potential and actual emissions of IPCC Category 2 F per substance group [Gg CO_2e] 1990-2003

	HFCs		PFCs		SF_6		Total	
Year	Potential	Actual	Potential	Actual	Potential	Actual	Potential	Actual
1990	439.68	219.16	32.28	29.05	586.57	249.24	1 058.53	497.46
1991	462.31	334.57	40.99	36.89	839.14	376.12	1 342.44	747.58
1992	486.06	386.59	56.70	45.08	903.00	444.51	1 445.75	876.17
1993	584.69	444.24	58.41	52.92	966.86	516.47	1 609.95	1 013.62
1994	620.08	505.20	64.77	58.65	1 127.73	612.86	1 812.58	1 176.70
1995	841.87	555.26	75.99	68.74	1 216.26	696.06	2 134.12	1 320.05
1996	1 112.84	637.15	73.24	66.27	942.80	607.41	2 128.88	1 310.83
1997	1 272.47	729.62	107.20	96.83	1 098.77	770.98	2 478.45	1 597.42
1998	1 347.21	812.53	110.71	44.75	1268.99	743.80	2 726.92	1 601.08
1999	1 476.21	866.99	191.14	64.54	1 027.51	661.74	2 694.86	1 593.27
2000	2 086.77	1 019.00	243.28	72.33	983.99	625.67	3 314.03	1 717.00
2001	2 231.80	1 122.34	285.95	82.15	1 025.89	628.97	3 543.65	1 833.46
2002	2 270.47	1 218.92	316.48	86.87	1 030.86	633.19	3 617.81	1 938.99
2003	2 311.71	1 308.22	380.59	102.54	812.96	593.52	3 505.25	2 004.28

Key Sources

For the key source analysis emission data of this category were aggregated as suggested in the IPCC GPG:

2 F 1/2/3 ODS (Ozone Depleting Substances) Substitutes (HFCs), *2 F 6 Semiconductor Manufacture* (HFCs, PFCs and SF_6),

2 F 4 Electrical Equipment (SF_6) and

2 F 8 Other Sources of SF_6.

Three of these sources have been identified as key sources: *2 F 1/2/3 ODS (Ozone Depleting Substances) Substitutes* (HFCs), *2 F 6 Semiconductor Manufacture* (HFCs, PFCs and SF_6) and *2 F 8 Other Sources of SF_6* (for further information on key sources see Chapter 1.5.1).

4.5.2 Methodological Issues

A study has been contracted out to determine the consumption data and emissions from 1990-2000 for all uses of FCs (study has not been published). In this study, buttum up data for consumption per sector were compared with top-down data from importers and retailers of FCs as well as with data from the national statistics (import/export statistics).

The study also included projections until 2010, these were used to estimate emissions from 2001-2003, except for the subcategories *2 F 6 Semiconductor Manufacture* and *2 F 7 Electrical Equipment* where data for these years were available. The total consumption (potential emissions) was checked against import/export statistics to verify the trend.

Data about consumption of HFC, PFC and SF_6 were determined from the following sources:

- data from national statistics
- data from associations of industry
- direct information from importers and end users

Since 2004 there is also a reporting obligation under the Austrian FC-regulation[27] for users of FCs 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 brought together with data from the electronic system).

The first reporting year is 2003, from this year on the end users of FCs have to report annually about the amounts used and recycled. Theoretically, almost the whole activity data used for inventory preparation is covered by the reporting obligation. 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. That's why not all enterprises reported their consumption, and the results of the first reporting round could not be used for these applications; however, for the next submission results will be considered as far as possible.

Emissions for all subcategories were estimated using a country specific methodology, emission factors are based on information of 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 Halocarbons or SF_6 containing products.

27 „Industriegas-Verordnung (HFKW-FKW-SF6-VO)" federal law gazette 447/2002

Annual stocks correspond to the amounts of FCs stored in applications in the year before, minus emissions of the year before, plus consumption of the considered year.

Potential emissions correspond to the amounts consumed in the considered year.

The following subchapters present emission factors and data sources used for the respective subcategories.

Table 133: Emissions of IPCC Category 2 F by subsector 1990-2003

GHG	*GWP*	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2 F 1	**Refrigeration and Air Conditioning Equipment**															
HFC-32	*650*	t	0.00	0.00	0.00	0.00	0.02	0.09	0.19	0.39	0.68	1.02	1.86	2.64	3.40	4.11
HFC-125	*2 800*	t	0.00	0.00	0.00	0.00	0.03	1.47	5.73	10.96	14.26	15.07	19.81	27.62	34.85	41.51
HFC-134a	*1 300*	t	1.35	2.12	2.83	4.14	6.11	21.76	41.08	60.57	81.99	96.04	115.66	133.66	150.93	167.66
HFC-152a	*140*	t	0.00	0.00	0.00	0.00	0.00	0.06	0.33	0.57	0.72	0.61	0.66	0.70	0.74	0.78
HFC-143a	*3 800*	t	0.00	0.00	0.00	0.00	0.00	0.39	2.52	5.59	7.92	8.94	12.49	19.98	26.87	33.21
		GgCO2e	**1.76**	**2.75**	**3.68**	**5.38**	**8.03**	**33.95**	**79.22**	**131.02**	**177.14**	**201.74**	**254.60**	**328.82**	**398.21**	**463.16**
2 F 2	**Foam Blowing**															
HFC-134a	*1 300*	t	165.75	252.88	291.13	332.21	374.71	391.00	416.50	446.25	477.42	498.10	519.14	538.29	555.55	570.94
HFC-152a	*140*	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	489.06	498.42	507.78	518.31
		GgCO2e	**215.48**	**328.74**	**378.46**	**431.87**	**487.12**	**508.30**	**541.45**	**580.13**	**620.64**	**647.53**	**743.35**	**769.56**	**793.31**	**814.78**
2 F 3	**Fire Extinguishers**															
HFC-23	*11 700*	t	0.00	0.00	0.00	0.10	0.25	0.38	0.56	0.74	0.95	1.15	1.34	1.53	1.72	1.90
HFC-227	*2 900*	t	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.15	0.24	0.35	0.54	0.78	1.08	1.43
C4F10	*7 000*	t	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		GgCO2e	**0.00**	**0.00**	**0.35**	**1.52**	**3.22**	**4.83**	**7.09**	**9.38**	**12.15**	**14.84**	**17.62**	**20.54**	**23.58**	**26.74**
2 F 6	**Semiconductor Manufacture**															
HFC-23	*11 700*	t	0.16	0.26	0.38	0.50	0.61	0.73	0.83	0.81	0.25	0.28	0.32	0.32	0.36	0.33
CF4	*6 500*	t	3.66	4.11	4.57	5.03	5.17	5.97	5.82	8.52	2.72	4.83	6.33	6.33	6.40	6.90
C2F6	*9 200*	t	0.57	1.10	1.63	2.16	2.69	3.22	3.05	4.47	2.91	3.56	3.35	4.42	4.08	5.14
C3F8	*7 000*	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	1.44
C4F10	*7 000*	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	*23 900*	t	4.27	7.33	9.98	12.64	15.29	17.94	13.74	20.41	18.01	16.17	13.86	13.86	14.02	15.77
		GgCO2e	**133.08**	**215.20**	**287.79**	**360.38**	**430.86**	**505.68**	**403.95**	**593.76**	**477.80**	**453.93**	**407.08**	**416.90**	**425.79**	**483.04**
2 F 7	**Electrical Equipment**															
SF6	*23 900*	t	0.86	0.91	0.95	1.00	1.05	1.09	1.13	1.13	1.14	1.21	1.22	1.23	1.26	1.32
		GgCO2e	**20.59**	**21.69**	**22.79**	**23.89**	**24.98**	**26.07**	**26.91**	**27.07**	**27.22**	**28.86**	**29.09**	**29.36**	**30.05**	**31.46**
2 F 8	**Other Sources of SF6**															
SF6	*23 900*	t	5.30	7.50	7.66	7.97	9.31	10.09	10.55	10.71	11.97	10.31	11.10	11.23	11.22	7.74
		GgCO2e	**126.56**	**179.20**	**183.10**	**190.58**	**222.49**	**241.23**	**252.21**	**256.06**	**286.13**	**246.36**	**265.25**	**268.28**	**268.04**	**185.09**

4.5.2.1 2 F 1 Refrigeration and Air Conditioning Equipment

Consumption data was obtained directly from the most important importers of refrigerants. The volume of stocks of the different subcategories were estimated using information from the most important refrigerant retailers/ importers and experts from the refrigeration branch.

The following table describes what kind of refrigeration and air-conditioning equipment has been considered in which subcategory, and which refrigerants have been used in the respective subcategory in Austria.

From the annual stocks emissions are estimated using emission factors based on expert judgement from experts of the refrigeration branch. The emission factors are presented in Table 134. Annual stocks refer to total stock in Austria, thus import and export of pre-filled equipment is considered indirectly (but not separately).

Emissions from disposal have not been estimated but are considered to be low, as cooling devices are recycled in Austria, and the refrigerant is usually recovered[28]. There is production of fridges and freezers in Austria (equipment filled at the production site), however emissions from production have not been estimated and are considered to be minor (as emissions from larger devices that are filled after installation clearly dominate total emissions from this subcategory).

Table 134: Description of sub-categories of 2 F 1 Refrigeration and Air Conditioning Equipment and emission factors used

Subcategory	Description	Used Refrigerants	Emission factors [% of stocks]
Domestic Refrigeration	fridges and freezers at homes	134a	1.5%
Commercial Refrigeration	fridges and freezers in shops	134a	1.5%
Transport Refrigeration	chilled loading space of trucks, ships and rail	134a	10%
Industrial Refrigeration	mainly cooling devices for food trade, also including cooling devices for industrial machines (oil-cooling)	134a, 401a, 402a, 404a, 407c	10% until 1999, 8% since 2000
Stationary Air-Conditioning	industrial cooling in chemical industries, food processing and air-conditioning of office buildings, etc.; imported "ready to plug in" mobile refrigeration systems; heat pumps;	134a, 404a, 407c	as industrial 6% 1%
Mobile Air-Conditioning	mobile air-conditioning in passenger cars, busses, freight vehicles and rail.	134a	15% 5%

401a, 402a, 404a and 407c are blends containing HFC-32, HFC-125, HFC-134a, HFC-143a and/or HFC-152a, the two former also contain HCFCs.

[28] There is a regulation that old cooling devices have to be taken back by retailes for recycling/recovering ("Verordnung über die Rücknahme von Kühlgeräten" BGBl. Nr. 408/1992 idF BGBl. II Nr. 440/2001

4.5.2.2 2 F 2 Foam Blowing and XPS/PU Plates

Foam blowing

HFC 134a is used as blowing agent for PU foams. The consumption of PU foam cans was estimated using information from the construction industry. An average charge of blowing agent of 85g per can was assumed.

For calculating emissions it is assumed that 50% of the blowing agent is emitted in the first year, 25% in the second year, and the rest within the following three years (8.3% per year). This assumption is based on information from producers.

XPS/PU Plates

Production data and information about the used blowing agent were obtained from Associations of Industry (construction industry) and from producers. Emissions were calculated from the total consumption of XPS/PU plates in Austria - about 75% of the XPS/ PU plates are imported. The consumption per capita of XPS/ PU plates in Austria is higher than in all other European countries.

Based on expert judgement it was assumed that about 5 kg blowing agent per m³ plate are used. About 30% of that amount (1.5 kg) is emitted during production and storage at the place of production. The rest - about 3.5 kg per m³ XPS/ PU plate - is emitted gradually by diffusion.

For HFC 134a it was assumed that 0.6% per year is emitted through diffusion, for HFC 152a it is assumed that 100% is emitted in the first year. year). This assumption is based on information from producers.

Recalculations

Previously HFC use for foam blowing and emissions from this category were only considered from 1995 onwards, in this submission also the use and emissions of the years before are included.

Planned Improvements

A study was contracted out to update data for this category, the results will be incorporated for the 2006 submission.

4.5.2.3 2 F 3 Fire Extinguishers

Consumption data were obtained directly from the producers of fire extinguishers.

From 1992 to 1995 1.000 t of C_4H_{10} for the use in fire extinguishers in Austria was sold.

HFC-23 and HFC-227ea in fire extinguishers were first introduced to the Austrian market in 1993 and 1996, respectively.

Based on expert judgement it was assumed that actual emissions are 5% of annual stocks, these emissions include leakage and tests.

Recalculations

Previously HFC use for foam blowing and emissions from this category were only considered from 1995 onwards, in this submission also the use and emissions of the years before are included.

4.5.2.4 2 F 6 Semiconductor Manufacture (HFCs, PFCs, SF_6)

All consumption data and data about actual emissions from semiconductor manufacture were based on direct information from industry. Consumption data is not reported in the CRF as it istreated confidential.

4.5.2.5 2 F 7 Electrical Equipment (SF_6)

Information on SF_6 stocks in electrical equipment in 2003 were obtained from energy suppliers and industrial facilities (as mentioned above, there is a reporting obligation for operators of SF_6 filled equipment since 2004). For the time series information on new equipment per year and the average SF_6 content per equipment type was used; this information was obtained from energy suppliers and experts from industry.

SF_6 emissions were calculated based on the assumption that there are no emissions during first filling on site (furthermore, smaller equipment is already filled during manufacture); based on information from experts from industry, it was thus estimated that emissions during service and leakage are 1% of annual stocks.

4.5.2.6 2 F 8 Other Sources of SF_6

Noise insulating windows

Activity data were estimated based upon information from experts from industry.

The average consumption of SF_6 was calculated by multiplying the area of SF_6 filled insulate glass produced with the average SF_6 consumption per square meter glass (11 litre SF_6/m^2 – 8 litre filling plus 3 litre losses). The calculated volume was multiplied with a density of 6.18 g/litre.

The actual emissions are the sum of emissions during production and leakage, which is estimated to be 1% of the original SF_6 filling. Emissions at disposal are not yet relevant, because the average life time is estimated to be 25 years and the first SF6 filled windows were introduced in Austria in 1980.

Tyres

Information on the amount of SF_6 used for filling tyres was obtained from SF_6 retailers. Emissions were calculated as one third per year for the three years following consumption.

Shoes

Emissions from the imported amount of shoes with SF_6 filling was obtained from the producer. It was assumed that all SF_6 is emitted at the end of the lifetime of these shoes, which was estimated to be 3 years.

Research

SF_6 is used in research in electron microscope and other equipment, the annual consumption was estimated to be 100 kg per year until the total estimated stock of 500 kg was reached (1996), emissions are estimated to be 20 kg per year (after 1996 consumption = emissions).

4.5.3 Uncertainty estimate

For the key sources an uncertainty estimate was made:

2 F 1/2/3 ODS Substitute

Activity data uncertainty is estimated to be 20%, as on the one hand total consumption figures are adjusted with import/export statistics but on the other hand the categories of the statistics do not always distinguish between HFCs and HCFCs for example, resulting in a higher uncertainty.

Apart from the uncertainty of the activity data the following uncertainties occur for emissions from this source:

i. the uncertainty of disaggregating total consumption to sub sectors (which has an effect on emissions as the emission factors used for the different sub categories differ significantly). However, the foam blowing sub sector is small, there are only a few producers that have to be considered and information was available from most of them.

ii. the uncertainty of disaggregation from substance groups (eg. from the import/export statistics) into substances (which affects total GHG emissions because the GWPs differ significantly).

iii. the uncertainty of the emission factors.

The uncertainty of the emission factor is considered to be dominating, it is estimated to be 50%; the other uncertainties were considered to be negligible compared to the emission factor uncertainty.

2 F 6 Semiconductor Manufacture

Acitivty data 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%.

2 F 8 Other Use of SF6

According to emissions, 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.

4.5.4 Recalculations

As already mentioned above, in the previous submission data of 2000 was also used for the years 2001 and 2002; in this submission extrapolation techniques were used to estimate emissions for 2001 to 2003, except for the subcategories *2 F 6 Semiconductor Manufacture* and *2 F 7 Electrical Equipment* where data for these years were available.

During an audit of the study mentioned above, several calculation errors were identified and corrected. Furthermore, emissions of foam blowing before 1995, that were previously not included in the inventory was included in this submission. Additionally, the consumption of C_4F_{10} in fire extinguishers which was previously not included, was now included.

4.5.5 Planned Improvements

As already mentioned above, for the next submission results from the reporting obligation concerning the use of FCs will be considered as far as possible. Furthermore, results from a study on foam blowing will be incorporated.

5 SOLVENT AND OTHER PRODUCT USE (CRF SOURCE CATEGORY 3)

***NOTE:* There have been no changes in methodology for this sector since the last submission, and emission data has not been updated for 2003 (the values of 2002 were also reported for 2003 as a first estimate).**

5.1 Sector Overview

This chapter describes the methodology used for calculating greenhouse gas emissions from solvent use in Austria. Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). After application of these substances or other procedures of solvent use most of the solvent is 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.

Estimations for N_2O emissions from other product use (anaesthesia and aerosol cans) are also addressed in this chapter.

5.1.1 Emission Trends

In the year 2002 this category had a contribution of 0.5% to total greenhouse gas emissions (not considering CO_2 from LUCF). There has been a decrease of 17% in greenhouse gas emissions from 1990 to 2002 (see Table 135) due to the positive impact of the enforced laws and regulations in Austria[29] (regulations and directives on solvents, VOC-directive). In emission intensive activity areas such as coating, printing and in the pharmaceutical industry the number of waste air purification plants has grown during the period from 1990 to 1995. From 1995 to 1998 the quantities of solvents varied heavily due to the economic development, especially in the last years (1999-2002) an increase was observed.

Table 135: Trend in greenhouse gas emissions of Category 3 Solvent and Other Product Use 1990 – 2002

GHG [Gg CO_2 equivalent]	CO_2	N_2O	Total
1990	282.67	232.50	515.17
1991	236.77	232.50	469.27
1992	187.74	232.50	420.24
1993	187.35	232.50	419.85
1994	171.54	232.50	404.04
1995	189.88	232.50	422.38
1996	172.81	232.50	405.31
1997	190.09	232.50	422.59

29 Lösungsmittelverordnung, BGBL 492/1991; Lösungsmittelverordnung 1995, BGBl 872/1995; Lackieranlagen-Verordnung, BGBl. 873/1995; CKW Anlagenverordnung 1994, BGBl. 865/1994;

1998	172.24	232.50	404.74
1999	158.37	232.50	390.87
2000	181.02	232.50	413.52
2001	193.60	232.50	426.10
2002	193.60	232.50	426.10
Trend 1990 – 2002	*-31,51%*	*0.00%*	*-17.29%*

Table 136: Total greenhouse gas emissions and trend from 1990 – 2002 by subcategories of Category 3 Solvent and Other Product Use

GHG [Gg CO_2 equivalent]	3 A	3 B	3 C	3 D	Total
1990	119.69	36.11	42.25	317.13	515.17
1991	97.02	29.53	35.02	307.69	469.27
1992	74.37	22.85	27.48	295.54	420.24
1993	71.67	22.23	27.13	298.82	419.85
1994	63.28	19.84	24.58	296.35	404.04
1995	67.46	21.38	26.91	306.62	422.38
1996	59.76	20.15	24.21	301.20	405.31
1997	63.93	22.91	26.31	309.43	422.59
1998	56.29	21.45	23.56	303.45	404.74
1999	50.26	20.34	21.40	298.87	390.87
2000	55.73	23.97	24.16	309.66	413.52
2001	59.60	25.64	25.84	315.02	426.10
2002	59.60	25.64	25.84	315.02	426.10
Trend 1990 – 2002	*-50.20%*	*-29.00%*	*-38.84%*	*-0.66%*	*-17.29%*

5.1.2 Key Sources

The key source analysis is presented in Chapter 1.5. This chapter includes information about the key sources in the IPCC Sector *3 Solvents*. Both subcategories of this source have been identified as key categories.

Table 137: Key sources of category Solvent and Other Product Use

IPCC Category	Source Categories	Key Sources*	
		GHG	KS-Assessment
3	Solvent and Other Product Use	CO_2	LA 90, 91 TA 91-99, 01
		N_2O	LA 92-94

LA02 = Level Assessment 2002
TA02= Trend Assessment Base year-2002

5.1.3 Completeness

Table 138 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 subcategory have been estimated.

Table 138: Overview of subcategories of IPCC Category 3 Solvents and Other Product Use: transformation into SNAP Codes and status of estimation

IPCC Category	SNAP		CO_2	N_2O
3A Paint application	0601	Paint application	✓	NA
3B Degreasing and Dry Cleaning	0602	Degreasing, dry cleaning and electronics	✓	NA
3C Chemical Products, Manufacture and Processing	0603	Chemical products manufacturing and processing	✓	NA
3D Other	0604	Other use of solvents and related activities	✓	NA
	0605	Use of HFC, N2O, NH3, PFC and SF6	NA	✓

5.2 CO_2 Emissions from Solvent and Other Product Use

5.2.1 Methodology Overview

CO_2 emissions from solvent use were calculated from NMVOC emissions of this sector. So as a first step the quantity of solvents used and the solvent emissions were calculated.

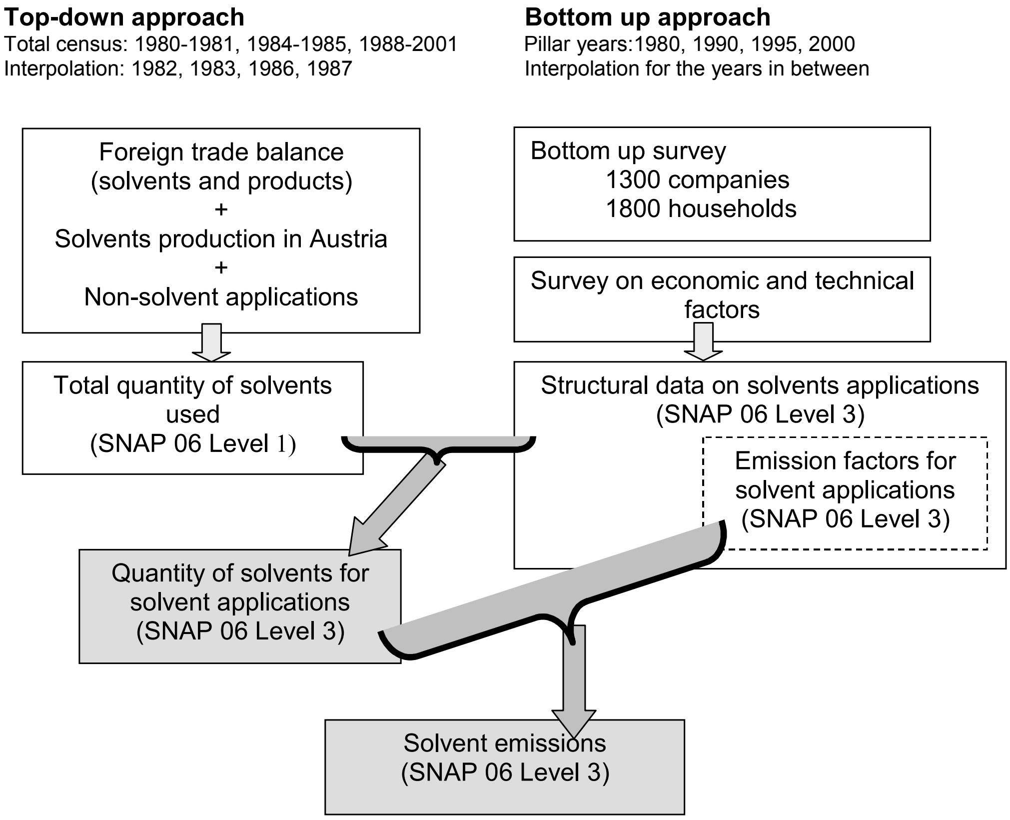
To determine the quantity of solvents used in Austria in the various applications, a bottom up and a top down approach were combined. Figure 13 presents an overview of the methodology.

The top down approach provided total quantities of solvents used in Austria. The share of the solvents used for the different applications and the solvent emission factors have been calculated on the basis of the bottom up approach. By linking the results of bottom up and top down approach, quantities of solvents annually used and solvent emissions for the different applications were obtained.

A study [FIEU&IIÖ, 2002b] showed that emission estimates only based on the top down approach overestimate emissions because a large amount of solvent substances is used for "non-solvent-applications". "Non-solvent application" are applications where substances usually used as solvents are used as feed stock in chemical, pharmaceutical or petrochemical industry (e.g. production of MTBE, formaldehyde, polyester, biodiesel, pharmaceuticals etc.) and where therefore no emissions from "solvent use" arise. However, there might be emissions from the use of the produced products, such as MTBE which is used as fuel additive and finally combusted, these emissions for example are considered in the transport sector.

Additionally the comparison of the top-down and the bottom-up approach helped to identify several quantitatively important applications like windscreens wiper fluids, antifreeze, moonlighting, hospitals, de-icing agents of aeroplanes, tourism, cement- respectively pulp industry, which were not considered in the top-down approach.

Figure 13: Overview of the methodology for solvent emissions



5.2.2 Top down Approach

The top-down approach is based on

1. import-export statistics
2. production statistics on solvents in Austria
3. a survey on non-solvent-applications in companies [IIÖ&FIEU, 2004]
4. a survey on the solvent content in products and preparations at producers and retailers [FIEU&IIÖ, 2002 b]

ad (1) and (2) Total quantity of solvents used in Austria were obtained from import-export statistics and production statistics provided by STATISTIK AUSTRIA.

Nearly a full top down investigation of substances of the import-export statistics from 1980 to 2002 was carried out (data in the years 1982, 1983, 1986 and 1987 were linearly interpolated).

A main problem was that the methodology of the import-export statistics changed over the years. In earlier years products and substances had been pooled to groups and whereas the current foreign trade balance is more detailed with regard to products and substances. It was necessary to harmonise the time series in case of deviations.

There are only a few facilities producing solvents in Austria. Therefore due to confidentiality the Statistic Austria provided the data in an aggregated form. The solvents production fluctuated especially in the last years considerably.

ad (3) In the study on the comparison of top down and bottom up approach [FIEU&IIÖ, 2002b] the amount of solvent substances used in "non-solvent-applications" was identified. The 20 most important companies in this context were identified and asked to report the quantities of solvents they used over the considered time period in „non-solvent-applications".

ad (4) Relevant producers and retailers provided data on solvent content in products and preparations. As the most important substance groups alcohols and esters were identified.

5.2.3 Bottom up Approach

In a first step an extensive survey on the use of solvents in the year 2000 was carried out in 1 300 Austrian companies [FIEU&IIÖ, 2002 a]. In this survey data about the solvent content of paints, cleaning agents etc. and on solvents used (both substances and substance categories) like acetone or alcohols were collected.

Information about the type of application of the solvents was gathered, divided into the three categories "final application", "cleaner" and "product preparation" as well as the actual type of waste gas treatment, which was divided into the categories "open application", "waste gas collection" and "waste gas treatment".

For every category of application and waste gas treatment an emission factor was estimated to calculate solvent emissions in the year 2000 (see Table 139).

Table 139: Emission factors for NMVOC emissions from Solvent Use

Category	Factor
final application	1.00
cleaner	0.85
product preparation	0.05
open application	1.00
waste gas collection	1.00
waste gas treatment	0.20

In a second step a survey in 1 800 households was made [FIEU&IIÖ, 2002 b] for estimating the domestic solvent use (37 categories in 5 main groups: cosmetic, do-it-yourself, household cleaning, car, fauna and flora). Also, solvent use in the context of moonlighting besides commercial work and do-it-yourself was calculated.

The comparison of top down and bottom up approach helped to identify several additional applications, that make an important contribution to the total amount of solvents used. Thus in a third step the quantities of solvents used in these applications such as windscreens wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism, cement- respectively pulp industry, were estimated in surveys.

The outcome of these three steps was the total quantities of solvents used for each application in the year 2000 (at SNAP level 3) [FIEU&IIÖ, 2002 b].

To archive a time series the development of the economic and technical situation in relation to the year 2000 was considered. It was distinguished between "general aspects" and "specific aspects" (see tables below). The information about these defined aspects were collected for three pillar years (1980, 1990, 1995) and were taken from several studies [SCHMIDT et al. 1998] [BARNERT 1998] and expert judgements from associations of industries (chemical industry, printing industry, paper industry) and other stakeholders. On the basis of this information calculation factors were estimated. With these factors and the data for solvent use and emission of 2000 data for the three pillar years was estimated. For the years in between data was linearly interpolated.

Table 140: General aspects and their development

General aspects	1980	1990	1995	2000
efficiency factor solvent cleaning	250 %	150 %	130 %	100 %
efficiency factor application	150 %	110 %	105 %	100 %
solvent content of water-based paints	15 %	12 %	10 %	8 %
solvent content of solvent-based paints	60 %	58 %	55 %	55 %
efficiency of waste gas purification	70 %	75 %	78 %	80 %

Table 141: Specific aspects and their development: distribution of the used paints (water based-paints - solvent-based paints) and part of waste gas purification (application - purification)

SNAP category	description	year	Distribution of used paints		Part of waste gas treatment	
			Solvent based paints	Water based paints	application	purification
060101	manufacture of automobiles	*2000*	73%	27%	10%	0%
		1995	80%	20%	8%	0%
		1990	90%	10%	5%	0%
		1980	100%	0%	0%	0%
060102	car repairing	*2000*	51%	49%	62%	1%
		1995	55%	45%	60%	0%
		1990	75%	25%	10%	0%
		1980	85%	15%	5%	0%
060107	wood coating	*2000*	46%	54%	46%	3%
		1995	60%	40%	45%	2%
		1990	85%	15%	10%	0%
		1980	100%	0%	0%	0%
060108	Other industrial paint application	*2000*	97%	3%	90%	46%
		1995	99%	1%	87%	45%
		1990	100%	0%	26%	20%
		1980	100%	0%	0%	0%
060201	Metal degreasing	*2000*	92%	8%	75%	0%

		1995	95%	5%	65%	0%
		1990	100%	0%	10%	0%
		1980	100%	0%	0%	0%
060403	Printing industry	*2000*			44%	17%
		1995			29%	10%
		1990			10%	5%
		1980			0%	0%
060405	Application of glues and adhesives	*2000*			58%	0%
		1995			53%	0%
		1990			15%	0%
		1980			0%	0%
060103	Paint application : construction and buildings	*2000*	91%	9%	19%	4%
		1995	93%	7%	15%	2%
		1990	100%	0%	5%	0%
		1980	100%	0%	0%	0%
060105	Paint application : coil coating	*2000*	100%	0%	63%	0%
		1995	100%	0%	60%	0%
		1990	100%	0%	25%	0%
		1980	100%	0%	0%	0%
060406	Preservation of wood	*2000*	83%	17%	0%	0%
		1995	85%	15%	0%	0%
		1990	95%	5%	0%	0%
		1980	100%	0%	0%	0%
060412	Other (preservation of seeds,…)	*2000*	100%	0%	90%	0%
		1995	100%	0%	80%	0%
		1990	100%	0%	10%	0%
		1980	100%	0%	0%	0%

Table 142: Specific aspects and their development: changes in the number of employees compared to the year 2000

SNAP97		Changes in the number of employees compared to the year 2000 [%]			
		1980	1990	1995	2000
0601	Paint application				
060101	manufacture of automobiles	88%	82%	72%	100%
060102	car repairing	94%	98%	96%	100%
060103	construction and buildings	96%	90%	102%	100%
060104	domestic use	separate analysed			
060105	coil coating	99%	113%	107%	100%
060107	wood coating	107%	109%	112%	100%
060108	industrial paint application	122%	112%	106%	100%
0602	Degreasing, dry cleaning and electronics				
060201	Metal degreasing	151%	113%	83%	100%

060202	Dry cleaning	63%	75%	88%	100%
060203	Electronic components manufacturing	143%	122%	104%	100%
060204	Other industrial cleaning	33%	77%	56%	100%
0603	Chemical products manufacturing and processing				
060305	Rubber processing	110%	101%	102%	100%
060306	Pharmaceutical products manufacturing	118%	112%	97%	100%
060307	Paints manufacturing	118%	112%	97%	100%
060308	Inks manufacturing	118%	112%	97%	100%
060309	Glues manufacturing	118%	112%	98%	100%
060310	Asphalt blowing	124%	120%	120%	100%
060311	Adhesive, magnetic tapes, films and photographs	33%	57%	76%	100%
060312	Textile finishing	241%	171%	132%	100%
060314	Other	117%	112%	98%	100%
0604	Other use of solvents and related activities				
060403	Printing industry	129%	125%	111%	100%
060404	Fat, edible and non edible oil extraction	129%	116%	112%	100%
060405	Application of glues and adhesives	239%	156%	104%	100%
060406	Preservation of wood	108%	105%	100%	100%
060407	Under seal treatment and conservation of vehicles	97%	102%	103%	100%
060408	Domestic solvent use (other than paint application	separate analysed			
060411	Domestic use of pharmaceutical products (k)				
060412	Other (preservation of seeds,…)	108%	105%	101%	100%

5.2.4 Combination Top down – Bottom up approach

To verify and adjust the data the solvents given in the top down approach and the results of the bottom up approach were differentiated by 15 defined categories of solvent groups (see below Table 143). The differences between the quantities of solvents from the top down approach and bottom up approach respectively are lower than 10%. Table 143 shows the range of the differences in the considered pillar years broken down to the 15 substance categories.

Table 143: Differences between the results of the bottom up and the top down approach

	Acetone	Methanol	Propanol	Solvent naphta	Paraffins	Alcohols	Glycols	Ester	Aromates	Ether	org. acids	Ketones	Aldehydes	Amines	cycl. Hydrocarb.	Others	Sum of differDifferences [kt/a]
2000																	-14
1995																	-2
1990																	14
1980																	-18

	Difference less than 2 kt/a
	Difference 2 -10 kt/a
	Difference greater than 10 kt/a

As the data of the top down approach were obtained from national statistics, they are assumed to be more reliable than the data of the bottom up approach. That's why the annual quantities of solvents used were taken from the top down approach while the share of the solvents for the different applications (on SNAP level 3) and the solvent emission factors have been calculated on the basis of the bottom up approach.

The following tables present activity data and implied emission factors (Table 144 and

Table 145).

Table 144: Activity data of Category 3 Solvent and other product use [Mg]

SNAP		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0601	**Paint application**													
060101	manufacture of automobiles	1.8	1.5	1.2	1.3	1.2	1.3	1.3	1.5	1.4	1.4	1.7	1.7	1.7
060102	car repairing	1.0	0.9	0.8	0.8	0.8	1.0	0.9	1.0	0.9	0.8	0.9	1.0	1.0
060103	construction and buildings	3.9	3.6	3.2	3.5	3.6	4.3	4.1	4.4	3.9	3.6	4.0	4.4	4.4
060104	domestic use	4.6	3.6	2.7	2.4	1.9	1.7	1.7	1.8	1.7	1.6	1.8	2.0	2.0

060105	coil coating	5.7	5.1	4.4	4.8	4.8	5.6	5.2	5.5	4.8	4.3	4.7	5.3	5.3
060107	wood coating	7.1	6.2	5.2	5.5	5.4	6.1	5.5	5.7	4.9	4.3	4.6	5.3	5.3
060108	Other industrial paint application	31.3	28.5	24.7	27.1	27.4	32.3	30.6	32.8	29.5	26.9	30.3	33.4	33.4
0602	**Degreasing, dry cleaning and electronics**													
060201	Metal degreasing	9.4	8.0	6.4	6.6	6.2	6.7	6.6	7.4	6.9	6.6	7.8	8.2	8.2
060202	Dry cleaning	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.5	0.5
060203	Electronic components manufacturing	2.5	2.2	1.7	1.8	1.7	1.8	1.7	1.8	1.6	1.5	1.6	1.8	1.8
060204	Other industrial cleaning	4.1	3.9	3.5	4.0	4.2	5.1	5.3	6.1	5.9	5.8	7.0	7.2	7.2
0603	**Chemical products manufacturing AND processing**													
060305	Rubber processing	1.0	0.9	0.7	0.8	0.7	0.8	0.8	0.8	0.7	0.6	0.6	0.7	0.7
060306	Pharmaceutical products manufacturing	8.4	7.0	5.5	5.5	5.0	5.2	5.6	6.7	6.7	6.8	8.4	8.4	8.4
060307	Paints manufacturing	60.0	55.0	50.0	45.0	40.0	35.0	34.5	33.9	33.4	32.8	32.2	34.9	34.9
060308	Inks manufacturing	7.2	6.9	6.7	6.4	6.2	6.0	5.8	5.6	5.5	5.3	5.1	5.6	5.6
060309	Glues manufacturing	4.2	4.2	4.1	4.1	4.1	4.0	4.1	4.2	4.3	4.4	4.5	4.9	4.9
060310	Asphalt blowing	1.3	1.2	1.0	1.0	1.0	1.1	1.0	1.0	0.8	0.7	0.7	0.8	0.8
060311	Adhesive, magnetic tapes, films and photographs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
060312	Textile finishing	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
060314	Other	41.5	40.7	39.8	39.0	38.1	37.3	37.6	37.9	38.2	38.5	38.8	42.0	42.0
0604	**Other use of solvents and related activities**													
060403	Printing industry	14.9	13.2	11.2	11.9	11.8	13.5	12.6	13.2	11.6	10.4	11.4	12.8	12.8
060404	Fat, edible and non edible oil extraction	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
060405	Application of glues and adhesives	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6
060406	Preservation of wood	0.7	0.6	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6
060407	Under seal treatment and conservation of vehicles	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
060408	Domestic solvent use (other than paint application)	14.0	13.5	12.3	14.1	14.9	18.2	18.3	20.6	19.6	18.9	22.4	23.4	23.4
060411	Domestic use of pharmaceutical products (k)	5.1	4.6	4.1	4.5	4.6	5.4	5.3	5.8	5.3	5.0	5.8	6.2	6.2
060412	Other (preservation of seeds,…)	7.6	6.8	5.8	6.3	6.3	7.3	7.0	7.6	6.9	6.4	7.3	8.0	8.0

Table 145: Implied NMVOC emission factors for Solvent Use 1990-2002 [in %]

SNAP		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0601	Paint application													
060101	manufacture of automobiles	94	88	82	76	70	64	63	62	60	59	57	56	56
060102	car repairing	98	97	97	97	96	96	95	93	92	91	89	88	88
060103	construction and buildings	92	90	89	87	86	84	85	86	86	87	88	89	89
060104	domestic use	88	89	89	89	89	89	89	89	89	89	89	89	89
060105	coil coating	84	79	74	69	63	58	57	56	55	54	53	52	52
060107	wood coating	94	89	85	80	76	71	71	70	69	68	67	66	66
060108	Other industrial paint application	78	70	62	54	46	37	36	35	33	32	30	29	29
0602	Degreasing, dry cleaning and electronics													
060201	Metal degreasing	93	86	78	71	63	56	54	51	49	47	45	43	43
060202	Dry cleaning	95	94	92	91	89	88	87	87	86	86	85	84	84
060203	Electronic components manufacturing	68	64	61	57	53	49	48	47	46	45	44	43	43
060204	Other industrial cleaning	72	72	71	71	70	70	69	69	69	68	68	68	68
0603	Chemical products manufacturing AND processing													
060305	Rubber processing	99	98	98	97	97	96	96	95	95	94	94	93	93
060306	Pharmaceutical products manufacturing	46	42	38	34	29	25	25	25	26	26	26	26	26
060307	Paints manufacturing	5	5	5	5	5	5	5	4	4	4	4	3	3
060308	Inks manufacturing	5	5	5	5	5	5	5	5	5	5	5	5	5
060309	Glues manufacturing	20	20	20	20	20	20	20	20	20	20	20	20	20
060310	Asphalt blowing	1	1	1	1	1	1	1	1	1	1	1	1	1
060311	Adhesive, magnetic tapes, films and photographs	100	100	67	100	100	75	75	100	100	100	80	100	100
060312	Textile finishing	89	88	89	89	89	88	89	89	87	89	89	89	89
060314	Other	22	22	21	21	20	20	19	18	18	17	16	15	15
0604	Other use of solvents and related activities													
060403	Printing industry	86	82	79	76	72	69	68	68	67	66	66	65	65
060404	Fat, edible and non edible oil extraction	19	19	19	20	20	20	20	20	20	20	20	20	20
060405	Application of glues and adhesives	86	83	79	76	72	69	68	67	66	65	64	63	63
060406	Preservation of wood	99	99	99	99	99	99	99	99	99	99	99	99	99
060407	Under seal treatment and conservation of vehicles	85	85	85	85	85	85	85	85	85	85	85	85	85

060408	Domestic solvent use (other than paint application)	84	84	84	84	84	84	84	84	84	84	84	84	84
060411	Domestic use of pharmaceutical products (k)	94	94	94	94	94	94	94	94	94	94	94	94	94
060412	Other (preservation of seeds,…)	92	82	72	62	53	43	41	40	38	36	35	33	33

5.2.5 Calculation of CO_2 emissions from Solvent Emissions

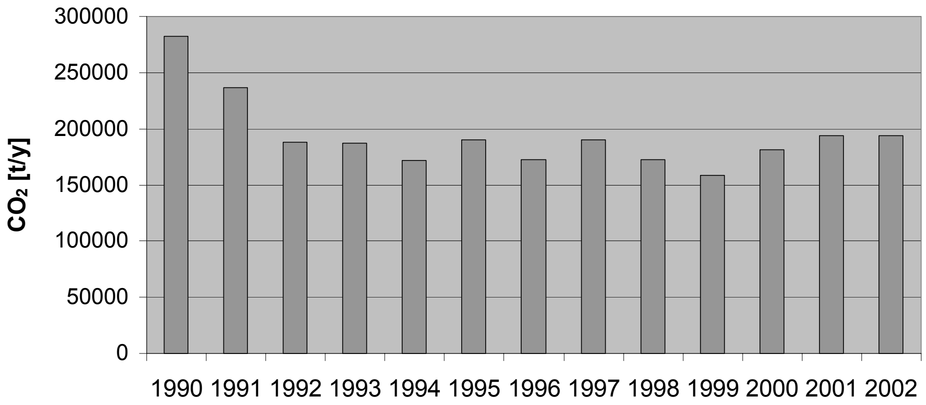
The basis for the calculation of the carbon dioxide emissions were the quantities of solvent emissions differentiated by the 15 groups of substances (acetone, methanol, propanol, solvent naphtha, paraffins, alcohols, glycols, ester, aromates, ketones, aldehydes, amines, organic acids, cyclic hydrocarbons, and others). Substance specific carbon dioxide factors for these 15 substance groups have been created (see Table 146) on the basis of the carbon content and the stoichiometrically formed CO_2.

Table 146: Substance specific carbon dioxide emission factors

Substances	CO_2 factor [kg CO_2/kg substance]
Acetone	2.28
Aldehydes	2.44
Alcohols	1.91
Alcohols / Propanols	2.20
Aromates	3.33
Cydic Hydrocarbons	3.14
Ester	2.16
Ether	2.38
Glycols	1.82
Ketones	2.45
Methanol	1.38
Paraffins	3.14
Residuals	0.92
Solvent naphta	3.14

The amount of carbon dioxide emissions was disaggregated to SNAP level 3 according to the share of solvents used and solvent emissions respectively, that were calculated in the context of the bottom up approach.

Figure 14: Carbon dioxide emission of Category 3 Solvent and Other Product Use 1990-2002 [t/a]



5.2.6 Uncertainty Assessment

The comparison of the results of the top-down approach (import-export statistics, substances and products, production statistics, non solvent application) and these of the bottom-up approach showed a gap of less than 10 % (difference between 2 and 14 kt/a) [IIÖ&FIEU, 2004].

Table 147 presents the uncertainties of data sources of the top down approach.

The top-down approach was mainly based on the import-export statistics. The uncertainty of the statistical data was assumed to be negligible compared to the other uncertainties. The method of the import-export statistics between 1980 and 2001 varied and to harmonise the time series it was necessary to adjust data. The current import-export statistics are more detailed in regard of the products and substances. Hence the uncertainty is assumed to be in the order of 0.5 and 10% whereas it is higher in 1990 than in 2000.

An other important data source on top-down level was the survey on "non-solvent-application" in the 20 most relevant companies. The companies reported data in different quality: partly they reported data for all years partly just for the pillar years. Generally due to increasing electronic data storage the data quality is in the last years better than in earlier years. Altogether it was assumed that the uncertainty is between 1.5% and 5%. As for the statistical data, the uncertainty is higher in 1990 than in 2000.

Table 147: Uncertainties of Top down approach

Uncertainty in Activities	Data source	1990 [%]	1995 [%]	2000 [%]	Uncertainty source
Substances	National statistics STAT.A, foreign trade balance	+2,5 to -2,5%	+1,5 to -1,5%	+0,5 to -0,5%	Expert judgement [IIÖ&FIEU, 2004]
Products	National statistics STAT.A, foreign trade balance	+10 to -10%	+5 to -5 %	+2,5 to -2,5%	Expert judgement [IIÖ&FIEU, 2004]
Solvent Production	National production statistics STAT.A,	0	0	0	Assumed to be negligible (see above)
Non solvent applications	Surveys in relevant companies	+5 to -5 %	+2,5 to -2,5%	+1,5 to -1,5%	Expert judgement [IIÖ&FIEU, 2004]

Table 148 presents the uncertainties of the emission factors that were obtained by expert judgement. A sensitivity analysis [FIEU&IIÖ, 2002a] showed a variation of 5% of the emission factors of solvent application in the year 2000.

Table 148: Uncertainties of Bottom- up approach

Uncertainty emissions factors	1990 [%]	1995 [%]	2000 [%]	Data and uncertainty source
Emissions factor	86%	63%	58%	[IIÖ&FIEU, 2004]
Uncertainty – emissions factor	+10 to –10%	+7 to –7%	+5 to 5%	Expert judgement [IIÖ&FIEU, 2004]

For calculation of the overall uncertainties of Sector 6 the upper and lower limit of activity data and emission factors was taken into account. Table 149.

Table 149: Uncertainties of Sector 6 Solvent and other product use

	1990 [%]	1995 [%]	2000 [%]	Data source
Uncertainty solvent emissions	-21 to +24%	-18 to +21%	-13 to +14%	[IIÖ&FIEU, 2004]

5.3 N_2O Emissions from Solvent and Other Product Use

Anaesthesia

100% of N_2O used for anaesthesia is released into atmosphere, therefore the emission factor is 1.00 Mg N_2O / Mg product use.

It is assumed that the use of N_2O for anaesthesia is constant at 350 tons per year. This estimation is based upon expert judgement and industry inquiries.

Fire Extinguishers

N_2O emissions from this category are not estimated. It is assumed that emissions from this source are very low in Austria since N_2O driven fire extinguishers are not used widely, the uncertainty of emission estimates would be very high and emissions are not expected to vary widely over time.

Aerosol Cans

100% of N_2O used for aerosol cans is released into atmosphere, that's why the emission factor used is 1.00. It is assumed that the use of N_2O for aerosol cans is constant at 400 tons per year. This estimate is based on expert judgement and industry inquiries.

6 AGRICULTURE (CRF SOURCE CATEGORY 4)

6.1 Sector Overview

This chapter gives information about the estimation of greenhouse gas emissions from sector *Agriculture* in correspondence to the data reported under the IPCC Category 4 in the Common Reporting Format.

The following sources exist in Austria: domestic livestock activities with enteric fermentation and manure management, agricultural soils and agricultural residue burning.

Applied methods are in line with the 1996 Revised IPCC Guidelines and are based on following studies commissioned by the Umweltbundesamt:

- *Gebetsroither E., Strebl F., Orthofer R., (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; ARC Seibersdorf research, July 2002*
- *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*
- *Strebl F., Gebetsroither E., Orthofer R., (2002): Greenhouse Gas Emissions from Agricultural Soils in Austria; ARC Seibersdorf research, revised version, Nov. 2002*

These studies are not published. A detailed description of the applied methods is given in this report.

To give an overview of Austria's agricultural sector some information is provided below (according to the 1999 Farm Structure Survey – full survey) [BMLFUW, 2003]:

Agriculture in Austria is small- structured: about 217 500 farms are managed, 41% of these farms manage less than 10 ha cultivated area. More than 85 000 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 3.4 million hectares that is a share of ~ 41% of the total territory (forestry ~46%, other area ~13%). The shares of the different agricultural activities are as follows:

41% arable land

27% 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)

6.1.1 Emission Trends

In the year 2003 the sector *Agriculture* contributed 8.0% to the total of Austria's greenhouse gas emissions (not considering CO_2 emissions from LUCF) in 2003. The trend of GHG emissions from 1990 to 2003 shows a decrease of 13.1% for this sector (see Figure 15 and Table 151) due to a decrease in activity data.

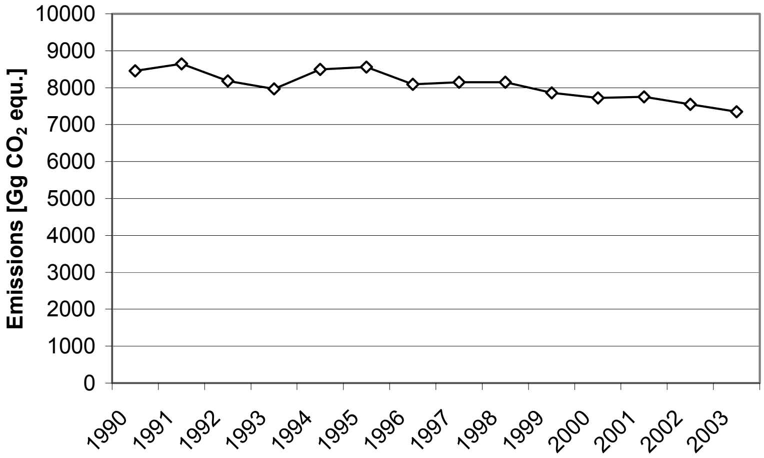


Figure 15: Trend of total GHG emissions from Agriculture

The fluctuations in the time series shown in Figure 15 are mainly due to fluctuations of N_2O emissions from agricultural soils.

Emission trends per gas

CH_4 emissions from IPCC Category *4 Agriculture* decreased by 13.3% since the base year mainly due to lower emissions from *Enteric Fermentation*. N_2O emissions decreased by 12.8% mainly due to lower emissions from *Agricultural Soils (direct and indirect emissions)*. The trend is presented in Table 150.

Table 150: Emissions of greenhouse gases and their trend from 1990-2003 from Category 4 Agriculture

Year	GHG emissions [Gg]	
	CH_4	N_2O
1990	219.15	12.43
1991	216.17	13.24
1992	208.14	12.31
1993	208.72	11.57
1994	210.63	13.13
1995	211.77	13.26
1996	208.45	11.97
1997	206.11	12.31
1998	205.52	12.36
1999	201.19	11.73
2000	197.73	11.52
2001	195.49	11.77

2002	191.25	11.41
2003	189.97	10.84
Trend 90-03	*-13.3%*	*-12.8%*

Emission trends per sector

Table 151 presents total GHG emissions and trend 1990-2003 from *Agriculture* by subcategories as well as the contribution to the overall inventory emissions. Important sub-sectors are *4 A Enteric Fermentation* (3.4%) and *4 D Agricultural Soils* (2.9%) followed by *4 B Manure Management* (1.7%).

Table 151: Total GHG emissions and trend 1990 - 2003 by subcategories of Agriculture

Year	GHG emissions [Gg CO_2 equivalent] by sub categories				
	4	4 A	4 B	4 D	4 F
1990	**8 456.23**	3 573.19	1 806.95	3 074.35	1.74
1991	**8 643.69**	3 524.91	1 783.58	3 333.47	1.72
1992	**8 187.31**	3 371.19	1 740.48	3 073.98	1.65
1993	**7 970.20**	3 371.82	1 754.88	2 841.88	1.63
1994	**8 492.49**	3 417.53	1 759.58	3 313.68	1.69
1995	**8 557.75**	3 444.32	1 765.90	3 345.83	1.71
1996	**8 089.34**	3 393.64	1 733.52	2 960.50	1.68
1997	**8 144.83**	3 344.21	1 727.01	3 071.84	1.77
1998	**8 146.26**	3 321.15	1 735.73	3 087.67	1.72
1999	**7 860.19**	3 281.83	1 670.28	2 906.32	1.76
2000	**7 724.46**	3 237.23	1 630.11	2 855.47	1.65
2001	**7 753.92**	3 183.17	1 632.05	2 936.96	1.74
2002	**7 552.64**	3 123.50	1 588.43	2 838.97	1.74
2003	**7 349.06**	3 093.65	1 589.00	2 664.80	1.61
Share in Austrian Total 2003	***8.0%***	*3.4%*	*1.7%*	*2.9%*	*0.0%*
Trend 1990-2003	***-13.1%***	*-13.4%*	*-12.1%*	*-13.3%*	*-7.5%*

As can be seen in Figure 16 and Table 151 the trend concerning emissions from all categories is decreasing. The reason for the nearly linear decrease of emissions from categories *4 A Enteric Fermentation* and *4 B Manure Management* is due to a decrease in livestock numbers (cattle and swine). Fluctuations of emissions from *4 D Agricultural Soils* are mainly due to varying underlying activity data (sales figures of mineral fertilizers).

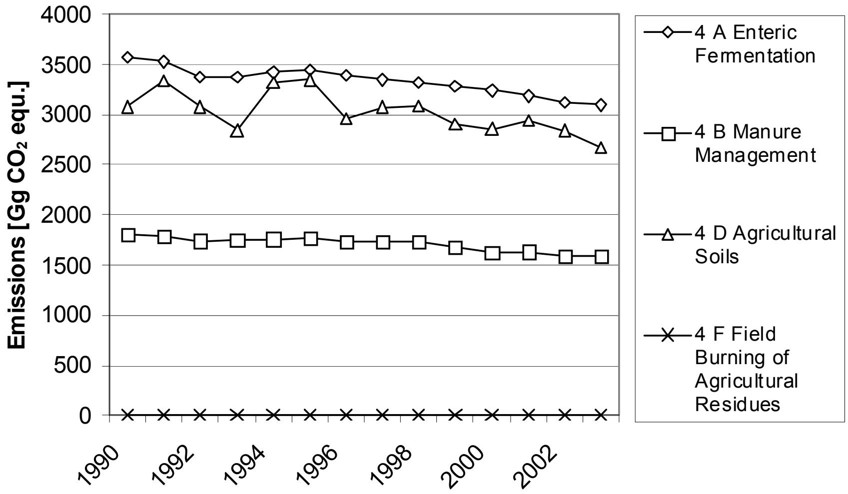


Figure 16: Emission trends of sub- sectors of Agriculture

As can be seen in Table 152, within the agricultural sector the subcategories *4 A* and *4 D* both contribute around 40% to total emissions, category *4 B* contributes another 20%. Sub category *2 F Field Burning of Agricultural Wastes* contributes only a negligible part (0.02% in 2003).

Table 152: Total greenhouse gas emissions and share of subcategories of Agriculture, 1990 and 2003

Year	GHG emissions [%] by sub categories				
	4	4 A	4 B	4 D	4 F
1990	100.0%	42.3%	21.4%	36.4%	0.0%
2003	100.0%	42.1%	21.6%	36.3%	0.0%

6.1.2 Key Sources

The key source analysis is presented in Chapter 1.5. This chapter includes information about the key sources in the IPCC Sector *4 Agriculture*. Key sources within this category are presented in Table 153.

Table 153: Key sources of Category 4 Agriculture

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment*
4 A 1	Cattle	CH_4	all
4 B 1	Cattle	N_2O	all LA
4 B 1	Cattle	CH_4	all LA, TA 96,97,00,01
4 B 8	Swine	CH_4	all LA
4 D 1	Direct Soil Emissions	N_2O	all except TA98
4 D 3	Indirect Emissions	N_2O	all

** LA 90 = Level Assessment 1990*
LA 90 - 01 = Level Assessments for all years between 1990 and 2001
TA 00 = Trend Assessment BY-2000

6.1.3 Methodology

For the sub sectors *4 A Enteric Fermentation, 4 B Manure Management* and *4 D Agricultural Soils* IPCC Tier 1 methods and IPCC default emission factors were used, except for key sources of these sub sectors (sub categories *Cattle* of *4 A* as well as *Cattle* and *Swine* of *4 B*) where the more detailed Tier 2 method and country specific emission factors were used.

For the calculation of emissions from category *4 A 9 Poultry* the IPCC Tier 2 method with Swiss emission factors (Gross Energy Intake, Methane Conversion Rate) was used. It is assumed that Swiss conditions are very similar to Austrian conditions.

As recommended in the Centralized Review 2003 for the estimation of emissions from category *4 F Field Burning of Agricultural Wastes* the IPCC methodology using default values was applied.

6.1.4 Quality Assurance and Quality Control (QA/QC)

Data were checked for transcription errors between input data and calculation sheets. Calculations were examined focusing on units/scale and formulas. Quality Control following the GPG is described in the chapters of the sub sectors. A description of the QMS (Quality Management System) is presented in chapter 1.6.

6.1.5 Uncertainty Assessment

Table 154 presents uncertainties for emissions as well as for activity data and the EFs applied as estimated or as provided by the IPCC GPG (for the cases where default values were used for estimating emissions).

Compared to high uncertainties of emission factors, the uncertainty of the underlying statistical activity data is relatively low reducing the uncertainty of the calculated emissions.

Table 154: Uncertainties of Emissions and Emission Factors (Agriculture)

Categories		CH_4 Emissions	N_2O Emissions	EF CH_4	EF N_2O
4A1a, 4A1b	Cattle	+/- 8%[3]	--	+/- 20%[1]	--
4A3/ 4A4	Sheep, Goats	+/- 62%[3]	--	+/- 30%[2]	--
4A6	Horses	+/- 10%[3]	--	+/- 30%[2]	--
4A8	Swine	+/- 42%[3]	--	+/- 30%[2]	--
4A9	Poultry	--	--	--	--
4B1a	Dairy Cattle			+/- 65%[1]	- 50% to + 100%[2]
4B1b	Non-dairy Cattle			+/- 75%[1]	- 50% to + 100%[2]

Categories		CH_4 Emissions	N_2O Emissions	EF CH_4	EF N_2O
4B8	Swine	+/- 90%.		+/- 70%[1]	- 50% to + 100%[2]
4B 3/ 4/ 6/ 9	Sheep, Goats, Horses, Poultry	+/- 90%[1]		+/- 20%[2]	- 50% to + 100%[2]
4D	Agricultural Soils	--	+/- 24 %	--	(see Table 196)
4F	Field Burning	--	--	--	--
Activity Data					
	animal population	+/- 10%[4]			
	agricultural used land	+/- 5%[4]			

(1) Expert judgement by Dr. Barbara Amon, University of Agriculture Vienna (see also below under "Recalculation")

(2) IPCC

(3) Calculation by expert (Monte Carlo Analysis), DI Gebetsroither (see also below under "Recalculation")

(4) [WINIWARTER & RYPDAL, 2001]

6.1.6 Recalculations

Update of activity data:

Animal Category *Other*:

In Austria animals of category *Other* which mainly is deer (but not wild living animals) have been counted from 1993 on. As recommended in the centralized review, the animal number of 1993 was used for the years 1990 to 1992.

Animal Category *Soliped*:

In the last submissions the number of soliped of the years 2000 to 2002 was based on expert judgement. For transparency reasons in this inventory the 1999 value was held constant until 2002. In the current inventory a new 2003 value of animal category *Soliped* is available.

Improvements of methodologies and emission factors:

Synthetic fertilizer use:

The S&A report 2004 noticed high inter-annual variations in N_2O emissions of sector 4 D synthetic fertilizer use. These variations are caused by effects of storage as well as the difference between the calendar year and the agricultural economic year: the amounts of synthetic fertilizers over the years reflect the amounts sold in one calendar year. However, the economic year for the farmer does not corresponded to the calendar year. Not the whole amount purchased is applied in the year of purchase. Considering these effects, in this submission the arithmetic average of each two years was used as fertilizer application data.

4 A 9 (Poultry), 4 A 10 (Other):

For the first time CH_4 emissions from *Poultry* and *Other (deer)* have been estimated.

4 B, 4 D (Non-dairy cattle):

The S&A report 2004 noticed high inter-annual variations in the CH_4 and N_2O IEF values between 1992/1993 and 1993/1994. An error regarding activity data of non-dairy cattle for the year 1993 was identified and corrected in this submission.

4 A, 4 B In the last submissions, the GE, N_{ex} and VS_{ex} values from 2000 to 2002 were extrapolated on the basis of the published GE, N_{ex} and VS_{ex} data with a corresponding milk yield of 5 000 kg. In this year's calculations also the corresponding values of a milk yield of 6 000 kg published in [GRUBER & STEINWIDDER, 1996] were considered. The values were calculated via interpolation.

4 D 3 Atmospheric nitrogen deposition:

Following a recommendation of the centralized review (October 2004), in contrast to the last submission also N volatised in housing, storage and pasture was taken into account. Now, in accordance with the IPCC good practice, the value $Frac_{GASM}$ relates to N excreted by livestock and not to Nex $_{\text{left for spreading}}$.

4 F 1 a Field burning (Cereals / Wheat):

As recommended in the Centralized Review 2003 the IPCC methodology using default values was applied.

CRF-Tables, background data:

According to the Centralized Review 2003 emissions from different animal waste management systems (AWMS) are reported under the appropriate AWMS in the CRF.

As recommended in the S&A report 2004 in table 4.B (b) notation keys instead of "0" have been used.

6.1.7 Completeness

Table 155 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 subcategory have been estimated.

Table 155: Overview of subcategories of Category Agriculture: transformation into SNAP Codes and status of estimation

IPCC Category		SNAP		CH_4	N_2O
4 A	**ENTERIC FERMENTATION**	**1004**	**ENTERIC FERMENTATION**	✓	**NA**
4 A 1	Cattle	--	--	✓	NA
4 A 1 a	Dairy Cattle	100401	Dairy cows	✓	NA
4 A 1 b	Non- Dairy Cattle	100402	Other cattle	✓	NA
4 A 2	Buffalo	100414	Buffalos	NO	NO
4 A 3	Sheep	100403	Ovines	✓	NA
4 A 4	Goats	100407	Goats	✓	NA
4 A 5	Camels and Lamas	100413	Camels	NO	NO
4 A 6	Horses	100405	Horses	✓	NA
4 A 7	Mules and Asses	100406	Mules and asses	IE(1)	NA

IPCC Category		SNAP		CH_4	N_2O
4 A 8	Swine	100404	Fattening pigs	✓	NA
4 A 9	Poultry	100408 /09/10	Laying hens, broilers, other poultry	✓	NA
4 A 10	Other	100415	Other	✓	NA
4 B	**MANURE MANAGEMENT**	**1005** **1009**	**MANURE MANAGEMENT REGARDING ORGANIC COMPOUNDS** **MANURE MANAGEMENT REGARDING NITROGEN COMPOUNDS**	✓ **NO**	NO ✓
4 B 1	Cattle	--	--	✓	✓
4 B 1 a	Dairy Cattle	100501	Dairy cows	✓	✓
4 B 1 b	Non-Dairy Cattle	100502	Other cattle	✓	✓
4 B 2	Buffalo	100514	Buffalos	NO	NO
4 B 3	Sheep	100505	Ovines	✓	✓
4 B 4	Goats	100511	Goats	✓	✓
4 B 5	Camels and Lamas	100513	Camels	NO	NO
4 B 6	Horses	100506	Horses	✓	✓
4 B 7	Mules and Asses	100506	Mules and asses	IE(2)	IE(2)
4 B 8	Swine	100503	Fattening pigs	✓	✓
4 B 9	Poultry	100507 /08/09	Laying hens, broilers, Other poultry (ducks, gooses,…)	✓	✓
4 B 10	Anaerobic		Anaerobic	NO	NO
4 B 11	Liquid Systems		Liquid Systems	NO	✓
4 B 12	Solid Storage and Dry Lot		Solid Storage and Dry Lot	NO	✓
4 B 13	Other		Other management / manure without bedding	NO	✓
4 B 13	Other	100515	Other animals (deer)	✓	✓
4 C	**RICE CULTIVATION**	100103 100103	Rice Field (with fertilizers) Rice Field (without fertilizers)	**NO**	**NO**
4 D	**AGRICULTURAL SOILS**	**1001** **1002**	**CULTURES WITH FERTILIZERS** **CULTURES WITHOUT FERTILIZERS**	**NO**	✓
4 D 1	Direct Soil Emissions	1001 / 1002	Cultures with and without fertilizers	NO	✓
4 D 2	Animal Production	1002	Cultures without fertilizers	NO	✓
4 D 3	Indirect Emissions	1001 / 1002	Cultures with and without fertilizers	NO	✓
4 D 4	Other (Sewage Sludge)	1001	Cultures with fertilizers	✓	✓
4 E	**PRESCRIBED BURNING OF SAVANNAS**	**--**	**--**	**NO**	**NO**
4 F	**FIELD BURNING OF AGRICULTURAL WASTE**	**1003**	**ON- FIELD BURNING OF STUBBLE, STRAW, …**	✓	✓
4 F 1	Cereals	100301	Cereals	✓	✓
4 F 2	Pulse	100302	Pulse	NO	NO

IPCC Category		SNAP		CH_4	N_2O
4 F 3	Tuber and Root	100303	Tuber and Root	NO	NO
4 F 4	Sugar Cane	100304	Sugar Cane	NO	NO
4 F 5	Other: Vine	100305 [0907]	Other: Open burning of agricultural wastes (except 1003)	✓	✓

(1) included in 4 A 6 Horses*, SNAP 100406*

(2) included in 4 B 6 Horses*, SNAP 100506*

6.1.8 Planned Improvements

Planned Improvements are presented in the respective subcategories of this chapter.

6.2 Enteric Fermentation (CRF Source Category 4 A)

This chapter describes the estimation of CH_4 emissions from *Enteric Fermentation*. In 2003 78% of agricultural CH_4 emissions arose from this source category.

6.2.1 Source Category Description

CH_4 emissions amounted to 170.2 Gg in the "Kyoto" base year and have decreased by 13.4% to 147.3 Gg in 2003. Almost all emissions (93.3% in 2003) are caused by cattle farming. The contribution of *Dairy Cattle* to total emissions from cattle decreased from 47.1% in 1990 to 40.0% in 2003.

Table 156: Greenhouse gas emissions from Enteric Fermentation by sub categories 1990-2003

Year	CH4 emissions [Gg] Livestock Category								
	4 A	4 A 1 a	4 A 1 b	4 A 3	4 A 4	4 A 6	4 A 8	4 A 9	4 A 10
	Total	Dairy	Non Diary	Sheep	Goats	Horses	Swine	Poultry	Other
1990	170.15	80.16	80.43	2.48	0.19	0.89	5.53	0.18	0.30
1991	167.85	77.94	80.12	2.61	0.20	1.04	5.46	0.19	0.30
1992	160.53	75.19	75.49	2.50	0.20	1.11	5.58	0.18	0.30
1993	160.56	74.27	76.00	2.67	0.24	1.17	5.73	0.19	0.30
1994	162.74	75.62	76.85	2.74	0.25	1.20	5.59	0.18	0.30
1995	164.02	68.55	84.90	2.92	0.27	1.30	5.56	0.18	0.32
1996	161.60	68.32	82.65	3.05	0.27	1.32	5.50	0.17	0.33
1997	159.25	71.22	77.17	3.07	0.29	1.34	5.52	0.19	0.45
1998	158.15	72.71	74.62	2.89	0.27	1.36	5.72	0.18	0.40
1999	156.28	70.28	75.77	2.82	0.29	1.47	5.15	0.19	0.31
2000	154.15	63.28	80.93	2.71	0.28	1.47	5.02	0.15	0.31
2001	151.58	61.65	79.97	2.56	0.30	1.47	5.16	0.16	0.31
2002	148.74	61.43	77.69	2.43	0.29	1.47	4.96	0.16	0.31
2003	147.32	58.85	78.65	2.60	0.27	1.57	4.87	0.17	0.33
Share 2003	*100%*	*40.0%*	*53.4%*	*1.8%*	*0.2%*	*1.1%*	*3.3%*	*0.1%*	*0.2%*
Trend 1990-2003	*-13.4%*	*-26.6%*	*-2.2%*	*5.0%*	*46.2%*	*77.0%*	*-12.0%*	*-5.7%*	*11.0%*

The overall reduction is caused mainly 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 gross energy intake and milk yield of milk cattle since 1990). CH_4 emissions from the subcategory *Cattle* are a key source.

6.2.2 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 "Tier 2" method is based on the "Tier 1" method, but it uses specific emission factors for different livestock sub-categories.

The IPCC Guidelines don't provide methodologies for the categories *Poultry* and *Other*.

In Austria, the animal category *Other* corresponds to deer. For the estimation of CH_4 emissions from category *4 A 10* the IPCC default emission factor of sheep was used, as sheep is the most similar livestock category to deer.

For the calculation of emissions from category *4 A 9 Poultry* the IPCC Tier 2 method with Swiss emission factors (Gross Energy Intake, Methane Conversion Rate) was used. It is assumed that Swiss conditions are very similar to Austrian conditions.

Activity data

The Austrian official statistics [STATISTIK AUSTRIA, 2003] provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year[30].

The activity data used is presented in the following table. The inherent uncertainty is estimated to be about 5% [FREIBAUER & KALTSCHMITT, 2001].

Table 157: Domestic livestock population and its trend 1990-2003 (I)

Year	Population size [heads] * Livestock Category							
	Dairy	Non Dairy	Mother Cows (suckling cows >2yr)	Young Cattle <1yr	Young Cattle 1-2yr	Cattle > 2yr	Sheep	Goats
1990	904 617	1 679 297	47 020	925 162	560 803	146 312	309 912	37 343
1991	876 000	1 658 088	57 333	894 111	555 432	151 212	326 100	40 923
1992	841 716	1 559 009	60 481	831 612	521 078	145 838	312 000	39 400
1993	828 147	1 420 872	61 845	668 926	544 994	145 107	333 835	47 276
1994	809 977	1 518 541	89 999	706 579	573 177	148 786	342 144	49 749
1995	706 494	1 619 331	210 479	691 454	564 352	153 046	365 250	54 228
1996	697 521	1 574 428	212 700	670 423	537 382	153 923	380 861	54 471
1997	720 377	1 477 563	170 540	630 853	514 480	161 690	383 655	58 340
1998	728 718	1 442 963	154 276	635 113	496 159	157 415	360 812	54 244
1999	697 903	1 454 908	176 680	630 586	488 283	159 359	352 277	57 993
2000	621 002	1 534 445	252 792	655 368	466 484	159 801	339 238	56 105
2001	597 981	1 520 473	257 734	658 930	455 712	148 097	320 467	59 452
2002	588 971	1 477 971	244 954	640 060	449 932	143 025	304 364	57 842
2003	557 877	1 494 156	243 103	641 640	446 121	163 292	325 495	54 607
Trend	*-38.3%*	*-11.0%*	*417.0%*	*-30.6%*	*-20.4%*	*11.6%*	*5.0%*	*46.2%*

30 For cattle livestock counts are also held in June, but seasonal changes are very small (for the years 1998 to 2003 the difference was 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).

The strong 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.

Table 158: Domestic livestock population and its trend 1990-2003 (II)

Year	Population size [heads] * Livestock Category								
	Horses	Swine	Fattening Pig >50kg	Swine for breeding >50kg	Young Swine <50kg	Poultry	Chicken	Other Poultry	Other
1990	49 200	3 687 981	1 308 525*	382 335*	1 997 120*	13 820 961	13 139 151	681 810	37 100
1991	57 803	3 637 980	1 290 785*	377 152*	1 970 044*	14 397 143	13 478 820	918 323	37 100
1992	61 400	3 719 600	1 319 744*	385 613*	2 014 243*	13 683 900	12 872 100	811 800	37 100
1993	64 924	3 819 798	1 355 295	396 001	2 068 502	14 508 473	13 588 850	919 623	37 100
1994	66 748	3 728 991	1 323 145	394 938	2 010 908	14 178 834	13 265 572	913 262	37 736
1995	72 491	3 706 185	1 312 334	401 490	1 992 361	13 959 316	13 157 078	802 238	40 323
1996	73 234	3 663 747	1 262 391	398 633	2 002 723	12 979 954	12 215 194	764 760	41 526
1997	74 170	3 679 876	1 268 856	397 742	2 013 278	14 760 355	13 949 648	810 707	56 244
1998	75 347	3 810 310	1 375 037	386 281	2 048 992	14 306 846	13 539 693	767 153	50 365
1999	81 566	3 433 029	1 250 775	343 812	1 838 442	14 498 170	13 797 829	700 341	39 086
2000	81 566	3 347 931	1 211 988	334 278	1 801 665	11 786 670	11 077 343	709 327	38 475
2001	81 566	3 440 405	1 264 253	350 197	1 825 955	12 571 528	11 905 111	666 417	38 475
2002	81 566	3 304 650	1 187 908	341 042	1 775 700	12 571 528	11 905 111	666 417	38 475
2003	87 072	3 244 866	1 243 807	334 329	1 666 730	13 027145	12 354 358	672 787	41 190
Trend	77.0%	-12.0%	-4.9%	-12.6%	-16.5%	-5.7%	-6.0%	-1.3%	11.0%

**…..adjusted age class split for swine as recommended in the centralized review (October 2003)*

The statistical data as presented above generally provides consistent time series. However, there have been minor inconsistencies for the categories cattle, poultry, horses and other. The explanations for these inconsistencies are presented below:

1991: A minimum counting threshold for poultry was introduced. Farms with less than 11 poultry were not counted any more. The marked increase of the soliped population between 1990 and 1991 is caused by a better data collection from riding clubs and horse breeding farms [STAT. ZENTRALAMT, 1991].

1993: New characteristics for swine and cattle categories were introduced in accordance with Austria's entry into the European Economic Area (EEA) and the EU guidelines for farm animal population categories. This is the reason why the 1993 data are not fully comparable with the previous data. For example, in 1993 part of the "*Young cattle < 1 yr*" category was included in the "*Young cattle 1-2 yr*". The same cause is the main reason of the shift from "Young swine < 50 kg" to "Fattening pigs > 50 kg" (before 1993 the limits were 6 months and not 50 kg which led to the shift).

Following the recommendations of the centralized review (October 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 there was a collection of wild animals in e.g. deer parks.

The increase of the "*mother and suckling cows"* population and a concurrent decrease of the "*dairy cattle*" population in 1993 and again in 1995 and 2000 is a result of the increased financial support for "*mother and suckling cows"* [STAT. ZENTRALAMT, 1993 and 1995].

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. It was decided to use the STATISTIK AUSTRIA data, because they are the best available.

Information about the extent of organic farming in Austria was provided in the Austrian INVEKOS[31] 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. However, INVEKOS data were available only for the years 1997 to 2000, and these data referred only to aggregated livestock categories. Furthermore, the INVEKOS data are not fully compatible with the STATISTIK AUSTRIA data because they rely on different data reporting periods.

The data gaps in the INVEKOS data sets (insufficiently detailed animal categories, lack of data for 1990-1996) were filled through expert judgments and trend extrapolations using surrogate data (e.g. the development of organic farming).

For all major animal categories the average share of organic farming in the 1997-2000 period was calculated from the INVEKOS data. This average share was then allocated to all animal sub-categories, assuming a default ratio between all sub-categories (e.g. assuming that the cattle in organic and conventional farming have the same ratios of dairy cattle, mother cows, calves etc.). Table 159 shows the results of the shares of organic farming in the relevant livestock categories for 1997-2000.

For the years 1990-1996, a trend extrapolation using surrogate data was made, namely the number of farms that apply organic farming practices [BMLFUW, 2002]. 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 after 2000 the data for 2000 was used.

Table 159: Share of animal population under organic farming systems (average 1997-2000, calculations by ARCS, based on INVEKOS data)

IPCC Category	% organic	IPCC Category	% organic
CATTLE	15%	SHEEPS	26%
MATURE DAIRY CATTLE		GOATS	29%
Dairy Cattle > 2 yr	15%	POULTRY	
MATURE NON DAIRY		Chicken	3%

31 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.

CATTLE		Other Poultry	2%
Mother Cows > 2 yr	25%		
Cattle > 2 yr	20%	SOLIPEDS	
YOUNG CATTLE		Horses	Not estimated
Young Cattle < 1 yr	13%	Other Solipeds	Not estimated
Young Cattle 1-2 yr	12%	OTHER ANIMALS	Not estimated
SWINE	1%		
MATURE SWINE			
Fattening pig > 50 kg	1%		
Swine for breeding > 50 kg	1%		
YOUNG SWINE			
Young Swine < 50 kg	2%		

6.2.2.1 Cattle (4 A 1)

Key Source: Yes

CH_4 emissions from *Enteric Fermentation - Cattle* (sum of dairy and non-dairy cattle) is 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 2003, emissions from *Enteric Fermentation - Cattle* contributed 3.15% 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 157 and Table 158.

Emission Factors

Country specific emission factors were used. They were calculated from the specific *gross energy intake* and the *methane conversion rate* (GPG, Equation 4.14).

$$EF = (GE * Y_m * 365 \text{ days/yr}) / 55.65 \text{ MJ/kg}$$

Y_m Methane conversion rate

The methane conversion rate (Y_m) was taken from the IPCC recommended value for "*all other cattle*" (0.06 +/- 8.3%) 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 (4 A 1 a)

The use of country specific values for the Gross Energy Intake results in a more precise estimation of CH_4 emissions from enteric fermentation than applying the IPCC default values.

The Gross Energy Intake for dairy cows was taken from a study by the animal nutrition experts [GRUBER & STEINWIDDER, 1996] who carried out intensive model calculations on nitrogen and phosphorus excretion of livestock. They modeled dairy cow diets typically fed in Austria, taking into account milk yields from 3 000 to 8 000 kg per cow and year and calculated the corresponding Gross Energy Intake (see Table 160).

Table 160: Energy intake for diary cattle in Austria in dependency of annual milk yield (after GRUBER & STEINWIDDER 1996)

Milk yield	3 500	4 000	4 500	5 000	5 500	6 000
Gross energy intake [MJ GE day^{-1}]	214.96	227.63	240.22	252.75	265.65	278.56

For calculation of the average gross energy intake of Austrian dairy cattle the average milk yield of Austrian cows was converted like presented in the study mentioned above. The time series of average milk yields of the cattle was taken from national statistics and are presented in Table 162. For dairy cattle there was a ~19% increase of GE intake between 1990 and 2003 due to the increase of the milk yield per dairy cow in this time.

GE Gross energy intake of Non-Dairy Cattle (1 A 1 b)

Gross energy intake for *Non-Dairy Cattle* was calculated from typical Austrian diets of these livestock categories. Animal nutrition expert Dr. Andreas Steinwidder[32] worked out animal diets as shown in Table 161. There are distinct differences in organic and conventional diets for *Non-Dairy Cattle*. 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]. As no major changes in diets of *Non-Dairy Cattle* occurred in the period from 1990-2003, methane emissions from enteric fermentation of *Non-Dairy Cattle* are calculated with a constant gross energy intake for the whole time series.

32 Dr. Andreas Steinwidder, head of department animal production of the Federal Research Institute for Agriculture in Alpine Regions (BAL Gumpenstein)

Table 161: Typical Austrian diets and gross energy intake of Non-Dairy Cattle, conventional and organic production system.

		Suckling cows	cattle < 1 year	cattle 1-2 years	non dairy cattle > 2 years
CONVENTIONAL	live weight	600 kg	210 kg	530 kg	600 kg
	animal diet	50 % green feeding	15 % green feeding	20 % green feeding	40 % green feeding
		20 % hay	20 % hay	15 % hay	20 % hay
		30 % grass silage	30 % grass silage	30 % grass silage	30 % grass silage
			35 % maize silage	35 % maize silage	10 % maize silage
	Gross Energy Intake [(MJ GE (kg dry matter)$^{-1}$]	191.56	84.36	166.96	163.44
		Suckling cows	cattle < 1 year	cattle 1-2 years	non dairy cattle > 2 years
ORGANIC	live weight	600 kg	190 kg	480 kg	580 kg
	animal diet	50 % green feeding	35 % green feeding	40 % green feeding	40 % green feeding
		20 % hay	20 % hay	15 % hay	15 % hay
		30 % grass silage	45 % grass silage	45 % grass silage	45 % grass silage
	Gross Energy Intake [(MJ GE (kg dry matter)$^{-1}$]	191.56	72.06	151.14	159.93

The resulting emission factors are presented in the following tables:

Table 162: Annual milk yield, Gross Energy Intake and Emission Factors of Dairy Cattle 1990-2002

Year	Milk Yield [kg/cow*yr]	Gross Energy Intake [MJ GE/head*day]	Emission Factor [kg CH4/head*yr]
1990	3791	225	89
1991	3862	226	89
1992	3934	227	89
1993	4005	228	90
1994	4076	237	93
1995	4619	247	97
1996	4670	249	98
1997	4787	251	99
1998	4924	254	100
1999	5062	256	101
2000	5210	259	102
2001	5394	262	103
2002	5487	265	104
2003	5638	268	105

Table 163: Emission Factors and Gross Energy Intake of Non- Dairy Cattle 1990-2002

IPCC Category	Farming type	Gross Energy Intake [MJ/head.day]	Calculated Emission Factor [kg CH_4/head.yr]
Mother cows suckling > 2 yr	conventional	192	75
Mother cows suckling > 2 yr	organic	192	75
Cattle >2 yr	conventional	163	64
Cattle >2 yr	organic	160	63
Young Cattle < 1 yr	conventional	84	33
Young Cattle < 1 yr	organic	72	28
Young Cattle 1-2 yr	conventional	167	66
Young Cattle 1-2 yr	organic	151	59

6.2.2.2 Sheep (4 A 3), Goats (4 A 4), Horses (4 A 6) Swine (4 A 8), Poultry (4 A 9) and Other (4 A 10)

Key Source: No

As presented in Table 156, CH_4 emissions from *Sheep, Goats, Horses, Swine, Poultry* and *Other (deer)* are only minor emission sources of category *4 A Enteric Fermentation*. Together they contributed 6.7% to total emissions from this category in 2003. The most important sub source is *Swine*, with a contribution of 3.3%, followed by *Sheep* (1.8%), *Horses* (1.1%), *Goats* and *Other (deer)* with each 0.2% and finally *Poultry* (0.1%). (figures are also presented in Table 156).

Emissions (except *Poultry*) were estimated using the IPCC Tier 1 methodology.

As sheep is the most similar animal category to deer, emissions from deer were estimated applying the default emission factor of sheep. For all swine categories an emission factor of 1.5 kg/head*yr was used. Default emission factors were taken from the IPCC Guidelines and are presented in the following table:

Table 164: 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]
4 A 3 Sheep (+deer)	8	4 A 6 Horses	18
4 A 4 Goats	5	4 A 8 Swine	1.5

** Source: IPCC Reference Manual p.4.10*

The IPCC Guidelines don't provide methodologies for the estimation of emissions from *Poultry*.

For the calculation of emissions from category *4 A 9 Poultry* the IPCC Tier 2 method with Swiss values (Gross Energy Intake (GE), Methane Conversion Rate (Y_m)) was used. It is assumed that Swiss conditions are very similar to Austrian conditions.

Y_m: 0,09%

GE: 2,18 MJ/head/yr (Swiss 2002 value)

Swiss values (see Swiss NIR [SAEFL, 2004]) are based on the study [Minonzio, 1998].

Activity data were obtained from national statistics and are presented in Table 157 and Table 158.

6.2.3 Uncertainties

Uncertainty of total CH_4 emissions from Enteric Fermentation: +/- 8%

Uncertainties of CH_4 emissions from *Enteric Fermentation* were estimated with a "Monte Carlo" simulation. Assuming a normal probability distribution, the calculated standard deviation is 4%. This indicates there is a 95% probability that CH_4 emissions are between +/- 2 standard deviations.

Uncertainties that were taken into account for calculations of the total uncertainty:

- Gross Energy Intake (GE): +/- 20% (estimated by expert judgement of Dr. Amon)
- Methane Conversion Factor (Y_m) cattle: +/- 8.3% [IPCC GUIDELINES, 1997]
- Livestock: (Source: STATISTIK AUSTRIA; sample survey –) statistical accuracy 95%
- Share of organic farming: +/- 10% (estimated by expert judgement of the ARC-Team)
- EF for Sheep, Swine, Horses, Goats (IPCC default values): +/- 30% [IPCC GUIDELINES, 1997]
- The emission factors for the "Tier 2" method are determined by the uncertainty of the gross energy intake (GE) and the CH_4 conversion rates (Y_m). The uncertainty was estimated to be to be about +/- 20% (Amon et al. 2002).

Table 165: Uncertainties of emission estimates for Enteric Fermentation

IPCC Category	Farming Type	Standard deviation (σ) in %
CATTLE	Conventional	4
CATTLE	Organic	6
CATTLE	Total	4
MATURE DAIRY CATTLE		
Dairy Cattle > 2 yr	Conventional	8
Dairy Cattle > 2 yr	Organic	11
Dairy Cattle > 2 yr	Total	8
MATURE NON DAIRY CATTLE		
Mother Cows > 2 yr	Conventional	8
Mother Cows > 2 yr	Organic	11
Mother Cows > 2 yr	Total	8
Cattle > 2 yr	Conventional	8
Cattle > 2 yr	Organic	11
Cattle > 2 yr	Total	8
YOUNG CATTLE		
Young Cattle < 1 yr	Conventional	8
Young Cattle < 1 yr	Organic	11
Young Cattle < 1 yr	Total	8

IPCC Category	Farming Type	Standard deviation (σ) in %
Young Cattle 1-2 yr	Conventional	8
Young Cattle 1-2 yr	Organic	11
Young Cattle 1-2 yr	Total	8
SWINE	Conventional	21
SWINE	Organic	24
SWINE	Total	21
MATURE SWINE		
Fattening pig > 50 kg	Conventional	30
Fattening pig > 50 kg	Organic	32
Fattened pig > 50 kg	Total	30
Swine for breeding > 50 kg	Conventional	30
Swine for breeding > 50 kg	Organic	32
Swine for breeding > 50 kg	Total	30
YOUNG SWINE		
Young Swine < 50 kg	Conventional	31
Young Swine < 50 kg	Organic	32
Young Swine < 50 kg	Total	31
SHEEPS	Conventional	31
SHEEPS	Organic	32
SHEEPS	Total	31
GOATS	Conventional	31
GOATS	Organic	32
GOATS	Total	31
POULTRY	Total	Not estimated
SOLIPEDS	Total	5
Horses	Conventional	5
Other Solipeds	Conventional	Not estimated
OTHER ANIMAL	Conventional	Not estimated
Total		**4**

Table 165 presents the standard deviations for CH_4 emissions from animal categories. The uncertainty is defined as +/- 2 σ.

6.2.4 Recalculations

4 A 1 a:

The estimation of CH_4 emissions from enteric fermentation / diary cattle is based on gross energy intake (GE) depending on milk yield data. Data were taken from [GRUBER & STEINWIDDER 1996] who carried out intensive model calculations on nitrogen excretion of cows taking into account milk yields from 3 000 to 8 000 kg.

In the last submission the GE values of the years 2000 to 2002 were extrapolated on the basis of the GE value with a corresponding milk yield of 5 000 kg. In this year's calculations also the corresponding GE value of a milk yield of 6 000 kg published in the study mentioned above was considered. The values for the years 2000, 2001 and 2002 were calculated via interpolation which led to higher emissions.

4 A 6:

In the last submissions the number of soliped of the years 2000 to 2002 was based on expert judgement. For transparency reasons in this inventory the official 1999 value was held constant until 2002. In the current inventory a new 2003 value of animal category *Soliped* is available.

4 A 9, 4 A 10:

For the first time emissions from the livestock categories *Other (deer)* and *Poultry* were estimated.

Table 166: Difference to last year's submission of CH_4 emissions from subcategories of Category 4 A

Year	CH_4 emissions [Gg]				
	4 A Total	4 A 1 a Dairy	4 A 6 Horses	4 A 9 Poultry	4 A 10 Other
1990	0.47	0	0	NE->0.18	NE->0,30
1991	0.48	0	0	NE->0.19	NE->0,30
1992	0.47	0	0	NE->0.18	NE->0,30
1993	0.48	0	0	NE->0.19	NE->0,30
1994	0.48	0	0	NE->0.18	NE->0,30
1995	0.50	0	0	NE->0.18	NE->0,32
1996	0.50	0	0	NE->0.17	NE->0,33
1997	0.64	0	0	NE->0.19	NE->0,45
1998	0.59	0	0	NE->0.18	NE->0,40
1999	0.50	0	0	NE->0.19	NE->0,31
2000	0.61	0.18	-0.03	NE->0.15	NE->0,31
2001	0.75	0.34	-0.06	NE->0.16	NE->0,31
2002	0.91	0.50	-0.06	NE->0.16	NE->0,31

6.3 Manure Management (CRF Source Category 4 B)

This chapter describes the estimation of CH_4 and N_2O emissions from animal manure. In 2003 22% of the agricultural CH_4 emissions and 21% of the agricultural N_2O emissions were caused by this source category.

6.3.1 Source Category Description

From 1990 to 2003 CH_4 emissions from *Manure Management* decreased by 13.3% to 42.16 Gg. This is mainly due a decrease of the livestock categories cattle and swine.

Table 167: CH_4 Emissions from Manure Management 1990-2003

	CH_4 emissions from Manure Management [Gg]								
	Livestock Categories								
	4 B Total	4 B 1 a Dairy	4 B 1 b N. Dairy	4 B 3 Sheep	4 B 4 Goats	4 B 6 Horses	4 B 8 Swine	4 B 9 Poultry	4 B 13 Other
1990	**48.60**	15.80	10.27	0.06	0.00	0.07	21.32	1.08	0.01
1991	**47.93**	15.33	10.29	0.06	0.00	0.08	21.03	1.12	0.01
1992	**47.23**	14.76	9.74	0.06	0.00	0.09	21.50	1.07	0.01
1993	**47.63**	14.56	9.69	0.06	0.01	0.09	22.08	1.13	0.01
1994	**47.42**	14.63	9.75	0.07	0.01	0.09	21.77	1.11	0.01
1995	**47.25**	13.10	11.05	0.07	0.01	0.10	21.83	1.09	0.01
1996	**46.34**	12.98	10.85	0.07	0.01	0.10	21.31	1.01	0.01
1997	**46.35**	13.45	10.21	0.07	0.01	0.10	21.35	1.15	0.01
1998	**46.86**	13.65	9.88	0.07	0.01	0.10	22.02	1.12	0.01
1999	**44.39**	13.12	10.11	0.07	0.01	0.11	19.84	1.13	0.01
2000	**43.06**	11.72	10.98	0.06	0.01	0.11	19.25	0.92	0.01
2001	**43.41**	11.32	10.80	0.06	0.01	0.11	20.12	0.98	0.01
2002	**42.02**	11.19	10.45	0.06	0.01	0.11	19.20	0.98	0.01
2003	**42.16**	10.64	10.77	0.06	0.01	0.12	19.54	1.02	0.01
Share 2003	***100%***	25.2%	25.5%	0.1%	0.0%	0.3%	46.3%	2.4%	0.0%
Trend 1990-2003	**-13.3%**	-32.6%	4.9%	5.0%	46.2%	77.0%	-8.4%	-5.7%	11.0%

From 1990 to 2003 the N_2O emissions from *Manure Management* decreased by 10.5% to 2.27 Gg. Emissions of cattle dominate the trend. The reduction of diary cows is partly counterbalanced by an increase in emissions per animal (because of the increasing gross energy intake, milk production and N excretion of diary cattle since 1990).

Table 168: N_2O Emissions from Manure Management 1990-2003

	N_2O emissions from Manure Management [Gg]								
	Livestock Categories								
	4 B	4 B 1 a	4 B 1 b	4 B 3	4 B 4	4 B 6	4 B 8	4 B 9	4 B 13
	Total	Dairy	Non Dairy	Sheep	Goats	Horses	Swine	Poultry	Other
1990	**2.54**	1.13	1.01	0.01	0.00	0.00	0.30	0.08	0.00
1991	**2.51**	1.10	1.01	0.01	0.00	0.00	0.30	0.09	0.00
1992	**2.41**	1.06	0.95	0.01	0.00	0.00	0.31	0.08	0.00
1993	**2.43**	1.04	0.97	0.01	0.00	0.00	0.31	0.09	0.00
1994	**2.46**	1.07	0.99	0.01	0.00	0.00	0.31	0.09	0.00
1995	**2.50**	0.97	1.12	0.01	0.00	0.00	0.31	0.09	0.00
1996	**2.45**	0.96	1.09	0.01	0.00	0.00	0.30	0.08	0.00
1997	**2.43**	1.01	1.02	0.01	0.00	0.00	0.30	0.09	0.00
1998	**2.42**	1.03	0.98	0.01	0.00	0.00	0.31	0.09	0.00
1999	**2.38**	0.99	1.00	0.01	0.00	0.00	0.28	0.09	0.00
2000	**2.34**	0.90	1.08	0.01	0.00	0.00	0.28	0.07	0.00
2001	**2.32**	0.88	1.07	0.01	0.00	0.00	0.29	0.08	0.00
2002	**2.28**	0.88	1.04	0.01	0.00	0.00	0.27	0.08	0.00
2003	**2.27**	0.85	1.05	0.01	0.00	0.00	0.28	0.08	0.00
Share 2003	***100%***	37.2%	46.4%	0.4%	0.0%	0.1%	12.4%	3.5%	0.0%
Trend 1990-2003	**-10.5%**	-25.4%	4.7%	5.0%	46.2%	77.0%	-7.7%	-5.4%	11.0%

6.3.2 Methodological Issues

The IPPC-Tier 2 methodology is applied to estimate CH_4 emissions from manure management of cattle and swine as these are key sources. This method requires detailed information on animal characteristics and the manner in which manure is managed. Sheep, goats, horses and other soliped, chicken, other poultry and other animals are of minor importance in Austria, therefore the CH_4 emissions of these livestock categories are estimated with the Tier 1 approach.

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.

Data of Austria's manure management system distribution were taken from [KONRAD, 1995].

Activity data

[STATISTIK AUSTRIA, 2003] provides national data of annual livestock numbers on a very detailed level (see Table 157 and Table 158).These data are basis for the estimation.

The animal numbers of *Young Swine* were not taken into account because the emission factors for *Breeding Sows* already includes nursery and growing pigs [SCHECHTNER, 1991].

6.3.2.1 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 (GPG, Equation 4.17):

$$EF_i = VS_i * 365 \, [days \, yr^{-1}] * B_{0i} * 0.67 \, [kg \, m^{-3}] * \Sigma_{jK} MCF_{jK} * MS\%_{ijK}$$

EF_i = annual emission factor (kg) for animal type i (e.g. dairy cows)
VS_i = Average daily volatile solids excreted (kg) for animal type i
B_{0i} = maximum methane producing capacity (m³ per kg of VS) for manure produced by animal type I
MCF_{jK} = methane conversion factors for each manure management system j by climate region K
$MS\%_{ijK}$ = fraction of animal type i`s manure handled using manure systems j in climate region K

Cattle (4 B 1)

Key Source: Yes (CH_4 level 0.64%, N_2O level 0.49%)

B_{0i} Values

IPCC default values were used (Appendix B, IPCC Guidelines, Reference Manual)

MCF Values

Due to the lack of sufficiently detailed information about manure systems in Austria, the default MCF values for “cool climate regions” presented in the IPCC Guidelines’ Reference Manual (table 4-8) were used. For liquid systems the revised GPG default value of 39% was used.

Manure Management Systems

In Austria national statistics on manure management systems are not available. Up to now, only one comprehensive survey has been carried out [KONRAD, 1995] (Table 169). This manure management system distribution was used for the whole period from 1990-2003.

Table 169: Manure Management System distribution in Austria: Cattle

Livestock category	Liquid/Slurry [%]	Solid Storage [%]	Pasture/range/paddock [%]
dairy cattle summer	16.7[1]	62.0[1]	21.3[1]
dairy cattle winter	21.2[1]	78.8[1]	---
Dairy cattle winter/summer	18.95[1]	70.4[1]	10.65[1]
suckling cows summer	16.7[1]	62.0[1]	21.3[1]
suckling cows winter	21.2[1]	78.8[1]	---
suckling cows winter/summer	18.95[1]	70.4[1]	10.65[1]
cattle 1 –2 years summer	7.7[1]	39.9[1]	52.4[1]
cattle 1 –2 years winter	16.2[1]	83.8[1]	---
cattle 1 –2 years winter/summer	11.95[2]	61.85[2]	26.2[2]
cattle < 1 year	28.75[1]	71.25[1]	---
non dairy cattle > 2 years	48.6[1]	51.4[1]	---

[1]. *“Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht” [KONRAD, 1995]*

[2]..*Estimation of Dipl.-Ing. Alfred Pöllinger (Federal Research Institute, Gumpenstein) following [KONRAD, 1995]*

MMS are distinguished for *Dairy Cattle*, *Suckling Cows* and *Cattle 1–2 years* in "summer situation" and "winter situation" (Table 169). During the summer months, a part of the manure from these livestock categories is managed in "pasture/range/paddock". The value for "pasture/range/paddock" is estimated as follows: During summer, 14.1% of Austrian dairy cows and suckling cows are on alpine pastures 24 hours a day. 43.6 % are on pasture for 4 hours a day and 42.3 % stay in the housing for the whole year [KONRAD 1995]. "Alpine pasture" and "pasture" are counted together as MMS "pasture/range/paddock". As "pasture" only lasts for about 4 hours a day, only 1/6 of the dairy cow pasture-% (43.6%) is added to the total number. This results in 21.3% "pasture/range/paddock" during summer. In winter, "pasture/range/paddock" does not occur in Austria. Summer and winter both last for six months.

VS Values

Values for VS excretion of *Diary Cattle* specific for Austria have been calculated with the country specific data given in [SCHECHTNER, 1991] and [GRUBER & STEINWIDDER 1996]:

Table 170: VS excretion after [GRUBER & STEINWIDDER 1996]

Milk yield	3 500	4 000	4 500	5 000	5 500	6 000
VS excretion	3.53	3.65	3.75	3.86	3.96	4.06

[GRUBER & STEINWIDDER 1996] calculated manure production of *Diary Cattle* in dependency on annual milk yields. Using this information, a time series of manure production was calculated:

Table 171:VS excretion of Austrian diary cows for the period 1990-2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Milk Yield [kg/cow*yr]	3791	3862	3934	4005	4076	4619	4670	4787	4924	5062	5210	5394	5487	5 638
VS	3.63	3.64	3.64	3.65	3.75	3.85	3.87	3.88	3.89	3.91	3.92	3.93	3.95	3.96

Austrian specific values on VS excretion of *Non-Dairy Cattle* were calculated from feed intake (gross energy intake, feed digestibility, ash content). This approach has been chosen as it allows to differ in organic and conventional production systems. Nutrition expert Dr. Steinwidder worked out country-specific feed rations under organic and conventional management (see Table 161). As no major changes in diets of *Non-Dairy Cattle* occurred in the period from 1990-2003, 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 following the formula presented in the IPCC guidelines (Reference Manual, Equation 4.15):

$$VS\ [kg\ dm\ day^{-1}] = Intake\ [MJ\ day^{-1}] * (1kg\ (18.45\ MJ)^{-1}) * (1 - DE\%/100) * (1 - ASH\%/100)$$

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 172 presents data for the calculation of VS excretion of the livestock categories *Non-Dairy Cattle*.

Table 172: Austrian VS excretion rates of Non-Dairy Cattle, conventional and organic production system

	Suckling cows		cattle < 1 year		cattle 1-2 years		non dairy cattle > 2 years	
	Conv.	Org.	Conv.	Org.	Conv.	Org.	Conv.	Org.
feed digestibility [%]	64	64	76	75	73	73	73	73
ash content [%]	11.5	11.5	12.0	12.0	11.5	11.5	11.0	11.0
Gross energy intake [MJ GE (kg dry matter)$^{-1}$]	191.56	191.56	84.36	72.06	166.96	151.14	163.44	159.93
VS excretion [kg head^{-1} day^{-1}]	3.31	3.31	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%.

Swine (4 B 8)

Key Source: Yes (CH_4, level assessment for 2003: 0.45%)

B_0 and MCF Values

IPCC default values were used.

Manure management System

The comprehensive survey carried out by [KONRAD, 1995] already mentioned above was used.

Table 173: Manure management distribution in Austria: Swine

Livestock category	Liquid/Slurry [%]	Solid Storage [%]	Pasture/ range/paddock [%]
breeding sows	70[2]	30[2]	---
fattening pigs	71.9[1]	28.1[1]	---

[1]. "Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht" [KONRAD, 1995]

[2]..Estimation of Dipl.-Ing. Alfred Pöllinger (Federal Research Institute, Gumpenstein) following [KONRAD, 1995]

VS excretion

VS excretion of *Swine* was estimated 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 174. 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

Animal numbers of *Young Swine* were not taken into account because the emission factors for *Breeding Sows* already include nursery and growing pigs [SCHECHTNER, 1991].

Sheep (4 B 3), Goats (4 B 4), Horses (4 B 6), Poultry (4 B 9) and Other Animals (4 B 13)

CH_4 emissions from *Manure Management* for *Sheep, Goats, Horses, Poultry* and *Other Animals* are estimated with the Tier 1 approach. A differentiation between organic and conventional management is not possible due to lack of data.

Default emission factors were taken from the IPCC guidelines (Table 4-5 of the Reference Manual). CH_4 emissions were estimated multiplying these emission factors by national animal numbers.

Table 175: CH_4 emissions from manure management systems for Sheep, Goats, Horses and Other Soliped, Chicken, Other Poultry and Other Animals 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	Chicken	0.078
Goats	0.12	Other Poultry[1]	0.078
Horses & other soliped	1.39	Other Animals (deer)	0.19

[1]*the IPCC guidelines do not differentiate between laying hens and other poultry. The same emission factor was applied to both livestock categories.*

The Austrian inventory does not distinguish between *Horses* and *Mules and Asses*. As *Mules and Asses* are only of very little importance in Austria, CH_4 emissions from manure of horses and other soliped were estimated with the default emission factors for *Horses*.

In Austria the animal category *Other Animal* corresponds to deer (held in pastures). As sheep is the most similar animal category to deer, emissions from deer were estimated applying the default emission factor of sheep.

6.3.2.2 Estimation of N_2O Emissions

Following the guidelines, all emissions of N_2O taking place before the manure is applied to soils are reported under *Manure Management*.

For the estimation of N_2O emissions from manure management systems only a Tier 1 approach is available. The IPCC Guidelines method 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 system distribution data used to estimate N_2O emissions from *Manure Management* are the same as those that were used to estimate CH_4 emissions from *Manure Management* (see Table 169 and Table 173).

N excretion

For *Goats, Sheep, Horses, Chicken, Other Poultry* and *Other Animal* default values for N excretion were used, whereas for *Cattle* and *Swine* country specific emission factors as presented below were applied.

N excretion from Austrian *Dairy Cattle* was calculated after [GRUBER & STEINWIDDER, 1996], who intensively reviewed research on N excretion in dependency on the annual milk yield (Table 176).

Table 176: N excretion of Austrian dairy cows for the period 1990-2003

Year	Milk yield *[kg yr^{-1}]*	*Nitrogen excretion [kg/animal/yr]*	*Year*	Milk yield *[kg yr^{-1}]*	*Nitrogen excretion [kg/animal/yr]*
1980	3 518	54.33	1997	4 787	62.25

1990	3 791	55.82	1998	4 924	62.86
1991	3 862	55.97	1999	5 062	63.48
1992	3 934	56.12	2000	5 210	64.50
1993	4 005	56.27	2001	5 394	65.52
1994	4 076	58.64	2002	5 487	66.54
1995	4 619	61.02	2003	5 638	67.56
1996	4 670	61.64			

N excretion rates for the livestock categories of *Non-Dairy Cattle* were derived from different sources (Table 177). The milk production of *Suckling Cows* is about 3 000 kg, thus the value of N excretion of *Dairy Cattle* with that annual milk production taken from [GRUBER & STEINWIDDER, 1996] was used for this livestock category. N excretion of *Cattle 1-2 years* were taken from this study as well. However, [GRUBER & STEINWIDDER, 1996] do not give data on N excretion of *Cattle <1 year* and *Cattle >2 years.* As there is no significant difference in husbandry of these livestock categories, N excretion of *Cattle <1 year* was taken from the revised German inventory on ammonia emissions and for N excretion of *Cattle >2 years* the value of the Swiss inventory was used. Austrian specific N excretion values for *Swine* were also taken from [GRUBER & STEINWIDDER, 1996] (Table 177).

Table 177: N excretion values used for calculation of N_2O emissions from manure management

Livestock category	*Nitrogen excretion* [kg per animal per yr]
suckling cows[1]	51.9[2]
cattle 1 – 2 years	42.2[2]
cattle < 1 year	16.0[3]
cattle > 2 years	60.0[4]
breeding sows[5]	26.9[2]
fattening pigs	15.0[4]
Sheep	20.0[6]
Goats	20.0[6]
Horses	50.0[7]
Chicken	0.8[7]
Other Poultry	2.0[7]
Other Animals (deer)	20.0[6]

(1) annual milk yield: 3 000 kg

(2) GRUBER & STEINWIDDER 1996

(3) DÖHLER ET AL. 2001

(4) Eidgenössische Forschungsanstalt für Agrarökologie und Landbau Zürich-Reckenholz 1997

(5) 2.1 litters per year

(6) IPCC REFERENCE MANUAL, Table 4-20

(7) CORINAIR

Livestock numbers per category can be found in Table 157 and Table 158, manure management system distribution for cattle and swine can be found in Table 169 and Table 173. For the other categories it is presented in the following table (Table 178).

Table 178: Distribution of manure management systems in Austria: Sheep, Goats, Horses, Poultry and Other Animals

Livestock category	Liquid/Slurry [%]	Solid Storage [%]	Pasture/ range/paddoc k [%]	Other Management System [%]
Sheep	0	2	87	11
Goats	0	0	96	4
Horses	0	0	96	4
Poultry (Chicken and Other Poultry)	1	13	2	84
Other Animals	0	0	96	4

Emission factors

Emission factors for animal waste management systems *Liquid/Slurry*, *Solid Storage*, *Pasture/Range/Paddock* and *Other Systems* were taken from the IPCC guidelines [IPCC GUIDELINES, 1997] (Reference Manual, Table 4-22).

Table 179. IPCC default values for N_2O emission factors from animal waste per animal waste management system

Animal Waste Management System	Emission Factor [kg N_2O-N per kg N excreted]
Liquid/Slurry	0.001
Solid Storage	0.02
Pasture/Range/Paddock	0.02
Other Systems	0.005

6.3.3 Uncertainties

Uncertainties are presented in Table 154.

6.3.4 Recalculations

4 B 1 a:

In the last submission, the Nex and VSex values from 2000 to 2002 were extrapolated on the basis of the Nex and VSex data with a corresponding milk yield of 5000 kg. In this year's calculations also the corresponding Nex and VSex values of a milk yield of 6 000 kg published in [GRUBER & STEINWIDDER 1996] were considered. The values were calculated via interpolation. This led to slightly higher emissions of N_2O in the years 2000, 2001, 2002.

4 B 1 b:

The S&A report 2004 noticed high inter-annual variations in the CH4 IEF values between 1992/1993 and 1993/1994. An error regarding activity data of non-dairy cattle for the year 1993 was identified and corrected in this submission.

4 B 13:

In Austria animals of category *Other* which mainly is deer (but not wild living animals) have been counted from 1993 on. As recommended in the centralized review, the animal number of 1993 was used for the years 1990 to 1992. This led to slightly higher emissions in those years.

Table 180: Difference to last submission of CH_4 emissions from subcategories of Category 4 B

IPCC Categories	[Gg CH_4]												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
4 B MANURE MANAGEMENT	0.01	0.01	0.01	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 B 1 a Dairy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 B 1 b Non Dairy	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 B 13 Other	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 181: Difference to last submission of N_2O emissions from subcategories of Category 4 B

IPCC Categories	[Gg N_2O]												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
4B MANURE MANAGEMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
4 B 1 a Dairy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
4 B 8 Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6.3.5 Planned Improvements

A survey on Austria's distribution of manure management systems is planned to be started this year.

6.4 Agricultural Soils (CRF Source Category 4 D)

6.4.1 Source Category Description

N_2O emissions from category *4 D Agricultural Soils* are a key source *(4 D 1: 1.54 %, 4 D 3: 1.11%,* see Table 153).

In 2003 79% of total N_2O emissions from *Agriculture* (48% of total Austrian N_2O emissions) originated from *Agricultural Soils*, the rest originates from *4 B Manure Management* and a very small share from *4 F Field Burning of Agricultural Waste*.

Emissions from this category contributed 2.9% (2 664.80 Gg CO_2 equivalents) to Austria's total greenhouse gas emissions in the year 2003. This is 36.3% of total GHG emissions of the sector *Agriculture*.

The trend of N_2O emissions from this category is decreasing: in 2003 emissions were 13.4% below 1990 levels.

Table 182 presents N_2O emissions of *Agricultural Soils* by subcategory as well as their trends and their share in total N_2O emissions.

Table 182: N_2O emissions from Category 4 D, 1990-2003

	N_2O emissions [Gg]										
	IPCC Categories										
Year	**4 D** total	**4 D 1** Direct Soil Emissions	Synthetic Fertilisers	Organic Fertiliser	Crop Residue	N-fixing Crops	**4 D 2** Animal Production	**4 D 3** Indir. Soil Emissions	Nitrogen Leaching	Athm. Deposition	**4 D 4** Sewage Sludge
1990	9.90	5.32	2.62	1.94	0.43	0.33	0.67	3.88	3.30	0.59	0.02
1991	10.73	5.85	3.07	1.94	0.48	0.36	0.69	4.17	3.58	0.58	0.02
1992	9.89	5.41	2.60	1.89	0.46	0.46	0.67	3.80	3.24	0.56	0.02
1993	9.14	4.89	2.05	1.92	0.47	0.45	0.71	3.50	2.95	0.55	0.03
1994	10.66	5.88	2.88	1.93	0.61	0.45	0.72	4.04	3.47	0.56	0.03
1995	10.76	5.89	2.92	1.96	0.69	0.32	0.75	4.09	3.53	0.56	0.03
1996	9.52	5.08	2.30	1.93	0.51	0.34	0.75	3.66	3.13	0.53	0.03
1997	9.88	5.32	2.45	1.94	0.53	0.40	0.76	3.76	3.23	0.53	0.03
1998	9.93	5.40	2.45	1.94	0.58	0.43	0.73	3.77	3.22	0.54	0.03
1999	9.34	5.05	2.16	1.89	0.61	0.39	0.73	3.53	3.01	0.52	0.03
2000	9.18	4.93	2.23	1.84	0.48	0.37	0.71	3.51	3.00	0.51	0.03
2001	9.44	5.12	2.39	1.83	0.54	0.36	0.70	3.60	3.09	0.51	0.03
2002	9.13	4.95	2.24	1.79	0.54	0.38	0.68	3.47	2.97	0.50	0.03
2003	8.57	4.56	1.90	1.81	0.46	0.39	0.70	3.28	2.78	0.50	0.03
Share 2003	*100%*	*53.2%*	*22.2%*	*21.1%*	*5.3%*	*4.6%*	*8.1%*	*38.3%*	*32.4%*	*5.8%*	*0.4%*
Trend 90-03	*-13.4%*	*-14.3%*	*-27.3%*	*-7.0%*	*7.0%*	*18.5%*	*4.4%*	*-15.6%*	*-15.7%*	*-14.8%*	*26.3%*

CH_4 emissions from Agricultural Soils originate from sewage sludge spreading on agricultural soils. Emissions from this category contribute only a negligible part of Austria's total greenhouse gas emissions (0.01% or 9.09 Gg CO_2 equivalents 2003). This is 0.12% of total GHG emissions of the sector *Agriculture*.

Table 183: CH_4 emissions from Category 4 D, 1990-2003

Year	CH_4 emissions [Gg] IPCC Category 4 D total	4 D 4 Other (sewage sludge application)
1990	0.33	0.33
1991	0.33	0.33
1992	0.31	0.31
1993	0.47	0.47
1994	0.40	0.40
1995	0.44	0.44
1996	0.45	0.45
1997	0.45	0.45
1998	0.45	0.45
1999	0.45	0.45
2000	0.45	0.45
2001	0.43	0.43
2002	0.43	0.43
2003	0.43	0.43
Share 2003	*100.0%*	*100.0%*
Trend 90-03	*32.0%*	*32.0%*

6.4.2 Methodological Issues

The IPCC Tier 1a and – where applicable – Tier 1b method was applied and IPCC default emission factors were used.

Table 184: N_2O emissions factors for Agricultural Soils

Category	Emission Factor [t N_2O-N / t N]	Source
4 D 1 Direct Soil Emissions		
Synthetic Fertilizers (mineral fert.)	0.0125	IPCC GPG (Table 4.17)
Animal Waste applied to soils		
N- fixing Crops		
Crop Residue		
4 D 2 Animal Production (Grazing animals)	0.02/ t N_{exGRAZ}	IPCC Guidelines (Table 4.22)
4 D 3 Indirect Soil Emissions		
Athmospheric Deposition	0.01/ t of volatized nitrogen	IPCC GPG (Table 4.18)

Nitrogen Leaching (and Run- off)	0.0025/ t N- loss by leaching	IPCC GPG (Table 4.18)
4 D 4 Other (Sewage Sludge)	0.0125	IPCC GPG (Table 4.17)

For sewage sludge application also CH_4 emissions were estimated (country specific method).

Activity Data

Data for necessary input parameters (activity data) were taken from the following sources:

Table 185: Data sources for nitrogen input to Agricultural Soils

Category	Data Sources
4 D 1 Direct Soil Emissions	
Synthetic Fertilizers (mineral fert.)	fertilizer consumption: Grüner Bericht 2004 [BMLFUW, 2004] (1) ; urea application in Austria: Sales data RWA, 2004 (2)
Animal Waste applied to soils	calculations and expert judgement by Dr. Barbara Amon following [GRUBER & STEINWIDDER, 1996]
N- fixing Crops	Cropped area legume production: [BMLFUW, 2004], (1)
Crop Residue	Harvested amount of agricultural crops: [BMLFUW, 2004], (1)
4 D 2 Animal Production (Grazing)	calculations and expert judgement by Dr. Barbara Amon following [GRUBER & STEINWIDDER, 1996]
4 D 3 Indirect Soil Emissions	
Athmospheric Deposition	calculations and expert judgement by Dr. Barbara Amon following [GRUBER & STEINWIDDER, 1996]
Nitrogen Leaching (and Run- off)	see above (synthetic fertilizers, animal waste, sewage sludge)
4 D 4 Other (Sewage Sludge)	Water Quality Report 2000 [PHILIPPITSCH ET AL., 2001], Report on sewage sludge [SCHARF ET AL., 1997], Gewäserschutzbericht 2002 [BMLFUW 2002]

[1] *http://www.gruenerbericht.at and http://www.awi.bmlf.gv.at*

[2] *RWA: Raiffeisen Ware Austria*

Detailed data about the use of different kind of fertilizers are available until 1994, because until then, a fertilizer tax („Düngemittelabgabe") had been collected. Data about the total synthetic 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). Annual sales figures about urea are available for the years 1994 onwards from a leading fertilizer trading firm (RWA). These sources were used to get a time series of annual fertilizer application distinguishing urea fertilizers and other fertilizers ("mineral fertilizers").

The S&A report 2004 noticed high inter-annual variations in N_2O emissions of sector 4 D synthetic fertilizer use. These variations are caused by effects of storage as well as the difference between the calendar year and the agricultural economic year: the amounts of synthetic fertilizers over the years reflect the amounts sold in one calendar year. However, the economic year for the farmer does not correspond to the calendar year. Not the whole amount purchased is applied in the year of purchase.

Considering these effects, in this submission the arithmetic average of each two years was used as fertilizer application data. The time series for fertilizer consumption is presented in Table 186.

Table 186: Mineral fertiliser N consumption in Austria 1990-2003 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[1]	136 842	2 833
1991	180 388	3 965	GB[1]	160 384	3 965
1992	91 154	3 886	GB[1]	135 771	3 926
1993	123 634	3 478	GB[3], RWA[2]	107 394	3 682
1994	177 266	4 917	GB[4], RWA[2]	150 450	4 198
1995	127 963	5 198	GB[4], RWA[2]	152 615	5 058
1996	112 641	4 600	GB[4], RWA[2]	120 302	4 899
1997	143 818	6 440	GB[4], RWA[2]	128 230	5 520
1998	113 301	6 440	GB[4], RWA[2]	128 560	6 440
1999	113 409	6 808	GB[4], RWA[2]	113 355	6 624
2000	120 541	3 848	GB[4], RWA[2]	116 975	5 328
2001	129 100	3 329	GB[4], RWA[2]	124 821	3 589
2002	105 899	5 297	GB[4], RWA[2]	117 500	4 313
2003	94 400	8 608	GB[4], RWA[2]	100 150	6 952

1 [GRÜNER BERICHT, 1999]

2 Raiffeisen Ware Austria, sales company

3 [GRÜNER BERICHT, 2002]

4 [GRÜNER BERICHT, 2004]

The yearly numbers of the legume cropping areas were taken from official statistics [BMLFUW, 2004].

Table 187: Cropped area legume production, 1990-2003

	Areas [ha]			
Year	peas	soja beans	horse/field beans	clover hey, lucerne,..
1990	40 619	9 271	13 131	57 875
1991	37 880	14 733	14 377	65 467
1992	43 706	52 795	14 014	64 379
1993	44 028	54 064	1 064	68 124
1994	38 839	46 632	10 081	72 388
1995	19 133	13 669	6 886	71 024
1996	30 782	13 315	4 574	72 052
1997	50 913	15 217	2 783	75 976
1998	58 637	20 031	2 043	76 245
1999	46 007	18 541	2 333	75 028
2000	41 114	15 537	2 952	74 266
2001	38 567	16 336	2 789	72 196

2002	41 605	13 995	3 415	75 429
2003	42 097	15 463	3 465	78 813

Harvest data were taken from [BMLFUW, 2004], partly adopted from [JONAS & NIELSEN, 2002] and are presented in Table 188.

Table 188: Harvest Data I, 1990-2003

	Harvest [1000 t]								
	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
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

Table 189: Harvest Data II, 1990-2003

	Harvest [1000 t]								
Year	silo-green maize	clover-hey	rape	sunflower	soja bean	horse-/fodder bean	peas	vege-tables	oil pumkin
1990	4 289	717	102	57	18	41	145	273	3
1991	4 252	797	128	72	37	37	133	277	4
1992	3 523	587	126	79	81	31	137	227	4
1993	4 220	628	125	104	103	29	107	230	3
1994	4 152	743	217	92	105	27	134	246	3
1995	3 996	823	268	61	31	17	60	302	5
1996	3 918	858	121	44	27	10	93	297	8
1997	3 940	962	129	44	34	6	162	349	8
1998	3 865	1 014	128	57	51	5	178	313	11
1999	3 729	1 025	193	64	50	6	140	399	6
2000	3 531	1 440	125	55	33	7	97	361	6
2001	3 035	1 349	147	51	34	7	112	391	7

2002	3 285	1 395	129	58	35	9	96	406	9
2003	3 026	1 425	78	71	39	9	93	376	10

Data about the annual amount of sewage sludge produced and agriculturally applied were taken from [PHILIPPITSCH ET AL., 2001], [SCHARF ET AL., 1997] and [BMLFUW, 2002].

Data were reported for 1991, 1993, 1995 and 1998 and 2001. For the years 1992 and 1994 interpolated values were used. For all other years the value of the year before was used.

Table 190: Amount of sewage sludge (dry matter) produced in Austria, 1990-2003

Year	produced [t dm]	agriculturally applied [t dm]	agriculturally applied [%]
1990	161 936	31 507	19.5
1991	161 936	31 507	19.5
1992	200 000	30 000	15.0
1993	300 000	45 000	15.0
1994	350 000	38 500	11.0
1995	390 500	42 400	10.9
1996	390 500	42 955	11.0
1997	390 500	42 955	11.0
1998	392 909	43 220	11.0
1999	392 909	43 220	11.0
2000	392 909	43 220	11.0
2001	398 800	41 600	10.0
2002	398 800	41 600	10.0
2003	398 800	41 600	10.0

6.4.2.1 Direct Soil Emissions (4 D 1)

Direct Soil Emissions is the most important subcategory of *4 D Agricultural Soils (Key Source 2003: 1.54%).* 53.2% (4.56 Gg in 2003) of N_2O emissions from *Agricultural Soils* arise from this subcategory (see Table 182).

Calculation of direct N_2O emissions from soils is based on the assumption that 1.25% of the nitrogen input to agricultural soils is emitted in the form of N_2O (expressed as N). In this method, the nitrogen input is corrected for gaseous losses through volatilization of NH_3 and NO_X.

N_2O emissions from following sub- sources were estimated:

- Synthetic fertilizers (mineral fertilizers and urea)
- Animal waste (manure collected in stables and applied to soils)
- Biological nitrogen fixation through legumes
- Crop residues remaining on the field after harvest

Nitrogen input from all sources were calculated using IPCC Tier 1a (GPG, equation 4.20/ 4.21) and the emission factor of 1.25% (IPCC GPG, p.4.54, 4.60). The calculation is described in the following subchapters. The conversion from N_2O-N to N_2O emissions was performed by multiplication with (44/28).

This method estimates total direct N_2O emissions, irrespective of type of soils, of land use (e.g. grassland and cropland soils) and of vegetation, irrespective of the nitrogen compounds (e.g. organic, inorganic nitrogen), and irrespective of climatic factors.

Nitrogen input through application of mineral fertilizers

The method applied for calculation of the emissions is IPCC Tier 1a (GPG, Equation 4.22):

$$F_{SN} = N_{FERT} * (1 - Frac_{GASF})$$

F_{SN} = Annual amount of synthetic fertilizer nitrogen applied on soils, corrected for volatile N-losses [t N]

N_{FERT} = Annual amount of nitrogen in synthetic fertilizers (mineral and urea) applied on soils [t N] – see Table 186

$Frac_{GASF}$ = Fraction of nitrogen lost through gaseous emissions of NH_3 and NO_x [t/t] – 0.023 for mineral fertilizers and 0.153 for urea fertilizers [EMEP/CORINAIR, 1999] p.1010-15, table 5.1.

Nitrogen input through application of animal manure

The method applied is IPCC Tier 1b but with Austria specific consideration of nitrogen losses (NH_3-N, NO_x-N, N_2O-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 value for $Frac_{gasm}$.

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 and N_2O losses that depend on the amount of manure N. 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

N_2O-N losses from manure management

- *The remaining N is applied to agricultural soils.*

Ammonia emissions from housig and storage were calculated following the CORINAIR EMEP - methodology (detailed methodology for cattle and swine). A detailed description of the method applied is given in the report "Austria's Informative Report 2004 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution".

In Table 191 the nitrogen left for spreading for the years 1990-2003 per animal type is presented.

Table 191: Animal manure left for spreading on agricultural soils per livestock category 1990-2003

Nitrogen left for spreading [tons N per year]														
year	IPCC Livestock Categories													
	total	dairy cattle	suckling cows	cattle 1-2 a	cattle < 1 a	cattle > 2 a	sows	fattening pigs	chicken	other poultry	sheep	goats	horses / solipeds	oth. animals
1990	120509	41060	1852	14825	12559	7442	8274	15802	8083	1054	5912	712	2225	708
1991	120423	39868	2258	14683	12137	7691	8162	15587	8292	1420	6221	781	2614	708
1992	116918	38410	2382	13775	11289	7418	8345	15937	7919	1255	5952	752	2777	708
1993	119011	37891	2729	15146	9578	8035	8570	16366	8360	1422	6369	902	2936	708
1994	119795	38625	3544	15153	9592	7568	8547	15978	8161	1412	6527	949	3019	720
1995	121356	35057	8288	14919	9386	7785	8689	15848	8094	1240	6968	1035	3278	769
1996	119450	34960	8376	14206	9101	7829	8627	15244	7515	1182	7266	1039	3312	792
1997	120194	36465	6715	13601	8564	8224	8608	15323	8582	1254	7319	1113	3354	1073
1998	119837	37251	6075	13116	8621	8007	8360	16605	8330	1186	6883	1035	3407	961
1999	116933	36024	6957	12908	8560	8106	7441	15104	8488	1083	6721	1106	3689	746
2000	113629	32571	9954	12332	8896	8128	7234	14636	6815	1097	6472	1070	3689	734
2001	113406	31861	10149	12047	8945	7533	7579	15267	7324	1030	6114	1134	3689	734
2002	110788	31872	9646	11894	8689	7275	7381	14345	7324	1030	5807	1103	3689	734
2003	111908	30654	9573	11794	8710	8306	7235	15020	7600	1040	6210	1042	3938	786

NH_3 and NOx volatilisation losses occuring during application of animal waste to agricultural soils were calculated following the CORINAIR EMEP –methodology (detailed methodology for cattle and swine - see "Austria's Informative Report 2004 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution"). This procedure enables the use of country specific data, which is more accurate than the use of the default value for $Frac_{gasm}$.

Nitrogen input through biological fixation

The amount of N-input to soils via N-fixation of legumes (F_{BN}) was estimated on the basis of the cropping areas and specific consideration of nitrogen fixation rates of all relevant N-fixing crops:

$$F_{BN} = LCA * B_{Fix} / 1000$$

F_{BN} = Annual amount of nitrogen input to agricultural soils from N-fixation by legume crops [t]

LCA = Legume cropping area [ha]

B_{Fix} = Annual biological nitrogen fixation rate of legumes [kg/ha]

Activity values (LCA) for the years 1990-2003 can be found in Table 187.

Values for biological nitrogen fixation (120 kg N/ ha for peas, soja beans and horse/field beans and 160 kg N/ ha for clover- hey, respectively) were taken from a publication made by the Umweltbundesamt [GÖTZ, 1998]; these values are constant over the time series.

Nitrogen input from crop residues

The method applied for calculation of the emissions is the IPCC Tier 1b method. During harvest crops and by-products (e.g. like cereal straw) are removed from fields, but stubble, roots or beet leaves are left on the field and release nitrogen during decay. The amount of crop residues is calculated on the basis of the harvest statistics.

Official data for annual yield for different agricultural products were adjusted for dry matter (e.g. cereals have a dry matter content of 86% at harvest) and multiplied with appropriate Austrian empirical factors for average ratios between crops and residues [GÖTZ, 1998]. The residues that are removed from the fields during harvest (such as cereal straw or leaves of fodder beet) are subtracted. Also considered is the loss of nitrogen that is lost if residues are burned on the fields.

The amount of nitrogen was calculated using the following formula:

$$F_{CR} = CY * dm * ExF * Frac_{NCR} * (1 - Frac_{CRR} - Frac_{CRB})$$

F_{CR}	=	Annual nitrogen input to soils from crop residues left on fields [t N]
CY	=	Annual crop yield [t] (Table 188)
dm	=	Dry matter fraction [t/t] , source: [GÖTZ, 1998]
ExF	=	Expansion factor that describes the ratio of crop residues per harvested crop [t/t], [GÖTZ, 1998]
$Frac_{NCR}$	=	Fraction of nitrogen in dry matter of crop residues [t N/t] [GÖTZ, 1998]
$Frac_{CRR}$	=	Fraction of crop residues removed by harvest [t/t] [LÖHR, 1990]
$Frac_{CRB}$	=	Fraction of crop residue that is burned on field [t/t] [OLI, 2000], [OZONBERICHT, 1997]

Harvest data were taken from [BMLFUW, 2003], partly adopted from [JONAS, 2002] and are presented in Table 188.

The other parameters used are presented in the following table:

Table 192: Input parameters used to estimate emissions from crop residues

	Dm [t/t]	ExF [t/t]	$Frac_{NCR}$ [t N/t d.m.]	$Frac_{CRR}$ [t/t]	$Frac_{CRB}$ [t/t]
Wheat	0.86	1.0	0.005	0.7	0.0031
Rye	0.86	1.4	0.005	0.7	0.0031
Barley	0.86	1.1	0.005	0.7	0.0031
Oats	0.86	1.5	0.005	0.7	0.0031
Maize (corn)	0.50	1.4	0.005	0.0	0
Potato	0.30	0.3	0.005	0.0	0.0031
Sugarbeet	0.45	0.8	0.005	0.0	0
Fodderbeet	0.20	3.0	0.005	1.0	0
Maize (silo)	0.30	0.0	0.005	1.0	0
Clover-hay	0.86	0.0	0.005	1.0	0
Rape	0.86	21	0.005	0.0	0
Sunflower	0.86	2.5	0.015	0.0	0

Sojabean	0.40	15.0	0.015	0.0	0
Fodderbean	0.40	1.5	0.015	0.0	0
Peas	0.40	1.0	0.015	0.0	0
Vegetables	0.20	0.8	0.005	0.0	0
Oil pumpkin	0.80	72.0	0.015	0.0	0

6.4.2.2 Animal Production (4 D 2)

Following the IPCC Guidelines, N_2O emissions resulting from nitrogen input through excretions of grazing animals (directly dropped onto the soil) were calculated under *Manure Management* but reported under *Agricultural Soils*.

$$F_{GRAZ} = N_{exGRAZ} * EF_{GRAZ}$$

F_{GRAZ} = N_2O emissions induced by nitrogen excreted from grazing animals, expressed as N_2O-N [t N].

N_{exGRAZ} = 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 193

EF_{GRAZ} = A constant emission factor for N_2O from manure of grazing animals has been used [t N_2O-N / t N], – 0.02 [IPCC Guidelines, 1997], workbook table 4-8

Table 193: Nitrogen excreted during grazing (N_{exGRAZ}) in Austria, 1990-2003

Nitrogen excreted during grazing [t N]													
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
21 232	21 853	21 184	22 454	22 953	23 860	23 880	24 071	23 341	23 224	22 634	22 198	21 754	22 172

6.4.2.3 Indirect Soil Emissions (4 D 3)

According to IPCC definition, indirect N_2O emissions are caused by atmospheric deposition of nitrogen and by nitrogen leaching from soils. The calculations are based on the recommendations of the IPCC guidelines.

N_2O emissions through atmospheric nitrogen deposition

Emissions were calculated following the formular taken from the IPCC GPG (Equation 4.31, Tier 1a):

$$F_{AD} = [(N_{FERT} * Frac_{GASF}) + (N_{ex} * Frac_{GASM})] * EF_{AD}$$

F_{AD} = N_2O emissions from atmospheric deposition, expressed as N_2O-N [t N]

N_{FERT} = Nitrogen in mineral fertilizers applied on soils [t N] see Table 186.

$Frac_{GASF}$ = Fraction of nitrogen lost from mineral fertilizer applications through gaseous emissions of NH_3 and NO_x. [t/t] - 0.023 for mineral fertilizers and 0.153 for urea fertilizers [EMEP/CORINAIR, 1999] p.1010-15, table 5.1.

N_{ex} = Total nitrogen annually produced in animal waste management systems [t N], see Table 176, Table 177

$Frac_{GASM}$ = Fraction of animal manure that is volatized as NH_3 or NO_x [t/t]

EF_{AD} = N_2O emission factor (constant over the time series) for emissions from atmospheric deposition: tons of N_2O-nitrogen released per ton of volatized nitrogen – 0.01 [t/t] [IPCC Guidelines, 1997]

Total N excretion by livestock that volatizes ($Frac_{GASM}$) includes:

- NH_3-N losses from housing, storage, grazing
- NH_3-N and NO_x-N losses from animal waste application

Table 194: N-losses and $Frac_{Gasm}$ 1990 to 2003

Year	total N-losses [t N/yr]	$Frac_{Gasm}$ (N_{losses}/Nex_{total})
1990	33 719	0.22
1991	32 965	0.22
1992	31 970	0.22
1993	32 032	0.21
1994	31 817	0.21
1995	31 689	0.21
1996	30 520	0.20
1997	30 284	0.20
1998	30 765	0.20
1999	29 661	0.20
2000	28 868	0.20
2001	29 266	0.20
2002	28 653	0.21
2003	28 533	0.20

Calculated N losses are about 20% of total N excretion, which is consistent with the IPCC default value (20%).

Ammonia emissions for Cattle and Swine were calculated with the CORINAIR detailed methodology [EMEP/CORINAIR, 1999], for the other categories the CORINAIR simple methodology was used.

NO_X emissions were estimated according to the assumption from [FREIBAUER & KALTSCHMITT, 2001], that 1% of the manure nitrogen left for spreading N_{LFS} (see Table 191) is emitted as NO_X- N.

A detailed description of the method applied for NH_3 and NOx is given in the report "Austria's Informative Report 2004 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution".

N_2O emissions through nitrogen leaching losses

The method applied for calculation of the emissions is IPCC Tier 1b.

Following IPCC recommended values, leaching losses from nitrogen fertilizers are estimated to be about 30% of the nitrogen inputs from synthetic fertilizer use, livestock excretion, and sewage sludge application. N_2O emissions are then estimated as 2.5% of the leaching losses, as suggested by the IPCC.

The calculation follows the following formular:

$$E\text{-}N_2O_{LL} = (F_{FERT} + N_{exLFS} + N_{exGRAZ} + F_{SSlu}) * Frac_{LEACH} * EF\text{-}N_2O_{LL}$$

$E\text{-}N_2O_{LL}$	=	N_2O emissions from leaching losses, expressed as N_2O-N [t N]
F_{FERT}	=	Annual amount of nitrogen in synthetic fertilizers (mineral and urea) applied on soils [t N] – see Table 186
N_{exLFS}	=	Annual amount of nitrogen in animal excreta left for spreading on agricultural soils, corrected for losses during manure management [t N] – see Table 191
N_{exGRAZ}	=	Annual amount of animal manure nitrogen produced by grazing animals and directly dropped on agricultural soils during grazing [t N] – see Table 193
F_{SSlu}	=	Annual nitrogen input from sewage sludge applied on agricultural soils [t N] – see Chapter *4 D 1 – Nitrogen input through the use of sewage sludge*
$Frac_{LEACH}$	=	Fraction of nitrogen applied on soils that leaches– 0.03 [t/t] [IPCC Guidelines, 1997], workbook table 4-19
$EF\text{-}N_2O_{LL}$	=	Emission factor for N_2O from leaching, expressed as N_2O-N – 0.025 [t/t] [IPCC Guidelines, 1997], workbook table 4-18

Annual nitrogen input from sewage sludge applied on agricultural soils as presented in Table 195 was calculated according to the formula presented in the subsection *Nitrogen input through the use of sewage sludge.*

Table 195: Annual nitrogen input from sewage sludge applied on agricultural soils (F_{SSlu}) in Austria, 1990-2003

Annual nitrogen input from sewage sludge applied on agricultural soils [t N]													
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1 232	1 232	1 170	1 755	1 502	1 654	1 675	1 675	1 686	1 686	1 686	1 555	1 555	1 555

6.4.2.4 Sewage Sludge Application (4 D 4)

N_2O emissions

In Austria fertilisation by sewage sludge is very small. In 2003 N_2O emissions from sewage sludge contributed only 0.36% of N_2O emissions from category 4 D Agricultural Soils.

The estimation of annually applied sewage sludge is based on the figures reported in the Austrian water protection report [PHILIPPITSCH et al., 2001] and [BMLFUW, 2002] which provide data for selected years. A mean value of 3.9% N in dry matter based on a large set of measurements [SCHARF et al., 1997] was taken to calculate the nitrogen content. The amount of agriculturally applied sewage sludge can be calculated through:

$$F_{SSlu} = SSlu_N * SSlu_{agric}$$

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 190

CH_4 emissions

According to the Institute for Applied Ecology and a study [SCHÄFER, 2002] the average carbon content of sewage sludge amounts about 300 kg carbon per ton sewage sludge. While 48% of the carbon remain in the soil, 52% are emitted to air. 5% of this emitted carbon is emitted as CH_4. Consequential about 10.4 kg methane is emitted per ton sewage sludge.

6.4.3 Uncertainties

The uncertainties for N_2O emissions are presented in Table 196 and were calculated by Monte Carlo analysis, using a model implemented with @risk software. The model uses a probability distribution as an input value instead of a single fixed value.

Table 196: Uncertainties of N_2O emissions from agricultural soils

Category	Uncertainty
4 D 1 Direct soil emissions	
Mineral fertilizer application	+/- 27%
Animal waste application	+/- 25%
Crop residues	+/- 25%
Biological N fixation	+/- 50%
4 D 2 Animal production	
Emissions from animal production (grazing)	+/- 58%
4 D 3 Indirect emissions	
Leaching	+/- 25%
Atmospheric deposition	+/- 57%
4 D 4 Other (Sewage sludge application)	+/- 25%
Total	**+/- 24%**

6.4.4 Recalculations

Synthetic fertilizer use:

The S&A report 2004 noticed high inter-annual variations in N_2O emissions of sector 4 D synthetic fertilizer use. These variations are caused by effects of storage as well as the difference between the calendar year and the agricultural economic year: the amounts of synthetic fertilizers over the years reflect the amounts sold in one calendar year. However, the economic year for the farmer does not correspond to the calendar year. Not the whole amount purchased is applied in the year of purchase. Considering these effects, in this submission the arithmetic average of each two years was used as fertilizer application data.

Animal Numbers

In Austria animals of category *Other* which mainly is deer (but not wild living animals) have been counted from 1993 on. As recommended in the centralized review, the animal number of 1993 was used for the years 1990 to 1992.

4 D 3 Atmospheric nitrogen deposition:

Following a recommendation of the centralized review (October 2004), in contrast to the last submission also N volatised in housing, storage and pasture was taken into account. Now, in accordance with the IPCC good practice, the value $Frac_{GASM}$ relates to N excreted by livestock and not to $Nex_{\text{left for spreading}}$.

4 D 4 Sewage Sludge:

In the previous submission N_2O and CH_4 emissions from sewage sludge application were reported under category 4 D 1. Following a recommendation of the centralized review (October 2004) sewage sludge spreading is now reported under *4 D 4 Other.*

Table 197: Difference to submission 2003 of N_2O emissions from Category 4 D Agricultural Soils

IPCC Category 4D AGRICULTURAL SOILS [N_2O]													
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
4 D	0.01	-0.52	1.51	-0.46	-0.80	0.81	0.27	-0.46	0.52	0.03	-0.08	-0.09	0.41
4 D 1	-0.14	-0.46	0.78	-0.41	-0.61	0.37	0.05	-0.39	0.20	-0.09	-0.16	-0.17	0.15
4 D 2	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 D 3	0.11	-0.10	0.68	-0.09	-0.22	0.40	0.18	-0.10	0.28	0.09	0.05	0.05	0.24
4 D 4	NE-> 0.02	NE-> 0.02	NE-> 0.02	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03	NE-> 0.03

6.5 Field Burning of Agricultural Waste (CRF Source Category 4 F)

6.5.1 Source Category Description

Key Source: No

Emissions: CH_4, N_2O

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 the category *Field Burning of Agricultural Waste* to the total emissions is very low.

In the year 2003 total emissions from this category amounted to 1.6 Gg CO_2 equivalent, this is a share of 0.02% in total GHG emissions from agriculture. CH_4 and N_2O emissions for the years from 1990 to 2003 are presented in Table 198.

Table 198: Greenhouse gas emissions from Category 4 F Field Burning of Agricultural Waste 1990-2003

	CH_4	N_2O
1990	0.07	0.001
1991	0.07	0.001
1992	0.06	0.001
1993	0.06	0.001
1994	0.06	0.001
1995	0.07	0.001
1996	0.06	0.001
1997	0.07	0.001
1998	0.07	0.001
1999	0.07	0.001
2000	0.06	0.001
2001	0.07	0.001
2002	0.07	0.001
2003	0.06	0.001
Trend	*-7.6%*	*-6.8%*
Share in Agriculture	*0.02%*	*0.01%*

6.5.2 Methodological Issues

6.5.2.1 Cereals/ Wheat (4 F 1 a)

Following a recommendation of the Centralized Review 2003 the IPCC method with default emission factors was applied.

According to an expert judgement from Dr. Reindl from the *Presidential Conference of Austrian Agricultural Chambers*, about 2 500 ha of straw fields are burnt every year (this corresponds to about 0.3% of total area under cereals).

Following the guidelines, a default value of 0.90 for fraction oxidised was used. For cereals the default values of wheat were taken (IPCC GPG Table 4-17). For dry matter fraction an Austrian specific value of 0.86 was used [LÖHR 1990].

6.5.2.2 Other (4 F 5)

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 used.

Activity data (viniculture area) are taken from the Statistical Yearbooks 1992-2002 [STATISTIK AUSTRIA]. 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 199: Activity data for 4 F Field Burning of Agricultural Waste 1990–2003

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377
1991	58 364	4 377
1992	58 364	4 377
1993	57 216	4 291
1994	57 216	4 291
1995	55 628	4 172
1996	55 628	4 172
1997	52 494	3 937
1998	52 494	3 937
1999	51 214	3 841
2000	51 214	3 841
2001	51 214	3 841
2002	51 214	3 841
2003	51 214	3 841

The emission factors (4 828 g CH_4 /t and 49.7 g N_2O/t burnt wood) were calculated by multiplying the emission factors of 7 kg N_2O/ TJ and 680 g CH_4 /TJ [JOANNEUM RESEARCH, 1995] with a calorific value of 7.1 MJ/kg burnt wood which corresponds to burning wood logs in poor operation furnace systems.

7 LAND USE, LAND USE CHANGE AND FORESTRY (CRF SOURCE CATEGORY 5)

7.1 Sector Overview

This category comprises CO_2 emissions and removals arising from land use, land use change and forestry, emissions of other GHG are not estimated.

The following table presents emissions and removals from this sector by sub categories.

Table 200: CO_2 emissions and removals from Sector 5 LULUCF by sub categories

	Greenhouse gas emissions/removals [Gg CO2 equivalent]										*Trend BY-2003*
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	
5 Total	-9 013	-7 046	-5 192	-11 690	-12 707	-12 637	-13 646	-13 345	-11 311	-12 773	*41.7%*
A. Forest Land	-9 271	-7 358	-5 503	-11 978	-12 994	-12 925	-13 933	-13 632	-11 598	-13 060	*40.9%*
B. Cropland	115	117	117	116	116	116	116	116	116	116	*1.4%*
C. Grassland	116	144	144	131	131	131	131	131	131	131	*13.4%*
D. Wetlands	2	4	4	3	3	3	3	3	3	3	*45.5%*
E. Settlements	10	18	18	14	14	14	14	14	14	14	*45.5%*
F. Other Land	16	29	29	23	23	23	23	23	23	23	*44.3%*

As can be seen from the table, the Sector *Land Use, Land Use Change and Forestry* is a net sink in Austria.

The most important sub category is *5 A Forest Land*, in particular its sub source *5 A 1 Forest Land remaining Forest Land*. This category is a net sink for CO_2, whereas all other sub categories are sources of CO_2 emissions. However, total emissions arising from the other sub categories amount only 2-3% of removals from *5 A Forest Land*.

7.1.1 Emission Trends

In 2003, removals from that category corresponded to 17% of total GHG in Austria (without LUCF), compared to 15% in the base year, they increased by 41.7% from the base year to 2003, mainly due to an increase of the carbon stock in forest land.

7.1.2 Methodology

The methodology for estimating emissions from this category is described in the sub chapters 7.2 and 7.3. Following the methodology of the actual emission/removal calculations, all land use changes from forest land (which are sub categories of 5 B – 5 F) are included in the methodological description of *5 A 2 Land converted to Forest Land*.

Table 201 presents land use data and data for land use changes for the year 1990 for Austria as used for the calculations.

Table 201: Land use and LUC data for Austria for the year 1990

	Area 1990 [1 000 ha]	LUC 1990[(1)] [ha]
Total forest	3 893	6 253
Exploitable forest	*3 338*	*2 480*
Non-exploitable forest	*560*	*3 773*
Arable land (incl. commercially used gardens)	1 341	-5 413
Meadows and pastures	1 093	-9 978
Meadows	*896*	*-6 188*
Pastures	*197*	*-3 790*
Alpine grassland	893	3 140
Grassland	1 939	-6 838
Vineyards, orchards and gardens	136	861
Other productive area[(2)]	67	1 212
Wetlands	133	370
Sealed areas	234	3 553
Other non-productive areas	634	0
TOTAL	**8 386**	**0**

(1) (year – (year-1)) with 5 year average as basis

(2) abandoned grassland, plantations for biomass production, tree nurseries and gardens and Christmas tree plantations

7.1.3 Completeness

Table 202 gives an overview of the new IPCC categories included in this chapter and the corresponding sub-divisions for which the actual calculations are made. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this subcategory have been estimated; for LULUCF only CO_2 emissions/removals are estimated.

Table 202: IPCC categories according to the IPCC-Good Practice Guidance for Land-Use, Land-Use Change and Forestry.

IPCC categories[33]/ Sub division for calculation	Description	Status for CO_2
5 A	Forest land	
5.A.1	Forest land remaining forest land	✓
Coniferous	Increase, decrease, net change of carbon stock	✓(gG C)
Coniferous	Net carbon stock change in dead organic matter	NE
Coniferous	Net carbon stock change in soils	NE
Deciduous	Increase, decrease, net change of carbon stock	✓(gG C)
Deciduous	Net carbon stock change in dead organic matter	NE

33 IPCC categories33 – applied according to the "Good Practice Guidance for LULUCF (2003)"

Deciduous	Net carbon stock change in soils	NE
5.A.2	Land converted to forest land	□
5.A.2.1	Cropland converted to forest land	□
5.A.2.2	Grassland converted to forest land	□
5.A.2.3	Wetlands converted to forest land	□
5.A.2.4	Settlements converted to forest land	□
5.A.2.5	Other land converted to forest land	□
5.A.1_BiomassBurn_contr.	Biomass Burning: Controlled: Forest land remaining forest land	NO
5.A.1_BiomassBurn_wildfires	Biomass Burning: Wildfires: Forest land remaining forest land	IE(1)
5 B	Cropland	□ (2)
5 C	Grassland	□ (2)
5 D	Wetlands	□ (3)
5 E	Settlements	□ (3)
5 F	Other Land	□ (3)

(1) CO_2 emissions caused by wildfires (CRF Table 5(V)) are included in the category 5.A.1. Data on the area affected by wildfires are available for the years 1992 to 2002[34].

(3) Only cropland remaining cropland (grassland remaining grassland) and forest land converted to cropland (and grassland, respectively) are estimated

(3) Only conversion from forest land is estimated

7.2 Forest Land (5 A)

3.96 Mio ha (47.2%) of Austria are forest land [BFW, 2004a]. 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 320 ± 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 [Weiss et al., 2000].

Emission/Removal trends of Forest Land

With regard to forest land the annual net CO_2 removals under sector 5 of the reported period 1990 – 2003[35] range from 5 384 Gg CO_2 to 13 838 Gg CO_2 (mean: 10 619 Gg CO_2). The most relevant parts derive from the sub-category 5.A.1 (Forest Land remaining Forest Land), whereas land use changes to forests (5.A.2) and from forests (5.B.2 to 5.F.2) have only minor influence on the net CO_2 balance.

For the years between two observation periods data on increments and harvests of forest biomass were taken from the next following period.

For the year 2003 the means for the last period (2000 to 2002) of the National Forest Inventory (NFI) have been reported.

34 In the 90-ies the annual maximum area affected by forest fires in Austria was 135 ha, but usually this annually affected area is much lower. Hence, biomass losses and emissions of other GHGs by forest fires are negligible

35 For the year 2003 the means for the last period (2000 to 2002) of the National Forest Inventory (NFI) have been reported

As already reported in previous submissions [e.g. UMWELTBUNDESAMT, 2004], changes in the Austrian forest biomass also resulted in a net carbon sink in the years before 1990. In the period 1961 to 1989 the mean annual net carbon sink amounted to 8 305 Gg CO_2 (from 3 718 Gg CO_2 to 13 526 Gg CO_2 with an uncertainty of ±2.743 Gg CO_2). Between 1980 and 1996 the net carbon sink of this category equals to about 15% of the gross CO_2 equivalent emissions of the GHGs CO_2, CH_4 and N_2O in this period [Weiss et al., 2000].

According to the new reporting tables for Land Use, Land Use Change and Forestry increments and losses at areas of land use change to and from forests (incl. also non-productive forests) must be taken into account. Therefore the figures of previous reports are not exactly comparable with the actual figures. For forest land the new calculation of the CO_2 net removals of the category 5 show slightly lower figures of at most 0.5%, whereas the figures reported for the category 5.A (Forest land) are slightly above results of previous submissions.

Details on the methodology, uncertainty assessment, quality assurance, quality control and verification are given in each sub chapter.

For the reported period 1990 to 2003 the total annual net CO_2 removals (only biomass) from land use changes to forest range from about 27 Gg CO_2 to 63 Gg CO_2. The total annual emissions (only biomass) from land use changes from forests vary between 65 Gg CO_2 and 119 Gg CO_2. These figures are in the order of approximately ± 1% of the annual net CO_2 removals under sector 5.

Table 203: CO_2 removals/emissions from IPCC Category 5 for Forest Land from 1990-2003

	GHG removals/emissions [Gg CO2]									*Trend BY-2003*
	1990	1996	1997	1998	1999	2000	2001	2002	2003	
5[36]	9 205.87	5 384.13	11 882.99	12 899.64	12 829.99	13 838.45	13 537.31	11 503.50	12 965.09	*40.8%*
5.A	9 271.23	5 503.20	11 977.78	12 994.43	12 924.78	13 933.24	13 632.10	11 598.29	13 059.89	*40.8%*
5.A.1	9 243.38	5 440.29	11 928.71	12 945.35	12 875.70	13 884.16	13 583.03	11 549.21	13 010.81	*40.8%*
5.A.2	27.86	62.91	49.08	49.08	49.08	49.08	49.08	49.08	49.08	*76.2%*
5 Forestland Conv	35.36	119.07	94.79	94.79	94.79	94.79	94.79	94.79	94.79	*168%*

7.2.1 Forest Land remaining Forest Land (5 A 1)

7.2.1.1 Methodological Issues

Activity data

A national method is applied which follows the new IPCC – Good Practice Guidelines for Land Use, Land Use Change and Forestry (2003). The use of country specific conversion factors provides more accurate and appropriate figures for the Austrian forests. The main basis of the estimates are measured data on the forest area, volume increment of the growing stock and harvest (for both stem wood over bark with a diameter at breast height > 5 cm) according to the Austrian National Forest Inventory (NFI - [SCHIELER et al., 1995], [BFW, 2004a,b], [WINKLER,1997]). The NFI was carried out in the periods 1961-70, 1971-80, 1981-85, 1986-90, 1992-96 and 2000/02.

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. In addition to the NFI harvest data,

36 Considering only LULUC from and to forest land

which are based on measurements in the forests, further harvest statistics exist: the annually reported records of wood felled and the Austrian wood balance [BITTERMANN and GERHOLD 1995], [BMLF 1964-2003]. These statistics are not based on measured data. Therefore, it is assumed that the NFI provides more accurate figures on the harvest and for this reason the estimates are based on NFI harvest figures. However, the results of the other statistics are used to derive "relative harvest indices for individual years"(see below). In addition, the absolute harvest figures of these statistics are also included in the uncertainty analysis to guarantee an overall consistency of the calculated figures (see below).

Further comments for a better understanding of the NFI increment and harvest data:

The NFI increment data include all possible reasons for biomass increments and losses in the forests. This means that biomass increments due to abandonment of managed land and regrowth by forests or biomass losses due to e.g. traditional (non-commercial) fuel wood consumption, forest land conversion, forest fires (wild-fires) and other damages are already considered in calculations based on the NFI data.

In order to fulfil the requirements of the new reporting format and to report on the category "Forest land remaining forest land (5 A 1)", estimations of the emissions and removals due to annual land use changes from and to commercial forests had to be made and subtracted from the total net CO_2 figures. The approaches on calculating CO_2 emissions and removals related to land use changes are described in more detail in chapter 1.3.

The NFI provides means of annual increment and harvest for the individual periods. Instead of using these means or interpolated values for single years, these NFI means are converted with indices[37] to obtain annual data of increment and harvest. For harvest these relative indices are derived from further national statistics on harvest which are the annually reported records of wood felled [BMLF 1964-2003] and the wood balance [BITTERMANN and GERHOLD 1995], which provides data until 1996. For increment a representative Austrian set of tree ring cores [HASENAUER et al. 1999a, b] is used to calculate the relative indices. These indices are available until 1994 but the amendment of the figures 1995 to 2002 based on the results of the recent NFI is planned for the next submission. The means of these estimated annual data on increment and harvest for a certain inventory period are equal to the measured periodic means provided by the NFI. This method allows more accurate estimates of the figures for individual years for the category 5 A 1. The figures for annual growth and for annual harvest differ year by year for several reasons (e.g. weather conditions; timber demand and prices, wind throws). Such reasons for different growth and different harvest in individual years explain the high annual variations in the CO_2 net removals by the Austrian forests.

Conversion factors

Conversion factors are used to convert the measured m^3 stem wood over bark (o.b.) to t carbon increment and t carbon harvest of the whole trees (including also below ground biomass).

These conversion factors are not based on default values given by the IPCC (1997) but on estimates, which give more accurate figures for the Austrian forests. These estimates of the used conversion factors are based on the species and age class composition of increment and harvest according to NFI and literature values for the wood densities for all individual tree species (compiled in [KOLLMANN, 1982], [LOHMANN, 1987]), literature values on the dry mass relations of stem wood to the other tree compartments for the main tree species in Austria and

37 Values for the relative variation in the individual years of the time series

for individual age classes (compiled in [KÖRNER et al., 1993]) and literature values on C contents for individual tree compartments and species (see Table 204). The conversion factors are calculated for each inventory period and separately for increment and harvest respectively.

Further details on the approach and methodology are given in [WEISS et al., 2000].

Table 204: Conversion factors for the Austrian forests [WEISS et al. 2000]

Conversion factors	Coniferous	Deciduous
m^3 o.b. t dm (stemwood)	0.39	0.53
t dm stemwood → t dm whole tree (incl. also below ground biomass)		
increment	1.45	1.46
harvest	1.54	1.50
t dm whole tree → t C whole tree	0.49	0.48

The time series of accurate and measured values for individual years ends with the year 2002. For 2003 the means for the last inventory period (2000/02) are reported.

7.2.1.2 QA/QC, Verification, Uncertainty Assessment

Since the results of the CO_2 removals reported for the new category 5 A 1 derive from the same data base and show only minor changes compared to the results in sector 5 A of previous reports, the QA/QC, the verification and the uncertainty assessment of the previous calculations is still valid.

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 [SCHIELER and HAUK, 2001]). The calculation of the data for category 5 A 1 is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 1.6):

The calculation of the uncertainty of the reported data for category 5 A 1 takes into account:

• The statistical uncertainty of the forest inventory,

• The uncertainty related to the calculation of annual data,

• The uncertainty related to the missing consistency of different statistics[38]

• and the uncertainty of each conversion and expansion factor.

The estimates of the uncertainty include a consistency approach with other national statistics.

Because of the differing quality of the data classic statistical approaches were not always adequate. For instance, the uncertainties of the conversion factors were estimated in a pragmatic as well as conservative way (Table 205, details are described in [WEISS et al., 2000]). Such an approach takes into account that the conversion factors were not measured by a systematic inventory (like NFI) but derived from a few local ecosystem studies (expansion

38 e.g.: There are three different Austrian statistics for annual harvest: measured harvest according to NFI, national annual records of wood felled, and the national wood balance.

factors) and literature data on wood densities and C contents. Therefore, the uncertainty related to these conversion factors is comparably higher than the one of the systematically measured stem wood volume of increment and harvest. Error propagation was used to calculate the overall uncertainty.

Table 205: Relative uncertainties of the used data for the calculations [WEISS et al. 2000]

	Relative uncertainties [%]				
	Forest inventory	Uncertainty related to the calculation of annual data and to the necessary consistency of different statistics	Conversion factor „m^3 o.b. → t dm"	Conversion factor „t dm stemwood → t dm whole tree"	Conversion factor „t dm → t C"
Increment	2.0	3.2	11.1	6.5	2.0
Harvest	3.5	12.2			

7.2.1.3 Recalculations

The extrapolation of trends for increment and harvest 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 the increment did not increase as in the years before. A use of means for increment and for harvest, which are based on the latest NFI results, for years after the latest NFI provides more reliable figures than an extrapolation of trends which are rather uncertain. This is particularly true for increment which strongly depends on weather conditions, but also for harvest, when - for instance – storm fellings are taken into consideration. The revision of these means and constant figures for the year 1991 and the years between 1997 and 1999 have been carried out.

7.2.1.4 Planned improvements

CO_2 emissions and removals from net carbon stock changes in dead organic matter and soils are not estimated at the moment. As given in the introduction, Weiss et al. (2000) estimated the carbon-stock of the Austrian forest soils by using data of the Austrian forest soil survey (humus layers and mineral soil layers 0-50 cm were sampled at the grid points of an 8,7 x 8,7 km grid across all Austria in the period 1987 to 1989; FBVA 1992). Similar carbon stock estimates are also available for the Austrian agricultural soils (see UNFCCC submission 2000). The changes in the carbon content of the soils are very small and slow and so far no reassessments of the Austrian soil inventories have taken place that would allow estimates for the carbon stock changes of the soils. Modelling approaches were used to estimate the carbon stock change of the Austrian forest soils in the period 1961 to 1996 [WEISS et al., 2000]. According to these estimates it is assumed that the Austrian forest soils were a carbon sink of about 10% of the net carbon sink of the forest biomass in the period 1961–1996. However, these results have to be considered as hypothetical because repeated soil measurements are missing, which would help to verify the modelled carbon stock changes. It is planned to carry out such a reassessment of the forest soil inventory in the near future. This will allow providing measured figures for the carbon stock changes in this category.

7.2.2 Land Use Changes to and from Forest Land (Categories 5 A 2 and 5 B 2.1, 5 C 2.1, 5 D 2.1, 5 E 2.1, 5 F 2.1).

7.2.2.1 Methodological Issues

Activity data

Areas were land use changes to and from forests take place are generally very small in Austria. By means of the NFI, which follows a regular grid of 4 x 4 km (see also 1.2.1.1) land use changes can only be observed by chance and therefore the number of grid points with observed land use change is small. Therefore the estimates for land use changes from and to forest uses have a significantly higher uncertainty compared to the uncertainty for the total forest land (see below).

In case a land use change has been observed at an inventory point of the last NFI (2000/02) the type of the neighbouring non-forest land was recorded. The evaluation of 2/3 of such forest boundary points led to the land use statistic shown in the tables 4 and 5. It is assumed, that the other third follows the same distribution.

The total increase of forest area from 1997 to 2002 was 68,000 ha (total forest area). The loss of forest area for the same period was calculated with about 32,000 ha, leading to a net increase of the total forest area of about 36,000 ha (19.000 ha for the productive forest) for the years 1997 to 2002.

Table 206: Land use changes to forest area (%, ha) of the total increase of the forest area observed for the period 2000/02 [based on BFW, 2004a]

Categories of land use changes according to the IPCC GPG 2003	Land use changes to forest land (% total increase of forest land)	Land use changes to forest land [1000 ha]
Cropland (5 A.2.1)	16.0	10.9
Grassland (5 A.2.2)	59.0	40.3
Wetlands (5 A.2.3)	5.0	3.4
Settlements (5 A.2.4)	14.0	9.6
Others (5 A.2.5)	6.0	4.1
Total	100.0	68.3

Table 207: Land use changes from forest area (%, ha) of the total loss of the forest area observed for the period 2000/02 [based on BFW, 2004a]

Categories of land use changes from forests according to the IPCC GPG 2003	Land use changes to forest land (% total increase of forest land)	Land use changes from forest land [1000 ha]
Cropland (5 B.2.1)	5.0	1.6
Grassland (5 C.2.2)	53.0	16.8
Wetlands (5 D.2.3)	3.0	0.9
Settlements (5 E.2.4)	15.0	4.8
Others (5 F.2.5)	24.0	7.6
Total	100.0	31.8

As shown in Table 206 and Table 207 the land use changes to and from forests mainly appear from/to grassland sites (59% or 53%, respectively). The Land use changes from or to other categories are far below this value and should only be seen as relative figures, due to a high degree of uncertainty (see 1.3.1.2).

For the years before 1997 it was assumed that the land use changes between two observation periods show the same ratio of distribution as in the latest inventory because only the total amount of land use decrease and loss is available for all the observed periods.

The annual increment of stemwood over bark (o.b.) on areas which have become forests was estimated with 3 m^3/ha.

The annual average loss of stemwood o.b. on lost forest areas was estimated with 31.2 ± 8.1 m^3/ha for coniferous and 6.5 ± 1.9 m^3/ha for deciduous trees (in total 13.8 ± 2.9 m^3/ha).

Conversion factors

In Table 208 the conversion factors for the total above ground biomass (with no further division into coniferous and deciduous) is shown.

Table 208: Conversion factors for land use changes to forest land.

Conversion factors	Total biomass (conif. and dec.)
m^3 stemwood o.b.→ t dm whole tree (incl. also below ground biomass)	
increment	0.8
harvest	0.72
t dm whole tree → t C whole tree	0,49

7.2.2.2 Uncertainty Assessment

The results of the NFI provide very accurate and reliable data on the increment, harvest, distribution of tree species and other characteristics of the Austrian forest as a whole. The regular grid of 4 x 4 km is an appropriate way to meet this information. It is obvious, that only a few of the observed grid points of the NFI by chance describe a forest boundary, where land use changes can be detected. Therefore a high uncertainty on the results of the categories on land use changes must be considered.

7.3 5 B Cropland and 5 C Grassland

In this category emissions/removals from cropland and grassland management are considered.

Some sub sources are not relevant for Austria (e.g. slash and burn etc.), and for some not sufficient data for emission estimation was available (e.g. changes of tillage practices).

Emissions/Removals where thus only estimated for the sub categories and related sources/sinks as shown in Table 209.

Table 209: Sources (or sinks) considered for cropland and grassland management

Category / source or sink
5 B 1 Cropland remaining Cropland
- carbon stock change of living biomass on perennial cropland

Category / source or sink
- carbon stock change due to changes in organic matter input (harvest residues) to cropland soils
- CO_2 emissions due to liming of cropland and grassland
5 C 1 Grassland remaining Grassland
- carbon stock change in grassland soils due to abandonment of grassland

Emission were only estimated for 1990, the same value was reported for all years.

The following table presents emission and removals estimates from cropland and grassland management.

Table 210: Emissions from cropland and grassland management in 1990

Category	Net carbon stock change [Gg CO_2]		Net CO_2 emissions [Gg]
	biomass	soils	
5 B 1 Cropland remaining Cropland	132.63	-136.62	3.99
5 C 1 Grassland remaining Grassland		81.06	81.06
Liming of Cropland and Grassland (reported in 5 B Cropland)			107.49

7.3.1 Methodological Issues

Note: most calculations are based on the methods described in the "Draft IPCC Good Practice Guidance for LULUCF" released in May 2003. The revised version draft guidelines that were published in October 2003 were also considered in some respects, but not all of the new calculation methods and emission factors could be incorporated. A first look at the new versions made it obvious that major changes have meanwhile occurred (e.g. compare calculations of stock changes for cropland remaining cropland-biomass changes). However, for a first estimate, and considering the low contribution to total emissions, the methodologies seem appropriate.

Emissions were estimated applying the IPCC Tier 1 methodology, except for soil carbon stocks, where a country specific methodology was used.

Below the source of activity data is explained, in the following sub chapters the methodologies and emission factors used for calculation of emissions of by sub category is explained.

Activity Data

The IPCC-GPG (Oct 2003) describe three different approaches for representing land areas using the above listed categories:

1) The first approach identifies the total area for each individual land use category. It does not require detailed information on changes of land areas between the different categories and is only spatially explicit at the national or regional level.
2) The second approach provides information of the changes between the categories, but also lacks the spatial relation of the different areas.

3) The third approach provides information of the changes and also the spatial basis of each area.

Existing data about land-use change in Austria is in accordance with approach (1), it was taken from [Geisler and Jonas, 2001] and [Jonas and Nielsen 2002], in which the original national statistic data have been used to calculate an area-consistent LUC data base of Austria[39].

To improve this information about land use changes, a set of rules based on expert judgement was defined. Together with these rules land-use information similar to approach (2) was generated[40].

Rules that determine the land use change processes in Austria:

R1: Increase of abandoned grassland has its origin in grassland.

R2: Increase of wetland has its origin exclusively from grassland.

R3: Loss of grassland, which is not an increase of "abandoned grassland" or "wetland" leads to an increase of forest land.

R4: Increase of sealed land comes from arable land (cropland).

R5: Increase of vineyards and orchards come from arable land (cropland).

R6: Increase of plantations (biomass production, tree nurseries and Christmas tree plantations) come from old vineyards and orchards.

R7: Losses of vineyards and orchards which are not included in new plantations are included in forest increase.

R8: Decrease of abandoned grassland leads to an increase of forest land.

The following table shows a model based on the relations between the different land use categories as expressed in the rules.

[39] Values obtained from these studies slightly differ from official statistical data for different land-use classes, as data had to be harmonized over the time series due to changes of the methodology: e.g. in the year 1983 the unit for reporting land-use changes to national statistics was officially changed from 0.5 to 1 ha; which results in a sudden decline of orchard areas by nearly 50%.

[40] It should be noted that this approach can only take into account net changes of land-use. This means that in case grassland is converted to cropland, but at the same time the same amount of cropland is converted to grassland the net land-use distribution will remain the same. The actual changes that have occurred and might have different effects on GHG emissions and uptake cannot be reflected appropriately with the available land-use data, that reflect only net changes of land-use but not the full dynamics of it. An improvement of this limitation could only be achieved by the development of spatially explicit land-use information with sufficient time resolution to track land-use changes.

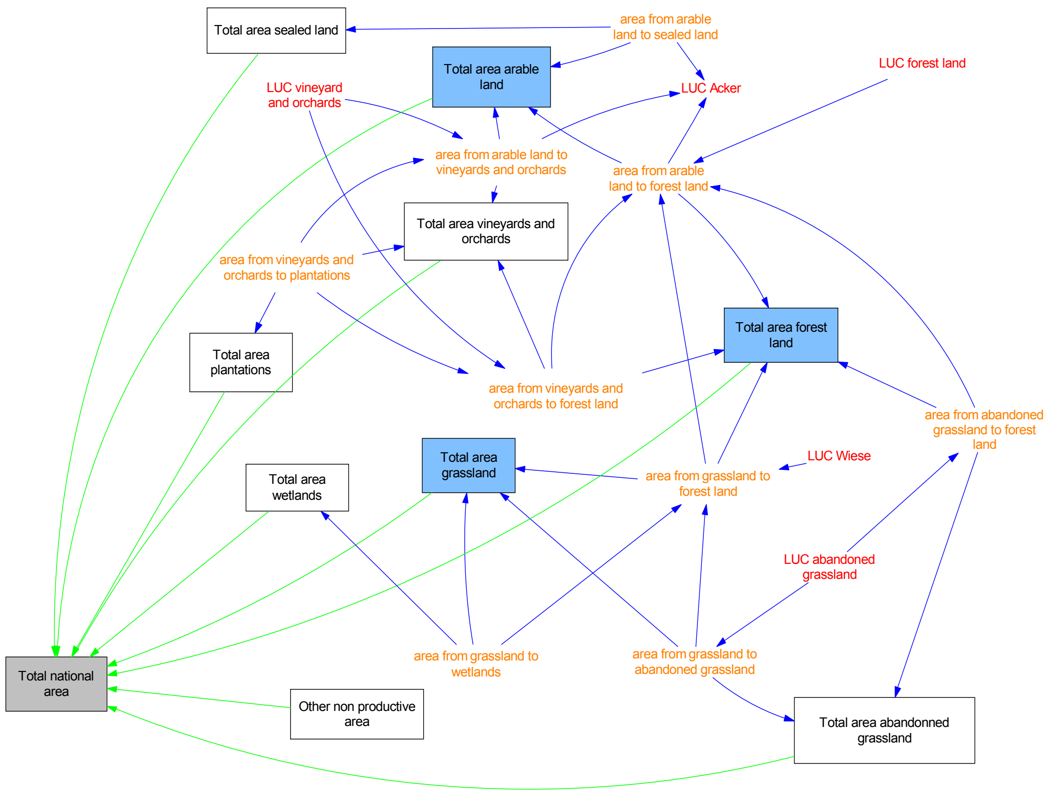


Figure 17: Model for land use changes

With the current availability of data and knowledge it is not feasible to produce verifiable time series of emission/removal estimates for cropland/grassland management (activities relating to Article 3.4 of the Kyoto Protocol). The main reason is that such an estimate would require spatially explicit land-use and soil management data for the period preceding the base year 1990, i.e. 1970-1990. Such data are not available in Austria and do not seem to be available easily in the near future.

7.3.1.1 Cropland: changes in carbon stocks in biomass

For calculating the carbon stock change of living biomass on perennial cropland the following formula was applied:

*Annual change in biomass= Area of perennial cropland * Carbon accumulation rate*

For the carbon accumulation rate the IPCC default value of 2.1 t C / ha.yr was used.

The area of perennial cropland was taken from the studies as explained above (under Activity Data).

The following woody crops were relevant: vineyards, orchards, plantations for biomass production, Christmas tree plantations and tree nurseries and gardens.

7.3.1.2 Cropland: changes in carbon stocks of soils

Emissions were calculated using a country specific methodology.

The methodology followed closely the formula presented by the IPCC guidelines, where the original IPCC formula also included a tillage factor, which was not considered in the country specific methodology as information was not available[41].

The formula used for calculating the change in carbon stocks of cropland soils was:

*Annual net change of C in soils = [(SOC * $Area_t$ * Input factor) – (SOC * $Area_{(t-10)}$ * Input factor)] / 10*

where SOC is the soil organic carbon content – the Austrian specific value of 50 t C/ ha for 0-30 cm depth of cropland taken from [Gerzabek et al., 2003] was used.

For the input factor the IPCC default values were used:

- 0.9 for crops with low input (cereals and fodder maize),
- 1.1 for crops with high input (clover)
- 1.0 for crops with medium input (fodder cereals, legumes, beets, potatoes, oil seeds, other crops)

7.3.1.3 Grassland: changes in carbon stocks of soils

In this chapter the net CO_2 emissions/removals due to the change in grassland use (abandonment of grassland) is considered.

Emissions were calculated using the IPCC Tier 1 methodology.

According to the IPCC GPG, the carbon stock of "improved grassland" is 10% higher than the carbon stock of "generic grassland". This factor of -0.1 was applied to calculate the carbon stock change due to abandonment of grassland:

*Carbon loss = Area of abandoned grassland * SOC * (-0.1)*

For the figure of soil organic carbon (SOC) of improved grassland a value of 70 t C/ ha for 0-30 cm depth taken from [Gerzabek et al., 2003] was used.

However, Austrian specific values for extensive alpine grassland show a significantly higher carbon storage capacity for alpine grasslands (which are unimproved extensive grasslands): 70 t C/ ha for improved grassland versus 104 t C / ha for extensive alpine grassland. Thus it is not realistic for Austria to use the IPCC default values of carbon stock changes. It might be more appropriate to assume that there are no significant changes in soil carbon content after abandonment.

However, as a first estimate to obtain an idea of the relevance of emissions from this category, the IPCC default value was used.

7.3.1.4 CO_2 emissions due to liming of cropland and grassland

The amount of lime applied to grassland and cropland soils was based on expert judgment as no statistical data is available, the following information was used:

- 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.yr.

[41] The "base factor" included in the IPCC formula is considered in the Austrian specific values for content of organic carbon in soils.

- however, according to expert judgement only 25% of this recommended value is actually applied
- additionally it has to be considered that about 60% of Austrian croplands and grasslands need no liming as they are based on carbonate ground rock

--> this results in a factor of **0.07 t lime /ha.yr**

For calculating CO_2 emissions from the amount of lime applied the IPCC default value was used.

7.3.2 Uncertainty assessment

The following uncertainties were estimated, they are based on uncertainty estimates for IPCC default values taken from the GPG (as for most sources these default values were used), and on expert judgment:

- cropland/ changes in carbon stocks in biomass: 78%
- cropland/ changes in carbon stocks in soils: 15%
- grassland/ changes in carbon stocks in soils: 100%
- liming of cropland and grassland: 54%

8 WASTE (CRF SECTOR 6)

8.1 Sector Overview

This chapter includes information on and descriptions of methods for estimating greenhouse gas emissions as well as references of activity data and emission factors concerning waste management and treatment activities reported under IPCC Category *6 Waste*.

The emissions addressed in this chapter include emissions from the IPCC categories 6 A Solid Waste Disposal on Land, 6 B Wastewater Handling, 6 C Waste Incineration and 6 D Other Waste (Compost Production).

Waste management and treatment activities are sources of methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions.

8.1.1 Emission Trends

Table 211 presents greenhouse gas emissions for the period from 1990 to 2003 for the IPCC Category *6 Waste*.

Overall greenhouse gas emissions from waste management and treatment activities during the year 2003 amounted to 3 414.59 Gg CO_2 equivalent. This are about 3.7% of total greenhouse gas emissions in Austria in 2003 and 5.7% in the base year. In 2003, greenhouse gas emissions from the waste sector were 24% below the level of the base year. Figure 18 shows the trend of GHG emissions from this category from 1990 to 2003.

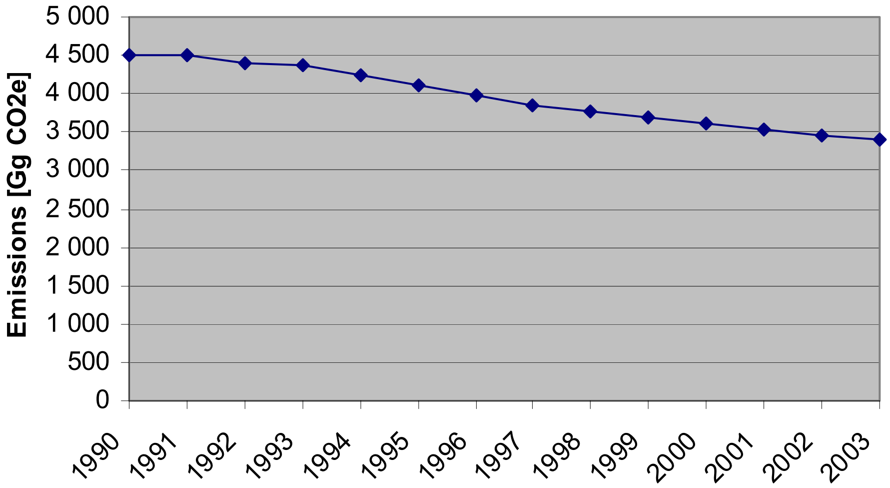


Figure 18: GHG emissions from IPPC Sector 6 Waste 1990-2003

Table 211: Emissions of greenhouse gases and their trend from 1990-2003 from category 6 Waste

	CO_2 [Gg CO_2 e]	CH_4 [Gg CO_2 e]	N_2O [Gg CO_2 e]	Total [Gg CO_2 e]
1990	20.70	4 441.34	41.06	4 503.10
1991	18.45	4 433.95	42.71	4 495.12

1992	7.55	4 348.71	48.07	4 404.33
1993	8.50	4 307.52	55.64	4 371.66
1994	9.75	4 145.90	79.77	4 235.43
1995	10.09	3 985.85	106.46	4 102.39
1996	10.40	3 831.59	129.73	3 971.72
1997	10.70	3699.54	139.99	3 850.23
1998	10.99	3 599.74	167.63	3 778.36
1999	11.31	3 496.70	187.84	3 695.85
2000	11.28	3 379.83	210.86	3 601.98
2001	11.24	3 272.62	246.13	3 529.99
2002	11.27	3 208.86	244.97	3 465.11
2003	11.27	3 156.61	246.70	3 414.59
Trend 1990-2003	-45.6%	-28.9%	500.8%	-24.2%

Emission trends by greenhouse gas

Table 212 presents greenhouse gas emissions from the sector *Waste* for the base year (1990) and for 2003 as well as their share in greenhouse gas emissions from this sector.

Table 212: Greenhouse gas emissions from the Waste sector in the base year and in 2003.

Greenhouse gas emissions	Base year*	2003	Base year	2003
	CO_2 equivalent [Gg]		[%]	
Total	4 503.1	3 414.6	***100%***	***100%***
CO_2	20.7	11.3	*0.5%*	*0.3%*
CH_4	4 441.3	3 156.6	*98.6%*	*92.4%*
N_2O	41.1	246.7	*0.9%*	*7.2%*

**1990 for CO_2, CH_4 and N_2O*

The major greenhouse gas emissions from this sector are CH_4 emissions, which represent 92.4% of all emissions from this sector in 2003 compared with 98.6% in 1990, followed by N_2O (7.2% 2003 and 0.9% 1990 respectively) and CO_2 (0.3% 2003 and 0.5% 1990 respectively).

CH_4 emissions

CH_4 emissions from the sector *Waste* have decreased by 28.9% since 1990 (see Table 211) as a result of waste management policies: the amount of land filled waste has decreased and in addition the implemented methane recovery systems have increased during the period.

CH_4 emissions originate from most subcategories within the sector but the largest source is *Solid Waste Disposal on Land*.

N_2O emissions

N_2O emissions from the waste sector have remarkably increased over the considered period (see Table 211). In 2003, N_2O emissions from the Waste sector amounted to 246.70 Gg CO_2 equivalent. This was 500% above the level of the base year.

N_2O emissions mainly arise from the category Other Waste (Compost production) but also from *Wastewater Handling* (*Domestic and Commercial Wastewater* and *Industrial Wastewater*). *Waste Incineration* (*Municipal Solid Waste* and *Waste Oil*) is a minor source of N_2O emissions.

CO_2 emissions

CO_2 emissions of the sector Waste decreased (see Table 211). In 2003, CO_2 emissions from this sector amounted to 11.3 Gg CO_2 equivalent, this was 45.6% below the level of the base year.

CO_2 emissions originate from *Waste Incineration* (*Municipal Solid Waste, Waste Oil and Incineration of Corpses*). 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.

Emission trends by sources

Table 213 presents the greenhouse gas emissions for the period from 1990 to 2003 from the different subcategories within the IPCC *Category 6 Waste*.

Table 213: Total greenhouse gas emissions and trend from 1990–2003 by subcategories of Category 6 Waste

CO_2 equivalent [Gg]	6 A	6 B	6 C	6 D	Total
1990	4 144.07	303.40	20.85	34.78	4 503.10
1991	4 133.27	306.83	18.60	36.43	4 495.12
1992	4 042.61	310.77	7.56	43.39	4 404.33
1993	3 995.46	313.51	8.52	54.17	4 371.66
1994	3 829.35	331.93	9.77	64.37	4 235.43
1995	3 667.53	356.53	10.11	68.22	4 102.39
1996	3 511.77	378.14	10.42	71.38	3 971.72
1997	3 379.67	389.50	10.72	70.34	3 850.23
1998	3 278.70	415.87	11.02	72.78	3 778.36
1999	3 173.90	433.57	11.34	77.04	3 695.85
2000	3 056.57	457.23	11.31	76.87	3 601.98
2001	2 948.17	493.06	11.26	77.49	3 529.99
2002	2 882.74	493.12	11.29	77.96	3 465.11
2003	2 828.85	495.19	11.29	79.25	3 414.59
Trend 1990 -2003	*-31.74*	*63.21*	*-45.83*	*127.84*	*-24.17*

The dominant subcategory in the sector *6 Waste* is *6 A Solid Waste Disposal on Land*. In 2003, *Solid Waste Disposal on Land* contributed 82.5% to total greenhouse gas emissions from the sector *Waste*. However, the contribution decreased over the period: in 1990 92.3% of the greenhouse gas emissions originated from this subcategory.

6 A Solid Waste Disposal on Land

For *Solid Waste Disposal on Land,* greenhouse gas emissions decreased by 31.7% from 1990 to 2003. The main greenhouse gas originating from this subcategory is CH_4.

The decreasing amount of land filled waste and the increasing recovery rate of landfill gas causes a decreasing trend in emissions.

6 B Wastewater Handling

For *Wastewater Handling* greenhouse gas emissions increased by 63.2% from 1990 to 2003. This was mainly due to increasing N2O emissions from handling of industrial and domestic/commercial wastewater, and due to a revised methodology.

6 C Waste Incineration

For *Waste Incineration,* greenhouse gas emissions decreased by 45.9% from 1990 to 2003. This was mainly due to the shut down of the only plant for incineration of municipal waste without energy recovery in 1991, which resulted in a drop of CO_2 emissions from 1991-1992.

6 D Other Waste

This category addresses *Compost Production*. Greenhouse gas emissions from this subcategory increased by 127.8% due to the increasing amount of composted waste.

8.1.2 Key Sources

Key source analysis is presented in Chapter 1.5. This chapter includes information about the key sources in the IPCC Sector *6 Waste*. Table 214 presents the source categories in the level of aggregation as used for the key source analysis.

The key sources of *IPCC Category 6* are *6 A Managed Waste disposal on Land* and *6 B Wastewater Handling*.

Compared to last year's key source analysis, one more key category namely N_2O emissions from *Wastewater Handling* has been identified. Emissions increased compared to last years submission mainly due to the revision of calculation method. For example the amount of wastewater that is treated in sewage plants and the amount of denitrification has been updated.

In the base year, 5.32% of total greenhouse gas emissions originate from the two key sources of the sector Waste, whereas Wastewater Handling has a share of less than 0.1%. In the year 2003 3.3% of total greenhouse gas emissions originate from the sector Waste - the share of Wastewater Handling is 0.2%.

Table 214: Key sources of Category 6 Waste

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
6 A	Managed Waste disposal on Land	CH_4	LA90-LA03 TA97-TA03
6 B	Wastewater Handling	N_2O	LA90-LA02 TA97-TA03

LA00= Level Assessment 2000

TA00= Trend Assessment BY-2001

8.1.3 Methodology

Detailed information on the methodology can be found in the corresponding subchapters, where it was applied.

8.1.4 Uncertainty Assessment

In this submission uncertainty estimates based on expert judgement by Umweltbundesamt for subcategory Solid Waste Disposal on Land is provided (see respective subchapter). It is planned to provide uncertainty estimates for the second key source Waste Water Handling for the next submission as well.

8.1.5 Recalculations

Recalculations have been made for the subcategories *6 A 1 Managed Waste Disposal on Land (*see Table 224), 6 B Wastewater Handling (see Table 230) and 6 D Other Waste (see Table 238). For further information please refer to the respective subchapters.

8.1.6 Completeness

Table 215 gives an overview of the IPCCC 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 subcategory have been estimated; the grey shaded cells are those also shaded in the CRF.

Table 215: Overview of subcategories of Category Waste: transformation into SNAP Codes and status of estimation

IPCC Category	SNAP	CO_2	CH_4	N_2O
6 A SOLID WASTE DISPOSAL ON LAND				
6 A 1 Managed Waste Disposal	090401 Solid Waste Disposal on Land	NO	✓	
6 A 2 Unmanaged Waste Disposal	090402 Unmanaged Waste Disposal			
6 B WASTEWATER HANDLING				
6 B 1 Industrial Wastewater	091001 Waste water treatment in industry		✓	✓
6 B 2 Domestic and Commercial Wastewater	091002 Waste water treatment in residential/commercial sect.		✓	✓
6 C WASTE INCINERATION				
	090901 Incineration of corpses	✓	NO	NO
	090201 Incineration of municipal waste	✓	✓	✓
	090208 Incineration of waste oil	✓	NA	✓
6 D OTHER WASTE				
	091003 Sludge spreading	IE	IE	IE
	091005 Compost production	NO	✓	✓

In Austria all waste disposal sites are managed sites (also see Chapter 8.2.1.1).

Sludge spreading is included in category 4 D 1.

8.2 Waste Disposal on Land (CRF Source Category 6 A)

8.2.1 Managed Waste Disposal on Land (CRF Source Category 6 A 1)

8.2.1.1 Source Category Description

Key Source: Yes

Emissions: CH_4

In Austria all waste disposal sites are managed sites (landfills). Emissions from unmanaged deposition of waste was assumed to be negligible because it was assumed that unmanaged, deposited waste mainly consists of construction waste and other waste with no or very low biodegradable content.

In the year 2003, CH_4 emissions from managed waste disposal on land (landfills) contributed 3.0% to total greenhouse gas emissions in Austria.

Managed waste disposal on land accounts for the largest contribution to CH_4 emissions in the IPCC Category *6 Waste*.

The anaerobic degradation of land filled organic substances results in the formation of landfill gas. About 55% of this landfill gas is CH_4. Most active landfills in Austria have gas collection systems.

Table 216 presents CH_4 emissions from managed waste disposal on land for the period from 1990 to 2003.

The trend of CH_4 emissions during the period is decreasing. From 1990 to 2003 CH_4 emissions decreased by 32% due to decreasing amounts of land filled waste and increasing amounts of the collected landfill-gas.

Table 216: Greenhouse gas emissions from Category 6 A 1 1990-2003

6A1	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CH_4 [Gg]	197.34	196.82	192.51	190.26	182.35	174.64	167.23	160.94	156.13	151.14	145.55	140.39	137.27	134.71

8.2.1.2 Methodological Issues

A country specific method was applied.

For calculation of emissions of solid waste disposal on land the directly deposited waste is separated into two categories: "residual waste" and "non residual waste", the methodology used for estimating emissions of these two subcategories are presented in the following subchapters.

Activity data and the implied emission factors for "Residual waste" and "Non Residual Waste" are presented in Table 217.

Table 217: Activity data and implied emission factors for "*Residual waste" and "Non Residual Waste" 1990–2003*

Year	Residual Waste	Non Residual Waste	Total Waste	IEF CH4
	[Mg/a]	[Mg/a]	[Mg/a]	[kg /Mg]
1990	1 995 747	863 051	2 858 798	69.0

Year	Residual Waste	Non Residual Waste	Total Waste	IEF CH4
1991	1 799 718	863 051	2 662 769	73.9
1992	1 614 157	863 051	2 477 208	77.7
1993	1 644 718	863 051	2 507 769	75.9
1994	1 142 067	863 051	2 005 118	90.9
1995	1 049 709	863 051	1 912 760	91.3
1996	1 124 169	863 051	1 987 220	84.2
1997	1 082 634	863 051	1 945 685	82.7
1998	1 081 114	863 051	1 944 165	80.3
1999	1 083 618	927 077	2 010 695	75.2
2000	1 052 061	928 358	1 980 419	73.5
2001	1 032 895	843 326	1 876 221	74.8
2002	1 347 795	864 953	2 212 748	62.0
2003	1 347 795	864 953	2 212 748	60.9

Residual waste

"Residual waste" corresponds to waste from households and similar establishments directly deposited at landfills without any treatment. It originates from private households, administrative facilities of commerce, industry and public administration, kindergartens, schools, hospitals, small enterprises, agriculture, market places and other generation points covered by the municipal waste collecting system.

According to the "federal waste management plan 2001" recycling and treatment of waste from households and similar establishments followed the following routes in 1999:

- 34.3% recycling
- 15.4% recycling (biogenous waste)
- 0.8% treatment in plants for hazardous waste
- 6.3% mechanico-biological pre-treatment
- 14.7% thermal treatment (incineration)
- 28.5% direct deposition at landfills ("residual waste");

Methodology

The detailed methodology for calculation of CH_4 emissions from "residual waste" is discussed in Table 218. The emissions are calculated according the methodology of Tabasaran and Rettenberger [described in BAUMELER et al. 1998].

First the overall amount of generated landfill gas per ton waste was calculated, taking into account the DOC-content (see Table 220) of the waste and the average temperature at the landfill (30°C). Once disposed, waste emits landfill-gas for many years. The amount of gas emitted per year is not constant. It declines exponentially over time. For the calculation the amount of landfill-gas produced in the year of disposal and in the 30 years after disposal are taken into account. To determine the total amount of landfill gas emissions for one year, the amounts generated by waste disposed in the last 31 years are summed up. After subtracting the collected and burnt gas and multiplying by the CH_4 content of landfill gas (approximately 55%) the emitted quantity of CH_4 from residual waste was obtained.

Table 218: Calculation of the CH_4 emissions of residual waste

Calculation of	Formula		Explanation
G_L...Long term specific quantity of generated landfill gas [m^3/ t waste]	G_L=1.868*DOC*(0.014T +0.28)	T………… DOC	Temperature of the disposal site (approximately 30°C) Bio-degradable organic carbon content of directly deposited residual waste (estimated in [ROLLAND, SCHEIBENGRAF, 2003])
G_t…Cumulated specific quantity of gas after t years [m³/ t waste]	$G_t=G_L*(1-10^{(-kt)})$	G_L………. k………… t…………	Long term specific amount of generated landfill gas Degrade constant =0.035 [TABASARAN & RETTENBERGER] Number of years
G_t(a)...Specific accrued quantity of gas in the t^{th} year [m³/ t waste]	$G_t(a)=G_t-G_{t-1}$	G_t………. G_{t-1}………..	Cumulated specific amount of gas in the year t Cumulated specific amount of gas in the year before t
G_{geb}...Quantity of incidental landfill gas in the year t [m³]	$G_{geb}=G_t(a)*waste_{t=0}$	G_t(a)……. $waste_{t=0}$…	Specific accrued amount of gas in the year t Waste deposited in the year t=0
G_T...Total incidental gas in the year t [m³]	$G_T=\Sigma_0^{31}(G_{geb})$ Quantity of gas generated in the last 31 years is summed up	G_{geb}…….	Quantity of incidental landfill gas in the year t
G…Emitted gas [m³]	$G=G_T*(1-j)$	G_T………. j…………	Total incidental gas in the year t Collecting factor [ROLLAND, OLIVA, 2004]
EM…Emitted CH_4 [kg]	EM=G*0.55*(1-v)*ρ	G………… 0,55……. v………… ρ…………	Emitted gas Concentration of CH_4 in landfill gas Percentage of methane, that is oxidized in the upper layer of the waste site, v=10% [IPPC default] Density of methane, ρ=0.65kg/m^3

Activity data

The quantities of "residual waste" from 1998 to 2003 were taken from the database for solid waste disposals "Deponiedatenbank" ("Austrian landfill database"). According to the Landfill Ordinance [Deponieverordnung (Federal Gazette BGBl. Nr 164/1996)], which came into force in 1997, the operators of landfill sites have to report their activity data annually to the UMWELTBUNDESAMT, where they are stored in the database for solid waste disposals (*Deponiedatenbank*).

Landfill gas recovery

2004 the Umweltbundesamt made an investigation [ROLLAND, OLIVA; 2004] and asked the operators of landfill sites to report their annual collected landfill gas. The results of this investigation are presented in Figure 19: the amount of the collected and burnt landfill gas increased constantly over the time period. While for example the amount of the collected landfill gas was about 2% in 1990, this amount reached 13% in the year 2002.

As this study considers only the amount of collected landfill gas from 1990 until 2002, for the calculation the amount of 2002 was used for the year 2003 as well.

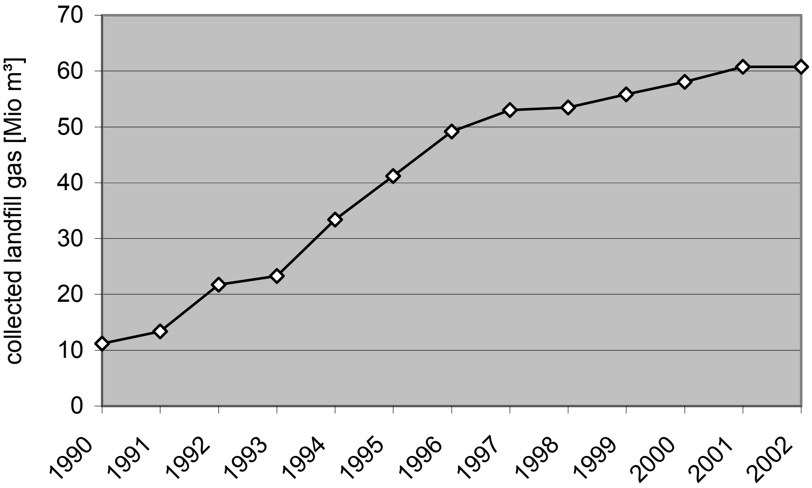


Figure 19: Amount of collected landfill gas 1990 to 2002 [ROLLAND, OLIVA; 2004]

Biodegradable organic carbon

According to the study "Biologisch abbaubarer Kohlenstoff im Restmüll" [ROLLAND, SCHEIBENGRAF, 2003] the content of biodegradable organic carbon of directly deposited residual waste decreased over the time series due to increasing separate collection of bio waste in biowaste containers and separate collection of paper. Figure 20 presents the trend of separate collection and organic share of residual waste over the time series. As can be seen the amount of biowaste that is collected separately increased while the organic share of residual waste decreased. Table 219 presents the composition of residual waste for several years between 1990 and 1999. On the basis of this information a time series for DOC was estimated (see Table 220). For the years before 1990 quantities according to a national study [HACKEL & MAUSCHITZ, 1999] were used.

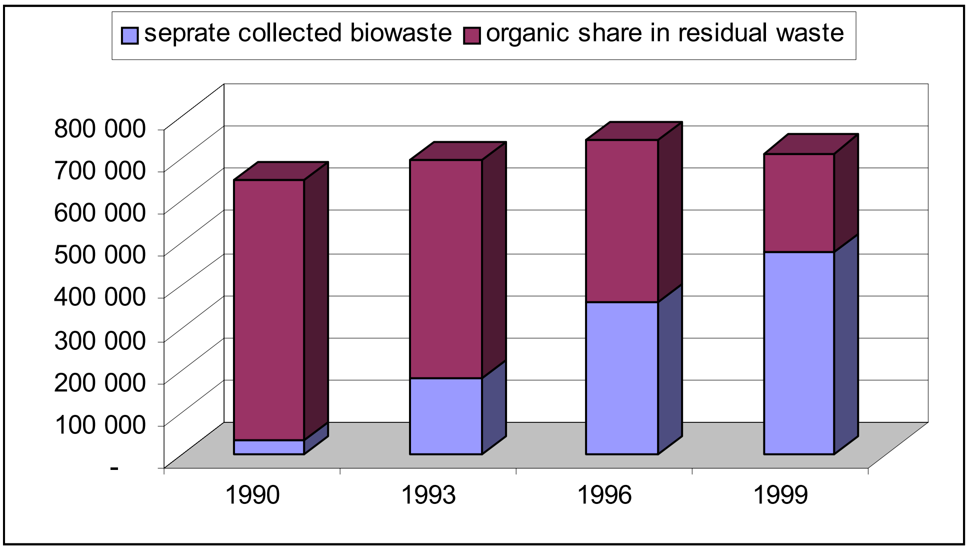


Figure 20: Separate collection of biowaste and organic share of residual waste

Table 219: Composition of residual waste

Residual waste	1990 [% of moist mass]	1993 [% of moist mass]	1996 [% of moist mass]	1999 [% of moist mass]
Paper, cardboard	21.9	18.3	13.5	14
Glass	7.8	6.3	4.4	3
Metal	5.2	4.4	4.5	4.6
plastic	9.8	9.3	10.6	15
Composite materials	11.3	11.3	13.8	-
textiles	3.3	3.1	4.1	4.2
wood	-	-	1.1	2.6
Hygiene materials	-	-	-	12
Biogenic components	29.8	34.4	29.7	17.8
Hazardous household waste	1.4	1.5	0.9	0.3
Mineral components	7.2	7.9	3.8	-
Wood, leather, rubber, other components	2.3	3.6	-	-
Residual fraction	-	-	13.6	26.5

Table 220: Time series of bio-degradable organic carbon content of directly deposited residual waste [ROLLAND, SCHEIBENGRAF, 2003]

	bio-degradable organic carbon [g/kg Waste (moist mass)]
1960-1969	230
1970-1979	220
1980-1989	210
1990	200
1991	190
1992	180
1993	170
1994	160
1995	150
1996	140
1997	130
1998	130
1999	120
2000	120
2001	120
2002	120
2003	120

Non Residual Waste

"Non Residual Waste" is directly deposited waste other than residual waste but with biodegradable lots. Non Residual Waste comprises for example:

- bulky waste
- construction waste
- mixed industrial waste
- road sweepings
- sewage sludge
- rakings
- residual matter from waste treatment

Methodology

For the calculation the methodology of Marticorena [described in BAUMELER et al. 1998] was used. The deposited Non Residual Waste was split up into two groups and the incidental quantity of gas was calculated for each group.

- Well biodegradable waste (half-life period: 1-20 years)
- Hardly biodegradable waste (half-life period: 20-100 years)

Because of a half-life period of more than 2.500 years the emissions of very hardly biodegradable waste are not relevant and were not considered.

After calculating the total emitted gas of each group the values were summed up, multiplied by the collecting factor and the share of CH_4 in the generated gas. This resulted in the emitted quantity of CH_4 of "Non Residual Waste".

The detailed calculation steps are shown in Table 221.

Table 221: Calculation of the CH_4 emissions of Non Residual Waste

Calculation of	Formula		Explanation
Methodology of Marticorena to calculate the formation potential for 100 years	$M=M_0e^{-(kt)}$	M………	Incidental quantity of gas [m³]
		M_0……….	Formation potential of landfill gas [m³]*
		k…………	Velocity constant $k=-\ln(0.5)/t_{1/2}$
		$t_{1/2}$……….	Half life period (calculated for each group, weighted by the quantity of the deposited waste [BAUMELER ET AL. 1998]) [a]
		t………….	Running parameter; years from 0-100
G…Total emitted quantity of landfill gas after 100 years under the restriction, that the quantity and the formation of the deposited waste is constant during 100 years [m³]	$G=\Sigma_1^3(M_{t=0}-M_{t=100})$	$M_{t=0}$……	Gas formation potential in the year 0
		$M_{t=100}$……	Gas formation potential in the year 100
		$M_{t=0}-M_{t=100}$	Total emitted quantity of landfill gas in each group after 100 years
		Σ_1^2……….	Summation of the 2 groups
EM…Emitted CH_4 [kg]	EM=G*(j-1)*0,55* *(1-v)*ρ	G………	Total emitted quantity of landfill gas [m³]
		j………….	Collecting factor; [ROLLAND, OLIVA, 2004]
		0,55……	Concentration of CH_4 in landfill gas
		v…………	Percentage of CH_4, that is oxidized in the upper layer of the waste site, v=10% [IPCC default value]
		ρ…………	Density of CH_4, ρ=0.65kg/m³ (30°C)

**For each of the 2 groups the kind of waste was specified, the quantity and the carbon-flow were listed. For each carbon flow, a formation potential of landfill gas was calculated, and the summed up formation potential was displayed as M_O.*

Activity data

The quantities of "non residual waste" from 1998 to 2003 were taken from the database for solid waste disposals "Deponiedatenbank" ("Austrian landfill database"), whereas only the amount of waste with biodegradable lots was considered. The following tables (Table 222 and Table 223) present a list of waste that was considered.

Because there are no data for "non residual waste" available for the years before 1998, the value for 1998 is used for these years. For the next submission efforts will be made to improve the time series.

Table 222: Well biodegradable waste

Waste Identification No	Type of Waste	Dry matter [%]	C content [g/kg TS]
170904	Mixed construction and demolition waste	86	99
190805	Sludges from treatment of urban waste water	34	250
20 01 25	Edible oil and fat	100	300
020303	wastes from solvent extraction	100	300
190811 - 14	Sludges from treatment of industrial waste water	34	250
040106	Sludges, in particular from on-site effluent treatment containing chromium	40	450
190809	Grease and oil mixture from oil/water separation containing only edible oil and fats	100	200
040221	Wastes from unprocessed textile fibres	90	450
200101	Paper and cardboard	90	440
030310	Fibre rejects, fibre-, filler-, and coating sludges from mechanical separation	44	440
030307	Mechanically separated rejects from pulping of waste paper and cardboard	44	515
200108	Biodegradable kitchen and canteen waste	35	350
200302	Waste from markets	35	350
200201	Biodegradable wastes	50	350

Table 223: Hardly bio-degradable waste

Waste Identification No	Type of Waste	Dry matter [%]	C content [g/kg TS]
200307	bulky waste	83	173
303	wastes from pulp, paper and cardboard production and processing	80	350
1908	wastes from waste water treatment plants not otherwise specified	34	300
1909	wastes from the preparation of water intended for human consumption or water for industrial use	73	300
40109	waste from dressing and finishing	90	450
30105	sawdust, shavings, cuttings, wood, particle board and veneer	90	496
150103	wooden packaging	90	500
170201	Wood	90	507
170204	glass, plastic and wood containing or contaminated with dangerous substances	94	520
170903	other construction and demolition wastes (including mixed wastes) containing dagerous substances	80	510
170204	glass, plastic and wood containing or contaminated with dangerous substances	94	520
30105	sawdust, shavings, cuttings, wood, particle board and veneer	85	450
30304	de-inking sludges from paper recycling	44	515

30307	mechanically separated rejects form pulping of waste paper and cardboard	44	515
200102	paper and cardboard	80	367
40221	wastes from unprocessed textile fibres	90	450
200111	Textiles	90	770
1905	wastes from aerobic treatment of solid waste	60	300
1912	wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	70	250 000
170904	mixed construction and demolition wastes	86	99 000

Uncertainty Assessment

According to [WINIWARTER & ORTHOFER, 2000] the uncertainty for emission factors for *6 A Solid Waste Disposal* is 35% and 25% for activity data, respectively.

The study refers to data of submission 2000 but since then the method was continually improved, now activity data and data for calculation of emissions refer to actual data compared to expert judgements or data from surveys of one year only that was used for all years used before: activity data is now taken from the Austrian landfill database reported from landfill operators, data on the amount of annual collected landfill gas were collected and the DOC was updated according to a new study of the Umweltbundesamt.

That's why experts of the Umweltbundesamt assumed that the uncertainty is now lower: 15% for activity data and 30% for the emission factors, respectively.

8.2.1.3 Recalculations

The following improvements have been made compared to last year's submission:

In the last submission an oxidation factor of 0.2 was used. But because recommended by the ERT in this submission the IPCC default value was used.

The activity data of "residual waste" and of "non residual waste" were updated. According to the Landfill Ordinance [Deponieverordnung (Federal Gazette BGBl. Nr 164/1996)] the operators of landfill sites have to report their data annually. Due to reports after the due-date there are minor changes of the activity data in this submission compared to the previous submission.

Due to QA/QC activities a mistake in the calculation of half-life period was identified and corrected in this submission.

Table 224: Recalculations with respect to previous submission from Category Managed Waste Disposal on Land 1990-2002

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CH_4 [Gg Difference]	19.56	19.56	19.13	18.93	18.11	17.32	16.57	16.01	15.90	15.58	16.29	16.89	17.78

8.3 Wastewater Handling (CRF Source Category 6 B)

Key Source: Yes

Emissions: CH_4, N_2O

In the year 2003, greenhouse gas emissions from Wastewater Handling contributed 0.2% to total greenhouse gas emissions in Austria.

The trend of greenhouse gas emissions during the period is increasing. From 1990 to 2003 greenhouse gas emissions increased by 63.2% due to increasing amounts of wastewater that is treated in treatment plants and increasing amount of denitrification. Table 225 presents CH_4 and N_2O emissions from category Wastewater Handling for the period from 1990 to 2003.

Table 225: Emissions of greenhouse gases from 1990-2003 from category 6 B Wastewater Handling

6 B	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CH_4 [Gg]	13.64	13.77	13.93	14.04	14.09	14.12	14.14	14.15	14.17	14.19	14.23	14.28	14.36	14.42
N2O [Gg]	0.05	0.06	0.06	0.06	0.12	0.19	0.26	0.30	0.38	0.44	0.51	0.62	0.62	0.62

This source category is separated into the subcategories *6 B 1 Industrial Wastewater Handling* and *6 B 2 Urban Wastewater Handling*.

Table 226 shows CH_4 and N_2O emissions and their trend from both subcategories for the period from 1990 to 2003.

Table 226: Greenhouse gas emissions from Subcategories Industrial Wastewater Handling 6B1 and Urban Wastewater Handling 6B2 for the period 1990-2003

	6 B 1 Industrial Wastewater Handling		6 B 2 Urban Wastewater Handling		Total
	CH_4 emissions [Gg]	N_2O emissions [Gg]	CH_4 emissions [Gg]	N_2O emissions [Gg]	[CO_2 equivalent Gg
1990	4.64	0.01	9.00	0.04	303.4
1991	4.68	0.01	9.09	0.04	306.8
1992	4.74	0.01	9.19	0.05	310.8
1993	4.78	0.01	9.26	0.05	313.5
1994	4.79	0.03	9.30	0.09	331.9
1995	4.80	0.04	9.31	0.15	356.5
1996	4.81	0.06	9.33	0.20	378.1
1997	4.81	0.07	9.34	0.23	389.5
1998	4.82	0.09	9.35	0.29	415.9
1999	4.83	0.10	9.37	0.34	433.6
2000	4.84	0.12	9.39	0.39	457.2
2001	4.86	0.14	9.43	0.48	493.1

2002	4.88	0.14	9.47	0.48	493.1
2003	4.90	0.14	9.51	0.48	495.2
Trend 1990-2002	*5.7%*	*1 030%*	*5.7%*	*1 030%*	*63.2%*

8.3.1 Methodology

8.3.1.1 CH_4 Emissions

The calculation of CH_4 emissions for the year 1993 is shown in Table 227 and was taken from a study [STEINLECHNER et al., 1994].

First the amount of generated methane per unit of wastewater is determined separately for each of the three different types of treatments (mechanical/ biological/ further). These factors were multiplied with the corresponding capacities of the Austrian wastewater treatment plants and then summed up, resulting in total CH_4 emissions for the sub sector urban wastewater of the year 1993. Emissions from industrial wastewater were calculated separately, its wastewater was treated like biological treated wastewater.

By dividing the emissions of 1993 by the number of inhabitants of 1993 an implied emission factor for Industrial and Urban Wastewater Treatment was obtained.

For all other years the implied emission factors of 1993 was used to calculate emissions.

IEF (Industrial wastewater handling): 604.05 g CH_4 /inhabitant

IEF (Urban wastewater handling): 1 171.94 g CH_4 /inhabitant

Table 227: Calculation of methane emissions for the year 1993

Explanation	Calculation factors and ratings/ Calculation results
The amount of methane generated (MG) per unit of organic substance is presumed.	MG = 0.22 kg CH_4/ kg organic substance
Apart from temperature sewage provides ideal conditions for methane production: moisture, pH value and nutrient supply. The temperature is too low, this is taken into account by applying a methane conversion factor (MCF). Calculations are made with an average temperature of 20°C for 8 months and 10°C for the rest of the year.	$MCF_{20°C}$= 35% (67% of a year) $MCF_{10°C}$= 10% (33% of a year)
Using MCF the effective amount of incidental methane (EM) is calculated: $EM=MCF_{20}*MG*0,67+MCF_{10}*MG*0,33$	EM = 0.058 kg CH_4/ kg organic substance
For each of the three types of wastewater treatment (1: Mechanical/ 2: Biological/ 3: Further) the quantity of organic substance per inhabitant and day (G_1..G_3) as well as the share of dry substance for each type was assumed.	G_1= 45 g organic substance/ inhabitant/ day; including 70% dry substance G_2= 80 g organic substance/ inhabitant/ day; including 60% dry substance G_3= 45 g organic substance/ inhabitant/ day; including 35% dry substance
The factors G_1..G_3 are converted into the unit kg dry substance/ inhabitant/ year {e.g: $I_1=G_1$*days (365)*0,7 (share of dry substance)}	I_1= 11.5 kg/ inhabitant/ year I_2= 17.5 kg/ inhabitant/ year I_3= 12.8 kg/ inhabitant/ year

Explanation	Calculation factors and ratings/ Calculation results
Multiplying the quantity of incidental dry organic substance per inhabitant and year ($I_1..I_3$) by the effective amount of incidental methane (EM) results in a factor for methane emissions per inhabitant and year ($F_1..F_3$)	F_1 = 0.67 kg CH_4/ inhabitant/ year F_2 = 1 kg CH_4/ inhabitant/ year F_3 = 0.75 kg CH_4/ inhabitant/ /year
The capacity (WWT) of Austrian wastewater treatment plants given in population equivalent [pe] for each type of wastewater treatment (1: Mechanical/ 2: Biological/ 3: Further) are:	WWT_1= 137 420 pe WWT_2= 6 965 411 pe WWT_3= 1 070 065 pe
Industrial wastewater treatment is calculated separately (IWWT): Inhabitants without public wastewater treatment are also considered (PWWT):	IWWT = 4 827 000 pe PWWT = 2 263 265 pe
Domestic and commercial wastewater: By multiplying the delivery rates (WWTs) with the factor for methane emission per inhabitant and year (EM) the methane emission for each treatment type is calculated. These values are summed up (7 849 Mg/a) and also the CH_4 emissions of inhabitants without waste water treatment (these are handled like mechanical treatment – 1 516 Mg/a) are added.	Total CH_4 emissions of domestic and commercial wastewater treatment amount to 9 365 Mg/a
Industrial wastewater: Industrial wastewater is managed like biological treatment, so methane emissions of biological treatment (F_2) are multiplied by the delivery rate of industrial treatment plants (IWWT).	CH_4 emissions from industrial wastewater treatment amount to 4 827 Mg/a

Main difference between the Austrian and the IPCC method

The main difference is that the Austrian method calculates emissions using an implied emission factor per inhabitant and not per kg DOC. To calculate emissions therefore the amount of produced biogas was estimated together for industrial and urban wastewater, based on the amount of organic waste. It was not calculated on the basis of BOD (biochemical oxygen demand) and COD (chemical oxygen demand).

8.3.1.2 N_2O Emissions

N_2O emissions from Urban Wastewater Handling were calculated in accordance with the IPCC methodology and a national study [ORTHOFER et al., 1995]. The emissions were calculated taking into account the amount of wastewater that is treated in sewage plants and the amount of nitrogen that is denitrificated. According to [ORTHOFER et al., 1995] only 1% of the total nitrogen in the denitrification process is emitted as N_2O. The formula for estimating the N_2O emissions from this category is:

$$N_2O\ Emissions = WW_{tr} * DF * 0.01 * P * Frac_{NPR} * Inhabitants * F$$

Where:

WWtr	amount of wastewater that is treated in sewage plants
DF	percentage of nitrogen that is denitrificated
P	annual protein intake per capita [kg protein/ person/ a]42

[42] Daily protein intake per capita taken from FAO statistics: http://apps.fao.org/page/collections?subset=nutrition

$Frac_{NPR}$	Fraction of nitrogen in protein (IPCC default value – 0,16 kg N/kg protein)
Inhabitants	number of inhabitants in Austria
F	Factor [1.57 kg N_2O/ kg N]

It is assumed that industrial wastewater handling additionally contributes 30% of N_2O emissions from urban wastewater handling.

The amount of wastewater that is treated in sewage plants as well as the denitrification rate increased over the time series as presented in Table 228. Data were taken from the Austrian reports on water pollution control [GEWÄSSERSCHUTZBERICHTE 1993 – 2002]; data in between were interpolated.

Table 228: Trend of amount of wastewater that is treated in sewage plants 1990 – 2003 and amount of nitrogen that is denitrificated

	Wastewater treatment [%]	Denitrification [%]
1990	59.0	0.10
1991	60.0 *)	0.10
1992	61.4	0.10
1993	62.7	0.10
1994	64.1	0.18
1995	73.5 *)	0.27
1996	74.2	0.35 *)
1997	75.0	0.40
1998	80.9 *)	0.46
1999	81.4	0.51 *)
2000	81.9	0.60
2001	86.0 *)	0.68 *)
2002	86.0	0.68
2003	86.0	0.68

**) data were taken from Austrian reports on water pollution control [GEWÄSSERSCHUTZBERICHTE 1993 – 2002];*

The number of inhabitants was provided by STATISTIK AUSTRIA. The daily protein intake was updated according to FAO statistics. The data are presented in Table 229.

Table 229: Number of inhabitants and protein intake per capita 1990–2003

Year	Inhabitants	Protein intake [g/ day/ capita]
1990	7 678 000	102
1991	7 754 891	102
1992	7 840 709	103
1993	7 905 632	102

1994	7 936 118	104
1995	7 948 278	104
1996	7 959 016	106
1997	7 968 041	104
1998	7 976 789	109
1999	7 992 323	110
2000	8 011 566	110
2001	8 043 046	111
2002	8 083 797	110
2003	8 117 754	110

8.3.2 Recalculation

- Emissions of N_2O have been recalculated taking into account the increasing amount of wastewater treated in sewage plants and the increasing amount of nitrogen that is denitrificated. The data were taken from the Austrian reports on water pollution control (GEWÄSSERSCHUTZBERICHTE 1993 –1996).
- The number of inhabitants was updated according to recent statistics provided by STATISTIC AUSTRIA
- The daily protein intake per capita was updated according to FAO statistics.

Table 230 Recalculations with respect to previous submission from Category Wastewater Handling 1990-2002

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CH_4 [Gg Difference]	-0.09	-0.10	-0.13	-0.15	-0.17	-0.18	-0.18	-0.18	-0.18	-0.18	-0.17	0.02	0.09
N2O [Gg Difference]	-0.02	-0.02	-0.01	-0.01	0.04	0.12	0.19	0.22	0.30	0.36	0.43	0.55	0.54

8.3.3 Planned Improvements

For this submission the activity data were updated, while the methodology remained unchanged. But until the next submission it is planned to review and improve the methodology of estimating emissions from wastewater handling (*IPCC Category 6 B*). Furthermore it is planned to estimate uncertainties for the new methodology.

8.4 Waste Incineration (CRF Source Category 6 C)

8.4.1 Source Category Description

Key source: No

In this category CO_2 emissions from incineration of corpses and waste oil are included as well as CO_2, CH_4 and N_2O emissions from municipal waste incineration without energy recovery. All CO_2 emissions from Category *6 Waste* are caused by waste incineration. The share in total emissions from sector 6 is 0.5% for the year 1990 and 0.3% for the year 2003.

In Austria waste oil is incinerated in especially designed so called "USK-facilities". The emissions of waste oil combustion for energy recovery (e.g. in cement industry) are reported under *CRF sector 1 A Fuel Combustion*.

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 in *CRF sector 1 A 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 *CRF sector 1 A Fuel Combustion* from 1996 onwards.

Table 231: Greenhouse gas emissions from Category 6 C.

	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 equiv. [Gg]
1990	21	0.002	0.0003	21
1991	18	0.002	0.0003	19
1992	8	0.000	0.0000	8
1993	9	0.000	0.0001	9
1994	10	0.000	0.0001	10
1995	10	0.000	0.0001	10
1996	10	0.000	0.0001	10
1997	11	0.000	0.0001	11
1998	11	0.000	0.0001	11
1999	11	0.000	0.0001	11
2000	11	0.000	0.0001	11
2001	11	0.000	0.0001	11
2002	11	0.000	0.0001	11
2003	11	0.000	0.0001	11
Trend 1990-2003	*-45.6%*	*-99.7%*	*-77.4%*	*-45.8%*

Completeness

Table 232 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 subcategory have been estimated.

Table 232: Overview of subcategories of Category 6 C Waste Incineration,: transformation into SNAP Codes and status of estimation

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
6 C WASTE INCINERATION	090901 Incineration of corpses	✓	NO	NO
	090201 Incineration of domestic or municipal waste.	✓	✓	✓
	090208 Incineration of waste oil	✓	NA	✓

8.4.2 Methodological Issues

CORINAIR methodology is applied: the quantity of waste is multiplied with an emission factor for CO_2, CH_4 and N_2O.

Emission factors

National emission factors for CO_2 and CH_4 are taken from [BMWA-EB, 1990], [BMWA-EB, 1996] and [UBAVIE, 2001]. N_2O emission factors are taken from a national study [ORTHOFER et al., 1995].

For municipal solid waste, the emission factors for waste combustion in district heating plants were selected. The CO_2 emission factor in [BMWA-EB, 1996] is quoted as 100 kg CO_2 /TJ. In the national energy balance 62% of municipal solid waste is reported as non renewable waste and therefore an emission factor of 62 kg CO_2/TJ was selected. A heating value of 8.7 GJ/Mg Municipal Waste was used to convert the emission factors from [kg/TJ] to [kg/Mg].

For waste oil, the emission factors for heavy oil were selected and a heating value of 40.3 GJ/Mg Waste Oil was used to convert the emission factors from [kg/TJ] to [kg/Mg].

Table 233: Emission factors of IPCC Category 6 C Waste Incineration.

Waste Type	CO_2 [kg/ Mg]	CH_4 [g / Mg]	N_2O [g / Mg]
Municipal Waste	539.40	104.40	12.18
Waste Oil	3224.00	NA	24.18

For incineration of corpses only CO_2 emissions were considered, the emission factor of 175 kg CO_2/capita was taken from a Swiss study [BUWAL, 1995]. It was calculated based on measured values of CO_2 in the exhaust gases of crematories.

Activity data

For municipal solid waste the known capacity of 22 000 tons of waste per year of one waste incineration plant was taken.

For waste oil the activity data 1990 to 1999 were taken from [BOOS et al., 1995]. For 2000 to 2003 actvity data of 1999 was taken. [PERZ, 2001] quotes that in 2001 total waste oil accumulation was about 37 500 t. Waste oil is mainly used for energy recovery in cement kilns or public power plants and considered in the energy balance as *Industrial Waste*

For incineration of corpses the activity data as presented in Table 234 were taken from STATISTIK AUSTRIA. It was assumed that 12% of the total number of corpses was incinerated every year.

Table 234: Activity data for IPCC Category 6 C Waste Incineration.

Year	Municipal Waste [Mg]	Waste Oil [Mg]	Total number of corpses	Number of incinerated corpses
1990	22 000	2 200	82 952	9 954
1991	22 000	1 500	83 428	10 011
1992	0	1 800	83 162	9 979
1993	0	2 100	82 517	9 902
1994	0	2 500	80 684	9 682
1995	0	2 600	81 171	9 741
1996	0	2 700	80 790	9 695
1997	0	2 800	79 432	9 532
1998	0	2 900	78 339	9 401
1999	0	3 000	78 200	9 384
2000	0	3 000	76 780	9 214
2001	0	3 000	74 767	8 972
2002	0	3 000	76 131	9 136
2003	0	3 000	76 131	9 136

8.5 Other Waste (CRF Source Category 6 D)

In this category compost production is addressed.

8.5.1 Compost Production

Key Source: No

Emission: CH_4, N_2O

This category includes CH_4 and N_2O emissions from compost production, which are presented in Table 235 for the period from 1990 to 2003.

CH_4 and N_2O emissions, that arise from the subcategory compost production increased over the time period as a result of the increasing amount of composted waste.

Table 235: Greenhouse gas emissions from Category Compost Production 1990-2003

	CH_4 emissions [Gg]	N_2O emissions [Gg]	Total [CO_2 equivalent Gg]
1990	0.52	0.08	34.8
1991	0.54	0.08	36.4
1992	0.65	0.10	43.4
1993	0.82	0.12	54.2
1994	0.98	0.14	64.4
1995	1.04	0.15	68.2
1996	1.09	0.16	71.4
1997	1.05	0.15	68.4
1998	1.12	0.16	72.8
1999	1.15	0.17	75.4
2000	1.16	0.17	76.6
2001	1.17	0.17	77.5
2002	1.17	0.17	78.0
2003	1.19	0.18	79.3
Trend 1990-2003	*130.2*	*126.8*	*127.8*

8.5.1.1 Methodological Issues

Emissions were estimated using a country specific methodology.

To estimate the amount of composted waste it was split up into three fractions of composted waste:

- mechanical biological treated residual waste
- Bio-waste, loppings, home composting
- Sewage Sludge

CH_4 emissions were calculated by multiplying an emission factor by the quantity of waste.

Activity data

The activity data were taken from several national studies. For years where no data were available they were inter-/extrapolated or the value of the year before was used respectively.

Table 236: Activity data for IPCC Category 6 D Other Waste (Compost Production)

	Total	Bio-waste, loppings, home composting[(1)]		mechanical biological treated residual waste		Sewage Sludge	
	[Gg/a]	[Gg/a]	ref.	[Gg/a]	references	[Gg/a]	references
1990	765.0	413.2	[AMLINGER, 2003]	345.0	[BAUMELER et al., 1998]	6.8	
1991	800.1	448.3		345.0		6.8	[BAWP,1995]
1992	947.5	591.3		345.0		11.1	
1993	1 176.7	816.2		345.0		15.5	
1994	1 393.3	1 028.5		345.0		19.8	
1995	1 470.8	1 151.6		295.0	[ANGERER, 1997]	24.2	[SCHARF et al., 1998]
1996	1 537.5	1 233.5		280.0		24.0	
1997	1 513.0	1 244.1		245.0	[LAHL et al., 1998]	23.9	
1998	1 564.7	1 300.9		240.0	[LAHL et al., 2000]	23.8	[BAWP, 2001]
1999	1 654.3	1 355.6	[AMLINGER et al]	265.0	[GRECH&ROLLAND, 2001]	33.6	
2000	1 647.2	1 338.8		265.0		43.	
2001	1 657.0	1 338.8		265.0		53.3	[AMLINGER et al.; 2004]
2002	1 667.0	1 348.8		265.0		53.3	
2003	1 696.8	1 348.8		294.8	[DOMENIG, 2004]	53.3	

Emission factors

Due to different emission factors in different national references an average value was used for each of the three fractions of composted waste.

Table 237: Emission factors for IPCC Category 6 D Other Waste (Compost Production)

	CH_4 [kg/t FS]	N_2O [kg/t FS]	References
mechanical biological treated residual waste	0.6	0.1	[UBA Berlin, 1999] [AMLINGER et al., 2003] [ANGERER, FRÖHLICH, 2002] [DOEDENS et al., 1999]
Bio-waste, loppings, home composting	0.75	0.1	[AMLINGER et al., 2003]
Sewage Sludge	0.04	0.2	[AMLINGER et al., 2003]

8.5.1.2 Recalculations

Activity data were updated due to new available data mainly for the years 2000 to 2003. Because of interpolation the time series from 1997 onwards was updated.

Table 238: Recalculations with respect to previous submission from sub category 6 D Other Waste 1990-2002

	1997	1998	1999	2000	2001	2002
CH_4 emissions [Gg]	0.07	0.10	0.13	0.16	0.16	0.17
N_2O emissions [Gg]	0.01	0.01	0.02	0.03	0.03	0.03

9 RECALCULATIONS AND IMPROVEMENTS

This chapter quantifies the changes in emissions for all six greenhouse gases compared to the previous submission – UNFCCC 2004 (in the format of the IPCC Summary Table 1A).

9.1 Explanations and Justifications for Recalculations

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, ...
- Methodological changes: a new methodology must be applied to fulfil the reporting requirements 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.

For detailed information on recalculations and their justifications see the corresponding subchapters of Chapters *3 Energy – 8 Waste*.

Below an overview of recalculations made in response to the UNFCCC review process is given.

Table 239: Improvements made in response to the UNFCCC review process (centralized review 2004)

Energy
1 A 2 Manufacturing Industries and Construction: Sectoral division of natural gas consumption is improved by energy statistics.
1 A 2 a Iron and steel production: Fuel consumption and CO_2 emissions are now corresponding in a more accurate way with pig iron production and process emissions of category *2 C 1 Iron and Steel*.
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries: Includes now emissions from oil/gas extraction and compressors for storage and liquidification of natural gas only.

Industrial Processes

2 F Consumption of Halocarbons and SF_6: emissions from 2001 and 2002 were updated using extrapolation techniques (following recommendations from the ERT) and data from industries, previously the same estimated as for 2000 was used for these years.

Agriculture

Animal Category *Other*: In Austria animals of category *Other* which mainly is deer (but not including wild living animals) have been counted from 1993 on. As recommended in the centralized review 2003, in this inventory for the years 1990 to 1992 the animal number of 1993 was used.

Synthetic fertilizer use: The S&A report 2004 noticed high inter-annual variations in N_2O emissions of sector 4 D synthetic fertilizer use. These variations are caused by effects of storage as well as the difference between the calendar year and the agricultural economic year: the amounts of synthetic fertilizers over the years reflect the amounts sold in one calendar year. However, the economic year for the farmer does not corresponded to the calendar year. Not the whole amount purchased is applied in the year of purchase. Considering these effects, in this submission the arithmetic average of each two years was used as fertilizer application data.

4 A, 4 B, 4 D (Non-dairy cattle): The S&A report 2004 noticed high inter-annual variations in the CH_4 and N_2O IEF values between 1992/1993 and 1993/1994. An error regarding activity data of non-dairy cattle for the year 1993 was identified and corrected in this submission.

4 D 3 Atmospheric nitrogen deposition: Following the recommendation of the centralized review (October 2004), in contrast to the last submission also N volatised in housing, storage and pasture was taken into account. Now, in accordance with the IPCC good practice, the value $Frac_{GASM}$ relates to N excreted by livestock and not to $Nex_{\text{left for spreading}}$.

4 F Field burning: As recommended in the Centralized Review 2003 the IPCC methodology using default values was applied.

CRF-Tables, background data:

According to the Centralized Review 2003 emissions from different animal waste management systems (AWMS) are reported under the appropriate AWMS in the CRF.

As recommended in the S&A report 2004 in table 4 B (b) notation keys instead of "0" have been used.

Waste

6 A 1 Managed waste disposal on land: As recommended in the Centralized Review 2004 the IPCC default CH_4 oxidation factor (0.1) was applied.

Table 240 presents the issues raised at the centralized review 2004 together with a short description of improvements made in response to the UNFCCC review. For details please refer to the respective sub chapter of the NIR.

Table 240: Issues raised in the UNFCCC review 2004 and improvements made

Paragraphs from the review Report for Austria (Centralized Review 2004) FCCC/WEB/IRI/2004/AUT	Improvements made / Comments
Uncertainties 10. Tier 1 of the IPCC good practice guidance has been applied to estimate uncertainties, including all sectors, CO_2, CH_4 and N_2O for the years 1990–1997. Uncertainty compilation, the choice of priorities in assessing uncertainties, and the assessment of uncertainties using Monte Carlo analysis are described in detail in the NIR. Emissions of CO_2 have a low uncertainty (about 2 per cent) whereas the uncertainty for N_2O is up to 90 per cent. Since 1999, no improvements have been made in the uncertainty assessment. Moreover, the uncertainties are not quantified for the years 1998–2002. However, it is assumed that the uncertainty has been reduced by the application of improved QA/QC systems. Austria plans to update the uncertainty estimates for all key sources as a part of its 2005 submission.	In the submission 2005 an updated uncertainty estimate for all key sources is provided.
Energy	
Reference and sectoral approach 20. The differences between the sectoral and reference approaches are compared and explained in the NIR. Comparing the reference approach estimates against those from the sectoral approach the differences vary between –1.18 per cent and +2.04 per cent for the total CO_2 emissions over the time series. The negative differences for the emissions from solid fuels (–3.9 per cent for the year 1990 and –4.7 per cent for 2002) need further consideration. For the period 1996–2001, the difference is positive and as high as +7.6 per cent.	This will be addressed in the inventory improvement plan.
International bunker fuels 21. Given the geographical location of the Party, no emissions are reported for marine bunker fuels. The consumption of aviation bunker fuels reported in the CRF differs from that reported by the International Energy Agency (IEA) by less than 5 per cent. The split between national and domestic aviation has been calculated based on aircraft movements and fuel calculated for international aviation has been adjusted so that total fuel corresponds to total fuel sales. There is nevertheless a discrepancy of 6 per cent in 2002 between total fuel use for aviation reported in the CRF and that given by IEA. In its response to the draft of this report, Austria stated that the split between national and international aviation for 2001 and 2002 would be recalculated for 2005 on the basis of the national energy balance.	For the submission 2005, the split of national and international aviation for 2001 and 2002 has been recalculated following data of the national energy balance (previously the split for these years was not consistent with the national energy balance as it was based on aircraft movement data).
1.A.2 Manufacturing industries and construction 22. Significant inter-annual variations of CO2 emissions are observed between 1999 and 2000 as well as between 2001 and 2002 in the subcategories of 1.A.2 as a result of differences in the way in which natural gas consumption as reported by the national energy statistics is divided between the sectors. The ERT would recommend Austria to improve the sectoral division of natural gas consumption and also check that emission sources are fully accounted for. Austria indicated that energy statistics for 2002 are preliminary and would be corrected for the next submission.	Sectoral division of energy statistics for the year 2002 is generally of low quality (the last reporting year is always a preliminary estimate) which will be corrected by the next submission. CO_2 emissions of iron & steel industry are the main driver for the fluctuating trend of total industry.
1.A.2.a Iron and steel production 24. Estimated CO_2 emissions from energy use increased by 24.7 per cent between 2001 and 2002. This does not correspond to the data on fuel consumption, according to which consumption of solid fuels decreased by 7.2 per cent, consumption of liquid fuels increased by 15.5 per cent and consumption of gaseous fuels decreased by 6.3 per cent. Furthermore, process CO_2 emissions under 2.C.1 Iron and Steel Production decreased by 6 per cent	Emissions have been recalculated for this submission.

during the same period, whereas production increased by 6.2 per cent. Some of these discrepancies may be due to inconsistencies in the allocation of emissions between the two sectors even though a reallocation of these emissions has taken place as part of the latest recalculations. If indeed some allocation problems persist, the ERT recommends a proper allocation of these emissions between the two sectors together with an appropriate explanation of these issues in Austria's next NIR. Austria indicated its intention to correct this for its next submission.	
1.A.3.b Road transport — gasoline – N_2O 25. Implied emission factors (IEFs) (in kg/TJ) increased until 1994 and decreased after 1996. Emissions have been calculated using the CORINAIR methodology but country-specific EFs. The NIR only gives a general explanation of this trend. The ERT recommends that the Party explain the basis for the N_2O EFs used for different inventory years and how the average IEF has been affected by changes in technologies since 1990.	Information has been included in the NIR.
1.A.3.e Other transport – gas – CO_2 26. The CO_2 emissions reported for pipeline transport (gas turbine compressors) vary considerably from year to year. The Party has explained that the reason is the annual differences in international gas transfer. It is recommended that the Party document in the NIR the basis for the determination of gas consumption and specifically explain the emission trend, for example, by showing the annual volumes of gas transfer.	Additional information is now provided in the respective chapter of the NIR.
1.A Fuel combustion 27. The CH_4 time series for solid fuel in 1.A.1 Energy Industries seems to be inconsistent as a result of significant variation in the EF between 1990 and 2000. An explanation of this variation should be provided in the NIR.	Additional information is now provided in the respective chapter of the NIR.
28. For 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, data are provided for 1990–1995 only; for 1996–2002 no AD or emission estimates have been provided ("0" is reported in the CRF). As the statistics do not report these data, the ERT would encourage Austria to collect the data from the producers or complete the time series using methods of the IPCC good practice guidance. Moreover gaseous fuel combustion in 1.A.1.c is approximately 14 per cent of total gas throughput in 2002 and appears to be rather high. The ERT recommends the Party to verify the data reported. In its response to the draft of this report Austria explained the increase of natural consumption for pipeline compressors with the increase of natural gas transferred through Austria but not accounted for as imports/exports in the national energy balance, and indicated its intention to provide additional information in its next NIR.	Additional information is now provided in the respective chapter of the NIR.
1.B.2 Oil and natural gas – CH_4 and CO_2 29. There is a general lack of transparency in the emissions reported within this category. For venting and flaring, and in the case of refineries as well, some of the combustion emissions are included in fugitive losses. The NIR only provides partial information on the EFs and methods used. This makes it difficult to assess the quality of the reporting of emissions. Furthermore, the reason for changes in the IEFs over time is not given.	The corresponding chapter of the NIR was improved regarding transparency.
Industrial Processes	
Sector Overview 34. The transparency of the reporting on the Industrial Processes sector could be improved, particularly the description in the NIR of methods used for F-gas emissions and for the allocation of energy and process emissions in the Cement and Iron and Steel production categories. Responding to the draft of this report, Austria stated its intention to improve transparency of the corresponding	The corresponding chapters of the NIR were improved regarding transparency.

chapters in the NIR.	
2.A.1 Cement production – CO_2 35. Austria applies the IPCC good practice guidance tier 2 method by using plant-specific data. However, the AD reported for clinker production are constant for the period 1998–2002 as no additional statistical data are available. Austria states in the NIR that cement production remained stable from 1999 to 2001. The ERT notes that it is unlikely that the production and therefore emissions were exactly the same for these years and recommends that this time series be brought up to date with more recent plant-specific AD. Work has been done, for this submission, to split the energy component of the cement emissions and allocate these to the Energy sector. However, no explanation of the method used to split process and energy emissions has been provided. The ERT encourages the Party to document the methodology used for splitting the energy and process emissions more clearly.	Data has been updated and the corresponding chapters of the NIR was improved regarding transparency.
2.A.2 Lime production – CO_2 36. Emissions have been estimated using a country-specific method based on detailed production data from all lime production plants for the period 1990–2002. However, the CO_2 estimate for 2002 has been calculated using the IEF of 2001 due to lack of reported emissions data. There is no explanation of why these data were not available in time for the submission. The ERT encourages Austria to secure timely annual reporting of emissions (or specific information on calcium (Ca) or magnesium (Mg) content), as well as production data from industry.	This issue is addressed in the national inventory system (see Chapter 4.1.3).
2.F Consumption of halocarbons and SF_6 – HFCs, PFCs and SF_6 27. Both actual and potential emissions of individual F-gases are reported, potential emissions of PFCs being included for the first time in the 2002 inventory. However, 2000 is the last year for which estimates of HFC, PFC and SF_6 emissions have been made, and Austria therefore retains the 2000 values for the 2001 and 2002 inventories. This approach could very likely result in an underestimation of HFC emissions in 2002, based on the trend up to 2000. Country-specific methodologies are used for all subcategories within 2.F but only general descriptions of these methodologies and their underlying assumptions are given in the NIR. Austria plans to update the emissions for F-gases for the 2005 submission. The ERT suggests that Austria take this opportunity to acquire the necessary information for all years and to improve the transparency of reporting for all relevant sources of these gases. The Party is encouraged to apply extrapolation methods as necessary, in accordance with the UNFCCC reporting guidelines, to avoid reporting the same estimate of emissions in succeeding years.	For this submission new estimates for F-gas emissions are reported.
Agriculture	
4.A.1 Enteric fermentation – Cattle– CH_4 43. The tier 2 method is used for cattle, which contributed 3.4 per cent of total GHG emissions in 2002 and 94 per cent of total CH_4 emissions from enteric fermentation. Cattle populations are based on counts made in December, but information provided during the review shows that this does not lead to the exclusion of significant numbers of animals that exist for part of the year. There is good agreement between the data on cattle populations in the CRF and those in the Food and Agriculture Organization of the United Nations (FAO) statistics. A decline in cattle numbers of 35 per cent from 1990 to 2002 should be explained in the NIR.	Additional information is now provided in the respective chapter of the NIR.
4.B Manure management – Cattle and swine – CH_4 46. Swine are characterized as breeding sows and fattening pigs, but the NIR states that the EF for the former account for emissions from nursery and growing pigs, and this introduces some lack of	Information has been included in the documentation boxes.

transparency and comparability. Austria is encouraged to improve transparency regarding the characterization of the swine population so that the EFs for individual categories are fully transparent. Default values of B_O and MCF are applied for swine and constant VS excretion rates are estimated on the basis of national studies which are referenced.	
4.B Manure management – Cattle – N_2O. 47. The country-specific nitrogen (N) excretion rates for cattle are significantly lower than the IPCC default values for European countries and those of other Parties. The figures for excretion of N by cattle are based on milk yield and other information taken from national studies and other referenced reports as used in deriving the CH_4 EFs for enteric fermentation and manure management. These references do not fully justify the adoption of 65 and 34 kg N/head for dairy cattle and other cattle, respectively, and the values appear to be inconsistent with the corresponding VS excretion and CH_4 EFs used by Austria for manure management. The NIR makes no reference to the N content of the typical diets presented for cattle or to the proportion of N lost from different types of forage. As N excretion rates have a major bearing on N_2O emissions, these low country-specific values should be documented more thoroughly.	Additional information will be provided in the NIR 2006 to document the N and VS excretion rates more detailed.
48. Although detailed information by animal waste management system (AWMS) is available and is used in the emission estimates, all N_2O emissions in category 4.B are reported under liquid systems. The IEF is apparently a weighted average of the IPCC default values for liquid systems, solid storage and other systems. To improve transparency, the ERT encourages the Party to report separately under the three systems applicable in the country.	This has been improved as recommended by the ERT.
49. Austria reports recalculations that address inconsistencies and errors detected in the 2003 review regarding the reporting of nitrogen per AWMS in tables 4.B(a), 4.B(b) and 4.D. However, there is still a lack of clarity and a possible underestimate in the accounting of N excreted by swine in table 4.B(b) in all years, because multiplication of total swine population by the rate of N excretion gives a greater amount of N excreted than is reported by AWMS, which could also affect N_2O emissions from agricultural soils (4.D). Further information gained during the review confirmed that N excretion by swine is not underestimated but the weighted N excretion rate reported for swine in table 4.B(b) is incorrect. By using the appropriate weighting of suitable N-excretion rates for the chosen swine categories, Austria will achieve the necessary accuracy and transparency in Table 4.B(b) and maintain consistency regarding the reporting of CH_4 emissions from manure management.	Information has been included in the documentation boxes.
4.D.1 Agricultural soils – Direct N_2O 50. The tier 1 method is used and all nitrogen inputs are taken into account. However, the definition of the parameter $Frac_{GASM}$ is different from that of the IPCC Guidelines, which results in a lack of transparency in the estimation of direct and indirect N_2O emissions. According to the IPCC good practice guidance, the value of 0.177 for $Frac_{GASM}$ given in table 4.D should represent the total ammonia (NH_3) and nitrogen oxide (NO_X) losses based on the total N excretion by animals, while in the estimation of F_{AW}, as described in the NIR, $Frac_{GASM}$ is the proportion of N volatilized only during the spreading of animal wastes. Austria should clarify the rationale for the modified version of the IPCC good practice guidance equation used for estimating F_{AW} and the way in which $Frac_{GASM}$ is used.	Now the IPCC definition for $Frac_{GASM}$ is used.
51. The ERT encourages Austria to specify in the documentation box in table 4.D that emissions from sewage sludge are included under synthetic fertilizers. The NIR should also state that F_{SN} includes the nitrogen contribution from sludge applied to agricultural soils. The ERT recommends Austria to provide in the NIR more detailed documentation of the country-specific methodology that is	To enhance transparency, "sewage sludge" is now reported under "Other" in CRF-Table 4.D. Additional information on the country-specific methodology

used to estimate emissions from N-fixing crops for comparison with the methodology given in the IPCC good practice guidance.	will be provided in the next NIR
4.D.3 Agricultural soils – Indirect N_2O 52. Austria's adaptation of the IPCC equation for estimating nitrogen input from atmospheric deposition underestimates this input because neither N volatilized in housing and storage nor that from animal waste excretion at pasture is taken into account. The Party should re-examine the methodology being used to estimate this component of N_2O emissions and the relationship to direct emissions through $Frac_{GASM}$ so that all emissions are fully accounted for in accordance with the IPCC good practice guidance. Responding to the draft of this report, Austria stated that total volatilized N and the IPCC definition of $Frac_{GASM}$ will be used for calculating indirect emissions for the next submission.	Now total N excretion is considered for calculating indirect N_2O emissions from atmospheric deposition.
53. The NIR gives no basis for the use of the default value of 0.3 for $Frac_{LEACH}$ in Austria. Nitrogen inputs may be too low to justify the use of this default value and the Party may wish to assess its suitability as part of its future inventory development. Responding to the draft of this report, Austria indicated its intention to re-examine the suitability of this default value for its 2006 submission.	Austria will re-examine the suitability of the use of the default value for the submission 2006.
LULUCF	
57. The procedure for QA/QC is well established and defined by the Party. The calculation of uncertainties takes into consideration the statistical uncertainty of the forest inventory, the calculation of annual data, and the conversion and expansion factors. However, the estimates for changes in forest and other woody biomass stocks still contain a high degree of uncertainty. The Party will improve the estimations of uncertainties through the Monte Carlo simulations.	The sector LULUCF is currently under revision, incorporating the new GPG. Data on sub sectors of LUCF is reported in this submission.
Waste	
Sector Overview 62. Austria has provided all CRF tables for all years from 1990 to 2002 covering all source categories and gases relevant to the Waste sector. Information gaps were identified in category 6.B Waste-water Handling, since most of the background data are reported as "NE". The ERT noted important improvements since the 2003 submission: these include the updating of AD for SWDS and the provision of explanations on documentation requested in the previous review.	Background data for waste water handling is now reported as "NA" (the methodology is different that's why these data is not available; however, the methodology will be revised until the submission 2006).
63. Austria has performed recalculations for the whole time series for SWDS (due to the updating of AD, quantities of municipal solid waste (MSW), degradable organic carbon (DOC) and CH_4 recovery) and compost production (due to the reallocation of sludge spreading to category 4.D.1 in the Agriculture sector). The recalculations resulted in a decrease in the figures for emissions from the sector of 35.5 per cent for 2001. Though the NIR provides clear explanations, the ERT recommends that regarding this recalculation Austria provide, in next submission, a description on the differences in AD and DOC compared with the previous submission, the reasons for them, or the amount of emissions reallocated that has led to this large reduction.	Detailed data on the recalculation has been provided during the review. Additional information on the data now used is now provided in the respective chapter of the NIR.
Solid waste disposal sites – CH_4 65. The method used for calculating the emissions from SWDS is country-specific. It separates waste into two categories, "residual waste" and "non-residual waste" for both of which country-specific AD and parameters are applied. The quantities of residual and non-residual wastes have been obtained from different referenced studies. The Party has made progress with regard to AD as it has collected and updated some additional data. However, it would be more appropriate to use extrapolation techniques for those years where no data are available (i.e., non-residual wastes before 1998) as recommended by the previous review, instead of considering it	Efforts to improve the time series of non-residual waste will be made for the submission 2006.

as constant (NIR, page 227, paragraph 8.2.1.3).	
66. The methodology used is well documented with a clear explanation. However, even though Austria has provided additional information on waste composition as requested by the ERT, it was not possible to replicate the calculations for biodegradable organic carbon for directly deposited wastes (table 194 of the NIR). The ERT encourages Austria to further document and reference in the NIR the following parameters and information: degradation constant used k=0.035; the composition of wastes through the years for residual wastes and its relation to DOC reported; and the composition of non-residual wastes and its relation to the half-life periods used.	Additional information is now provided in the respective chapter of the NIR.
67. As a result of the updating of AD (quantity of solid wastes disposed in landfills, kg DOC/kg wastes, CH_4 recovery), emissions have been recalculated. This has led to an important reduction in the figures for emissions (57 per cent in 1990 and 59 per cent in 2001) which needs further explanation. The fraction of DOC in MSW decreases continuously, presenting a reduction of 40 per cent in 2001 compared to 1990, while the composition of wastes reported in the CRF is constant through the years. This trend is different from that of any other Annex I Party. The ERT encourages Austria to review these figures for its next submission.	Additional information is now provided in the respective chapter of the NIR, and parameters used will be reviewed until submission 2006 as recommended by the ERT.
68. As stated in previous review reports, Austria uses an oxidation factor of 0.2 (double the recommended IPCC maximum default value of 0.1). The Party made references to recent studies and expert judgement and stated that this figure seemed to be more appropriate to the landfill management practices in Austria. The ERT encourages Austria to reconsider using the IPCC default value for its next submission.	The IPCC default value is now used.
Waste-water handling – CH_4 and N_2O 69. The methodology used for CH_4 emissions from domestic and industrial waste water, based on an IEF calculated for 1993 and held constant for all years, is not in line with the IPCC good practice guidance. In developing the already planned improvement of the methodology, Austria should consider the use of the check method described in the IPCC good practice guidance for domestic and commercial waste water and the use of default data (for Chemical Oxygen Demand (COD)) and expert judgement (IPCC good practice guidance page 5.20, decision tree) for industrial waste water, until country-specific data are available. 70. The N_2O IEF (0.00075) for human sewage is the lowest among reporting Parties (out of the range of IPCC good practice guidance 0.002–0.12). Austria has planned to improve the methodology for its next submission.	Some parameters used for calculating N_2O emissions from waste water handling have been updated for this submission, the methodology for CH_4 emissions will revised for submission 2006.
Waste incineration – CO_2 Documentation on the allocation of CO_2 emissions from the incineration of waste oil with and without energy recovery has been improved. However, the ERT recommends that Austria specify in the NIR or in the documentation box of table 6.C the quantities of waste oil that are specifically incinerated for energy recovery and those that are not.	An explanation is now provided in the NIR.

9.2 Implication for Emission Levels

Subchapters 9.2.1 to 9.2.3 present the implication of recalculations for emission levels by category for CO_2, CH_4, N_2O and FCs.

Table 241: IPCC codes and names of categories

0	TOTAL without sinks
1	ENERGY
1 A	FUEL COMBUSTION ACTIVITIES
1 A 1	Energy Industries
1 A 2	Manufacturing Industries and Construction
1 A 3	Transport
1 A 4	Other Sectors
1 A 5	Other
1 B	FUGITIVE EMISSIONS FROM FUELS
1 B 2	Oil and natural gas
2	INDUSTRIAL PROCESSES
2 A	MINERAL PRODUCTS
2 A 1	Cement Production
2 A 2	Lime Production
2 A 3	Limestone and Dolomite Use
2 A 4	Soda Ash Production and use
2 A 7	Other
2 B	CHEMICAL INDUSTRY
2 B 4	Carbide Production
2 B 5	Other
2 C	METAL PRODUCTION
2 D	OTHER PRODUCTION
3	SOLVENT AND OTHER PRODUCT USE
4	AGRICULTURE
5	LAND USE CHANGE AND FORESTRY
6	WASTE
6 C	WASTE INCINERATION
7	OTHER
I B	International Bunkers
Bio	CO2 Emissions from Bio-mass

9.2.1 Recalculation of CO_2 Emissions by Categories

Explanations are provided in Chapter 9.1 and in the sector specific chapters of this report.

Table 242: Recalculation Difference of CO_2 Emissions.

	CO_2 [Gg]; Differences with respect to Submission 2004												
IPCC Cat.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total	363.38	216.67	268.08	589.90	499.60	641.07	415.42	813.88	409.74	277.94	390.07	242.52	1 323.18
1	308.22	236.50	282.15	615.45	528.97	674.11	406.49	814.11	393.48	301.66	310.15	286.59	605.03
1 A	308.22	236.50	282.15	615.45	528.97	674.11	406.49	814.11	393.48	301.66	310.15	286.59	605.03
1 A 1	147.28	150.01	201.71	459.62	365.53	239.37	66.38	-303.76	50.34	-538.35	-225.05	-1 088.9	-1 665.3
1 A 2	-61.92	-9.34	-123.10	-199.22	63.48	99.24	253.34	1 110.21	428.15	238.00	592.15	1 143.94	1 890.65
1 A 3	-354.33	-174.65	-156.98	-105.57	-245.56	47.82	-21.40	-36.43	88.97	44.69	298.10	180.52	367.36
1 A 4	577.18	270.48	360.52	460.61	345.52	287.68	108.17	44.08	-173.99	557.31	-355.05	58.23	12.07
1 A 5												-7.16	0.26
1 B													
2	55.17	-19.83	-14.08	-25.55	-29.37	-33.04	8.93	-0.23	16.26	-23.72	79.92	-44.07	718.12
2 A									19.06	19.80	124.00	132.36	144.73
2 A 1									19.06	19.80	124.00	132.36	148.10
2 A 7													-3.36
2 B	3.12	2.86	14.63	9.08	-1.63								
2 B 5	3.12	2.86	14.63	9.08	-1.63								
2 C	52.04	-22.70	-28.71	-34.63	-27.74	-33.04	8.93	-0.23	-2.80	-43.52	-44.08	-176.43	573.39
2 C 1	31.23	-43.50	-49.52	-55.44	-48.55	-53.85	-9.84	-19.54	-21.97	-62.42	-62.98	-195.34	554.48
2 C 2	20.81	20.81	20.81	20.81	20.81	20.81	18.77	19.31	19.18	18.90	18.90	18.90	18.90
3													
4													
5	201.5	1 730.8	221.6	221.6	221.6	207.6	193.6	-4 057.1	-5 073.7	-5 004.1	-6 012.6	-5 711.4	-3 677.6
6													0.03
6 C													0.03
7													
I B												32.70	13.91
CO_2 [Mg] from Biomass:													
Bio	-0.13	-0.18	-33.77	-39.57	-37.70	-37.14	-32.87	-36.07	-37.81	773.81	325.77	297.93	-265.28

Blank fields indicate that no recalculation of emissions has been carried out.

9.2.2 Recalculation of CH4 Emissions by Categories

Explanations are provided in Chapter 9.1 and in the sector specific chapters of this report.

Table 243: Recalculation Difference of CH_4 Emissions.

	CH_4 [Gg]; Differences with respect to Submission 2004												
IPCC Cat.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total	20.17	20.02	19.50	19.83	18.35	17.60	16.91	16.40	16.22	16.10	16.93	17.36	18.65

IPCC Cat.	CH_4 [Gg]; Differences with respect to Submission 2004												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.10	-0.06	-0.12	-0.19	-0.28	-0.28	-0.21	-0.30	-0.32	-0.05	-0.04	-0.33	0.01
1 A	0.10	-0.05	-0.12	-0.19	-0.28	-0.27	-0.20	-0.29	-0.30	-0.04	-0.02	-0.30	-0.42
1 A 1	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.01	0.01	-0.01	0.00	-0.01	-0.05
1 A 2	-0.01	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.00	0.03	0.03	0.12
1 A 3	0.05	-0.08	-0.16	-0.22	-0.31	-0.30	-0.26	-0.28	-0.35	-0.32	-0.32	-0.35	-0.42
1 A 4	0.06	0.02	0.02	0.02	0.02	0.00	0.03	-0.03	0.01	0.29	0.27	0.03	-0.06
1 A 5													
1 B	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.03	0.43
1 B 1												-0.01	0.12
1 B 2	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	0.31
2	0.03	0.03	0.02	0.03	0.04	0.06	0.06	0.06	0.06	0.08	0.08	0.07	-0.04
2 A	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.03->NA	0.03->NA	0.04->NA	0.04->NA
2 A 5	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.04->NA	0.03->NA	0.03->NA	0.04->NA	0.04->NA
2 B	0.07	0.07	0.06	0.07	0.08	0.10	0.10	0.10	0.10	0.11	0.12	0.11	0.00
2 B 5	0.07	0.07	0.06	0.07	0.08	0.10	0.10	0.10	0.10	0.11	0.12	0.11	0.00
3													
4	0.47	0.48	0.47	1.06	0.48	0.49	0.49	0.64	0.58	0.50	0.60	0.74	0.90
4 A 1											0.18	0.34	0.50
4 A 6											-0.03	-0.06	-0.06
4 A 9	0.18	0.19	0.18	0.19	0.18	0.18	0.17	0.19	0.18	0.19	0.15	0.16	0.16
4 A 10	0.3	0.3	0.3	0.3	0.3	0.32	0.33	0.45	0.4	0.31	0.31	0.31	0.31
4 B	0.01	0.01	0.01	0.58									
4 F	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	-0.01	-0.01	-0.01
5													
6	19.56	19.56	19.13	18.93	18.11	17.32	16.57	16.01	15.90	15.58	16.29	16.89	17.78
6 A 1	19.65	19.67	19.26	19.08	18.28	17.50	16.75	16.12	15.98	15.63	16.31	16.71	17.52
6 B 1	-0.03	-0.04	-0.04	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	0.01	0.03
6 B 2	-0.06	-0.07	-0.09	-0.10	-0.11	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	0.01	0.06
6 D 2								0.07	0.10	0.13	0.16	0.16	0.17
7													
I B												0.00	0.00

Blank fields indicate that no recalculation of emissions has been carried out.

9.2.3 Recalculation of N_2O Emissions by Categories

Explanations are provided in Chapter 9.1 and in the sector specific chapters of this report.

Table 244: Recalculation Difference of N_2O Emissions.

IPCC Cat.	N_2O [Gg]; Differences with respect to Submission 2004												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total	-0.89	-1.79	0.04	-2.09	-2.47	-0.75	-1.11	-1.66	-0.68	-0.92	-0.94	-0.77	-0.36
1	-0.88	-1.26	-1.45	-1.61	-1.71	-1.68	-1.56	-1.43	-1.51	-1.33	-1.32	-1.26	-1.36
1 A	-0.88	-1.26	-1.45	-1.61	-1.71	-1.68	-1.56	-1.43	-1.51	-1.33	-1.32	-1.26	-1.36
1 A 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2	0.07	0.07	0.06	0.06	0.06	0.05	0.04	0.04	0.03	0.04	0.01	0.01	0.03
1 A 3	-1.02	-1.33	-1.52	-1.67	-1.78	-1.70	-1.59	-1.45	-1.49	-1.32	-1.25	-1.20	-1.33
1 A 4	0.06	0.01	0.01	0.00	0.01	-0.03	-0.01	0.00	-0.05	-0.04	-0.09	-0.07	-0.07
1 A 5												0.00	0.00
1 B													
2													
3													
4	0.01	-0.52	1.51	-0.47	-0.80	0.80	0.26	-0.47	0.51	0.02	-0.08	-0.08	0.43
4 B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
4 D	0.01	-0.52	1.51	-0.46	-0.80	0.81	0.27	-0.46	0.52	0.03	-0.08	-0.09	0.41
4 D 1	-0.14	-0.46	0.78	-0.41	-0.61	0.37	0.05	-0.39	0.20	-0.09	-0.16	-0.17	0.15
4 D 2	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 D 3	0.11	-0.10	0.68	-0.09	-0.22	0.40	0.18	-0.10	0.28	0.09	0.05	0.05	0.24
4 D 4	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5													
6	-0.02	-0.02	-0.01	-0.01	0.04	0.12	0.19	0.23	0.32	0.38	0.46	0.57	0.57
6 B 1	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.05	0.07	0.08	0.10	0.13	0.13
6 B 2	-0.01	-0.01	-0.01	-0.01	0.03	0.09	0.14	0.17	0.23	0.28	0.33	0.42	0.42
6 D							0.00	0.01	0.01	0.02	0.03	0.03	0.03
7													
I B										0.00	0.00	0.00	0.00

Blank fields indicate that no recalculation of emissions has been carried out.

9.2.4 Recalculation of National Total GHG Emissions

Table 245 compares national total GHG emissions of UNFCCC submission 2005 with UNFCCC submission 2004. Due to the recalculations national total GHG emissions are now higher: for the base year they are 0.7% higher and for the year 2002 2.1%.

Table 245: Recalculation Difference of National Total GHG Emissions

Year	National Total GHG emissions without LUCF		
	Submission 2004 [Gg CO_2e]	Submission 2005 [Gg CO_2e]	Recalculation Difference [%]
Base year	77 998.09	78 535.22	0.7%
1990	77 746.24	78 573.05	1.1%
1991	82 154.07	82 647.00	0.6%
1992	75 135.27	76 062.64	1.2%
1993	75 412.78	76 177.63	1.0%
1994	76 480.37	77 045.38	0.7%
1995	79 355.70	80 159.10	1.0%
1996	82 775.93	83 237.39	0.6%
1997	82 340.31	83 046.10	0.9%
1998	81 999.95	82 513.72	0.6%
1999	80 082.72	80 402.96	0.4%
2000	80 640.20	81 083.55	0.5%
2001	84 398.39	84 871.78	0.6%
2002	84 620.79	86 433.79	2.1%

Table 246 and Table 247 present recalculation differences per gas.

Table 246: Recalculation Difference of National CO_2 and CH_4 Emissions.

Year	CO_2 [Gg CO_2e]			CH_4 [Gg CO_2e]		
	Submission 2004	Submission 2005	Recalculation Difference [%]	Submission 2004	Submission 2005	Recalculation Difference [%]
Base Year	60 899.24	61 262.62	0.6%	9 374.18	9 797.69	4.5%
1990	60 899.24	61 262.62	0.6%	9 374.18	9 797.69	4.5%
1991	64 535.42	64 752.08	0.3%	9 339.51	9 759.88	4.5%
1992	59 080.06	59 348.14	0.5%	9 051.14	9 460.60	4.5%
1993	59 309.75	59 899.64	1.0%	9 009.30	9 425.66	4.6%
1994	59 703.64	60 203.24	0.8%	8 872.32	9 257.72	4.3%
1995	62 474.38	63 115.45	1.0%	8 773.33	9 142.84	4.2%
1996	66 147.04	66 562.46	0.6%	8 603.59	8 958.72	4.1%
1997	65 713.42	66 527.30	1.2%	8 336.93	8 681.40	4.1%
1998	65 808.07	66 217.81	0.6%	8 216.35	8 557.07	4.1%
1999	64 336.20	64 614.14	0.4%	8 027.55	8 365.73	4.2%

Year	CO_2 [Gg CO_2e]			CH_4 [Gg CO_2e]		
	Submission 2004	Submission 2005	Recalculation Difference [%]	Submission 2004	Submission 2005	Recalculation Difference [%]
2000	65 064.05	65 454.12	0.6%	7 790.64	8 146.25	4.6%
2001	69 037.12	69 279.64	0.4%	7 655.84	8 020.50	4.8%
2002	69 671.29	70 994.47	1.9%	7 464.64	7 856.28	5.2%

The main reason for the increase of reported CO_2 emissions are

- An improved estimation methodology of category *1 A 1 b Petroleum Refining*.
- and higher emissions from Industrial Processes mainly due to update of activity data for *2 A 1 Cement Production*.

The main reason for the increase of reported methane emissions are higher emissions from *6 A 1 Solid Waste disposal on Land* which is mainly due to the use of the IPCC default value for methane oxidation instead of a country-specific value previously used.

Table 247: Recalculation Difference of National N_2O and HFC,PFC,SF_6 Emissions

Year	N_2O [Gg]			HFC, PFC, SF_6 [Gg CO_2-equivalent]		
	Submission 2004	Submission 2005	Recalculation Difference [%]	Submission 2004	Submission 2005	Recalculation Difference [%]
Base Year	5 988.22	5 711.76	-4.6%	1 736.44	1 763.16	1.5%
1990	5 988.22	5 711.76	-4.6%	1 484.60	1 800.99	21.3%
1991	6 616.07	6 060.03	-8.4%	1 663.08	2 075.01	24.8%
1992	5 693.93	5 706.80	0.2%	1 310.13	1 547.10	18.1%
1993	6 210.62	5 561.46	-10.5%	883.12	1 290.86	46.2%
1994	6 801.08	6 034.88	-11.3%	1 103.32	1 549.54	40.4%
1995	6 371.54	6 137.65	-3.7%	1 736.44	1 763.16	1.5%
1996	6 139.55	5 794.74	-5.6%	1 885.75	1 921.47	1.9%
1997	6 405.61	5 890.80	-8.0%	1 884.35	1 946.60	3.3%
1998	6 184.16	5 973.57	-3.4%	1 791.37	1 765.27	-1.5%
1999	6 093.28	5 807.59	-4.7%	1 625.69	1 615.50	-0.6%
2000	6 050.15	5 758.53	-4.8%	1 735.36	1 724.65	-0.6%
2001	5 970.07	5 730.53	-4.0%	1 735.36	1 841.11	6.1%
2002	5 749.51	5 636.41	-2.0%	1 735.36	1 946.63	12.2%

The main reason for the decrease of reported N_2O emissions are lower emissions from *1 A 3 b Road Transport*. The emission factors have been updated (updated handbook of emission factors (version 2.1).

The main reason for an increase of reported emissions of fluorinated compounds is that during an internal audit several mistakes and inconsistencies were identified and corrected and the data quality could be improved for some sub-sectors using information from industry. Furthermore emissions from 2001 and 2002 were updated using extrapolation techniques and data from industries (previously the same estimated as for 2000 was used for these years).

Furthermore, in this year's submission emissions from industrial electricity and heat autoproducers were shifted from category *1 A 2 f Other* to the corresponding industrial branches of subcategories *1 A 2 a* to *1 A 2 e, 1 A 1 b, 1 A 1 c* and *1 A 4 a.*

For further information see Chapter 9.1 and the sector specific chapters of this report.

9.3 Implications for Emission Trends

As can be seen in Table 245 and Figure 21, Austria's greenhouse gas emissions as reported in the UNFCCC submission 2004 are higher than the values reported last year due to recalculations: for the base year they are 0.7% lower and for the year 2002 2.1%. This results in a stronger increasing trend: last year the trend from the base year to 2002 was plus 8.5% whereas now it is plus 10.1% (for explanations please refer to Chapter 9.1).

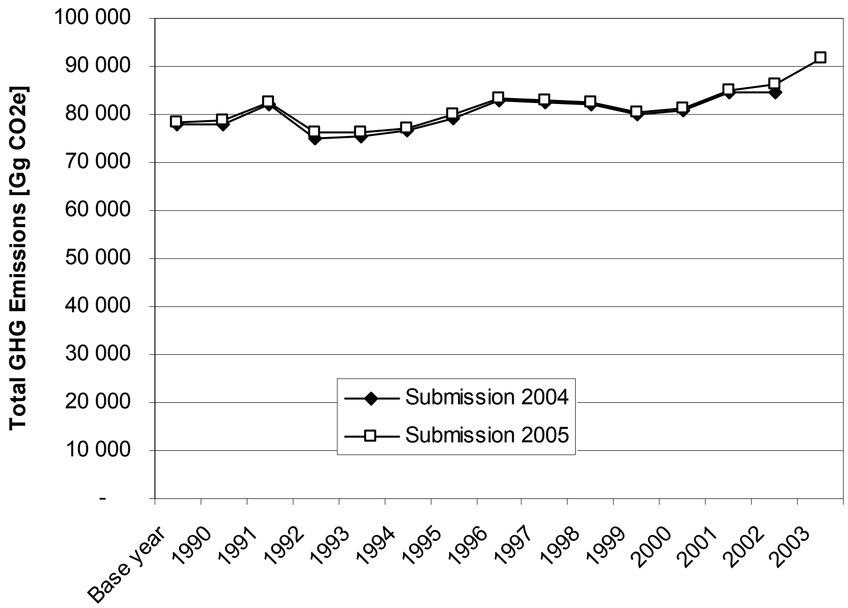


Figure 21: Emission estimate of the submission 2003 and recalculated values of the submission 2004

9.4 Planned Improvements

Source specific planned improvements are presented in the respective subchapters of Chapters 3-8.

Goals

The overall goal is to produce emission inventories which are fully consistent with the UNFCCC reporting guidelines and the IPCC Guidelines.

An improvement program has been established to help meet this goal including implementation of the Good Practice Guidance 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, 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 international standards (EN 45000, ISO 9000).

Updating

The improvement programme is updated every year in January.

Responsibilities

The Umweltbundesamt is responsible for the management of the improvement programme.

ABBREVIATIONS

General

AMA	Agrarmarkt Austria
BAWP	Bundes-Abfallwirtschaftsplan Federal Waste Management Plan
BMLFUW	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft Federal Ministry for 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
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
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
IEA	International Energy Agency
ISO	International Standards Organisation
LTO	Landing/Take-Off cycle
LUCF	Land Use Change and Forestry – IPCC-CRF Category 5
LULUCF	Land Use and Land Use Change and Forestry

NACE	Nomenclature des activites economiques de la Communaute Europeenne
NAPFUE	Nomenclature for Air Pollution Fuels
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
UMWELTBUN DESAMT	„Austria's Federal Environment Agency"
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 UNFCCC guidelines on reporting and review [FCCC/CP/2002/8]

"NO" (not occurring)	for activities or processes in a particular source or sink category that do not occur within a country;
"NE" (not estimated)	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 of CO_2 , CH_4 , N_2O, HFCs, PFCs, or SF_6 , the Party should indicate in both the NIR and the CRF completeness table why emissions or removals have not been estimated
"NA" (not applicable)	for activities in a given source/sink category that do not result in emissions or removals of a specific gas. If categories in the CRF 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 greenhouse gases 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, using 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 expected category;
"C" (confidential)	for emissions by sources and removals by sinks of greenhouse gases which could lead to the disclosure of confidential information, given the provisions of paragraph 27 of above];

Chemical Symbols

Symbol	Name
Greenhouse gases	
CH_4	Methane
CO_2	Carbon Dioxide
N_2O	Nitrous Oxide
HFCs	Hydroflurocarbons
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
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 000g	
1t	= 1 000kg	= 1Mg
1kt	= 1 000t	= 1Gg
1Mt	= 1 Mio t	= 1Tg

Metric Symbol	Prefix	Factor
P	peta	10^{15}
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
h	hecto	10^{2}
da	deca	10^{1}
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}

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