BE-225

BERICHTE

Umweltbundesamt

AUSTRIA'S NATIONAL INVENTORY REPORT 2003

Submission under the United Nations Framework Convention on Climate Change 2003

AUSTRIA'S NATIONAL INVENTORY REPORT 2003

Submission under the United Nations Framework Convention on Climate Change 2003

BE-225

Vienna, May 2003

Authors

Klaus RADUNSKY
Manuela WIESER
Stephan POUPA
Michael ANDERL
Günther LICHTBLAU
Roman ORTNER
Andreas HRABAL
Daniela WAPPEL
Peter WEISS

Reporting entity	Überwachungsstelle Emissionsbilanzen (*Inspection Body for Emission Inventories)* at the Umweltbundesamt - Federal Environment Agency Spittelauer Lände 5 A -1090 Wien
Contracting entitiy	BMLFUW (*Federal Ministry of Agriculture, Forestry, Environment and Water Management*) Stubenring 1 A-1012 Wien
Date of order acceptance	20.08.1998 (Umweltkontrollgesetz - *Environmental Control Act*)
Responsible for the content of this report	Dr. Klaus Radunsky (*Head of the inspection body*) Signature:
Date of submission	22.05.2003

Further information concerning publications of the Federal Environment Agency Ltd. can be found at: http://www.ubavie.gv.at

Impressum
Editor: Umweltbundesamt GmbH (Federal Environment Agency Ltd.)
Spittelauer Lände 5, A-1090 Vienna, Austria

ISBN 3-85457-681-1

CONTENTS

EXECUTIVE SUMMARY 9
ES.1 Background Information 9
ES.2 Summary of National Emission and Removal Related Trends 11
ES.3 Overview of Source and Sink Category Emission Estimates and Trends 13
ES.4 Overview of Emission Estimates and Trends of Indirect GHGs and SO_2 13

1 INTRODUCTION 15
1.1 Background Information 15
1.2 Institutional Arrangement for Inventory Preparation 17
1.2.1 Austria's Obligations 17
1.2.2 History of NISA 18
1.2.3 Adaptation of NISA according to the Kyoto Protocol 18
1.3 Inventory Preparation Process 21
1.3.1 The CORINAIR System 21
1.3.2 Data Management 22
1.3.3 Reporting 22
1.4 Methodologies and Data Sources Used 24
1.5 Key Source Analysis 26
1.5.1 Austria's Key Source Categories 26
1.5.2 Description of Methodology 29
1.6 Quality Assurance and Quality Control (QA/QC) 31
1.7 Uncertainty Assessment 36
1.7.1 First Comprehensive Uncertainty Analysis 36
1.7.2 Procedure 38
1.8 Completeness 39

2 TREND IN TOTAL EMISSIONS 41
2.1 Emission Trends for Aggregated GHG Emissions 41
2.2 Emission Trends by Gas 42
2.3 Emission Trends by Source 44
2.4 Emission Trends for Indirect Greenhouse Gases and SO_2 47

3 ENERGY (CRF SECTOR 1) 50
3.1 Sector Overview 50
3.1.1 Emission Trends 50

3.2 Fuel Combustion Activities (CRF Source Category 1 A) ... 52
3.2.1 Source Category Description ... 52
3.2.1.1 Key Sources ... 52
3.2.1.2 Completeness ... 53
3.2.2 Methodological issues ... 58
3.2.2.1 1 A 1 a Public Electricity and Heat Production ... 59
3.2.2.2 1 A 1 b Petroleum Refining ... 60
3.2.2.3 1 A 1 c Manufacture of Solid Fuels and Other Energy Industries ... 61
3.2.2.4 1 A 2 a Iron and Steel ... 62
3.2.2.5 1 A 2 b Non-Ferrous Metals ... 63
3.2.2.6 1 A 2 c Chemicals ... 65
3.2.2.7 1 A 2 d Pulp, Paper and Print ... 66
3.2.2.8 1 A 2 e Food Processing, Beverages and Tobacco ... 68
3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other ... 69
3.2.2.10 1 A 3 a Civil Aviation ... 74
3.2.2.11 1 A 3 b Road Transport ... 78
3.2.2.12 1 A 3 c Railways ... 80
3.2.2.13 1 A 3 d Navigation ... 81
3.2.2.14 1 A 3 e Other Transportation ... 82
3.2.2.15 1 A 4 Other sectors ... 82
3.2.2.16 International Bunkers ... 87
3.2.2.16.1 International Bunkers - Aviation ... 87
3.2.2.16.2 International Bunkers - Marine ... 89
3.2.3 Quality Assurance and Quality Control and Verification ... 89
3.2.4 Recalculations ... 89
3.2.5 Planned Improvements ... 90
3.2.6 Comparison of the Sectoral Approach with the Reference Approach ... 90
3.3 Fugitive Emissions (CRF Source Category 1 B) ... 93
3.3.1 Source Category Description ... 93
3.3.1.1 Emission Trends ... 93
3.3.1.2 Completeness ... 93
3.3.2 Methodological issues ... 94
3.3.2.1 1 B 1 a Fugitive Emissions from Fuels – Coal Mining ... 94
3.3.2.2 1 B 1 b Fugitive Emissions from Fuels – Solid Fuel Transformation ... 95
3.3.2.3 1 B 2 a Fugitive Emissions from Fuels – Oil ... 95
3.3.2.4 1 B 2 b Fugitive Emissions from Fuels – Natural Gas ... 97
3.3.3 Recalculations ... 97
3.3.4 Planned Improvements ... 98

4 INDUSTRY (CRF SECTOR 2) ... 99
4.1 Sector Overview ... 99
4.1.1 Emission Trends ... 99
4.1.2 Key Sources ... 104
4.1.3 Methodology ... 106
4.1.4 Uncertainty Assessment ... 106
4.1.5 Quality Assurance and Quality Control (QA/ QC) ... 106
4.1.6 Recalculations ... 106

4.1.7 Completeness ... 107
4.1.8 Planned Improvements ... 109
4.2 Mineral Products (CRF Source Category 2 A) ... 110
4.2.1 Cement Production (2 A 1) ... 110
4.2.1.1 Source Category Description ... 110
4.2.1.2 Methodological Issues ... 111
4.2.1.3 Planned Improvements ... 114
4.2.1.4 Recalculation ... 114
4.2.2 Lime Production (2 A 2) ... 114
4.2.2.1 Source Category Description ... 114
4.2.2.2 Methodological Issues ... 115
4.2.2.3 Planned Improvements ... 116
4.2.3 Asphalt Roofing (2 A 5) ... 116
4.2.3.1 Source Category Description ... 116
4.2.3.2 Methodological Issues ... 117
4.2.3.3 Recalculation ... 117
4.2.4 Mineral Products – Other (2 A 7) ... 118
4.2.4.1 Source Category Description ... 118
4.2.4.2 Glass Production ... 118
4.2.4.3 Magnesia Sinter Production ... 120
4.3 Chemical Industry (CRF Source Category 2 B) ... 122
4.3.1 Ammonia Production (2 B 1) ... 122
4.3.1.1 Source Category Description ... 122
4.3.1.2 Methodological Issues ... 123
4.3.1.3 Recalculation ... 123
4.3.2 Nitric Acid Production (2 B 2) ... 124
4.3.2.1 Source Category Description ... 124
4.3.2.2 Methodological Issues ... 125
4.3.2.3 Recalculation ... 125
4.3.3 Chemical Industry – Other: Production of Fertilizers and Urea (2 B 5) ... 126
4.3.3.1 Source Category Description ... 126
4.3.3.2 Methodological Issues ... 128
4.3.3.3 Recalculation ... 128
4.3.3.4 Time Series Consistency ... 129
4.4 Metal Production (CRF Source Category 2 C) ... 130
4.4.1 Iron and Steel (2 C 1) ... 130
4.4.1.1 Source Category Description ... 130
4.4.1.2 Methodological Issues ... 130
4.4.1.3 Time Series Consistency ... 131
4.4.1.4 Planned Improvements ... 132
4.4.2 Aluminium Production (2 C 3) ... 132
4.4.2.1 Source Category Description ... 132
4.4.2.2 Methodological Issues ... 132
4.4.3 SF_6 Used in Aluminium and Magnesium Foundries (2 C 4) ... 133
4.4.3.1 Source Category Description ... 133
4.4.3.2 Methodological Issues ... 133
4.4.4 Metal Production - Other (2 C 5) ... 134

4.4.4.1 Electric Furnace Steel Plants ... 134
4.4.4.1.1 Source Category Description ... 134
4.4.4.1.2 Methodological Issues ... 134
4.4.4.1.3 Recalculation ... 135
4.4.4.2 Rolling Mills ... 136
4.4.4.2.1 Source Category Description ... 136
4.4.4.2.2 Methodological Issues ... 136
4.5 Other Production (CRF Source Category 2 D) ... 137
4.5.1 Food and Drink (2 D 2) ... 137
4.5.1.1 Source Category Description ... 137
4.5.1.2 Methodological Issues ... 138
4.5.1.3 Recalculations ... 139
4.6 Consumption of Halocarbons and SF_6 (CRF Source Category 2 F) ... 141
4.6.1 Source Category Description ... 141
4.6.2 Methodological Issues ... 141
4.6.2.1 2 F 1 Refrigeration and Air Conditioning Equipment ... 143
4.6.2.2 2 F 2 Foam Blowing and XPS/PU Plates ... 143
4.6.2.3 2 F 3 Fire Extinguishers ... 143
4.6.2.4 2 F 4 Aerosols/Metered Dose Inhalers ... 143
4.6.2.5 2 F 5 Solvents concerning Halocarbons ... 144
4.6.2.6 2 F 6 Semiconductor Manufacture (HFCs, PFCs, SF_6) ... 144
4.6.2.7 2 F 7 Electrical Equipment (SF_6) ... 144
4.6.2.8 2 F 8 Other Sources of SF_6 (noise insulate glass, tyres and research) ... 144
4.6.3 Planned Improvements ... 145
5 SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3) ... 147
5.1 Sector Overview ... 147
5.2 Source Categories ... 149
5.3 Planned Improvements ... 151
6 AGRICULTURE (CRF SECTOR 4) ... 153
6.1 Sector Overview ... 153
6.1.1 Emission Trends ... 153
6.1.2 Key Sources ... 155
6.1.3 Methodology ... 156
6.1.4 Quality Assurance and Quality Control (QA/QC) ... 156
6.1.5 Uncertainty assessment ... 156
6.1.6 Recalculations ... 157
6.1.7 Completeness ... 158
6.1.8 Planned Improvements ... 159
6.2 Enteric Fermentation (CRF Source Category 4 A) ... 160
6.2.1 Source Category Description ... 160
6.2.2 Methodological Issues ... 160
6.2.2.1 Cattle (4 A 1) ... 163
6.2.2.2 Sheep (4 A 3), Goats (4 A 4), Horses (4 A 6) and Swine (4 A 8) ... 166

6.2.3 Uncertainties 166
6.2.4 Recalculations 168
6.2.5 Planned Improvements 169

6.3 Manure Management (CRF Source Category 4 B) 170
6.3.1 Source Category Description 170
6.3.2 Methodological Issues 171
6.3.2.1 Estimation of CH_4 Emissions 171
6.3.2.1.1 Cattle (4 B 1) 172
6.3.2.1.2 Swine (4 B 8) 174
6.3.2.1.3 Sheep (4 B 3), Goats (4 B 4), Horses (4 B 6), Poultry (4 B 9) and Other Animals (4 B 13) 175
6.3.2.2 Estimation of N_2O Emissions 175
6.3.3 Uncertainties 178
6.3.4 Recalculations 178
6.3.5 Planned Improvements 179

6.4 Agricultural Soils (CRF Source Category 4 D) 180
6.4.1 Source Category Description 180
6.4.2 Methodological Issues 180
6.4.2.1 Direct Soil Emissions (4 D 1) 183
6.4.2.1.1 Nitrogen input through application of mineral fertilizers 184
6.4.2.1.2 Nitrogen input through application of animal manure 184
6.4.2.1.3 Nitrogen input through biological fixation 186
6.4.2.1.4 Nitrogen input from crop residues 186
6.4.2.1.5 Nitrogen input through use of sewage sludge 187
6.4.2.2 Animal Production (4 D 2) 187
6.4.2.3 Indirect Soil Emissions (4 D 3) 188
6.4.2.3.1 N_2O emissions through atmospheric nitrogen deposition 188
6.4.2.3.2 N_2O emissions through nitrogen leaching losses 189
6.4.3 Uncertainties 189
6.4.4 Recalculations 190

6.5 Field Burning of Agricultural Waste (CRF Source Category 4 F) 191
6.5.1 Source Category Description 191
6.5.2 Methodological Issues 191
6.5.2.1 Cereals/ Wheat (4 F 1 a) 191
6.5.2.2 Other (4 F 5) 191
6.5.3 Recalculations 192
6.5.4 Planned Improvements 193

7 LAND USE CHANGE AND FORESTRY (CRF SECTOR 5) 195

7.1 Source Category Description 195

7.2 Changes in Forest and Other Woody Biomass Stocks (5 A) 196
7.2.1 Methodological Issues 196
7.2.2 QA/QC, Verification, Uncertainty Assessment 198

7.3 Forest and Grassland Conversion (5 B), Abandonment of Managed Lands (5 C)199

7.4 CO_2 Emissions and Removals from Soil (5 D) 199

8 WASTE (CRF SECTOR 6) ... 201

8.1 Sector Overview ... 201

8.1.1 Emission Trends ... 201

8.1.2 Key Sources ... 203

8.1.3 Methodology ... 204

8.1.4 Recalculations ... 204

8.1.5 Completeness ... 204

8.2 Waste Disposal on Land (CRF Source Category 6 A) ... 205

8.2.1 Managed Waste Disposal on Land (CRF Source Category 6 A 1) ... 205

8.2.1.1 Source Category Description ... 205

8.2.1.2 Methodological Issues ... 205

8.2.1.2.1 Residual waste ... 205

8.2.1.2.2 Non Residual Waste ... 207

8.2.1.3 Recalculations ... 209

8.2.1.4 Planned Improvements ... 210

8.3 Wastewater Handling (CRF Source Category 6 B) ... 211

8.3.1 Industrial Wastewater (6 B 1) ... 211

8.3.1.1 Source Category Description ... 211

8.3.1.2 Methodological Issues ... 211

8.3.1.3 Planned Improvements ... 214

8.3.2 Domestic and Commercial Wastewater (6 B 2) ... 214

8.3.2.1 Source Category Description ... 214

8.3.2.2 Methodological Issues ... 215

8.3.2.3 Planned Improvements ... 215

8.4 Waste Incineration (CRF Source Category 6 C) ... 216

8.4.1 Source Category Description ... 216

8.4.2 Methodological Issues ... 217

8.4.3 Recalculations ... 218

8.4.4 Planned Improvements ... 218

8.5 Other Waste (CRF Source Category 6 D) ... 219

8.5.1 Source Category Description ... 219

8.5.2 Sludge Spreading ... 219

8.5.2.1 Methodological Issues ... 219

8.5.2.2 Planned Improvements ... 219

8.5.3 Compost Production ... 220

8.5.3.1 Methodological Issues ... 220

8.5.3.2 Planned Improvements ... 220

9 RECALCULATIONS AND IMPROVEMENTS ... 221

9.1 Explanations and Justifications for Recalculations ... 221

9.2 Implication for Emission Levels ... 222

9.2.1 Recalculation of CO_2 Emissions by Categories ... 222

9.2.2 Recalculation of CH_4 Emissions by Categories ... 223

9.2.3 Recalculation of N_2O Emissions by Categories ... 224

9.2.4 Recalculation of HFC, PFC and SF_6 Emissions by Categories ... 224
9.2.5 Recalculation of National Total GHG Emissions ... 225
9.3 Implications for Emission Trends ... 227
9.4 Planned Improvements ... 228

ABBREVIATIONS ... 229

REFERENCES ... 233

DATA SOURCES BY SECTOR ... 238

ANNEX 1: Key Sources
ANNEX 2: Fossil Fuel Combustion
ANNEX 3: CO_2 Reference Approach
ANNEX 4: National Energy Balance
ANNEX 5: CRF
ANNEX 6: Extracts from Austrian Legislation

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 2001.

By taking decision 3/CP.5 (see document FCCC/CP/1999/6/Add.1) the Conference of the Parties (COP) has undertaken to implement the UNFCCC guidelines on reporting and reviewing (FCCC/CP/1999/7). 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 32 of FCCC/CP/1999/7). This is the third version of the National Inventory Report (NIR) submitted by Austria, it is an update of the NIR submitted in 2002[1]. This report is based on the figures that have been submitted to the UNFCCC in the common reporting format (CRF submission 2003). 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*). The inventory as presented in the NIR 2003 and as submitted to the UNFCCC in the data submission 2003 replaces all previous versions of data submissions.

The structure of the NIR has also been changed and follows quite closely the proposal as included in the Appendix of document FCCC/SBSTA/2002/L.5/Add.1. 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 are 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).

Abbreviations and references used are also included as well as the underlying emission data for the year 2001 as included in the tables of the common reporting format of the data submission 2003 to the convention. 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.

It is the intention of this report to help understanding the calculation of the Austrian GHG emission data. Those who want to know more details will have to consult the background literature cited in this document.

The preparation and review of Austria's National Greenhouse Gas Inventory as well as the preparation of the NIR is the responsibility of Manfred Ritter as head of the *Department of Air Emissions* of the Federal Environment Agency.

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

[1] Austria's National Inventory Report 2002 – Submission Under the United Nations Framework Convention of Climate Change. BE-206; Austria's Federal Environment Agency, Vienna.

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

Project leader for the preparation of the NIR 2003 has been Manuela Wieser.

Specific responsibilities for the NIR 2003 have been as follows:

Executive Summary	Manuela Wieser
Chapters 1.1 – 1.5	Manuela Wieser
Chapters 1.6 – 1.8	Andreas Hrabal
Chapter 2	Manuela Wieser
Chapter 3.1/ 3.2 Energy	Stephan Poupa
Chapter 3.2 Road Transport	Günther Lichtblau
Chapter 3.2 Aviation	Roman Ortner
Chapter 3.3	Manuela Wieser
Chapter 4	Manuela Wieser
Chapter 5	Daniela Wappel
Chapter 6	Michael Anderl, Andreas Hrabal
Chapter 7	Peter Weiss
Chapter 8	Daniela Wappel, Stephan Poupa
Chapter 9	Stephan Poupa, Manuela Wieser, Andreas Hrabal
Annexes	Stephan Poupa, Manuela Wieser

The Austrian Federal Environment Agency expresses its thanks and appreciation for the effort in producing a national methodology and emission inventory of high quality. Contributors to the development of methodologies have been acknowledged in the respective sections of the Sector Analysis of the NIR.

ES.2 Summary of National Emission and Removal Related Trends

In the year 2001, the most important GHG in Austria was carbon dioxide (CO_2) contributing 80.5% to total national GHG emissions expressed in CO_2 equivalent, followed by CH_4, 10.6% and N_2O, 6.9%. PFCs, HFCs and SF_6 contributed for 2.0% to the overall GHG emissions in the country. The energy sector accounted for 67.1% of the total GHG emissions followed by Industrial Processes 17.9%, Agriculture 8.9% and Waste 5.4%.

Total GHG emissions (excluding land-use change and forestry (LUCF)) amounted to 85 880 Gg CO_2 equivalent and increased by 10.0% from 1990 to 2001 (9.7% 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 2001.

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]	**69 110**	**78 325**	48 128	15 567	755	8 142	-9 215	5 732
1990		**68 858**	**78 073**	48 128	15 315	755	8 142	-9 215	5 732
1991		**68 737**	**82 241**	52 480	14 965	669	8 495	-13 504	5 632
1992		**66 634**	**75 291**	48 520	13 181	614	7 411	-8 656	5 565
1993		**67 598**	**76 580**	49 320	13 143	593	8 070	-8 982	5 453
1994		**69 906**	**77 768**	49 179	14 024	594	8 619	-7 862	5 352
1995		**73 543**	**80 797**	51 841	14 953	613	8 148	-7 254	5 241
1996		**79 239**	**84 624**	56 383	14 610	612	7 867	-5 385	5 153
1997		**76 513**	**84 146**	54 593	15 749	638	8 159	-7 633	5 007
1998		**76 185**	**83 819**	55 708	14 762	628	7 876	-7 633	4 846
1999		**74 490**	**82 123**	54 286	14 664	628	7 764	-7 633	4 781
2000		**74 317**	**81 951**	54 072	14 877	628	7 680	-7 633	4 693
2001		**78 247**	**85 880**	57 642	15 358	628	7 602	-7 633	4 650

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

Over the period 1990-2001 CO_2 emissions increased by 15.0%, mainly by increased emissions from transport. Methane emissions decreased during the same period by 15.0% mainly due to lower emissions from *Solid Waste Disposal*; N_2O emissions increased by 2.5% over the same period due to increased emissions from *Transport*. Emissions from HFCs and PFCs increased by 89.2% and 61.0% respectively whereas SF_6 emissions decreased by 42.4% from the base year (1995) to 2001.

Table 2: Austria's greenhouse gas emissions by gas

GHG		**Total**	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
BY*	[Gg CO2 equivalent]	**78 325**	60 113	10 672	5 804	546	16	1 175
1990		**78 073**	60 113	10 672	5 804	4	963	518
1991		**82 241**	63 595	10 552	6 431	6	974	683
1992		**75 291**	58 455	10 280	5 247	9	576	725
1993		**76 580**	59 307	10 318	6 072	12	48	823
1994		**77 768**	59 744	10 168	6 752	17	54	1 033
1995		**80 797**	62 627	10 074	6 360	546	16	1 175
1996		**84 624**	66 629	9 955	6 154	625	15	1 246
1997		**84 146**	66 208	9 609	6 445	718	18	1 148
1998		**83 819**	66 333	9 442	6 252	816	21	955
1999		**82 123**	65 020	9 300	6 177	870	25	730
2000		**81 951**	64 928	9 134	6 153	1 033	25	677
2001		**85 880**	69 120	9 074	5 951	1 033	25	677

*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 2001, 57 642 Gg CO_2 equivalent, that are 67.1% of national total emissions arose from the sector *Energy*. 99.6% of these emissions arise from fuel combustion activities. The most important subsector of *Fuel Combustion* with 34.5% of total emissions from this sector in 2001 is transport. From 1990 to 2001 emissions from the energy sector increased by 19.8%.

Industrial Processes is the second largest sector in Austria with 17.9% of total GHG emissions in 2001 (15 358 Gg CO_2 equivalent). In the year 2001, 60.2% of these emissions arose from *Metal Production*. From the base year to 2001 emissions from industrial processes decreased by 1.3%.

In the year 2001, 0.7% of total GHG emissions in Austria (628 Gg CO_2 equivalent) arose from the sector *Solvent and Other Product Use*. From 1990-2001 emissions from this category decreased by 16.8%.

Emissions from *Agriculture* amounted to 7 602 Gg CO_2 equivalent in the year 2001, that are 8.9% of national total emissions. The most important sub sector is *Enteric Fermentation* with 41.4% of the greenhouse gas emissions from the agricultural sector in 2001, the second important sub source is *Agricultural Soils* with 37.2%. In the year 2001 emissions from that category were 6.6% below the level of the base year.

5.4% of Austria's total greenhouse gas emissions in the year 2001 arose from the IPCC Category *Waste.* Emissions from this category decreased: from 1990 to 2001 emissions by 18.9% from 5 732 Gg CO_2 equivalent to 4 650 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 1990-2001

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	[Gg]											
NO_X	204	209	200	197	191	188	207	195	203	193	196	199
CO	1 238	1 246	1 198	1 167	1 117	1 030	1 050	985	953	907	859	860
NMVOC	345	323	293	282	270	271	269	250	242	237	232	232
SO_2	79	72	59	58	52	52	51	46	43	39	38	37

Emissions of indirect greenhouse gases decreased from the period from 1990 to 2001: for NMVOCs by 32.6%, for CO by 30.6%, NO_X by 2.2% and for SO_2 emissions decreased significantly by 53.4%.

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 deposition. 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, Austria has lately 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[2]: 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).

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

Five years after adoption of the Climate Change Convention in 1997, governments took a further step forward and adopted the landmark Kyoto Protocol. Building on the Convention, the Kyoto Protocol broke new ground with its legally-binding constraints on greenhouse gas emissions and its innovative "mechanisms" aimed at cutting the cost of curbing emissions. Under the terms of the Protocol, the industrialised world - known as Annex 1 countries - pledged to reduce their greenhouse (GHG) emissions by 5% below 1990 levels by the period 2008-2012. The European Union is also a Party to the Convention and the KP and agreed on a reduction target of 8% below 1990 levels during the five-year commitment period from 2008 to 2012. The EU and its Member States decided to achieve this goal jointly, for Austria an emission target of minus 13% was set.

The KP will entry into force after 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, this is expected to happen in 2003.

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 1 countries (basically, the industrialised nations) to purchase the rights to emit greenhouse bases (GHG) from other Annex 1 countries which have reduced their GHG emissions below their assigned amounts. Trading can be carried out by intergovernmental emission trading, or inter-source trading where assigned amounts are allocated to sub-national entities.
- *Joint Implementation*: Article 6 allows for a developing nation to gain a credit (converted to Assigned Amounts) by investing in another country in a project which reduces carbon emissions.
- *Clean Development Mechanism*: Article 12 allows countries (or companies) which fund projects in developing countries to get credits for certified emission reductions providing that "benefits" accrue to host country.

Tradeable 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 2001. 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 Austria's *Federal Environment Agency* 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. However, Austria had already taken part in an in-country review and a centralized review in 2001 during the trial period of the review process. The reports on these reviews can be found on the UNFCCC website[3].

[3] http://unfccc.int/resource/webdocs/iri(2)/2001/aut.pdf and http://unfccc.int/resource/webdocs/iri(3)/2001/aut.pdf

1.2 Institutional Arrangement for Inventory Preparation

For the Austrian Federal Environment Agency of a national air emission inventory that identifies and quantifies the main 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.

The Austrian Federal Environment Agency (UBAVIE) is responsible for the preparation of Austrian emission inventories by law (ENVIRONMENTAL CONTROL ACT, 1998)[4]. As Austria has to fulfil various national and international obligations, the Austrian Federal Environment Agency prepares a comprehensive Austrian Air Emission Inventory (Österreichische Luftschadstoff-Inventur, OLI) comprising all air pollutants stipulated in the various national and international obligations. The Austrian Air Emission Inventory and all reporting obligations are the responsibility of the *Department of Air Emissions* which is part of the Austrian Federal Environment Agency.

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 1993/389/EEC of June 24th 1993 for a Monitoring Mechanism of Community CO_2 and other Greenhouse Gas Emissions as amended by Council Decision 1999/296/EC.
- Austria's obligation under the United Nations Framework Convention on Climate Change (UNFCCC, 1992). 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).
  - 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).
  - Document FCCC/CP/1999/7 Review of the Implementation of Commitments and of other Provisions of the Convention – UNFCCC Guidelines on Reporting and Review.
  - 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 Marrakesh from 29 October to 10 November 2001, Addendum, Part two: Action taken by the Conference of the Parties, Volume III (Decision 20/CP.7:

---

4 ENVIRONMENTAL CONTROL ACT, (1998): Environmental Control Act (Umweltkontrollgesetz). Federal Law Gazette 152/1998.

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 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 Air Quality Protection Act (AUSTRIAN AIR QUALITY PROTECTION ACT, 1997)[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.
- 1997 a consistent time series for the emission data from 1980 to 1995 was reported for the first time.

1.2.3 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. 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.

[5] AUSTRIAN AIR QUALITY PROTECTION ACT (1997): Austrian Air Quality Protection Act (Immissionsschutzgesetz-Luft). Federal Law Gazette I 115/1997.

As the Kyoto Protocol is expected to enter into force in 2003, Austria is making preparations to meet all requirements it entails. The National Inventory System Austria shall fulfil all the requirements of the Kyoto Protocol and it shall also fulfil all the other obligations Austria has to comply with.

The emission inventory system, which is currently being adapted, will have a structure as illustrated in Figure 1.

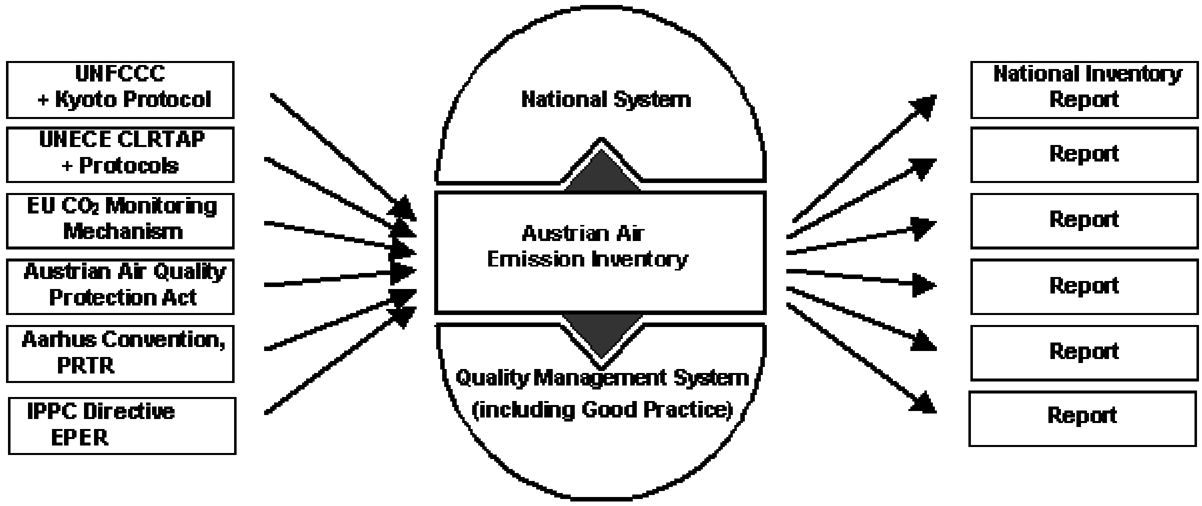


Figure 1: Structure of the future emission inventory system in Austria (NISA)

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.

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 Austrian National Inventory System should be able to take account of any type of flexible mechanism such as international emission trading as defined in the Kyoto Protocol. Details are provided with respect to:

- Adaptation of the national system according to Article 5.1 of the Kyoto Protocol
- Quality management system
- Uncertainty analysis
- Identification of key source categories

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.

The following steps have already been made to prepare NISA to meet the requirements of the Kyoto Protocol:

- Conceptual design for an adaptation of the national system according to Article 5.1 of the Kyoto Protocol
- Development of a quality management system
- Implementation of the quality management system
- First comprehensive uncertainty analysis
- Identification of key source categories

The next steps are:

- Further improvement of the national system according to Article 5.1 of the Kyoto Protocol

It is planned that the national system will be fully operated according to Article 5.1 of the Kyoto Protocol by 2004. The system will include all institutions whose data have a significant impact on the emission data and identify their collaboration with the Federal Environment Agency. Among them are:

- Federal Provinces
- Austrian Federal Economic Chamber
- Statistics Austria
- Federal Ministry of the Environment
- Operators of installations covered by the European IPPC Directive

At the moment the Austrian Federal Environment Agency uses only published information of these institutions. The inventory of the Federal Provinces is prepared by the Austrian Federal Environment Agency with a top down method using the emissions of the Austrian Air Emission Inventory.

1.3 Inventory Preparation Process

The present Austrian greenhouse gas inventory for the period 1990 to 2001 was compiled according to the recommendations for inventories set out in the UNFCCC reporting guidelines according to Decision 3/CP.5, the Common Reporting Format (CRF)[6] (version 1.01) and the IPCC 1996 Guidelines for National Greenhouse Gas Inventories, which specify the reporting obligations according to Articles 4 and 12 of the UNFCCC [IPCC-Rev. Guidelines, 1997].

1.3.1 The CORINAIR System

The OLI is based on the CORINAIR (CORe INventory of AIR emissions) system which has been developed by the ETC/AE (European Topic Centre on Air Emissions) since 1995. Austria, as many other European Countries, uses this calculation method for quantifying national emissions. The CORINAIR system is designed to collect and report air emissions from the EC and PHARE countries to the EEA in a common format. This common European-wide database can easily be adapted to the preparation of specific inventories in accordance with the guidelines under the UNECE/CLRTAP and UNFCCC. In the following a brief description from the EEA homepage is given:

The aim is to collect, maintain, manage and publish information on emissions into the air, by means of a European air emission inventory and database system. This concerns air emissions from all sources relevant to the environmental problems of climate change, acidification, eutrophication, tropospheric ozone, air quality and dispersion of hazardous substances.

As the CORINAIR inventory is source-oriented, there is a distinction between point and area sources. Point sources are large, stationary sources of emissions that release pollutants into the atmosphere. In Austria steam boilers with more than 50 MW are categorised as large point sources. These combustion plants have to collect their data on emissions and fuel consumption monthly and report them annually. The Austrian Federal Environment Agency calculates emissions for the pollutants addressed in the inventory on the basis of these reported emission data and on the basis of fuel consumption.

The fuel consumption of all considered point sources is subtracted from the total consumption of each category. The rest is considered as area source, it is the sum of facilities or activities whose individual small amounts of emissions do not qualify them as point sources. Collectively these facilities or activities can release significant amounts of a pollutant. To estimate emissions from area sources emission factors are used. Information about the source of the emission factors used is provided below.

SNAP and SPLIT Codes

Similar to the IPCC categories the CORINAIR system has its own nomenclature, called SNAP (Selected Nomenclature for sources of Air Pollution). It is designed to estimate not only emissions of greenhouse gases but all kind of air pollutants.

---

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

The current SNAP code version used in the NISA is called *SNAP 97* which provides three levels of detail:

Level 1: 11 main categories numbered from 01 to 11.

Level 2: 76 subcategories of Level 1. Examples: 01 01, 11 25.

Level 3: 414 subcategories of Level 2. Examples: 01 01 01, 02 02 05.

Additionally these SNAP categories may be expanded by so called SPLITs which may be specified by the ETC or user. A SPLIT code consists of three alphanumeric digits.

Fuel Codes

Fuel codes provide an additional possibility for SNAP code extension and are defined as 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.

OLI-Source Categories

Emission sources are the basis of OLI. Each source is unambiguously identified by a combination of SNAP, SPLIT and an optional Fuel Code. A source category is defined for a closed time series and usually consists for each year of the time series of an activity, an emission factor and an emission value for each pollutant of the inventory.

Each activity has an IPCC code which is used for transforming the SNAP system to the CRF. A list of IPCC categories and the corresponding SNAP categories is provided in each of the corresponding sector analysis chapters (Chapters 3 *Energy* – 8 *Waste*).

1.3.2 Data Management

OLI needs a reliable data management to fulfil the data collecting and reporting requirements. Data collection is performed by many co-workers 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. The whole data is stored on a central network server which is back uped daily for the needs of data security.

1.3.3 Reporting

The Austrian Air Emission Inventory currently uses the EMEP/CORINAIR calculation method for quantifying national emissions, the results are presented in CollectER databases on the EIONET. Each database stores one year of the time series and can be read by using the CollectER V1.3 Software. The databases also include information about non-GHG air pollutants which are needed to comply Austria's reporting obligations under the UNECE/CLRTAP convention (see Chapter 1.2.1). The databases can be found using the following hyperlink: http://nfp-at.eionet.eu.int:8980/Public/irc/eionet-circle/Home/main[7]

As mentioned above the Austrian Federal Environment Agency internally uses an expert system, which is a combination of a MS Access™ data bank and MS Excel™ spreadsheets. This system is more comprehensive and more flexible than the CollectER databases.

[7] You need a valid user-account to have access to the data at this link!

Austria’s national emissions (as reported in the Austrian Air Emission Inventory) are transferred to the UNFCCC Common Reporting Format using CORINAIR standard procedures in order to comply with UNFCCC reporting obligations and to ensure comparability of the reported data. For every SNAP item in CORINAIR there is only one IPCC source category as defined in standard data tables. The Austrian Federal Environment Agency has extended these tables to improve the transformation of activity data from the EMEP/CORINAIR format to the CRF format. A table for transforming fuels is presented in Chapter 3 *Energy*.

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;	UBAVIE, plant operators
Industry	National production statistics, import/export statistics, direct information from industry or associations of industry;	UBAVIE, plant operators
Waste	Database on landfills	UBAVIE
LUCF	National statistics on forests obtained from STATISTIK AUSTRIA	UBAVIE
Solvent	Import/ export statistics, production statistics, consumption statistics;	Contractor: Forschungsinstitut für Energie und Umweltplanung, Wirtschaft und Marktanalysen GmbH*
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.

A complete list of data sources for activity and emission data or emission factors used by sector can be found on page 238.

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 UBAVIE 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 suppliers 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 Work, "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 who provides statistics on production data[8]. 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 UBAVIE. National and sometimes international studies are also used as data suppliers. Operators of landfill sites also report their activity data directly to UBAVIE. Emissions of the years 1998-2001 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.

[8] "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.

1.5 Key Source Analysis

In order to prepare for a National System according to Article 5.1 of the Kyoto Protocol each Annex I Party shall identify its key source categories.

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. All IPCC source categories are included except the category LUCF as guidelines for this category are not yet available in the IPCC Good Practice Guidance.

The presented key source analysis was performed by UBAVIE with data for greenhouse gas emissions of the submission 2003 to the UNFCCC and comprises a level assessment for all years between 1990 and 2001 and a trend assessment for the trend of the years 1991 to 2001 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 82 910 Gg CO_2 equivalent in the year 2001, which is a share of 96.5% of Austria's total greenhouse gas emissions (without sector LUCF).

Table 5: Austrian key source categories based on emission data submitted 2003 to the UNFCCC

IPCC 96 / Code	Name (Emission source)	Gas
1 A 1 a gaseous	Public Electricity and Heat Production	CO_2
1 A 1 a liquid	Public Electricity and Heat Production	CO_2
1 A 1 a other	Public Electricity and Heat Production	CO_2
1 A 1 a solid	Public Electricity and Heat Production	CO_2
1 A 1 b gaseous	Petroleum refining	CO_2
1 A 1 b liquid	Petroleum refining	CO_2
1 A 1 c gaseous	Manufacturing of Solid fuels and Other Energy Industries	CO_2
1 A 2 gaseous	Manufacturing Industries and Construction	CO_2
1 A 2 mob-liquid	Manufacturing Industries and Construction-mobile	CO_2
1 A 2 solid	Manufacturing Industries and Construction	CO_2
1 A 2 stat-liquid	Manufacturing Industries and Construction-stationary	CO_2
1 A 3 b diesel oil	Road Transportation	CO_2

IPCC 96 / Code	Name (Emission source)	Gas
1 A 3 b gasoline	Road Transportation	CO_2
1 A 3 b gasoline	Road Transportation	N_2O
1 A 3 e gaseous	Transport-Other	CO_2
1 A 4 mobile-diesel	Fuel Combustion_Other Sectors-mobile_Agriculture and Forestry	CO_2
1 A 4 stat-biomass	Fuel Combustion_Other Sectors-stationary	CH_4
1 A 4 stat-gaseous	Fuel Combustion_Other Sectors-stationary	CO_2
1 A 4 stat-liquid	Fuel Combustion_Other Sectors-stationary	CO_2
1 A 4 stat-solid	Fuel Combustion_Other Sectors-stationary	CO_2
2 A 1	Cement Production	CO_2
2 A 2	Lime Production	CO_2
2 A 7 b	Magnesia Sinter Plants	CO_2
2 B 1	Ammonia Production	CO_2
2 B 2	Nitric Acid Production	N_2O
2 C 1	Iron and Steel Production	CO_2
2 C 4	SF6 used in Aluminium and Magnesium Foundries	SF6
2 C 3	Aluminium production	PFCs
2 F 6	Semiconductor Manufacture	PFCs/HFCs/SF_6
2 F 1/2/3	ODS Substitutes	HFCs
2 F 8	Other Sources of SF6	SF6
3	Solvent and Other Product Use	CO_2
4 A 1	Cattle	CH_4
4 B 1	Cattle	N_2O
4 B 1	Cattle	CH_4
4 B 8	Swine	CH4
4 D	Agricultural Soils	N_2O
6 A 1	Managed Waste disposal	CH_4
6 D 1	SNAP 091003 Sludge spreading	CH_4

The most important key source of the Austrian greenhouse gas inventory is Category *1 A 3 b Road Transportation - diesel oil (CO_2)* because of its contribution to total greenhouse gas emissions and also because of its contribution to the trend. It has been identified a key source category both for the level and the trend assessment for all years and has been number one key source in the level assessment of the years 1996 and 1998-2001 as well as in the trend assessment of the years 1995-2001. In the year 2001 this category contributed 13.7% to national total greenhouse gas emissions. CO_2 Emissions from *Road Transportation - diesel oil (CO_2)* increased from 1990 to 2001 from 4 364 Gg CO_2 to 10 476 Gg, this is an increase of 169%.

Also the second most important source for greenhouse gas emissions is road transportation, this time with gasoline used as fuel. The Category *1 A 3 b Road Transportation – gasoline (CO_2)* was the most important source for greenhouse gas emissions in the years 1991-1994, thus ranking number one in the level assessment of these years. In the year 2001 emissions from this category amounted to 6 107 Gg CO_2, it was the forth important source category of 2001. From 1990 to 2001 emissions from this category decreased by 22.3%.

The third most important key source is *2 C 1 Iron and Steel Production*, it belonged to the three most important sources for all years from 1990-2001. In the year 2001 it contributed 10.7% to national total greenhouse gas emissions, this was 9.3% more than in 1990. As the trend of this category is similar to the overall trend of the inventory, it was not rated a key source in the trend assessment 2001.

Another important source is *1 A 1 a Public Electricity and Heat Production (solid fuel)*. In the year 2001 it contributed 6.8% to national total greenhouse gas emissions, ranking number 5 in the level assessment of that year. This source is an important source category with respect to the contribution to the overall inventory's trend: in the trend assessment of the years 1992-1999 it was within the three most important sources with respect to the contribution to the overall trend of Austria's greenhouse gas inventory.

Comparison to last year's submission

In last year's submission a key source analysis for the years 1990 and 2000 using data of the submission 2002 was presented. This year the key source analysis was performed for all years from 1990 to 2001 using data of the submission 2003. There is a difference in the identified key source categories compared to the results of last year's analysis. The explanations for the differences are as follows:

- Allocation/Recalculation of greenhouse gas emissions to different categories (for further information see Chapter 9 *Recalculations and Improvements*).
- More detailed split in source categories to be consistent with the IPCC GPG:

  Emissions of the category *2 F Consumptions of Halocarbons and Sulfurhexaflouride* have been split into the categories

  - *2 F 6 Semiconductor Manufacture* (HFCs, PFCs and SF6),
  - *2 F 1/2/3 ODS (Ozone Depleting Substances) Substitutes* (HFCs),
  - *2 F 4 Electrical Equipment* (SF_6) and
  - *2 F 8 Other Sources of SF_6*.

  Furthermore the category *SF_6 Used in Aluminium and Magnesium Foundries*, which also included PFC emissions from aluminium production in last year's key source analysis, was split: emissions from aluminium production are now a separate source category.
- This year the key source analysis was performed for all years, where as last year it was only performed for the years 1990 and 2000.

No CH_4 emissions from category *4 D Agricultural Soils* (CH_4) were reported in this year's submission, it was a key source in last year's assessment (for explanations see Chapter 6)

For the reasons explained above the following key sources have been identified additionally:

- *1 A 1 a other* *Public Electricity and Heat Production* (CO_2)
- *1 A 1 b gaseous* *Petroleum Refining* (CO_2)
- *1 A 1 c gaseous* *Manufacturing of Solid fuels and Other Energy Industries* (CO_2)
- *1 A 2 gaseous* *Manufacturing Industries and Construction* (CO_2)
- *1 A 2 mobile-liquid* *Manufacturing Industries and Construction* (CO_2)
- *1 A 2 stationary-liquid* *Manufacturing Industries and Construction* (CO_2)
- *1 A 3 e gaseous* *Transport – Other* (CO_2)
- *1 A 4 biomass* *Fuel Combustion Other Sectors – stationary* (CH_4)
- *2 B 2* *Nitric Acid Production* (N_2O)
- *2 F 6* *Semiconductor Manufacture* (HFCs, PFCs and SF_6)
- *2 F 1/2/3* *ODS (Ozone Depleting Substances) Substitutes* (HFCs)
- *2 F 8* *Other Sources of* SF_6 (SF_6)
- *2 C 4* SF_6 *Used in Aluminium and Magnesium Foundries* (SF_6)
- *2 C 3* *Aluminium Production* (PFCs)
- *4 B 1* *Agriculture Manure Management Cattle* (CH_4)
- *4 B 8* *Swine* (CH_4)

1.5.2 Description of Methodology

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

The identification 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 LUCF as a good practice guidance for this category is not yet available.

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. Minor adaptations of the suggested IPCC source categories as presented in the IPCC GPG have been made, but the applied methodology follows the guidance which describes good practice in determining the appropriate level of detail.

Table A.1 of Annex 1 presents the determined 150 source categories and their greenhouse gas emissions expressed in CO_2 equivalent for the years 1990 to 2001.

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 the GHG emissions (expressed in CO_2-equivalent) of each source category to national total emissions was calculated. The calculation was performed for the years 1990 to 2001 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 years 1992 to 1999 33 and for the other years 32 source categories comprised > 95% of the cumulative total and were thus rated 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 1991 to 2001 were compared with base year emissions (1990 for CO_2, CH_4, N_2O and 1995 for HFCs, PFCs and SF_6), resulting in 11 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 23 and 28 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 that meets 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. To this end an emission inventory improvement programme (see Chapter 9.4) has been developed as a basis for further improvement of the emission data.

1.6 Quality Assurance and Quality Control (QA/QC)

A quality management system (QMS) has been designed to ensure compliance with requirements such as transparency, accuracy and completeness. After its full implementation by 2003 the accreditation of the *Department for Air Emissions* as inspection body is scheduled for the end of 2003. The QMS contains all relevant features of EN 45000 (a series of European standards), such as the strict independence, impartiality and integrity of accredited bodies and demonstrates the full compatibility with the QA/QC requirements of the IPCC-GPG.

Quality Management System (QMS)

Quality assurance and quality control during the compilation of an emission inventory is an advisable feature. As soon as the Kyoto Protocol has entered into force, however, a QMS will be essential to ensure the quality of emission data according to the requirements of the IPCC-GPG as a basis for any kind of international emission trading. The Austrian Federal Environment Agency has decided to implement a QMS based on the EN 45004. The EN 45000 series that has been drawn up as a quality management standard (similar to the ISO 9000 series) has the objective of increase confidence in bodies performing testing, inspection or certification. It consists of the following standards:

- 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 45004 (General criteria for the operation of various types of bodies performing inspection)
- EN 45011 (General criteria for certification bodies operating product certification)
- EN 45012 (General criteria for certification bodies operating quality system certification)
- EN 45013 (General criteria for certification bodies operating certification of personnel)
- EN 45014 (General criteria for supplier's declaration of conformity)
- EN 45020 (General terms and their definitions concerning standardisation and related activities)

As already noted, the Federal Environment Agency Austria is currently implementing a QMS based on the European standard EN 45004. This system is process-based and illustrated in Figure 2.

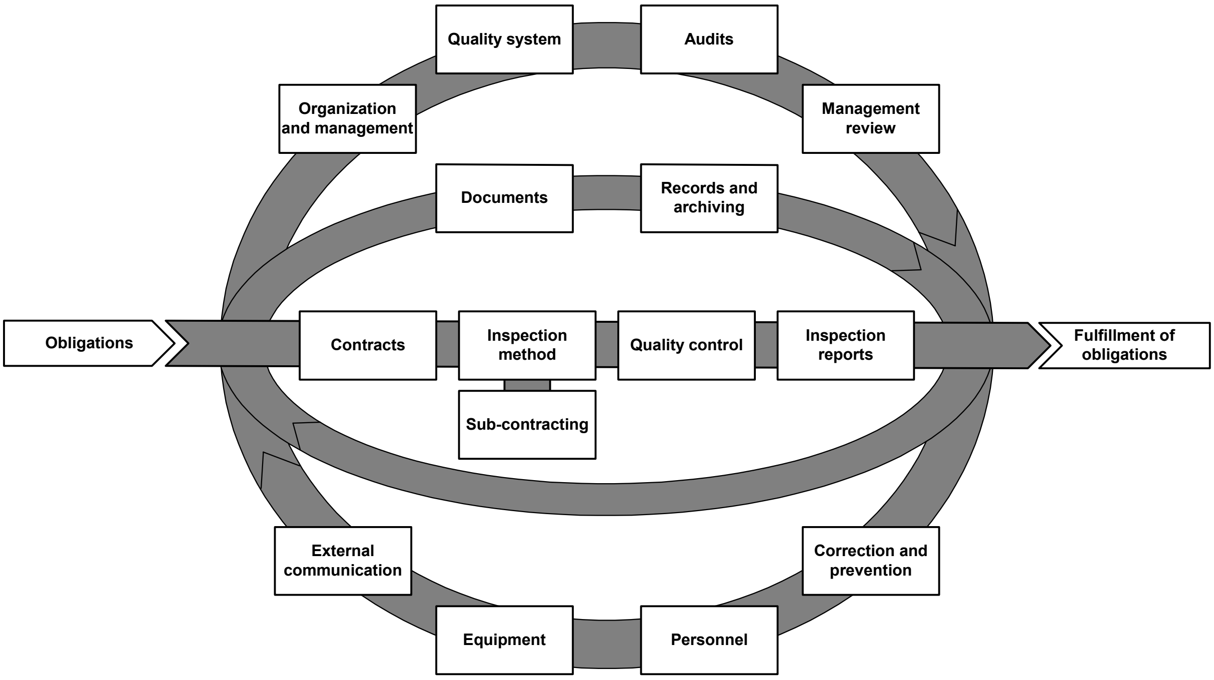


Figure 2: Process-based QMS (the outer circle corresponds to management processes, the straight line to realisation processes and the inner circle to supporting processes)

The process-based QMS consists of three process groups:

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

They comprise all activities that are necessary for the management and control of an organisation, e.g. organisation and management, quality system, audits, management review, correction and prevention, personnel, equipment, external communication. The most important aspect with respect to organisation and management is that the manager has to ensure that the personnel is free from any commercial, financial or other pressure which might affect their judgement. The personnel has to meet other requirements too. It has to have appropriate qualification, training, experience and knowledge of the requirements for the inspections to be carried out. They shall have the ability to make professional judgements as to conformity with general requirements using examination results and to report thereon.

As regards equipment, mainly computers are used during the compilation of emission inventories. Any software applied has to be tested and confirmed in advance. Furthermore access authorisation must be strictly limited to protect the integrity of data and to guarantee data confidentiality if necessary.

2) **Realisation processes** (straight line)

These processes are the most important ones as they concern the compilation of emission inventories. They start with a contract control system which ensures that the methods to be used are selected in advance, while taking into account that for key source categories the most detailed method, i.e. the method with the lowest uncertainty, should be applied. The inspection process consists of two steps, the data collection and the application of methods for the estimation of emissions. The Federal Environment Agency currently uses IPCC methods, CORINAIR methods and specific methods. The latter are country-specific and have to be fully documented and validated. All emission data are subject to appropriate quality control checks and data verification before they are released in an inspection report.

Usually an inspection body has to perform inspections itself. When it sub-contracts any part of the inspection, however, it must ensure that the sub-contractor complies with the standard EN 45004.

3) **Supporting processes** (inner circle)

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

All relevant requirements addressed in the IPCC-GPG are included in the quality management system.

Inspection bodies

The European Standard EN 45004 specifies general criteria for the competence of impartial bodies performing inspection, irrespective of the sector involved. It covers the functions of bodies whose work may include the examination of materials, products, installations, plants, processes, work procedures or services, and the determination of their conformity with requirements, as well as the subsequent reporting of results of these activities to clients and – if required – to supervisory authorities. In the case of emissions inventories, inspection concerns the examination of air emissions and covers the collection of emission data or of data which are used to estimate them, their compilation and the check of their conformity with emission reduction limits.

For this purpose a quality management system based on EN 45004 is being implemented by the Department of *Air Emissions* of the Austrian Federal Environment Agency. The quality management system takes into account recommendations of European and international documents such as the ISO 9000 series of standards and Guide EAL-G24 (Accreditation of Inspection Bodies - Guidelines on the application of EN 45004. European Co-operation for Accreditation: 1996) as far as they are relevant for inspection bodies.

Accreditation Act

The EN 45000 series is implemented in the Austrian legislative system, whereas the ISO 9000 series is not. 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 series and the ISO 9000 series is shown.

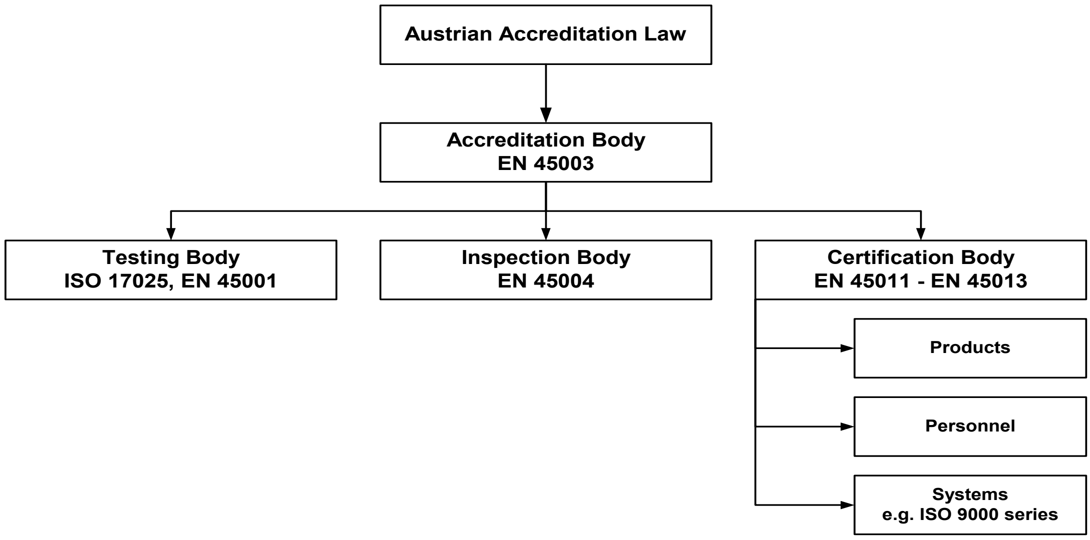


Figure 3: Inter-relationship between the Austrian Accreditation Act, the EN 45000 series and the ISO 9000 series.

The most important difference between the EN 45000 series and the ISO 9000 series is that accredited bodies under the EN 45004 have to ensure strict independence, impartiality and integrity in their activities. The personnel of the inspection body has 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.

Accredited bodies are entitled to be labelled with the federation emblem and an accreditation mark and their reports are official documents. Any corrections of or additions to an inspection report after it has been issued have to be recorded and justified.

Implementation of QA/QC

The implementation of the QMS has been started by February 2002.

The procedures to perform record-keeping, checking and improving are described in the quality manual as "Standard Operation Procedures", covering all relevant aspects of the activities of our inspection body.

The full implementation (including accreditation) of the QMS has been delayed in comparison to the timetable included in the NIR 2001 because key staff responsible for QA/QC left the UBAVIE in 2001.

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. Full implementation of the quality management system	2002 – 2003
3. Accreditation of the inspection body	2003/2004

QA/QC Activities

During the year 2002 QA activities were focused on transparent documentation, adaptation of SOPs (Standard Operation Procedures) to be practically applicable and fulfil the requirements of IPCC and EN 45004 at the same time.

One of the highlights was the improvement of the key process "Correction Measures and Preventive Actions" including a efficient process to establish and keep transparency and completeness in the improvement process, taking into account all complaints by IPCC Expert Review Teams as well as discrepancies that found during investigation.

Most of the QC procedures were conducted following the GPG criteria on Validation (chapter 8 - table 8.1 of the GPG)

It is planned that for the submission 2004 all key sources will be validated and some of them verified.

Treatment of confidentiality issues

Only one source, the activity of SF_6 (cast aluminium) from aluminium foundries, has to be treated confidential ("C"). One of the aluminium foundries wanted to keep its production volume (its activity) confidential, and as there are less than four such companies in Austria the overall activity for this source category has to be treated as confidential.

1.7 Uncertainty Assessment

In comparison to last year's submission, there was no change in the survey of uncertainty assessment for the Austrian greenhouse gas emission inventory.

This chapter summarises work on a first comprehensive uncertainty analysis comprising the whole emission inventory, which was funded by the Austrian Federal Environment Agency and completed in 2000. It presents the results for three greenhouse gases (CO_2, CH_4 and N_2O) for the years 1990 to 1997. Compilation, prioritisation, uncertainty assessment and Monte Carlo analysis are addressed in greater detail.

The uncertainty estimates are based on emission estimates of the year 1999. Since then, the data was recalculated several times, new data became available and for e.g. agriculture a higher TIER method has been applied. Thus the uncertainty estimate as presented here is no more up to date and it is planned to be recalculated. However, it is assumed that the uncertainty has decreased due to introduction of new, more accurate and more detailed methodologies.

1.7.1 First Comprehensive Uncertainty Analysis

One of the main requirements arising from the IPCC-GPG is the estimation of uncertainties along with the determination of key source categories. 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 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 7 the most important emission sources with respect to uncertainty are listed.

Table 7: 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		×	

Table 8 shows the estimates for total uncertainty including systematic uncertainty and random uncertainty and Table 9 refers to random uncertainty.

Table 8: 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 9: 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%**

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.

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%.

1.7.2 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 transformed into IPCC source categories first. 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 some additional useful information. An assessment of completeness for each sector can be found in the Sector Overview part of the corresponding subchapters.

Sources and sinks

All sources and sinks included in the IPCC Guidelines are covered. Others, specific to Austria, have not been identified.

Gases

The direct GHGs as well as the precursor gases postulated 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 reasons for different allocation to categories used by the party differ, e.g. allocation in national statistics, no information in the national statistics, national methods, impossible disaggregation of emission declarations,…

- IE (included elsewhere):

For detailed explanations see table 9. It is planned to further improve the level of disaggregation in the future in order to avoid "IE".

- NE (not estimated):

For detailed explanations see CRF- table 9. 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 sources or sinks are either estimated or allocated to "NO".

- NA (not applicable):

The increase of this number is due to improved completeness of the CRF- tables.

- C (confidential):

The only activity treated confidentially is SF_6 from Aluminium Foundries (cast aluminium – sector *2 C*).

Table 10 presents the number of "Not estimated" and "Included Elsewhere" subcategories by GHG on reporting level 3[9]. All categories are estimated on level 1 and 2.

[9] As the significance of the reporting level differs between the categories, some "NE" that are on a more detailed level than level 3 were also added.

Table 10: Numbers of notation keys of Austria's UNFCCC Submission 2003, by GHG

Submission 2003	NE				IE			
	CO_2	CH_4	N_2O	HFC, PFC, SF_6	CO_2	CH_4	N_2O	HFC, PFC, SF_6
1 Energy	0	0	0	0	17	17	5	0
2 Industrial processes	10	12	3	9	3	0	0	23
3 Solvents	0	0	1	0	1	0	0	0
4 Agriculture	0	1	0	0	0	2	2	0
5 LUCF	12	2	2	0	7	0	0	0
6 Waste	1	1	1	0	0	0	0	0
Total	**23**	**16**	**7**	**9**	**28**	**19**	**7**	**23**
	55				**77**			

source: CRF_2002_2001

Compared to last submission, where 112 subcategories were indicated as not estimated, the number is only about half of last year' s value (see Table 11). Also the number of emissions "included elsewhere" decreased from 103 to 77. This is due to advanced completeness of the inventory on the one hand, and to proper use of notation keys on the other hand.

Table 11: Numbers of notation keys for the UNFCCC-Submission 2001 and 2002

Sector	Submission 2001		Submission 2002	
	IE	NE	IE	NE
1 Energy	44	11	60	4
2 Industrial processes	23	50	23	61
3 Solvents	3	9	3	9
4 Agriculture	9	11	11	8
5 LUCF	5	16	6	30
6 Waste	-	-5	-	-
Total	**84**	**102**	**103**	**112**

Total figures are composed of sectors and subsectors. The increases in notation key "NE" can be regarded as a fact of higher transparency since many appeared as "0,00" in the submission 2001 and are not to be considered as a decrease in the quality of the inventory.

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[10] which includes emission limitations and/or 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

Table 12 presents a summary of Austria's anthropogenic greenhouse gas emissions for the period from 1990 to 2001.

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 12: Summary of Austria's anthropogenic greenhouse gas emissions from 1990-2001

	Greenhouse gas emissions [Gg CO2 equivalent]												Trend BY*-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
TOTAL	78 073	82 241	75 291	76 580	77 768	80 797	84 624	84 146	83 819	82 123	81 951	85 880	+9.65%
CO_2	60 113	63 595	58 455	59 307	59 744	62 627	66 629	66 208	66 333	65 020	64 928	69 120	+14.98%
CH4	10 672	10 552	10 280	10 318	10 168	10 074	9 955	9 609	9 442	9 300	9 134	9 074	-14.97%
N2O	5 804	6 431	5 247	6 072	6 752	6 360	6 154	6 445	6 252	6 177	6 153	5 951	+2.52%
HFCs	4	6	9	12	17	546	625	718	816	870	1 033	1 033	+89.21%
PFCs	963	974	576	48	54	16	15	18	21	25	25	25	+61.04%
SF6	518	683	725	823	1 033	1 175	1 246	1 148	955	730	677	677	-42.37%

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

Greenhouse gas emissions in Austria have been fluctuating since 1990, the overall trend has been increasing emissions (see Figure 4). From 2000 to 2001 total greenhouse gas emissions in Austria increased strongly, making up the moderate but steady downward trend that was observable from 1996 to 2000.

[10] 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

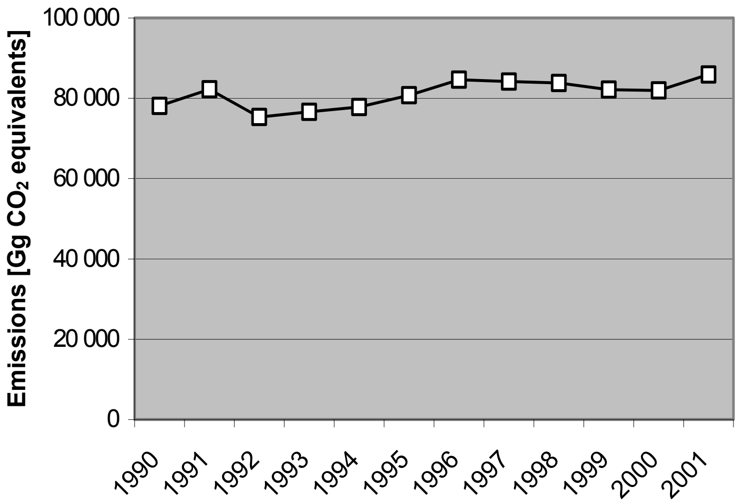


Figure 4: Austria's total greenhouse gas emissions (without LUCF) for the period from 1990-2001

As can be seen in Figure 4, there has been a strong increase in total emissions from 1990 to 1991 (+ 5.3%), followed by a drop of emissions (- 8.5%) from 1991 to 1992. From 1993 to 1996 emissions increased steadily (total increase of 12.4%), followed by a steady decrease of 3.2% until 2000. From 2000 to 2001 emissions increased strongly by 4.8%, resulting in total emissions of 85 880 Gg CO_2 equivalent in the year 2001. The increase was caused by an increase of CO_2 emissions by 6.5% from 2000 to 2001.

Austria's total greenhouse gas emissions in 2001 were 9.7% above the level of the base year.

2.2 Emission Trends by Gas

Table 13 presents the greenhouse gas emissions of the base year and 2001 and their share in total greenhouse gas emissions.

Table 13: Austria's greenhouse gas emissions by gas in the base year and in 2001.

GHG	Base year*	2001	Base year*	2001
	CO_2 equivalent [Gg]		[%]	
Total	78 325	85 880	*100.0%*	*100.00%*
CO_2	60 113	69 120	*76.8%*	*80.5%*
CH_4	10 672	9 074	*13.6%*	*10.6%*
N_2O	5 804	5 951	*7.4%*	*6.9%*
F-Gases	1 736	1 735	*2.2%*	*2.0%*

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 80.5% of total greenhouse gas emissions in 2001 compared with 76.8% in the base year, followed by CH_4 (10.6% in 2001 respectively 13.6% in the base year), N_2O (6.9% in 2001 and 7.4% in the base year) and finally fluorinated hydrocarbons (2.0% in 2001 and 2.2% in the base year).

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).

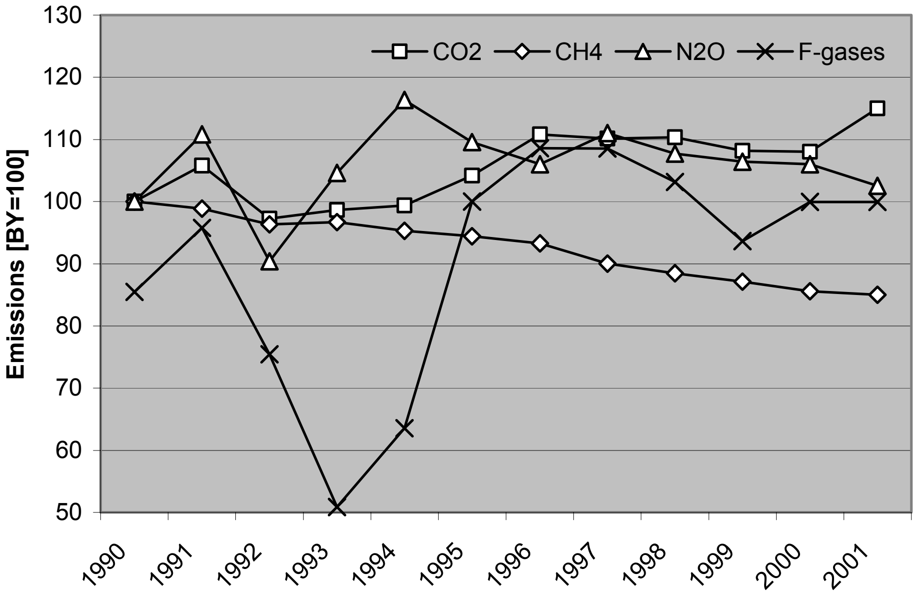


Figure 5: Trend in greenhouse gas emissions 1990-2001 by gas in index form (base year = 100)

CO_2

CO_2 emissions have been fluctuating at the beginning of the decade, after this an upward trend until 1996 could be observed, then emissions were slightly decreasing until the year 2000. A sharp increase in emissions from 2000 to 2001 by 6.5% resulted in a total increase of 15.0% from 1990 to 2001. Quoting in absolute figures, CO_2 emissions increased from 60 113 to 69 120 Gg (see Table 12) during the period from 1990 to 2001 mainly due higher emissions from transport.

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 2001, from 10 672 to 9 074 Gg CO_2 equivalent (see Table 12). In 2001 CH_4 emissions were 15.0% 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 1997, increasing by 11.0% over this period. Since then emissions have a moderate decreasing trend, resulting in 5 951 Gg CO_2 equivalent compared to 5 804 in the base year, this is 6.9% above the level of the base year. The increase is mainly due higher N_2O emissions from transport.

The main sources of N_2O emissions are agricultural soils and fossil fuel combustion.

HFCs

HFC emissions increased remarkably during the period from 1990 to 2000, from 4 to 1.033 Gg CO_2 equivalent. As no update has been made, for the year 2001 the same value as for 2000 is reported. In 2000 the HFC emissions were 89% above the level of the base year (1995).

The main sources of HFC emissions are refrigeration and air conditioning equipment, foam blowing and XPS/ PU plates.

PFCs

PFC emissions show the inverse trend as HFC emissions. The PFC emissions decreased remarkably during the period from 1990 to 2000, from 963 to 25 Gg CO_2 equivalent. As no update has been made, for the year 2001 the same value as for 2000 is reported.

In 2000 PFC emissions were 61% above the level of the base year (1995).

The main source of PFC emissions is semiconductor manufacture.

SF_6

SF_6 emissions in 1990 amounted to 518 Gg CO_2 equivalent. They increased steadily until 1996 reaching a maximum of 1 246 Gg CO_2 equivalent. Since then they are deceasing, in 2000 SF_6 emissions amounted to 677 Gg CO_2 equivalent. As no update has been made, for the year 2001 the same value as for 2000 is reported.

In 2000 the SF_6 emissions were 42% below the level of the base year (1995).

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

2.3 Emission Trends by Source

Table 14 presents a summary of Austria's anthropogenic greenhouse gas emissions by sector for the period from 1990 to 2001:

- 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 14: Summary of Austria's greenhouse gas emissions by sector 1990–2001.

Sector	BY*	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Trend BY-2001
	CO_2 equivalent [Gg]													
Total	**78 325**	**78 073**	**82 241**	**75 291**	**76 580**	**77 768**	**80 797**	**84 624**	**84 146**	**83 819**	**82 123**	**81 951**	**85 880**	**+9.65%**
1	48 128	48 128	52 480	48 520	49 320	49 179	51 841	56 383	54 593	55 708	54 286	54 072	57 642	+19.77%
2	15 567	15 315	14 965	13 181	13 143	14 024	14 953	14 610	15 749	14 762	14 664	14 877	15 358	-1.34%
3	755	755	669	614	593	594	613	612	638	628	628	628	628	-16.82%
4	8 142	8 142	8 495	7 411	8 070	8 619	8 148	7 867	8 159	7 876	7 764	7 680	7 602	-6.64%
5	-9 215	-9 215	-13 504	-8 656	-8 982	-7 862	-7 254	-5 385	-7 633	-7 633	-7 633	-7 633	-7 633	-17.16%
6	5 732	5 732	5 632	5 565	5 453	5 352	5 241	5 153	5 007	4 846	4 781	4 693	4 650	-18.87%

Total emissions are without LUCF
*Base Year: 1990 for CO_2, CH_4 and N_2O and 1995 for HFCs, PFCs and SF_6

The dominant sectors are the energy sector, which caused 67% of the total greenhouse gas emissions in Austria in 2001 (61% in 1990), followed by the Sector *Industrial Processes*, which caused 18% of the greenhouse gas emissions in 2001 (20% in 1990).

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

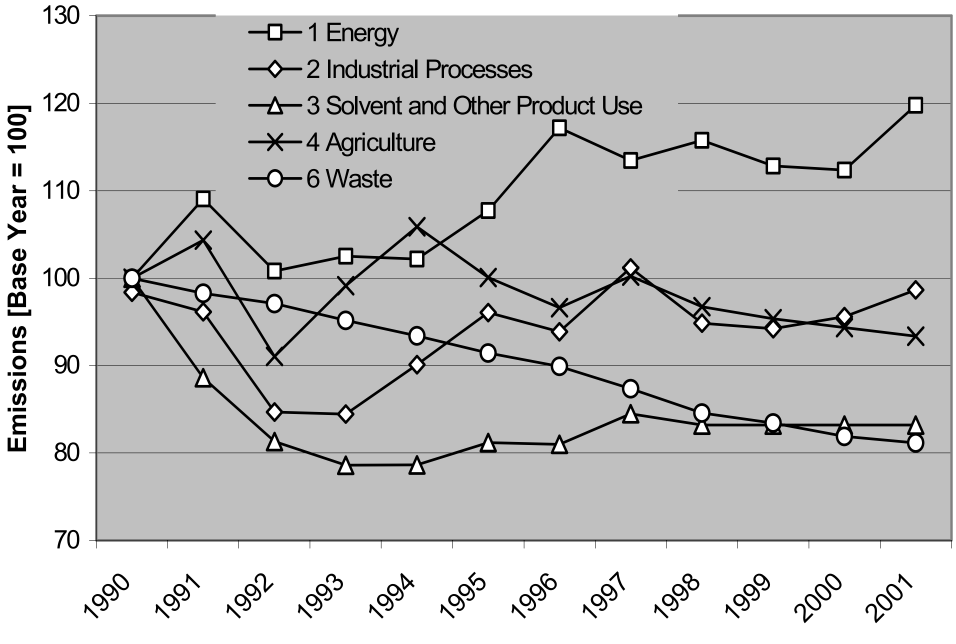


Figure 6: Trend in emissions 1990-2001 by sector in index form (base year = 100)

Table 15: Austria's greenhouse gas emissions by sector in the base year and in 2001.

GHG	Base year*	2001	Base year*	2001
	CO_2 equivalent [Gg]		[%]	
Total	78 325	85 880	*100.0%*	*100.0%*
1 Energy	48 128	57 642	*61.5%*	*67.1%*
2 Industry	15 567	15 358	*19.9%*	*17.9%*
3 Solvent	755	628	*1.0%*	*0.7%*
4 Agriculture	8 142	7 602	*10.4%*	*8.9%*
6 Waste	5 732	4 650	*7.3%*	*5.4%*

Total emissions without LUCF
*1990 for CO_2, CH_4 and N_2O and 1995 for F-Gases

Energy (IPCC Category 1)

The trend for greenhouse gas emissions from Category *1 Energy* shows increasing emissions. They seemed to have stabilized at the level of 1996, but from 2000 to 2001 emissions increased strongly from 54 072 Gg CO_2 equivalent to 57 642, which corresponds to an increase of 6.6%. The total increase from the base year 1990 to 2001 was 19.8% and the energy sector is the only sector which's emissions are higher in 2001 than in the base year.

99.6% of emissions from this sector in 2001 originate from fossil fuel combustion.

CO_2 emissions from fossil fuel combustion is the main source of greenhouse gas emissions in Austria. The most important source for greenhouse gas emissions in the year 2001 in Austria was the transport sector with a share of 23.0% in national total greenhouse gas emissions.

CO_2 contributes 96.9% to total GHG emissions from *Energy*, N_2O 2.4% and CH_4 0.7%.

Industrial Processes (IPCC Category 2)

Greenhouse gas emissions from the industrial processes sector fluctuated during the period, they reached a minimum in 1993 and increased until 1997. After a decrease until 1999 they reached in 2001 almost the level of the base year, only remaining 1.3% below. In 2001 greenhouse gas emissions from Category *2 Industrial Processes* amounted to 15 358 Gg CO_2 equivalent.

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Production* and *Mineral Products*, which caused 60.3% respectively 20.0% of the emissions from this sector in 2001.

The most important GHG of the industry sector was carbon dioxide with 83.6% of emissions from this category, followed by HFCs with 6.7%, N_2O with 5.1%, SF6 with 4.4%, PFCs with 0.2% and finally CH_4 with 0.02%.

Solvent and Other Product Use (IPCC Category 3)

In the year 2001, 0.7% of total GHG emissions in Austria (628.14 Gg CO_2 equivalent) arose from the sector *Solvent and Other Product Use*.

Greenhouse gas emissions from Category *3 Solvent and Other Product Use* fluctuated during the period from 1990 to 2001, the overall trend showed decreasing emissions. From 1990 to 1993 emissions decreased by 21.4% and then increased steadily until 1997, since then they have stabilized on the 1997 level. In 2001 greenhouse gas emissions from *Solvent and Other product Use* were 16.8% below the level of the base year.

63.0% of these emissions were CO_2 emissions, N_2O emissions contributed 37.0%.

Agriculture (IPCC Category 4)

Greenhouse gas emissions from the agricultural sector fluctuated over the period from 1990 to 2001, the overall trend shows decreasing emissions: in the year 2001 emissions from that category were 6.6% below the level of the base year.

Emissions from *Agriculture* amounted to 7 602 Gg CO_2 equivalent in 2001, which corresponds to 8.9% to national total emissions. The most important sub sector *Enteric Fermentation* contributed 41.4% to total greenhouse gas emissions from the agricultural sector in 2001, the second largest sub source is *Agricultural Soils* with a share of 37.2%. *Agriculture* is the largest source for both N_2O and CH_4 emissions: 59.5% of all N_2O emissions and 44.8% (193 Gg CH_4) of all CH_4 emissions in Austria in 2001 originated from this sector. N_2O emissions from *Agriculture* amounted to 11.4 Gg in 2001 (3 541.0 Gg CO_2 equivalent), which corresponds to 46.6% of the GHG emissions from this sector, methane contributed 53.4%.

Waste (IPCC Category 6)

Greenhouse gas emissions from Category *6 Waste* decreased steadily during the period. In 2001 the greenhouse gas emissions from the waste sector amounted to 4 650 Gg CO_2 equivalent. This was 18.9% below the level of the base year. The decrease in emissions is mainly due to lower emissions from managed waste disposal sites, which is the most important source of this category, as a result of methane recovery systems installed at landfills. The share of emissions from this category in total emissions was 5.4% in the year 2001.

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 2001.

99.2% of all greenhouse gas emissions from *Waste* are CH_4 emissions, 0.5% are N_2O and 0.2% 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) 2003, Submission under the UNECE/CLRTAP Convention*, which will be published by the end of 2003.

Table 16 presents a summary of emission estimates for indirect greenhouse gases and SO_2 for the period from 1990 to 2001. 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 16. These reduction targets should be met by 2010 by parties to the UNECE/CLRTAP convention who signed this protocol.

Table 16: Emissions of indirect GHGs and SO_2 1990-2001

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	NEC
	[Gg]												
NO_X	204	209	200	197	191	188	207	195	203	193	196	199	107
CO	1 238	1 246	1 198	1 167	1 117	1 030	1 050	985	953	907	859	860	---
NMVOC	345	323	293	282	270	271	269	250	242	237	232	232	159
SO_2	79	72	59	58	52	52	51	46	43	39	38	37	39

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

Emissions of indirect greenhouse gases decreased from the period from 1990 to 2001: for NMVOCs by 32.6%, for CO by 30.6% and NO_X emissions decreased by 2.2% over this period. SO_2 emissions had a significant negative trend, emissions decreased by 53.4% compared to 1990 levels.

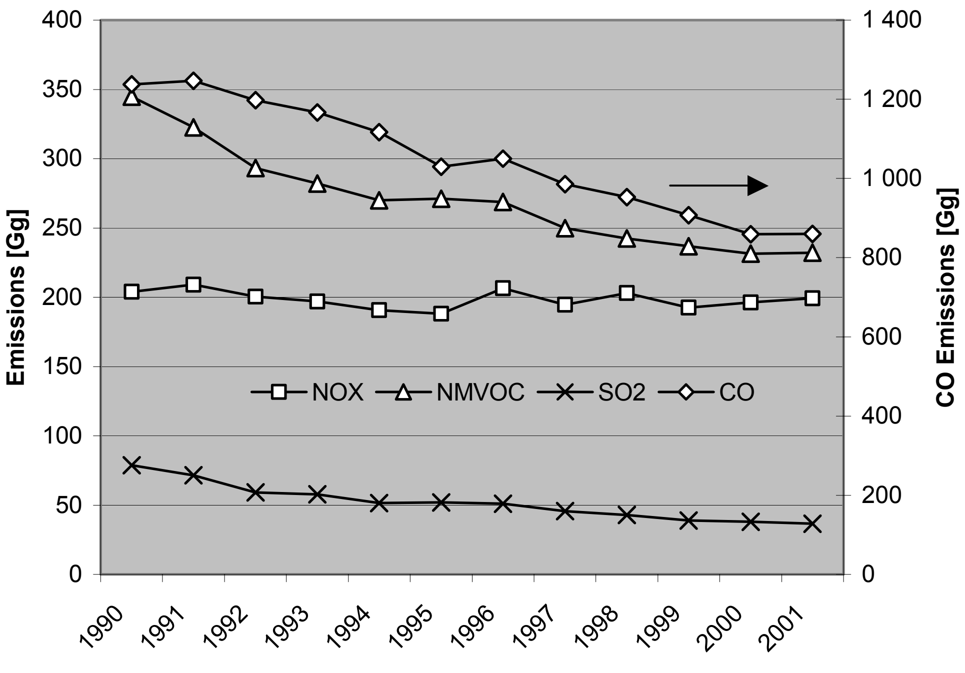


Figure 7: Emissions of indirect GHGs and SO_2 1990-2001

.

NO_X

NO_X emissions decreased from 204 to 199 Gg during the period from 1990 to 2001. In 2001 the NO_X emissions were 2.2% below the level of 1990.

Over 90% of NO_X emissions in Austria originate from fossil fuel combustion.

CO

CO emissions decreased from 1 238 to 860 Gg during the period from 1990 to 2001. In 2001 CO emissions were 30.6% below the level of 1990.

In the year 2001, 74.9% of total CO emissions in Austria originated from fuel combustion activities, another important source is metal production with a share of 20.0% in total CO emissions.

NMVOC

NMVOC emissions decreased from 345 to 232 during the period from 1990 to 2001. In 2001 NMVOC emissions were 32.6% below the level of 1990.

The most important emission source for NMVOC emissions is *Other Solvent Use*, in 2001 54.7% of total NMVOC emissions in Austria originated from this source. Another important source is fossil fuel combustion which had a share of 33.9% in total NMVOC emissions.

SO_2

SO_2 emissions decreased from 79 to 37 Gg during the period from 1990 to 2001. In 2001 SO_2 emissions were 53.4% below the level of 1990.

In the year 2001, 75.8% of total SO_2 emissions in Austria originated from fuel combustion activities, another important source is metal production with a share of 14.4% in total SO_2 emissions.

3 ENERGY (CRF SECTOR 1)

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 2001 about 66.7% of total GHGs emissions and 80.3% of total anthropogenic CO_2 emissions from Austria were caused by the use of fossil fuels 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 19.8% from 48.13 Gg CO_2 equivalent in 1990 to 57.64 Gg CO_2 equivalent in 2001, which is mainly caused by increasing emissions from the transport sector.

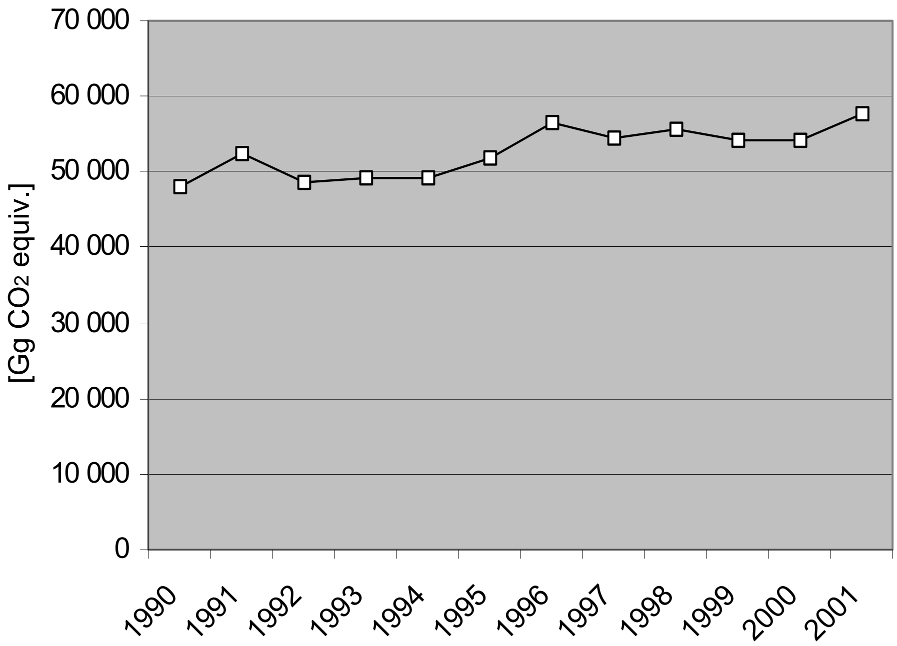


Figure 8: Trend of GHG emissions from 1990-2001 for Sector 1 Energy.

Table 17 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 decrease of CH_4 emissions is mainly caused by the decrease of CH_4 emissions from biomass combustion in category *1 A 4 Other.*

Table 17: Emissions of greenhouse gases and their trend from 1990-2001 from category 1 Energy

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	46 649	50 763	46 768	47 479	47 278	49 878	54 391	52 792	53 855	52 499	52 333	55 879	+19.8%
CH_4	26.47	28.38	26.10	26.18	24.48	25.41	26.66	19.12	18.83	18.73	17.85	18.84	-28.8%
N_2O	2.98	3.61	3.88	4.16	4.47	4.61	4.62	4.51	4.70	4.49	4.40	4.41	+48.0%

Emission trends by sectors

Table 18 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 caused by the increase of CH_4 emissions from natural gas distribution.

Table 18: Total greenhouse gas emissions from 1990–2001 by sub categories of sector 1 Energy.

	GHG emissions [Gg CO_2 equivalent]											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	**48 128**	**52 480**	**48 520**	**49 320**	**49 179**	**51 841**	**56 383**	**54 593**	**55 708**	**54 286**	**54 072**	**57 642**
1 A	47 913	52 249	48 282	49 084	48 925	51 577	56 165	54 331	55 420	53 967	53 764	57 308
1 A 1	13 272	14 147	11 010	10 957	11 310	12 479	13 752	13 731	12 906	12 952	12 287	14 436
1 A 2	7 059	7 606	7 525	8 242	8 718	8 882	9 112	9 981	9 759	8 931	9 219	7 896
1 A 3	13 285	14 879	14 913	15 143	15 341	15 440	17 069	15 974	18 118	17 410	18 374	19 775
1 A 4	14 298	15 618	14 834	14 743	13 556	14 776	16 232	14 644	14 637	14 673	13 884	15 202
1 A 5	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B	214.90	230.29	237.46	235.40	254.41	264.83	217.54	262.31	287.27	318.62	307.65	333.14
1 B 1	0.37	0.31	0.26	0.25	0.20	0.19	0.17	0.17	0.17	0.17	0.19	0.19
1 B 2	214.53	229.98	237.20	235.15	254.20	264.63	217.38	262.14	287.10	318.45	307.46	332.95

3.2 Fuel Combustion Activities (CRF Source Category 1 A)

3.2.1 Source Category Description

In 2001, the most important source for GHGs in this category in Austria was the transport sector (IPCC Category 1 A 3), a share of 23.0% from national total GHG emissions. 15.6% of national GHG emissions are released by passenger cars, 1.8% by light duty vehicles, 4.2% by heavy-duty vehicles, 0.2 % by mopeds and motorcycles.

Austria's railway system is mainly driven by electricity, only 0.2% of overall GHGs originate from this sector. Fuels used by ships driven on inland waterways have a share of 0.1% from 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.

In the commercial, agricultural and house holding sector (small combustion, Category *1 A 4 Other Sectors*), which is the second largest subcategory, fossil fuels are mainly used for heating purposes. Emissions of this category are very dependant on the climatic circumstances because of the temperate climate. A "cold winter" combined with an economic up trend may influence emissions from this sector in a strong way. The main share of biomass in Austria is used in the small combustion sector. This sector also includes emissions from off-road activities. GHG emissions from tractors and other mobile machines used in the agricultural and forestry sector have a share of 2.2% from the national total.

The third largest GHG source of the energy sector in Austria in 2001 is category *1 A 1 Energy Industries*, in which fossil fuels are combusted to produce electrical power or district heating. In the year 2001 74.5 % of the overall gross production of 55 457 GWh of public electricity were generated by hydro plants[11]. 13 955 GWh (that are 25.2%) were produced by thermal power plants, 176 GWh by solar and wind plants. Industrial auto producers generated 8 617 GWh of electricity in the year 2001. 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. Biomass used in this sector is mainly used by smaller district heating plants. The refinery industry which consists of only one plant in Austria is now also included in this category (subcategory *1 A 1 b Petroleum refining-liquid fuels*).

3.2.1.1 Key Sources

Liquid fuel consumption of the subcategories *1 A 2 Manufacturing Industries and Construction* and *1 A 4 Other Sectors* was split into mobile and stationary sources. In general, emission sources which are estimated by using the same set of emission factors and source of activity data (which implies a similar range of uncertainty) were aggregated together.

Differences of key source determination compared to those of the submission 2001 are caused by recalculations:

- A new introduced source is CO_2 emissions from *1 A 1 b Petroleum Refining-gaseous;* it becomes a new key source due to the Level Assessment.
- CO_2 emissions from *1 A 1 c Manufacturing of Solid Fuels and Other Energy Industries-gaseous* becomes a new key source due to the Level and Trend Assessment.
- A new introduced source is CO_2 emissions from *1 A 3 e Transport-Other-gaseous* which becomes a new key source due to the Level and Trend Assessment.

Table 19 presents the source categories in the level of aggregation for the key source analysis (For the key source analysis see Chapter 3).

[11] Source: IEA Questionnaire jan/2003 by STATISTIC AUSTRIA.

Table 19: Key sources of Category 1 Energy

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	LA; TA
1 A 1 a liquid	Public Electricity and Heat Production	CO2	LA; TA1990-2000
1 A 1 a other	Public Electricity and Heat Production	CO2	LA1996-2001; TA1992-2001
1 A 1 a solid	Public Electricity and Heat Production	CO2	LA; TA
1 A 1 b gaseous	Petroleum refining	CO2	LA
1 A 1 b liquid	Petroleum refining	CO2	LA; TA
1 A 1 c gaseous	Manufacturing of Solid fuels and Other Energy Industries	CO2	LA1991,1993-1995; TA1996-2001
1 A 2 gaseous	Manufacturing Industries and Construction	CO2	LA; TA
1 A 2 mob-liquid	Manufacturing Industries and Construction-mobile	CO2	LA; TA1992-1995,1999-2001
1 A 2 solid	Manufacturing Industries and Construction	CO2	LA; TA1990-2000
1 A 2 stat-liquid	Manufacturing Industries and Construction-stationary	CO2	LA; TA1991,1993-2000
1 A 3 b diesel oil	Road Transportation	CO2	LA; TA
1 A 3 b gasoline	Road Transportation	CO2	LA, TA
1 A 3 b gasoline	Road Transportation	N2O	LA; TA
1 A 3 e gaseous	Transport-Other	CO2	LA1998-2001; TA1998-2001
1 A 4 mobile-diesel	Fuel Combustion-Other Sectors-mobile-Agriculture and Forestry	CO2	LA; TA1992-2001
1 A 4 stat-biomass	Fuel Combustion-Other Sectors-stationary	CH4	LA1990-1993; TA1997-2001
1 A 4 stat-gaseous	Fuel Combustion-Other Sectors-stationary	CO2	LA; TA
1 A 4 stat-liquid	Fuel Combustion-Other Sectors-stationary	CO2	LA; TA1991-1992,1994-2001
1 A 4 stat-solid	Fuel Combustion-Other Sectors-stationary	CO2	LA; TA1992-2001

TA = Trend Assessment 1990-2001
LA = Level Assessment 1990-2001

3.2.1.2 Completeness

Table 20 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 20: 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		NO	NO	NO
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		✓,IE(2)	✓,NE(2)	✓,NE(2)
1 A 2 a Solid Fuels		✓,IE(2)	✓,NE(2)	✓,NE(2)
1 A 2 a Gaseous Fuels		✓,IE(2)	✓,NE(2)	✓,NE(2)
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

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
1 A 2 c Chemicals	**0301 Comb. in boilers, gas turbines and stationary engines (Chemical Industry)**			
1 A 2 c Liquid Fuels		✓	✓	✓
1 A 2 c Solid Fuels		✓	✓	✓
1 A 2 c Gaseous Fuels		✓	✓	✓
1 A 2 c Biomass		✓	✓	✓
1 A 2 c Other Fuels		✓	✓	✓
1 A 2 d Pulp, Paper and Print	**0301 Comb. in boilers, gas turbines and stationary engines (Pulp, Paper and Print Industry)**			
1 A 2 d Liquid Fuels		✓	✓	✓
1 A 2 d Solid Fuels		✓	✓	✓
1 A 2 d Gaseous Fuels		✓	✓	✓
1 A 2 d Biomass		✓	✓	✓
1 A 2 d Other Fuels		✓	✓	✓
1 A 2 e Food Processing, Beverages and Tobacco	**0301 Comb. in boilers, gas turbines and stationary engines (Food Processing, Beverages and Tobacco Industry)**			
1 A 2 e Liquid Fuels		✓	✓	✓
1 A 2 e Solid Fuels		✓	✓	✓
1 A 2 e Gaseous Fuels		✓	✓	✓
1 A 2 e Biomass		✓	✓	✓
1 A 2 e Other Fuels		✓	✓	✓
1 A 2 f 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		✓,IE(5)	✓,NE(6)	✓,NE(6)
1 A 2 f Solid Fuels		✓,IE(5)	✓,NE(6)	✓,NE(6)
1 A 2 f Gaseous Fuels		✓,IE(5)	✓,NE(6)	✓,NE(6)
1 A 2 f Biomass		✓,IE(5)	✓,NE(6)	✓,NE(6)
1 A 2 f Other Fuels		✓,IE(5)	✓,NE(6)	✓,NE(6)
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		✓	✓	✓

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
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** **0801 Other Mobile Sources and Machinery-Military**			
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
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		✓	✓	✓

IPCC Category	SNAP	Status		
		CO_2	CH_4	N_2O
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				
1 A 5 Liquid Fuels		IE(3)	IE(3)	IE(3)
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(4)**	**IE(4)**	**IE(4)**

(1) CH_4 emissions from petroleum refining are included in *1 B 2 Fugitive Emissions from Fuels*.
(2) CO_2 emission from two iron and steel plants are included in *2 C Metal Production*. CH_4 and N_2O emissions from this two plants are not estimated.
(3) Energy consumption and emissions from Military Road Transportation are included in *1 A 3 b Road Transportation.* Energy consumption and emissions from Military Aviation are included in *1 A 3 a Civil Aviation.*
(4) Energy consumption and emissions from Multilateral Operations are included in *1 A 4 a Commercial / Institutional.*
(5) CO_2 emissions from fuel combustion in cement industry are included in *2 A 1 Cement Production.*
(6) CH_4 and N_2O emissions from fuel combustion in cement industry are not estimated.

3.2.2 Methodological issues

CORINAIR methodology is applied: the fuel quantity of each subcategory is multiplied with a fuel and technology dependent emission factor for CO_2, CH_4 and N_2O.

Contrary to the standard methodology described in general for category *1 Energy*, emissions due to combustion activities of Category *2 C 1 Iron and Steel Production* are not included in category *1 A Fuel Combustion Activities* where they should be included according to IPCC-guidelines. They are reported together with process-specific emissions under category *2 Industrial Processes.* As energy consumption from this category *is* considered under category *1 A,* the implied emission factors of category *1 A* reported in the CRF are in general lower than IPCC default values.

One reason for reporting combustion-related emissions as mentioned above in Category *2 Industrial Processes* is that this better corresponds to the interests of industry which sees principal difficulties in splitting its emissions into several categories as there are no clear rules how to split emissions resulting from complex processes.

Emission factors

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 are sometimes dependent on the fuel category, e.g. "hard coal" is a group of different hard coal types with different characteristics.

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.
- 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. If emission factors are measured in the unit kg/t the transformation to kg/GJ induces a different emission factor.
- The technology 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] and [UBAVIE, 2001]. 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.

Activity data

If the energy balance is based on mass or volume units the fuel quantities must be converted into energy units [TJ] by multiplying with the corresponding net calorific value (NCV), which is also provided by STATISTIK AUSTRIA together with the energy balance.

Only the quantities that are combusted are relevant for CO_2 emissions and therefore considered in the sectoral approach. The fuel quantities of each subcategory are taken from the energy balance as presented in Annex 4.

This means that the following share of the gross inland fuel consumption is not considered in the sectoral approach: non–energy use, international bunker fuels, transformation and distribution losses and transformations of fuels to other fuels like hard coal to coke oven coke or internal refinery processes which have been added to the transformation sector of the energy balance.

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* enfolds the emissions from fuel combustion in public power and heat plants. The share in total GHG emissions from sector *1 A* is 22.9% for the year 1990 and 20.6% for the year 2001.

Table 21: Greenhouse gas emissions from Category 1 A 1 a.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	10 912	11 659	8 453	8 434	8 712	9 908	10 944	10 990	10 047	10 269	9 705	11 723	7.4%
CH_4	0.14	0.16	0.14	0.15	0.14	0.15	0.18	0.19	0.18	0.19	0.22	0.30	113.5%
N_2O	0.14	0.16	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.14	0.16	19.6%

As can be seen from Table 22 during the last two years solid fossil fuels were dominant compared to other fuel types. CO_2 emissions from waste incineration in district heating plants which are reported as 'other fuels' increased from share of 1% in 1990 to share of 5% in 2001.

Table 22: Share of fuel types on total CO_2 emissions from Category 1 A 1 a.

Fuel	Share on CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	12%	13%	16%	24%	22%	16%	14%	18%	22%	19%	11%	12%
Solid	57%	58%	47%	37%	38%	46%	43%	46%	35%	38%	51%	50%
Gaseous	30%	27%	34%	36%	38%	36%	40%	34%	40%	40%	33%	33%
Other	1%	1%	3%	3%	3%	3%	3%	3%	3%	3%	5%	5%

Methodology

CORINAIR simple methodology was 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].

Activity data

Fuel consumption is taken from the energy balance 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 41 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 70% of the power needed is produced by hydroelectric power plants. If production of electricity by hydropower is low, production from thermal power plants is high and vice versa.

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 the emissions from fuel combustion and CO_2 emissions from thermal cracking of one petroleum refining plant except CH_4 emissions which are reported under category *1 B 2 a Fugitive Emissions from Fuels – Oil*. A share of emissions from refinery gas is reported under category *1 A 2 c Chemicals*. The share in total GHG emissions from sector *1 A* is 4.2% for the year 1990 and 4.3% for the year 2001. The increase of CO_2 emissions is caused by the increase of crude oil input which was 8 Mio t in 1990 and 8.9 Mio t in 2001.

Table 23: Greenhouse gas emissions from Category 1 A 1 b.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	2 019	2 138	2 237	2 187	2 262	2 203	2 590	2 487	2 640	2 464	2 384	2 482	22.9%
N_2O	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	111.2%

Table 24 presents the share of CO_2 emissions for the different fuel types. Natural gas combustion became less important whereas the combustion of liquid fossil fuels increased.

Table 24: Share of fuel types on total CO_2 emissions from Category 1 A 1 b.

Fuel	Share on CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	78%	79%	82%	80%	83%	81%	82%	83%	85%	84%	85%	84%
Solid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gaseous	22%	21%	18%	20%	17%	19%	18%	17%	15%	16%	15%	16%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

CO_2 emissions are reported by the *Association of the Austrian Petroleum Industry*. CO_2 emissions are divided to the fuel categories as the following: For liquid fossil fuels (residual fuel oil, gas oil, diesel, petroleum, jet gasoline, other oil products and LPG) and natural gas default emission factors are applied for calculating the CO_2 emissions. The remaining CO_2 emissions are assumed to result from combustion of refinery gas.

N_2O emissions are calculated by multiplying each fuel consumption with emission factors.

CH_4 emissions are reported under Category *1 B 2 a Fugitive Emissions from Fuels – Oil*.

Crude oil input data is reported under category *1 B 2 a Oil* in chapter 3.3.

Emission factors

N_2O emission factors are taken from a national study [BMUJF, 1994]. CO_2 emission factors are taken from [BMWA-EB, 1990], [BMWA-EB, 1996].

Emission factors for CO_2 and N_2O are presented in Table 25.

Table 25: Emission factors of Category 1 A 1 b for 2001.

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	0.60
Refinery Gas	(1)68.88	0.10
Natural Gas	55.00	0.10

(1) Implied emission factor of remaining CO_2 emissions including those from thermal cracking.

Activity data

Fuel consumption is taken from the energy balance as presented in Annex 4.

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 on sector *1 A* overall GHG emissions is 0.6% for the year 1990 and 0.3% for the year 2001.

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

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	294	297	276	289	288	316	166	204	164	166	147	170	-41.9%
CH_4	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	-41.9%
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-41.9%

Table 27 shows that all CO_2 emissions of category *1 A 1 c* originate from natural gas combustion.

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

Fuel	Share in total CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Solid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gaseous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

CORINAIR simple methodology was 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 28.

Table 28: 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

Activity data

Fuel consumption is taken from the energy balance as described in Annex 4.

3.2.2.4 1 A 2 a Iron and Steel

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

Category *1 A 2 a Iron and Steel* enfolds emissions from fuel combustion in iron and steel industry except those of two sites which are reported under category *2 C 1 Iron and Steel Production*. The share in total GHG emissions from sector 1 A is 0.1% for the year 1990 and 0.5% for the year 2001.

Table 29: Greenhouse gas emissions from Category 1 A 2 a.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	55	57	56	62	69	73	90	368	333	252	456	261	373.4%
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	113.4%
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	842.7%

As can be seen from Table 30, CO_2 emissions from category *1 A 2 a* are mainly arising from the combustion of liquid and gaseous fossil fuels.

Table 30: Share of fuel types in total CO_2 emissions from Category 1 A 2 a.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	25%	25%	20%	18%	18%	14%	43%	72%	75%	76%	45%	74%
Solid	12%	20%	24%	33%	32%	36%	29%	9%	8%	12%	8%	9%
Gaseous	63%	56%	56%	50%	50%	50%	28%	19%	17%	12%	47%	17%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

CORINAIR simple methodology was applied. Fuel consumption (activity data) is taken from the energy balance 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 2001 are presented in Table 31.

Table 31: Emission factors of Category 1 A 2 a for 2001.

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
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
LPG	64.00	1.50	0.10
Natural Gas	55.00	1.50	0.10
Wood Waste	(1)110.00	2.00	4.00

(1) included under CO2 emissions of biomass (not included in National Total!).

3.2.2.5 1 A 2 b Non-Ferrous Metals

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

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 2001.

Table 32: Greenhouse gas emissions from Category 1 A 2 b.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	114	108	128	136	155	161	167	202	197	186	207	188	64.2%
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	47.1%
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	118.5%

As can be seen from Table 33, CO_2 emissions from combustion of liquid fossil fuels became less important whereas the combustion of solid fossil fuels increased.

Table 33: Share of fuel types in total CO_2 emissions from Category 1 A 2 b

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	32%	32%	25%	23%	25%	24%	28%	28%	27%	23%	22%	22%
Solid	3%	6%	7%	1%	3%	3%	7%	9%	8%	10%	11%	12%
Gaseous	66%	62%	68%	77%	72%	73%	65%	63%	64%	66%	67%	66%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

CORINAIR simple methodology was applied. Fuel consumption is taken from the energy balance 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 2001 are presented in Table 34.

Table 34: Emission factors of Category 1 A 2 b for 2001.

Fuel	CO_2 [t / TJ]	CH_4 [kg / TJ]	N_2O [kg / TJ]
Hard Coal	94.00	5.00	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
Petroleum	78.00	0.20	0.60
LPG	64.00	1.50	0.10
Natural Gas	55.00	1.50	0.10

3.2.2.6 1 A 2 c Chemicals

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

Category *1 A 2 c Chemicals* enfolds emissions from fuel combustion in chemical industry and a share on emissions from refinery gas which is delivered from petroleum refinery to a petrochemical plant. The share in total GHG emissions from sector *1 A* is 1.1% for the year 1990 and 1.3% for the year 2001.

Table 35: Greenhouse gas emissions from Category 1 A 2 c.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	544	526	565	599	633	670	687	882	855	762	870	717	31.9%
CH_4	0.05	0.05	0.05	0.03	0.04	0.05	0.04	0.05	0.05	0.04	0.05	0.04	-13.5%
N_2O	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	-46.9%

As can be seen from Table 36, 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, natural gas and industrial waste got slightly less important.

Table 36: Share of fuel types in total CO_2 emissions from Category 1 A 2 c

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	13%	14%	10%	11%	13%	11%	11%	11%	10%	9%	8%	10%
Solid	4%	6%	14%	19%	19%	19%	22%	26%	25%	20%	21%	14%
Gaseous	79%	75%	72%	69%	66%	67%	65%	62%	63%	69%	68%	74%
Other	4%	5%	4%	2%	3%	3%	1%	2%	1%	2%	2%	2%

Methodology

CORINAIR simple methodology was 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 2001 are presented in Table 37.

Table 37: Emission factors of Category 1 A 2 c for 2001.

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 Bri-quettes	97.00	7.00	1.40
Coke	104.00	2.00	1.40
Industrial Waste	10.00	12.00	1.40
Wood Waste	(1)110.00	2.00	4.00
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	0.10
Refinery Gas	68.88	(2)0.00	0.10
Natural Gas	55.00	1.50	0.10
Fuel Wood	(1)100.00	2.00	4.00

(1) included under CO_2 emissions of biomass (not included in National Total!).
(2) zero because CH_4 emissions are included under 1 B 2 A iv

3.2.2.7 1 A 2 d Pulp, Paper and Print

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

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 2.8% for the year 1990 and 2.1% for the year 2001.

Table 38: Greenhouse gas emissions from Category 1 A 2 d.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	1 335	1 416	1 252	1 275	1 221	1 091	1 041	1 581	1 532	1 359	1 475	1 213	-9.1%
CH_4	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.08	0.08	0.08	0.09	0.08	2.4%
N_2O	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.05	0.04	0.05	0.05	26.1%

As can be seen from Table 39, natural gas combustion is the main source of CO_2 emissions from category *1 A 2 d*. The share of CO_2 emissions from liquid and solid fossil fuel combustion decreased since 1990.

Table 39: Share of fuel types in total CO_2 emissions from Category 1 A 2 d.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	30%	30%	30%	36%	37%	28%	24%	20%	19%	15%	16%	18%
Solid	17%	23%	16%	21%	23%	23%	19%	22%	22%	20%	17%	9%
Gaseous	53%	48%	54%	43%	40%	49%	57%	57%	59%	65%	67%	72%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

The CORINAIR simple methodology was 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 2001 are presented in Table 40.

Table 40: Emission factors of Category 1 A 2 d for 2001.

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 Bri-quettes	97.00	7.00	1.40
Coke	104.00	2.00	1.40
Industrial Waste	10.00	12.00	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
LPG	64.00	1.50	0.10
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

(1) included under CO emissions of biomass (not included in National Total!)

3.2.2.8 1 A 2 e Food Processing, Beverages and Tobacco

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

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 1.6% for the year 1990 and 1.2% for the year 2001.

Table 41: Greenhouse gas emissions from Category 1 A 2 e.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	753	783	727	732	763	774	688	735	714	651	728	659	-12.5%
CH_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-23.7%
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-47.7%

As can be seen from Table 42, 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 on CO_2 emissions decreased since 1990.

Table 42: Share of fuel types in total CO_2 emissions from Category 1 A 2 e.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	34%	36%	36%	42%	37%	33%	27%	28%	26%	21%	20%	21%
Solid	1%	1%	2%	0%	1%	0%	1%	2%	2%	2%	2%	2%
Gaseous	65%	62%	62%	58%	63%	66%	72%	71%	72%	77%	78%	76%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

CORINAIR simple methodology was applied.

Activity data (fuel consumption) is taken from the energy balance 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].

Emission factors for 2001 are presented in Table 43.

Table 43: Emission factors of Category 1 A 2 e for 2001.

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 Bri-quettes	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
LPG	64.00	1.50	0.10
Petroleum	78.00	0.20	0.60
Natural Gas	55.00	1.50	0.10
Industrial Waste	10.00	12.00	1.40
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

(1) included under CO2 emissions of biomass (not included in National Total!).

3.2.2.9 1 A 2 f Manufacturing Industries and Construction – Other

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

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 all industrial auto producer plants as well as emissions from off road machinery of total industry. The share in total GHG emissions from sector *1 A* is 8.8% for the year 1990 and 8.4% for the year 2001.

Table 44: Greenhouse gas emissions from Category 1 A 2 f.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	4 126	4 577	4 654	5 294	5 725	5 962	6 285	6 047	5 970	5 562	5 324	4 715	14.3%
CH_4	0.40	0.42	0.44	0.43	0.46	0.46	0.49	0.49	0.48	0.50	0.48	0.46	14.4%
N_2O	0.33	0.35	0.36	0.36	0.39	0.39	0.40	0.43	0.40	0.41	0.40	0.36	9.5%

As can be seen from Table 45, natural gas and liquid fossil fuel combustion is the main source of CO_2 emissions from category *1 A 2 f*. The share of natural gas combustion in total CO_2 emissions slightly decreased whereas liquid fossil fuel combustion slightly increased.

Table 45: Share of fuel types in total CO_2 emissions from Category 1 A 2 f.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	37%	37%	35%	41%	36%	38%	39%	44%	43%	41%	40%	41%
Solid	5%	6%	7%	3%	2%	3%	4%	3%	5%	2%	5%	4%
Gaseous	58%	56%	57%	56%	62%	59%	56%	53%	52%	56%	54%	55%
Other	1%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%

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 6.9% for the year 1990 and 6.4% for the year 2001.

Table 46: Greenhouse gas emissions from Category 1 A 2 f stationary sources.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	3 304	3 704	3 753	4 404	4 792	5 032	5 361	5 086	4 978	4 540	4 266	3 649	10.4%
CH_4	0.14	0.15	0.15	0.15	0.17	0.17	0.20	0.18	0.17	0.17	0.15	0.12	-13.8%
N_2O	0.04	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.05	0.06	0.05	0.04	0.5%

As can be seen in Table 47, 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 combustion in total CO_2 emissions slightly decreased whereas liquid fossil fuel combustion slightly increased.

Table 47: Share of fuel types on total CO_2 emissions from Category 1 A 2 f stationary sources.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	22%	23%	20%	29%	24%	27%	29%	33%	31%	28%	26%	24%
Solid	6%	7%	9%	4%	2%	3%	4%	4%	5%	3%	6%	5%
Gaseous	72%	69%	71%	67%	74%	70%	66%	63%	63%	69%	68%	71%
Other	1%	1%	1%	0%	0%	0%	1%	1%	0%	1%	0%	0%

Methodology

The CORINAIR simple methodology was applied. Fuel consumption is taken from the energy balance as presented 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 2001 are presented in Table 43.

Table 48: Emission factors of Category 1 A 2 f stationary sources for 2001.

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 Bri-quettes	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	78.00	0.20	0.60
Petroleum	78.00	0.20	0.60
LPG	64.00	1.50	0.10
Natural Gas	55.00	1.50	0.10
Industrial Waste	10.00	12.00	1.40
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

(1) included under CO2 emissions of biomass (not included in National Total!).

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 1.9% for the year 1990 and 2% for the year 2001.

Table 49: Greenhouse gas emissions from Category 1 A 2 f mobile sources.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	822	873	901	890	933	930	924	961	992	1 022	1 058	1 066	29.7%
CH_4	0.26	0.27	0.28	0.28	0.29	0.29	0.29	0.30	0.31	0.32	0.33	0.34	29.9%
N_2O	0.29	0.30	0.31	0.31	0.33	0.33	0.34	0.36	0.35	0.35	0.35	0.32	10.7%

As can be seen from Table 50, combustion of liquid fossil fuels is the only mobile source of CO_2 emissions from category *1 A 2 f*.

Table 50: Share of fuel types in total CO_2 emissions from Category 1 A 2 f mobile sources.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gaseous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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 b Military Activities
- 1 A 3 c Railways
- 1 A 3 d Navigation
- 1 A 4 b Household and Gardening
- 1 A 4 c Agriculture and Forestry

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

Due to the high fuel consumption of the off road sector the ratio of fuel consumption between the on- and off road transport sector has been recalculated.

Emission factors

Emission factors were defined for four categories of engine type depending on the year of construction. Emission factors are listed in Table 51 to Table 54. 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 bottom-up method national total fuel consumption and total emissions are calculated. 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 traffic is adjusted so that finally the calculated total fuel consumption equals the figure of fuel sold in the national energy balance.

Table 51: Emission Factors for diesel engines > 80 kW [g/kWh]

Year	Fuel	CO_2	CH_4	N_2O
	[g/kWh]			
1993	282	890	0.05	0.32
1997	273	861	0.04	0.35
2000	265	834	0.03	0.22

Table 52: Emission Factors for diesel engines < 80 kW [g/kWh]

Year	Fuel	CO_2	CH_4	N_2O
	[g/kWh]			
1993	296	935	0.10	0.32
1997	287	904	0.07	0.35
2000	278	876	0.06	0.22

Table 53: Emission Factors for 4-stroke-petrol engines [g/kWh]

Year	Fuel	CO_2	CH_4	N_2O
	[g/kWh]			
1993	550	1 734	2.16	0.04
1997	520	1 640	1.92	0.04
2000	500	1 577	1.78	0.04

Table 54: Emission Factors for 2-stroke-petrol engines [g/kWh]

Year	Fuel	CO_2	CH_4	N_2O
	[g/kWh]			
1993	700	2 207	3.00	0.01
1997	675	2 128	2.70	0.01
2000	655	2 065	2.40	0.01

Activity data

Activity data, vehicle stock and specific fuel consumption for vehicles and machinery were taken from:

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

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

Table 55: Emission factors and activities for industrial off-road traffic 1990–2001

Year	CO_2	CH_4	N_2O	Activity
	kg/kWh	g/kWh	g/kWh	GWh
1990	0.27	0.084	0.093	3080.6
1991	0.27	0.084	0.093	3270.7
1992	0.27	0.084	0.093	3374.4
1993	0.27	0.084	0.093	3334.3
1994	0.27	0.084	0.096	3494.5
1995	0.27	0.084	0.096	3484.0
1996	0.27	0.084	0.097	3462.9
1997	0.27	0.084	0.099	3599.1
1998	0.27	0.084	0.094	3715.5
1999	0.27	0.084	0.091	3829.1
2000	0.27	0.084	0.087	3964.8
2001	0.27	0.084	0.079	3994.5

3.2.2.10 1 A 3 a Civil Aviation

Key Source: No

CO_2 and CH_4 Emissions from aviation covered in this subcategory were calculated separately for VFR-flights (Visual Flight Rules), military aviation and IFR (Instrument Flight Rules) national LTO and IFR national cruise. Emissions from military flights are also considered in this category, it is planned to reallocate these emissions in next year's submission to category *1 A 5 Other*.

For N_2O emissions only IFR national LTO and IFR national cruise is considered.

Greenhouse gas emissions from aviation are low compared to emissions from the transport sector but show a strong increase: from 1990 to 2001 total GHG emissions from this subcategory increased by 86%. However, the trend for the different GHGs varies due to different methodologies of emission estimation. Furthermore, for calculating N_2O emissions VFR and military aviation were not considered.

Table 56: CO_2 and N_2O emissions from 1 A 3 a Civil Aviation including CO_2 emissions from military aviation by subcategories 1990-2001

Year	**CO_2 emissions [Gg]**					**N_2O emissions [Gg]**		
	national LTO	national cruise	Military	VFR	**TOTAL**	national LTO	national cruise	**TOTAL**
1990	9.97	14.20	32.88	7.84	**64.89**	0.00062	0.00045	**0.00107**
1991	10.76	18.68	34.97	8.07	**72.49**	0.00066	0.00059	**0.00126**
1992	11.56	23.16	31.56	8.32	**74.60**	0.00075	0.00074	**0.00148**
1993	12.36	27.63	37.29	8.57	**85.86**	0.00079	0.00088	**0.00167**
1994	13.16	32.11	39.46	8.84	**93.57**	0.00082	0.00102	**0.00184**
1995	13.95	36.59	30.47	7.06	**88.07**	0.00089	0.00116	**0.00205**

Year	CO_2 emissions [Gg]					N_2O emissions [Gg]		
	national LTO	national cruise	Military	VFR	**TOTAL**	national LTO	national cruise	**TOTAL**
1996	16.15	40.56	36.82	6.78	**100.32**	0.00102	0.00129	**0.00231**
1997	18.35	44.53	35.02	7.62	**105.53**	0.00110	0.00141	**0.00252**
1998	20.55	48.50	40.35	8.20	**117.60**	0.00120	0.00154	**0.00274**
1999	21.09	51.28	39.53	8.73	**120.64**	0.00122	0.00163	**0.00285**
2000	21.63	54.06	42.88	6.42	**124.99**	0.00136	0.00172	**0.00307**
2001	20.86	52.11	41.34	6.42	**120.73**	0.00131	0.00165	**0.00296**

Table 57: CH_4 emissions from 1 A 3 a Civil Aviation including CH_4 emissions from military aviation by subcategories 1990-2001

Year	CH_4 emissions [Gg]				
	national LTO	national cruise	Military	VFR	**TOTAL**
1990	0.00007	0.00010	0.00024	0.00141	**0.00183**
1991	0.00008	0.00014	0.00026	0.00145	**0.00192**
1992	0.00008	0.00017	0.00023	0.00149	**0.00198**
1993	0.00009	0.00020	0.00027	0.00157	**0.00214**
1994	0.00010	0.00024	0.00029	0.00162	**0.00224**
1995	0.00010	0.00027	0.00022	0.00129	**0.00189**
1996	0.00012	0.00030	0.00027	0.00124	**0.00193**
1997	0.00013	0.00033	0.00026	0.00140	**0.00211**
1998	0.00015	0.00036	0.00029	0.00150	**0.00230**
1999	0.00015	0.00038	0.00029	0.00160	**0.00242**
2000	0.00016	0.00040	0.00031	0.00118	**0.00205**
2001	0.00015	0.00038	0.00030	0.00118	**0.00201**

Table 58: Greenhouse gas emissions from category 1 A 3 a Civil Aviation including CO_2 and CH_4 emissions from military aviation 1990-2001

GHG	GHG emissions [Gg CO_2 equivalent]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	64.89	72.49	74.60	85.86	93.57	88.07	100.32	105.53	117.60	120.64	124.99	120.73	*+86%*
N_2O	0.33	0.39	0.46	0.52	0.57	0.64	0.72	0.78	0.85	0.88	0.95	0.92	*+176%*
CH_4	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.04	*+10%*
Total	**65.26**	**72.92**	**75.10**	**86.43**	**94.19**	**88.75**	**101.08**	**106.35**	**118.50**	**121.57**	**125.99**	**121.69**	***+86%***

Methodological Issues

Emission estimates for CO_2 were taken from a study commissioned by the UBAVIE that was finished in 2002 [KALIVODA et. al, 2002]. Emissions for the year 2001 have been calculated using implied emission factors and fuel allocation obtained from the values for the year 2000.

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[12] (flight distance and destination per aircraft type), aircraft/ engine performance data and emission factors.

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 UBAVIE 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 hold the highest uncertainty.

Only IFR national LTO and IFR national cruise is considered in *1 A 3 a Civil Aviation*, IFR international LTO and IFR international cruise is considered in *I B Av International Bunkers Aviation*.

CH_4 emissions were calculated using the fuel consumptions as obtained in the study and the implied emission factors as already used in last year's submission.

For calculation of CO_2 and CH_4 emissions VFR and military flights were considered as well.

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.

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, the fuel consumption was multiplied with the emission factor presented below.

For calculation of N_2O emissions VFR and military flights were not considered as the applied emission factors only refer to an "average international fleet with large aircraft" which is not true for these two subcategories. The applied emission factors were taken from the CORINAIR guidebook, they are based on LTO cycles and fuel used for cruise.

The number of LTO cycles performed were 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 an equal fuel consumption for domestic and international LTO).

Emission Factors

For calculation of CO_2 emissions an emission factor of 3 150 kg CO_2/ Mg fuel has been used for all subcategories (IFR, VFR and military aviation).

For calculation of CH_4-emissions an emission factor of 13.59 g/ GJ has been used for gasoline (VFR) and 0.53 g/GJ for kerosene (IFR and military). Fuel consumption in [t] was transformed into [GJ] using the heating values as presented in Annex 4.

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

N_2O emissions have been calculated using emission factors of the very simple methodology presented in the CORINAIR guidebook (0.1 kg N_2O / LTO for LTO and 0.1 kg N_2O / t fuel for cruise).

Activity data

Table 59: Number of national LTO cycles and fuel consumptions as obtained from the MEET model 1990-2001

Year	IFR national LTO	IFR national cruise	Military	VFR	national LTO
	Kerosene [Mg]			Gasoline [Mg]	[-]
1990	3 164	4 508	10 439	2 487	6 220
1991	3 417	5 929	11 102	2 563	6 644
1992	3 670	7 351	10 019	2 641	7 450
1993	3 924	8 773	11 840	2 722	7 947
1994	4 177	10 195	12 527	2 805	8 219
1995	4 430	11 616	9 672	2 241	8 923
1996	5 128	12 877	11 689	2 153	10 233
1997	5 827	14 137	11 119	2 417	11 013
1998	6 525	15 398	12 809	2 602	12 025
1999	6 697	16 279	12 551	2 771	12 210
2000	6 868	17 161	13 613	2 039	13 551
2001	6 621	16 544	13 124	2 039	13 064

Recalculations

Emissions reported in the last submission were based on a study of the year 1994. As emissions of aviation are increasing rapidly a new study was commissioned by the UBAVIE [KALIVODA et. al, 2002]. Using data presented in this study an up-to-date split of the fuel consumption into the different modes of transport (national/ international, LTO/ cycle) was possible.

This year for calculation of CO_2 and CH_4 emissions also military aviation was considered.

Table 60: Recalculations with respect to previous submission from Category 1 A 3 a 1990-2001

Gas	Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2 [Gg Diff]	nat. LTO	18.52	17.28	12.82	20.12	21.57	10.01	14.97	14.04	18.82	20.74	21.30
	VFR	-1.34	-1.51	-0.35	-0.45	2.17	0.38	0.14	1.52	1.35	1.86	-0.44
	nat. cruise	-21.78	-23.40	-21.65	-16.03	-13.80	-14.30	-15.64	-13.63	-13.73	-7.70	-9.84
	TOTAL	**-4.59**	**-7.63**	**-9.18**	**3.64**	**9.93**	**-3.91**	**-0.53**	**1.93**	**6.43**	**14.90**	**11.02**

Gas	Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N_2O [Mg Diff]	nat. LTO	0.43	0.44	0.51	0.57	0.58	0.63	0.73	0.80	0.88	0.91	1.02
	VFR	-0.56	-0.59	-0.53	-0.55	-0.41	-0.41	-0.41	-0.37	-0.42	-0.41	-0.41
	nat. cruise	0.17	0.27	0.39	0.54	0.66	0.77	0.85	0.96	1.06	1.17	1.22
	TOTAL	**0.04**	**0.12**	**0.37**	**0.55**	**0.84**	**0.98**	**1.17**	**1.39**	**1.52**	**1.67**	**1.82**
CH_4 [Mg Diff.]	nat. LTO	0.11	0.12	0.09	0.14	0.15	0.07	0.11	0.10	0.14	0.15	0.16
	VFR	-0.28	-0.30	-0.08	-0.06	0.41	0.09	0.04	0.29	0.25	0.34	-0.08
	nat. cruise	-0.20	-0.18	-0.17	-0.13	-0.11	-0.11	-0.12	-0.10	-0.10	-0.06	-0.07
	TOTAL	**-0.36**	**-0.36**	**-0.16**	**-0.05**	**0.46**	**0.05**	**0.03**	**0.29**	**0.29**	**0.44**	**0.00**

NOTE: in the submission 2003 military aviation is included in nat. LTO.

Planned Improvements

CH_4 emission factors are planned to be updated using results from the new study [KALIVODA et. al, 2002].

Emissions from military aviation will be allocated to *1 A 5 Other*.

3.2.2.11 1 A 3 b Road Transport

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

Emissions from road transportation and from military activity are covered in this category. However, for confidentiality reason emission estimates for emissions from military activities present only rough estimations [PISCHINGER, 2000].

Methodology

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

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 except emissions from military activities 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 (g/km, g/kWh, g/kg fuel). The emissions from cold starts are calculated separately – taking into account temperature, interception periods and driving distances.

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 was 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 51; 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).

Emission factors

Implied emission factors for road transport except military activities are listed in Table 61.

Table 61: Implied Emission Factors of Road Transport and activities for the year 2001

Emission Source	CO_2 kg/kWh	CH_4 g/kWh	N_2O g/kWh	Activity GWh
Passenger Cars	0.266	0.022	0.052	47312.8
Light Duty Vehicles	0.267	0.004	0.012	5759.7
Heavy Duty Vehicles and Buses	0.267	0.005	0.014	13322.1
Mopeds	0.266	2.003	0.006	143.9
Motorcycles	0.266	0.137	0.004	579.0

Implied emission factors and activity data for military activities are presented in the following table.

Table 62: Emission factors and activity data for military activities 1990–2001

Year	CO_2 kg/kWh	CH_4 g/kWh	N_2O g/kWh	Activity GWh
1990	0.27	0.085	0.095	8.0
1991	0.27	0.085	0.095	8.0
1992	0.27	0.085	0.095	8.0
1993	0.27	0.085	0.095	8.0
1994	0.27	0.085	0.095	8.0
1995	0.27	0.085	0.097	8.0
1996	0.27	0.085	0.098	7.9
1997	0.27	0.085	0.100	7.9
1998	0.27	0.085	0.102	7.9
1999	0.27	0.085	0.099	7.8
2000	0.27	0.085	0.095	7.8
2001	0.27	0.085	0.092	7.7

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: 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 approach is adjusted so that finally the calculated total fuel consumption equals the figure of fuel sold in the national energy balance.

Uncertainties/ Verification

As already mentioned above, the result of the bottom-up approach (calculated total fuel consumption) is compared with national fuel sales of the national energy balance: due to uncertainties of the bottom up method and tank tourism the values differ by about 5%.

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

Furthermore the carbon content of different fuel categories may vary over time.

Recalculation

In 2002 an updated driving performance and a cold start module has been applied, taking into account the high share of diesel vehicles in the Austrian vehicle fleet. Due to the new cold start module N_2O emissions slightly increased.

Planned Improvements

For the category *1 A 3 b* the following improvements are planned:

- improve and widen the underlying data sources for emission factors
- validate database with emission factors based on real driving cycles

3.2.2.12 1 A 3 c Railways

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). Activities used for estimating the emissions and the implied emission factors are presented in the following table.

Table 63: Emission factors and activity data for railway 1990–2001

Year	CO_2	CH_4	N_2O	Activity
	kg/kWh	g/kWh	g/kWh	GWh
1990	0.27	0.047	0.034	645.9
1991	0.27	0.047	0.034	670.0
1992	0.27	0.047	0.033	668.4
1993	0.27	0.047	0.033	651.7
1994	0.27	0.046	0.032	657.5
1995	0.27	0.046	0.032	613.3
1996	0.27	0.046	0.031	554.3
1997	0.27	0.046	0.031	552.5
1998	0.27	0.046	0.030	544.4
1999	0.27	0.046	0.030	671.6
2000	0.27	0.047	0.030	669.9
2001	0.27	0.047	0.030	631.5

3.2.2.13 1 A 3 d Navigation

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). Activities used for estimating the emissions and the implied emission factors are presented in the following table.

Table 64: Emission factors and activity data for the sector Navigation 1990–2001

Year	CO_2	CH_4	N_2O	Activity
	kg/kWh	g/kWh	g/kWh	GWh
1990	0.27	0.069	0.064	195.2
1991	0.27	0.068	0.063	177.2
1992	0.27	0.068	0.062	173.5
1993	0.27	0.068	0.061	174.8
1994	0.27	0.070	0.062	208.3
1995	0.27	0.070	0.061	202.1
1996	0.27	0.070	0.060	202.3
1997	0.27	0.072	0.060	231.7
1998	0.27	0.072	0.060	234.0
1999	0.27	0.072	0.059	235.7
2000	0.27	0.072	0.058	237.4
2001	0.27	0.073	0.057	239.1

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 (compressors). The share in total GHG emissions from sector *1 A* is 0.3% for the year 1990 and 1.1% for the year 2001.

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

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	167	181	196	213	208	225	232	231	349	429	530	638	280.8%
CH_4	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	280.8%
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	280.8%

As can be seen from Table 2, combustion of natural gas is the only source of CO_2 emissions from category *1 A 2 e*.

Table 2: Share of fuel types in total CO_2 emissions from Category 1 A 3 e.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Solid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gaseous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Methodology

CORINAIR simple methodology was applied.

Activity data (fuel consumption) is taken from the energy balance as described 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 2001 are presented in Table 3.

Table 3: Emission factors of Category 1 A 2 e for 2001.

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

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 29.8% for the year 1990 and 26.5% for the year 2001.

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

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	13 638	14 907	14 172	14 075	12 933	14 121	15 534	14 101	14 102	14 137	13 368	14 658	7.5%
CH_4	18.39	19.89	17.88	17.89	16.14	16.84	17.90	10.69	10.28	10.26	9.63	10.34	-43.7%
N_2O	0.88	0.94	0.93	0.94	0.92	0.97	1.04	1.03	1.03	1.04	1.01	1.05	19.7%

As can be seen from Table 5, liquid fossil fuels are the main source of CO_2 emissions from category *1 A 4* with a 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 5: Share of fuel types on total CO_2 emissions from Category 1 A 4.

Fuel	Share on CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	63%	61%	61%	61%	61%	61%	62%	62%	63%	63%	60%	63%
Solid	20%	20%	17%	15%	14%	13%	11%	10%	9%	8%	7%	6%
Gaseous	17%	19%	22%	24%	24%	26%	26%	28%	29%	29%	32%	31%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

1 A 4 Other sectors - stationary sources

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 26.8% for the year 1990 and 23% for the year 2001.

Table 6: Greenhouse gas emissions from Category 1 A 4 stationary sources.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	12 297	13 537	12 756	12 621	11 441	12 593	13 947	12 455	12 402	12 384	11 568	12 841	4.4%
CH_4	18.00	19.49	17.47	17.47	15.71	16.39	17.44	10.21	9.78	9.74	9.10	9.81	-45.5%
N_2O	0.46	0.52	0.48	0.49	0.45	0.48	0.53	0.48	0.47	0.47	0.45	0.50	7.3%

As can be seen from Table 7, 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 7: Share of fuel types in total CO_2 emissions from Category 1 A 4 stationary sources.

Fuel	Share in CO_2 emissions											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Liquid	59%	57%	56%	56%	56%	56%	58%	57%	58%	57%	54%	58%
Solid	23%	22%	19%	17%	16%	14%	13%	11%	10%	9%	9%	7%
Gaseous	18%	21%	25%	27%	27%	30%	29%	32%	32%	34%	37%	35%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Methodology

CORINAIR simple methodology was 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 (according to the energy balance) is combusted in devices which are equal 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.

In the case that only VOC emission factors are provided, CH_4 emission factors are determined assuming that a certain percentage of VOC emissions is methane as listed in Table 8. The split follows closely [STANZEL et. al, 1995].

Table 8: 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 studies provide emission factors for different fuel types and each of the three heating types as described in chapter *methodology*.

Emission factors for 2001 are presented in Table 9.

Table 9: Emission factors of Category 1 A 4 for the year 2001.

Fuel	CO_2 [t / TJ]	CH_4 [kg / TJ]		N_2O [kg / TJ]	
		Central and Apartment Heating	Stove	Central and Apartment Heating	Stove
Hard Coal	93.00	230.00	90.00	2.00	1.00
Hard Coal Briquettes	93.00	230.00	90.00	2.00	1.00
Lignite and brown coal	108.00	230.00	90.00	4.00	1.00
Brown Coal Briquettes	97.00	7.00	100.00	4.00	4.00
Coke	92.00	16.00	90.00	2.00	2.00
Light Fuel Oil	77.00	0.25	-	0.60	-
Medium 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
Industrial Waste	10.00	12.00	-	1.40	-
Wood Waste	(1)110.00	112.00	170.00	3.00	5.00
Fuel Wood	(1)100.00	112.00	170.00	3.00	7.00
Landfill Gas	(1)112.00	1.50	-	1.00	-

(1) included under CO_2 emissions of biomass (not included in National Total!).

Activity data

Fuel consumption is taken from the energy balance as described in Annex 4.

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). Activities used for estimating the emissions and the implied emission factors are presented in the following table.

Table 65: Emission factors and activity data for the sector Household and Gardening 1990–2001

Year	CO_2	CH_4	N_2O	Activity
	kg/kWh	g/kWh	g/kWh	GWh
1990	0.27	0.038	0.045	532.4
1991	0.27	0.038	0.045	534.0
1992	0.27	0.038	0.045	539.2
1993	0.27	0.038	0.045	542.6
1994	0.27	0.038	0.047	538.6

1995	0.27	0.038	0.048	541.6
1996	0.27	0.038	0.048	538.0
1997	0.27	0.038	0.048	534.2
1998	0.27	0.038	0.043	528.1
1999	0.27	0.038	0.042	526.2
2000	0.27	0.038	0.041	525.6
2001	0.27	0.037	0.036	520.4

1 A 4 c Agriculture and Forestry

Key Source: Yes (CO_2: mobile-diesel)

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

Table 66: Emission factors and activity data for the sector Agriculture 1990–2001

Year	CO_2	CH_4	N_2O	Activity
	kg/kWh	g/kWh	g/kWh	GWh
1990	0.27	0.082	0.087	3060.7
1991	0.27	0.082	0.088	3133.8
1992	0.27	0.082	0.088	3241.8
1993	0.27	0.082	0.088	3338.7
1994	0.27	0.082	0.088	3431.2
1995	0.27	0.082	0.089	3520.3
1996	0.27	0.082	0.091	3679.9
1997	0.27	0.082	0.092	3845.2
1998	0.27	0.082	0.092	3999.9
1999	0.27	0.082	0.090	4147.1
2000	0.27	0.082	0.088	4280.2
2001	0.27	0.083	0.086	4342.0

Table 67: Emission factors and activity data for the sector Forestry 1990–2001

Year	CO_2	CH_4	N_2O	Activity
	kg/kWh	g/kWh	g/kWh	GWh
1990	0.27	0.082	0.087	1432.1
1991	0.27	0.082	0.087	1467.5
1992	0.27	0.082	0.087	1523.4
1993	0.27	0.082	0.088	1566.9
1994	0.27	0.082	0.088	1621.6
1995	0.27	0.082	0.089	1663.9

1996	0.27	0.082	0.090	1728.3
1997	0.27	0.082	0.091	1788.2
1998	0.27	0.082	0.091	1840.8
1999	0.27	0.082	0.089	1893.1
2000	0.27	0.082	0.087	1939.3
2001	0.27	0.082	0.085	1943.9

3.2.2.16 International Bunkers

3.2.2.16.1 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 68: CH_4 emissions from 1 A 3 a Civil Aviation including military aviation by subcategories 1990-2001

Year	CO_2 emissions [Gg]			N_2O emissions [Gg]			CH_4 emissions [Gg]		
	int. LTO	int. cruise	**TOTAL**	int. LTO	int. cruise	**TOTAL**	int. LTO	int.cruise	**TOTAL**
1990	90.25	795.72	885.97	0.0056	0.0253	0.0309	0.0007	0.0059	0.0065
1991	103.04	890.83	993.88	0.0064	0.0283	0.0346	0.0008	0.0066	0.0073
1992	115.84	961.60	1077.44	0.0075	0.0305	0.0380	0.0009	0.0071	0.0079
1993	128.63	1011.36	1139.98	0.0083	0.0321	0.0404	0.0009	0.0074	0.0084
1994	141.42	1044.23	1185.65	0.0088	0.0332	0.0420	0.0010	0.0077	0.0087
1995	154.21	1173.21	1327.42	0.0099	0.0372	0.0471	0.0011	0.0086	0.0097
1996	164.79	1301.63	1466.42	0.0104	0.0413	0.0518	0.0012	0.0095	0.0107
1997	175.37	1350.20	1525.57	0.0105	0.0429	0.0534	0.0013	0.0099	0.0112
1998	185.95	1392.26	1578.21	0.0109	0.0442	0.0551	0.0014	0.0102	0.0116
1999	190.06	1351.61	1541.67	0.0110	0.0429	0.0539	0.0014	0.0099	0.0113
2000	194.17	1480.76	1674.93	0.0122	0.0470	0.0592	0.0014	0.0108	0.0123
2001	187.19	1427.56	1614.75	0.0117	0.0453	0.0570	0.0014	0.0105	0.0118

Methodological Issues

Emissions have been calculated using the methodology and emission factors as described in Chapter 3.2.2.10 *1 A 3 a Civil Aviation*. Activity data used for estimating emissions from international aviation are presented below.

Table 69: International LTO and fuel consumptions as obtained from the MEET model 1990-2001

Year	int. LTO [-]	int. LTO [Mg]	int. cruise [Mg]
1990	56 327	28 651	252 610
1991	63 599	32 712	282 805
1992	74 640	36 773	305 271
1993	82 709	40 834	321 065
1994	88 343	44 895	331 502
1995	98 606	48 957	372 447
1996	104 385	52 315	413 214
1997	105 229	55 673	428 634
1998	108 787	59 032	441 988
1999	110 009	60 336	429 082
2000	121 623	61 641	470 082
2001	117 253	59 426	453 194

Recalculations

Emissions reported in the last submission were based on a study of the year 1994. As emissions of aviation are increasing rapidly a new study was commissioned by the UBAVIE [KALIVODA et. al, 2002]. Using data presented in this study an up-to-date split of the fuel consumption into the different modes of transport (national/ international, LTO/ cycle) was possible.

Table 70: Recalculations with respect to previous submission from international aviation (International Bunkers Aviation) 1990-2001

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2 [Gg Diff]	LTO	-337.07	-396.75	-416.42	-390.07	-403.99	-450.30	-502.81	-515.57	-553.30	-510.55	-564.82
	cruise	281.79	289.74	321.46	387.53	388.27	446.18	498.71	519.21	503.18	509.00	567.93
	Total	**-55.27**	**-107.00**	**-94.96**	**-2.54**	**-15.73**	**-4.12**	**-4.10**	**3.64**	**-50.12**	**-1.55**	**3.11**
N_2O [Mg Diff]	LTO	2.26	2.48	3.33	4.24	4.60	5.17	5.25	5.16	5.14	5.56	6.26
	cruise	21.21	23.61	25.56	27.26	28.06	31.60	35.09	36.41	37.30	36.36	39.91
	Total	**23.47**	**26.09**	**28.89**	**31.50**	**32.65**	**36.76**	**40.34**	**41.57**	**42.43**	**41.92**	**46.18**
CH_4 [Mg Diffe]	LTO	-2.91	-3.04	-3.18	-2.96	-3.05	-3.38	-3.75	-3.82	-4.07	-3.73	-4.13
	cruise	1.55	1.98	2.23	2.74	2.77	3.15	3.57	3.75	3.67	3.74	4.17
	Total	**-1.36**	**-1.06**	**-0.95**	**-0.22**	**-0.28**	**-0.23**	**-0.18**	**-0.06**	**-0.40**	**0.00**	**0.04**

Planned Improvements

CH_4 emission factors are planned to be updated using results from the new study [KALIVODA et. al, 2002].

3.2.2.16.2 International Bunkers - Marine

Emissions from international marine bunkers to not occur as Austria is a land locked country. It is the understanding of Austria that (international) transport by ship on the Danube is not part of international bunkers. Emissions from fuel sold to ships in Austria, including shipping on the Danube is included in *1 A 3 d Navigation*.

3.2.3 Quality Assurance and Quality Control and Verification

For general QA/QC see Chapter 1.6.

The methodology as well as activity data used for estimating emissions from off-road transport have been verified by independent experts from TÜV Bayern.

Emission estimates from aviation as presented in this report have been compared with estimates obtained using other approaches. The comparison is included in [KALIVODA et. al, 2002].

For estimating emissions from road transport a bottom up- approach based on road performance per vehicle was used. To be consistent with the national energy balance total fuel consumption as obtained from this approach was compared with and adjusted to total fuel consumption of the energy balance. The difference is about 3%, one reason for this deviation is tank tourism.

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

- BGBI II 1997/ 331 Feuerungsanlagen-Verordnung
- BGBI 1989/ 19 Luftreinhalteverordnung für Kesselanlagen
- BGBI 1988/ 380 Luftreinhaltegesetz für Kesselanlagen

Extracts of the relevant paragraphs are provided in Annex 6.

3.2.4 Recalculations

The revision of the national energy statistics for the time series 1990-2000 by STATISTIC AUSTRIA implies changes for category *1 A* for all GHGs from 1990 onwards. The time series is now consistent regarding fuel categories, sectoral data splits and units. For details see description in Annex 4.

For information on recalculations of subcategories 1 A 3 a, 1 A 3 b and I B A see the corresponding subchapters of Chapters 3.2.2.10, 0 and 3.2.2.16.

Table 10: Recalculation difference with respect to previous submission from Category 1 Energy 1990-2000, in Gg CO_2 equiv.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gg CO_2 equiv.	-2 056	-2 261	-1 462	-972	-1 793	-922	1 747	-422	1 278	-665	-805

3.2.5 Planned Improvements

Energy Balance

In 2003 the UBA will perform an industry inquiry which will be the basis of allocating emission permits to installations according the *EC CO_2 trading directive*.

The results of this bottom up approach will be used to improve the sectoral breakdown of the energy balance from 1998 to 2001 and will provide an improved basis to split emissions of industrial electricity and heat auto producers between *1 A 2 a* to *1 A 2 f*.

Consistency check with EPER

Cross-check the emission declarations of the EPER reporting obligation with the national inventory.

1 A 1 b Petroleum refining

Inquire plant operators for historical fuel consumption data to avoid double counting of emissions.

1 A 2 a Iron and Steel

Estimate CH_4 and N_2O emissions from the two iron and steel plants.

Inquire plant operators for historical fuel consumption data to avoid double counting of emissions.

1 A 2 Manufacturing Industries and Construction

Shift fuel consumption and emissions of industrial electricity and heat auto producers which are now reported in category *1 A 2 f* into categories *1 A a* to *1 A e*.

3.2.6 Comparison of the Sectoral Approach with the Reference Approach

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

Table 11 compares the results of the two approaches.

Table 11: 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	27 381	13 503	11 463	52 347	26 320	9 503	10 495	211	46 529
1991	29 705	14 407	12 108	56 220	28 813	10 428	11 162	230	50 633
1992	29 394	10 643	12 167	52 203	28 043	7 065	11 225	297	46 629
1993	30 484	9 174	12 625	52 282	29 459	5 822	11 777	289	47 347
1994	29 999	9 164	13 289	52 451	28 802	5 668	12 362	299	47 131
1995	30 265	10 643	14 534	55 442	29 115	6 910	13 397	307	49 729
1996	32 192	11 027	15 493	58 712	32 306	7 104	14 506	381	54 296
1997	32 075	11 483	14 916	58 473	31 144	7 233	13 871	400	52 649
1998	34 261	9 723	15 336	59 320	33 507	5 618	14 191	375	53 690

1999	32 384	9 682	15 609	57 675	31 863	5 632	14 411	398	52 305
2000	31 435	10 993	14 876	57 305	30 972	6 759	13 929	486	52 146
2001	34 185	11 542	15 935	61 661	33 628	7 158	14 287	599	55 672

Table 12 presents the differences of the two approaches.

Table 12: Difference of CO_2 emissions of the two approaches.

Year	Liquid	Solid	Gaseous	Total
1990	4.03%	42.09%	9.22%	12.50%
1991	3.10%	38.15%	8.47%	11.03%
1992	4.82%	50.65%	8.39%	11.95%
1993	3.48%	57.57%	7.20%	10.42%
1994	4.15%	61.67%	7.50%	11.29%
1995	3.95%	54.03%	8.48%	11.49%
1996	-0.35%	55.24%	6.80%	8.13%
1997	2.99%	58.75%	7.53%	11.06%
1998	2.25%	73.07%	8.07%	10.49%
1999	1.63%	71.91%	8.31%	10.27%
2000	1.50%	62.63%	6.80%	9.89%
2001	1.66%	61.23%	11.53%	10.76%

Reasons for deviation of CO_2 emissions:

- In the sectoral approach some CO_2 emissions from combustion of fossil fuels are reported under categories *2 A 1(Energy Industries)* and *2 C 1 (Iron and Steel Production).*
- 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.
- *Solid Fuels:* The national approach doesn't separate between fuel related and non-fuel related CO2-emissions of iron and steel industry which are included in sector *2 C Metal Production*.
- *Gaseous Fuels:* In the reference approach the distribution losses and statistical differences are not considered.
- *Other Fuels:* In the sectoral approach emissions from fuel waste are reported as emissions from "other fuels". In the reference approach the emissions from fuel waste are not estimated.

Table 13 compares the energy consumption of the two approaches.

Table 13: 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	434 126	168 733	219 239	822 098	358 608	181 199	201 600	8 348	749 755
1991	467 938	178 010	231 794	877 742	388 559	191 496	212 477	9 149	801 681
1992	458 325	137 505	227 610	823 440	386 144	148 960	213 616	10 476	759 197
1993	464 937	121 901	240 044	826 882	414 042	134 341	223 567	8 210	780 161
1994	462 239	123 929	246 908	833 076	408 296	137 505	235 084	8 912	789 797
1995	462 252	142 538	269 583	874 374	408 612	159 078	254 421	9 010	831 121
1996	496 394	145 218	286 941	928 554	445 410	156 777	275 442	10 846	888 475
1997	499 917	153 817	276 551	930 285	433 758	167 759	265 653	11 388	878 558
1998	527 133	134 744	283 920	945 796	462 187	148 926	271 590	9 955	892 658
1999	500 717	132 893	288 876	922 486	436 626	144 662	275 740	11 905	868 932
2000	487 982	149 283	275 682	912 947	426 125	164 344	265 385	12 382	868 237
2001	529 121	156 063	293 982	979 166	460 566	166 148	273 202	14 025	913 942

Energy consumptions (except solid fuels) 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",

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

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

In the sectoral approach the solid fuel consumption is higher than in the reference approach because coke oven coke used for transformation into blast furnace gas and the produced blast furnace gas (which is 16 175 TJ in 1990) are both considered in the sectoral approach. To avoid double counting, blast furnace gas is subtracted from the total solid fuel consumption of the sectoral approach, which is then lower than in the reference approach

The remaining difference is caused by transformation losses of coking coal to coke oven coke and coke oven coke into blast furnace gas which are not considered in the sectoral approach.

3.3 Fugitive Emissions (CRF Source Category 1 B)

3.3.1 Source Category Description

In the year 2001 0.39% of national total emissions arose from IPCC Category *1 B Fugitive Emissions*. No key sources have been identified within this category.

3.3.1.1 Emission Trends

The following table presents GHG emissions arising from this category, their share and trend from 1990 to 2001.

Table 71: Greenhouse gas emissions from Category 1 B Fugitive Emissions

Sector/ Gas	GHG emissions [Gg CO_2 equivalent]												Share 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
TOTAL	**214.90**	**230.29**	**237.46**	**235.40**	**254.41**	**264.83**	**217.54**	**262.31**	**287.27**	**318.62**	**307.65**	**333.14**	***100.0%***	***+ 64.5%***
CO_2	119.97	129.99	138.65	131.67	147.73	149.09	94.51	143.14	165.07	194.27	187.48	206.89	*62.1%*	*+ 58.0%*
CH_4	94.93	100.30	98.81	103.73	106.67	115.74	123.03	119.17	122.21	124.34	120.16	126.25	*37.9%*	*+ 75.2%*

3.3.1.2 Completeness

Table 72 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 72: 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	NO	✓
1 B 1 b Solid Fuel Transformation		IE(1)	NO
1 B 2 a Oil			
i Exploration ii Production	0502 Extraction, 1st treatment and loading of liquid fossil fuels	IE(2)	IE(2)
iii Transport	050502 Transports and Depots	IE(3)	IE(3)
vi Refining/ Storage	0401 Processes in Petroleum Industries	NE	✓
v Distribution of oil products	0504 Liquid fuel distribution (Except Petrol distribution) 0505 Petrol distribution	IE(3)	IE(3)
1 B 2 b Natural Gas			

IPCC Category	SNAP	Status	
		CO_2	CH_4
Exploration	0503 Extraction, 1st treatment and loading of gaseous fossil fuels	✓	NE
i Production/Processing			
ii Transmission	050601 Pipelines	IE(3)	IE(3)
Distribution	050602 Distribution Networks	✓	✓
iii Other Leakage		NE	NE
1 B 2 c Venting/Flaring		IE(4)	IE(4)

(1) included in *2 C 1 Steel Production*
(2) included in *1 B 2 a Natural Gas Production*
(3) included in *1 B 2 a iii Natural Gas Distribution*
(4) included in *1 B 2 a iv Refining/ Storage*

3.3.2 Methodological issues

3.3.2.1 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 49% from 1990 to 2001 due to lower mining activities (see Figure 9 and Table 73).

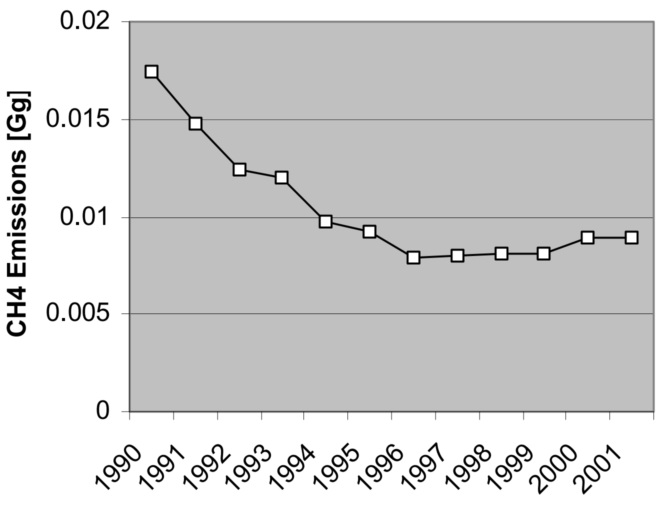


Figure 9: CH_4 emissions from Coal Mining 1990-2001

Emissions are calculated by multiplying the amount of brown coal produced (= activity data) with a country-specific emission factor. Activity data are taken from the national energy balance, for 2001 no up-to-date activity data was available, that's why the value of 2000 was also used for 2001.

The emission factor selected for methane of 7.11 g CH_4/t coal is taken from a national study [BMUJF, 1994]. The applied factor is very low compared to those of other countries because in Austria brown coal is only surface mined.

Table 73: Activity data (brown coal produced) and CH_4 emissions for Fugitive Emissions from Fuels-Coal Mining 1990-2001

Year	Coal Mined [Mg]	CH_4 emissions [Gg]
1990	2 447 710	0.0174
1991	2 080 726	0.0148
1992	1 746 756	0.0124
1993	1 691 675	0.0120
1994	1 369 217	0.0097
1995	1 297 919	0.0092
1996	1 108 558	0.0079
1997	1 130 839	0.0080
1998	1 140 651	0.0081
1999	1 137 888	0.0081
2000	1 254 605	0.0089
2001	1 254 605	0.0089

3.3.2.2 1 B 1 b Fugitive Emissions from Fuels – Solid Fuel Transformation

This category includes emissions from coke production. There is no other known occurrence of solid fuel transformation in Austria.

There is one steel plant that produces coke oven coke, that reports emissions from all its processes and combustion plants together. They are reported under category *2 C 1 Metal Production.*

3.3.2.3 1 B 2 a Fugitive Emissions from Fuels – Oil

In this category fugitive emissions from oil refining are addressed. Emissions from *1 B 2 C Venting/ Flaring* are also included in this category.

Emissions from *1 B 2 b i Oil Exploration* and *1 B 2 b i Oil Production* are included in Category *1 B 2 b i Natural Gas Production*. Emissions from *1 B 2 b iii Transport* and *1 B 2 b v Distribution of Oil Products* are included in Category *1 B 2 b Natural Gas Distribution*. CO_2 emissions from refining were not estimated.

CH_4 emissions from this category fluctuated somewhat over the period from 1990 to 2001, following the trend of crude oil refining in Austria (see Table 74). As can be seen in the following figure, the overall trend is increasing emissions: in 2001 emissions were 11% higher than in 1990.

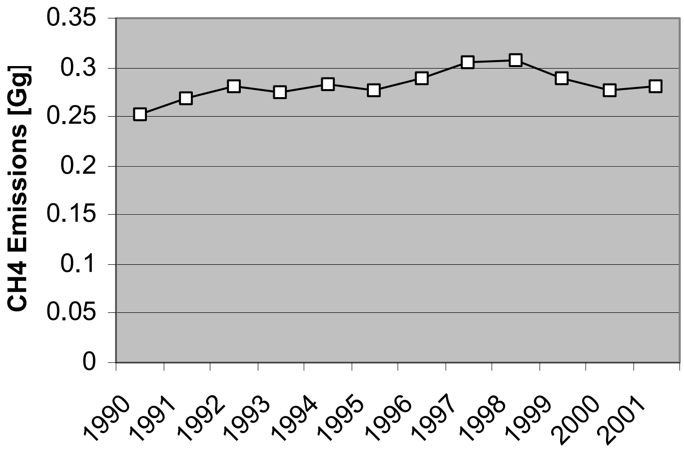


Figure 10: CH_4 emissions from Fugitive Emissions from Refineries 1990-2001

As Austria's only refinery does not report methane emissions, they 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 submitted by the *Association of the Austrian Petroleum Industry* (see Table 74).

The implied emission factor of 31 662.5 CH_4 kg/ 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).

Table 74: Activity data (Crude Oil Refined) and CH_4 emissions for Fugitive Emissions from Fuels- Oil Refining 1990-2001

Year	Crude Oil Refined [Mg]	CH_4 emissions [Gg]
1990	7 993 137	0.253
1991	8 463 000	0.268
1992	8 856 000	0.280
1993	8 659 000	0.274
1994	8 957 000	0.284
1995	8 721 000	0.276
1996	9 100 000	0.288
1997	9 656 000	0.306
1998	9 707 000	0.307
1999	9 123 000	0.289
2000	8 720 000	0.276
2001	8 855 000	0.280

3.3.2.4 1 B 2 b Fugitive Emissions from Fuels – Natural Gas

Category *1 B 2 b* includes emissions from natural gas production and distribution in Austria. Emissions from oil exploration and production (IPCC Category *1 B 2 a i and ii*) is included in *1 B 2 b i Natural Gas Exploration* and *Production*. Emissions from *1 B 2 a iii Transport* and *1 B 2 a v Distribution of Oil Products* is included in *1 B 2 a Distribution* (see Table 72).

Natural gas consumption increased by 35% from 1990 to 2001. As emissions from gas distribution were estimated using constant emission factors also emissions increased by the same value.

CO_2 emissions from natural gas production (see Table 75) are reported by the *Association of the Austrian Petroleum Industry* and also include emissions from category *1 B 2 a ii Oil Production*. CH_4 emissions from *Natural Gas and Oil Production* were not estimated.

Emissions from natural gas distribution are calculated by multiplying the gross inland consumption with a constant emission factor.

Activity data for natural gas distribution corresponds to the gross inland consumption of the energy balance. Activity data for natural gas production are reported by the *Association of the Austrian Petroleum Industry* (see Table 75).

Emission factors from natural gas distribution are calculated by means of net losses for the year 1990: 697.90 kg CH_4 / Mm^3 Gas distributed; 2 950 kg CO_2 / Mm^3 Gas distributed.

Table 75: Activity data and emissions for Fugitive Emissions from Fuels – Natural Gas 1990-2001

Year	Natural Gas Distribution			Natural Gas Production	
	Natural Gas Consumption [Mm^3]	CH_4 Emissions [Gg]	CO_2 Emissions [Gg]	Natural Gas Production [1000m^3]	CO_2 Emissions [Gg]
1990	6 090	4 250.02	17.97	390 625	102.00
1991	6 439	4 493.40	18.99	428 245	111.00
1992	6 323	4 412.29	18.65	484 030	120.00
1993	6 668	4 653.33	19.67	446 425	112.00
1994	6 859	4 786.39	20.23	514 881	127.50
1995	7 488	5 225.95	22.09	526 126	127.00
1996	7 971	5 562.44	23.51	269 191	71.00
1997	7 682	5 361.03	22.66	506 584	120.48
1998	7 887	5 503.87	23.27	564 871	141.80
1999	8 059	5 624.14	23.77	616 612	170.50
2000	7 791	5 437.11	22.98	580 561	164.50
2001	8 200	5 722.54	24.19	650 573	182.70

3.3.3 Recalculations

CO_2 emissions from Natural Gas Production/Processing for 2000 reported in this year's submission differs from the previously reported value. This is due a new emission value that has become available.

Also the CH_4 emission value from Coal Mining for the year 2000 has changed due to update of activity data.

The following table presents the differences with respect to last year's submission.

Table 76: Recalculations with respect to previous submission from Category 1 B Fugitive Emissions

	2000
CO_2 [Gg Difference]	+ 92.50
CH_4 [Gg Difference]	+ 0.00083

3.3.4 Planned Improvements

For next year's submission a complete revision of emission estimates of IPCC Category *1 B 2* is planned.

4 INDUSTRY (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 of activity data and emission factors reported under IPCC Category *2 Industrial Processes* for the period from 1990 to 2001 in the Common Reporting Format.

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

Except for *2 C 1 Iron and Steel Production* and *2 A 1 Cement Production*, where all emissions are reported in Sector *2 Industry*, 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).

Concerning some categories in this sector there are no emissions occurring as there is no such production in Austria. There are other categories where the emissions have not been estimated or emissions are included elsewhere. All these categories are all listed in Table 85.

4.1.1 Emission Trends

In the year 2001 17.9% of national total greenhouse gas emissions originated from industrial processes, compared to 19.9% 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 from 1990).

Greenhouse gas emissions from the industrial processes sector fluctuated during the period, they reached a minimum in 1993 and since then are increasing again. In 2001 they almost reached the level of the base year, only remaining 1.3% below (see Figure 11).

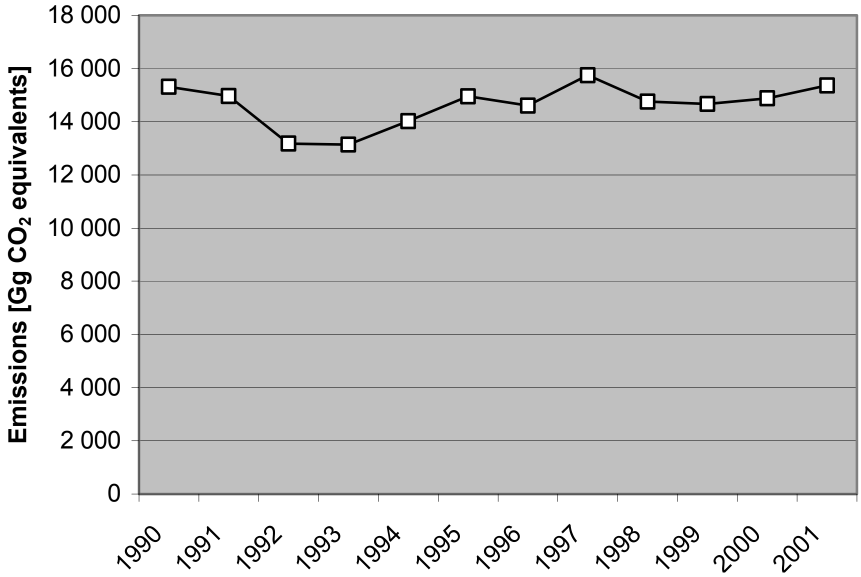


Figure 11: Emissions from IPCC Category 2 Industrial Processes 1990-2001

In 2001 greenhouse gas emissions from Category *2 Industrial Processes* amounted to 15 358 Gg CO_2 equivalent compared to 15 567 Gg in the base year.

Emission trends by gas

Table 77 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 2001.

Table 77: Greenhouse gas emissions from 2 Industrial Processes by gas in the base year and in 2001.

GHG	Base year*	2001	Base year*	2001
	CO_2 equivalent [Gg]		[%]	
Total	**15 567**	**15 358**	***100.00%***	***100.00%***
CO_2	12 921	12 834	*83.00%*	*83.56%*
CH_4	3	3	*0.02%*	*0.02%*
N_2O	907	786	*5.83%*	*5.12%*
HFCs	546	1 033	*3.51%*	*6.73%*
PFCs	16	25	*0.10%*	*0.16%*
SF_6	1 175	677	*7.55%*	*4.41%*

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

The major GHG of the industry sector was carbon dioxide with 83.6% of emissions from this category in 2001, followed by HFCs with 6.7%, N_2O with 5.1%, SF6 with 4.4%, PFCs with 0.2% and finally CH_4 with 0.02%. Emissions by gas and their trends are presented in Table 78.

Table 78: Emissions from IPCC Category 2 Industry by gas from 1990-2001 and their trend

Gas	GHG emissions [Gg]													Trend BY*-2001
	BY*	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Total	**15 567**	**15 315**	**14 965**	**13 181**	**13 143**	**14 024**	**14 953**	**14 610**	**15 749**	**14 762**	**14 664**	**14 877**	**15 358**	***–1.3%***
CO_2	12 921	12 921	12 377	11 298	11 459	12 094	12 358	11 848	13 000	12 071	12 114	12 188	12 834	*–0.7%*
CH_4	3	3	3	3	3	3	3	3	4	4	3	3	3	*–13.2%*
N_2O	907	907	922	570	798	823	855	872	861	895	921	952	786	*–13.3%*
HFCs	546	4	6	9	12	17	546	625	718	816	870	1 033	1 033	*+89.2%*
PFCs	16	963	974	576	48	54	16	15	18	21	25	25	25	*+61.0%*
SF_6	1 175	518	683	725	823	1 033	1 175	1 246	1 148	955	730	677	677	*–42.4%*

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

CO_2 emissions

As can be seen in Figure 12 CO_2 emissions from the industrial processes sector fluctuated during the period from 1990 to 2001 but stayed below the level of the base year over the whole period. In 2001 CO_2 emissions from Industrial Processes amounted to 12 834 Gg CO_2 equivalent, this was slightly lower than base year emissions (12 921 Gg).

CO_2 emissions from this sector mainly originate from *Metal Production (Iron and Steel Production)* and *Mineral Products (Cement Production)* and minor sources are *Chemical Industry (Ammonia Production)* and *Food and Drink Production*.

CH_4 emissions

As can be seen in Figure 12 CH_4 emissions from Industrial Processes increased from 1990 to 1998 by almost 40% and since then decreased remarkably due to lower emissions from urea production (*2 B 5 Other*). In 2001 CH_4 emissions from the industrial processes sector amounted to 2.54 Gg CO_2 equivalent, this was 13.8% below the level of the base year.

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

N_2O emissions

As can be seen in Figure 12 N_2O emissions from the industrial processes sector fluctuated during the period from 1990 to 2001, from 1992 to 2000 emissions increased steadily, from 2000 to 2001 emissions decreased. In 2001 N_2O emissions from Industrial Processes amounted to 786 Gg CO_2 equivalent. This was 13.3% below the level of the base year.

N_2O emissions from this sector arise from *Nitric Acid Production (Chemical Industry)*.

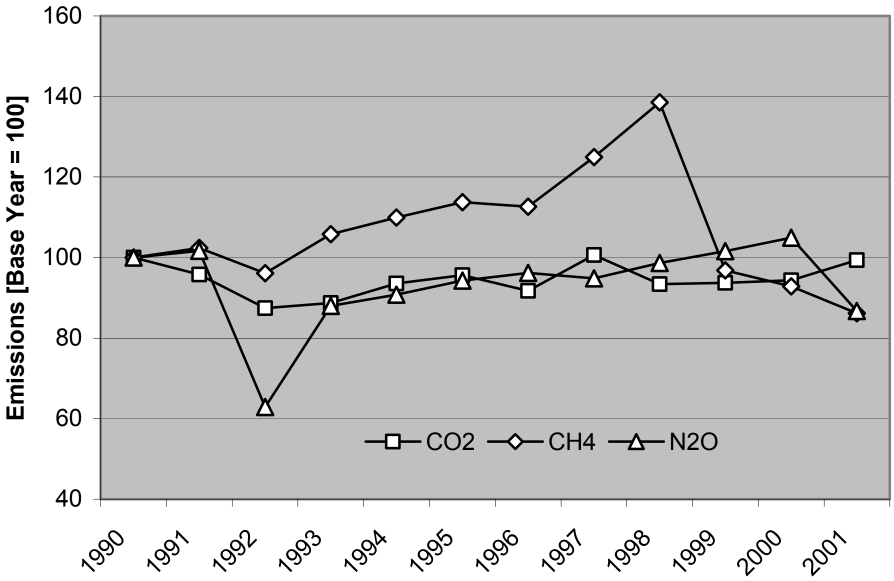


Figure 12: CO_2, CH_4 and N_2O emissions from Industrial Processes 1990-2001 in index form (base year = 100)

HFC emissions

As can be seen in Figure 13 HFC emissions increased remarkably during the period from 1990 to 2000. In 2000 HFC emissions amounted to 1 033 Gg CO_2 equivalent. This was 89.2% above the level of the base year (1995). For the year 2001 there was no update in activity data, therefore emissions are assumed to be constant on the level of 2000.

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

PFC emissions

As can be seen in Figure 13 PFC emissions increased remarkably during the period from 1990 to 2000. In 1990 PFC emissions amounted to 963 Gg CO_2 equivalent, they decreased until 1993 to around 50 Gg CO_2 equivalent due to termination of primary aluminium production in 1993 which was the major source for PFC emissions. Then PFC emissions decreased further and reached a minimum in 1996. In the year 2000 they amounted to 26 Gg CO_2 equivalent, this was 61.0% above the level of the base year (1995). For the year 2001 there was no update in activity data, therefore emissions are assumed to be constant on the level of 2000.

PFC emissions arise from semiconductor manufacture.

SF_6 emissions

As can be seen in Figure 13 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 2000 SF_6 emissions amounted to 677 Gg CO_2 equivalent. This was 42.4% below the level of the base year (1995). For the year 2001 there was no update in activity data, therefore emissions are assumed to be constant on the level of 2000.

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

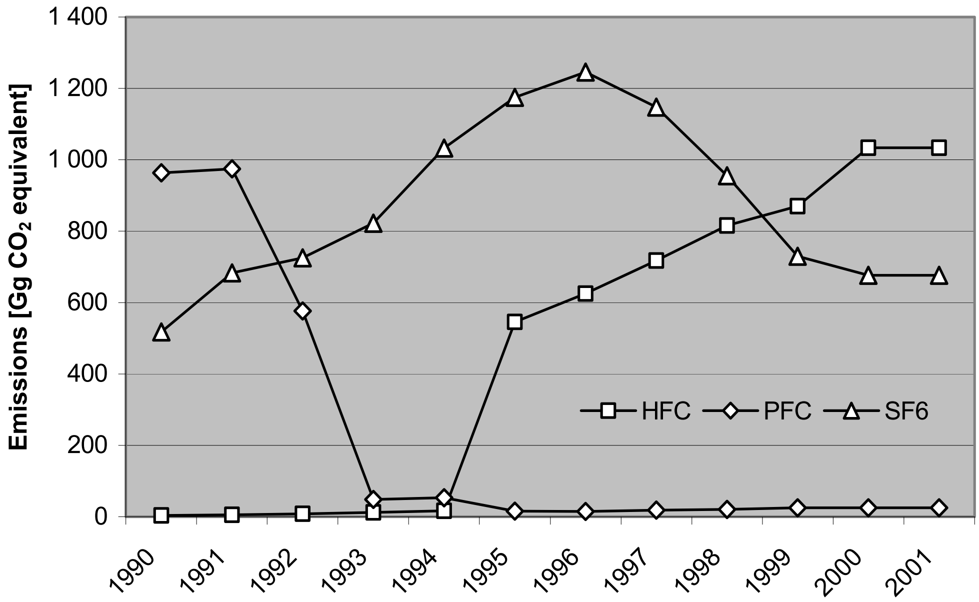


Figure 13: HFC, PFC and SF_6 emissions from Industrial Processes 1990-2001

Emission trends by sources

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Production* and *Mineral Products*, which caused 60.2% respectively 20.0% of the emissions from this sector in 2001 (see Table 79).

Emissions from processes in *Iron and Steel Production* are the most important single source of the industry sector. It also is one of the three most important sources of Austria's greenhouse gas inventory (see below and Chapter 1.5.1 Austria's Key Source Categories).

Table 79: Greenhouse gas emissions from IPCC Category 2 Industrial Processes by sector in the base year and in 2001.

GHG	Base year*	2001	Base year*	2001
	CO_2 equivalent [Gg]		[%]	
2 Industrial Processes	**15 567.10**	**15 358.43**	***100.00%***	***100.00%***
A Mineral Products	3 975.32	3 074.33	*25.54%*	*20.02%*
B Chemical Industry	1 333.04	1 250.61	*8.56%*	*8.14%*
C Metal Production	8 904.19	9 252.72	*57.20%*	*60.25%*
D Other Production (Food and Drink)	61.21	53.06	*0.39%*	*0.35%*
F Consumption of Halocarbons and SF_6	1 293.33	1 727.71	*8.31%*	*11.25%*

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

Table 80 presents greenhouse gas emissions from IPCC Category 2 Industrial Processes by sub category for the years 1990 to 2001.

The strongest declining trend had sub category *2 A Mineral Products*, emissions from this sub category decreased by 22.7% from 1990 to 2001. Also emissions from *Other Production (Food and Drink)* and *Chemical Industry* decreased, the overall trend from 1990 to 2001 was minus 13.3% and minus 6.2% respectively. In contrast to this, emissions from the most important sub category *Metal Production* increased by 3.9% and emissions from *Consumption of Halocarbons and SF_6* increased by 33.6%, almost compensating the decrease in greenhouse gas emissions from the other sources of that sector and resulting in a total trend of minus 1.3% for the sector *Industry*.

Table 80: Total greenhouse gas emissions and trend from 1990–2001 by subcategories of Category 2 Industry

	GHG emissions [Gg CO_2 equivalent]													Trend BY*-2001
	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
2	15 567	15 315	14 965	13 181	13 143	14 024	14 953	14 610	15 749	14 762	14 664	14 877	15 358	***-1.3%***
2 A	3 975	3 975	3 839	3 900	3 730	3 865	3 233	3 230	3 371	3 110	3 109	3 061	3 074	*-22.7%*
2 B	1 333	1 333	1 358	967	1 229	1 232	1 346	1 359	1 338	1 419	1 416	1 438	1 251	*-6.2%*
2 C	8 904	9 651	9 259	7 737	7 532	8 144	9 029	8 695	9 457	8 549	8 478	8 598	9 253	*+3.9%*
2 D	61	61	65	55	48	53	52	51	48	57	58	53	53	*-13.3%*
2 F	1 293	294	445	521	606	730	1 293	1 275	1 535	1 627	1 603	1 728	1 728	*+33.6%*

*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 22.7% from 1990 to 2001. This was mainly due to decreasing CO_2 emissions from cement production due to a decrease in cement production.

2 B Chemical Industry

For the source *Chemical Industry* greenhouse gas emissions decreased by 6.2% from 1990 to 2001. This was mainly due to decreasing N_2O emissions from nitric acid production because of the introduction of a new catalyst to reduce N_2O emissions.

2 C Metal Production

Greenhouse gas emissions from *Metal Production* increased by 3.9% compared to base year emissions. This was mainly due to an 9.3% increase in emissions from *Iron and Steel Production* from 1990 to 2001. A strong decrease in emissions from *SF_6 Used in Aluminium and Magnesium Foundries* from 443 Gg CO_2 equivalent in 1995 (base year for SF_6) to 8 Gg in 2001 could compensate to same content the increase of emissions from *Iron and Steel Production*.

2 D Other Production

Emissions from *Food and Drink* were considered in this sub category. Greenhouse gas emissions from this source decreased by 13.3% from 1990 to 2001 due to decreased production.

2 F Consumption of Halocarbons and SF_6

For the source *Consumption of Halocarbons and SF_6* greenhouse gas emissions increased by 33.6% compared to base year emissions (1995 for PFCs, HFCs and SF_6). In 2000 emissions were almost six 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*). For 2001 there was no update in activity data.

4.1.2 Key Sources

The key source analysis is presented in Chapter 1.5. This chapter includes information about the key sources in the IPCC Sector *2 Industrial Processes*. The key sources of the IPCC Category *2 Industry* are presented Table 81.

Due to a revision of the time series for N_2O emissions from *Nitric Acid Production* (see corresponding subchapter) this source has become a key source in this year's key source analysis.

Emission sources of fluorinated gases have been disaggregated differently than in last year's key source analysis, now following the suggestions in the IPCC GPG, therefore "additional" key sources were identified (there were only nine key sources from IPCC Category 2 last year and 11 this year).

Table 81: Key sources of Category 2 Industry

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
2 A 1	Cement Production	CO2	All except TA93
2 A 2	Lime Production	CO2	LA90-95; TA91
2 A 7 b	Magnesia Sinter Plants	CO2	All except LA00 and LA01

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
2 B 1	Ammonia Production	CO2	LA90-01
2 B 2	Nitric Acid Production	N2O	LA90-01, TA92-TA97, TA01
2 C 1	Iron and Steel Production	CO2	All except TA97 and TA01
2 C 4	SF6 used in Aluminium and Magnesium Foundries	SF6	LA94-97, TA91, TA92, TA96-01
2 C 3	Aluminium production	PFCs	LA90-92, TA91, TA92
2 F 6	Semiconductor Manufacture	HFCs, PFCs, SF6	LA93 - LA01, TA91, TA92, TA96, TA01
2 F 1/2/3	ODS Substitutes	PFCs	LA95-01, TA94, TA97-01
2 F 8	Other Sources of SF6	SF6	TA91

LA90 = Level Assessment 1990
LA00 = Level Assessment 2000
TA91 = Trend Assessment BY-1991
TA00 = Trend Assessment BY-2000

In 2001 17.6% of total greenhouse gas emissions in Austria originated from the 11 key sources of the industrial processes sector. The most important key source is *Iron and Steel Production* which had a share of 10.8% in total emissions in 2001. The second important is *Cement Production*: 2.7% of total emissions 2001 originated from this category. Another 1.20% 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 2001 (see Table 82).

Table 82: Level Assessment for the base year and 2001 for the key sources of Category 2 Industry

IPCC Category	Source Categories	GHG	Level Assessment	
			BY	2001
2 A 1	Cement Production	CO2	3.94%	2.73%
2 A 2	Lime Production	CO2	0.41%	0.34%*
2 A 7 b	Magnesia Sinter Plants	CO2	0.62%	0.39%*
2 B 1	Ammonia Production	CO2	0.51%	0.51%
2 B 2	Nitric Acid Production	N2O	1.16%	0.92%
2 C 1	Iron and Steel Production	CO2	10.80%	10.76%
2 C 4	SF_6 used in Aluminium and Magnesium Foundries	SF6	0.57%	0.01%*
2 C 3	Aluminium production	PFCs	0.00%*	0.00%*
2 F 6	Semiconductor Manufacture	HFCs, PFCs, SF6	0.56%	1.20%
2 F 1/2/3	ODS Substitutes	PFCs	0.70%	0.41%
2 F 8	Other Sources of SF_6	SF6	0.31%*	0.29%*

*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 for industry reporting are described in more detail.

4.1.4 Uncertainty Assessment

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.

No information is available concerning uncertainty assessment of sub sector data for this submission. For further information concerning uncertainty assessment see Chapter 1.7.

4.1.5 Quality Assurance and Quality Control (QA/ QC)

For the Austrian Inventory there is an internal quality management system, 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 83. This legislation also addresses verification. Some plants that are reporting emission data have quality management systems according to the ISO 9000–series or to similar systems.

Table 83: Austrian legislation with specific regulations concerning measurement and documentation of emission data

IPCC Source Category	Austrian legislation
2 A 1	BGBI 1993/ 63 Verordnung für Anlagen zur Zementerzeugung
2 A 7	BGBI 1994/ 498 Verordnung für Anlagen zur Glaserzeugung
2 C 1	BGBI 1994/ 447 Verordnung für Gießereien
2 C 1	BGBI II 1997/ 160 Verordnung für Anlagen zur Erzeugung von Eisen und Stahl
2 C 1	BGBI II 1997/ 163 Verordnung für Anlagen zum Sintern von Eisenerzen
2 A / 2 B /2 C / 2 D	BGBI II 1997/ 331 Feuerungsanlagen-Verordnung
2 C 2 / 2 C 3 / 2 C 5	BGBI II 1998/ 1 Verordnung zur Erzeugung von Nichteisenmetallen
2 A / 2 B /2 C / 2 D	BGBI 1988/ 380 Luftreinhaltegesetz für Kesselanlagen
2 A / 2 B /2 C / 2 D	BGBI 1989/ 19 Luftreinhalteverordnung für Kesselanlagen

Extracts of the applicable paragraphs are provided in Annex 6.

4.1.6 Recalculations

Due to update of activity data and the revision of the time series for N_2O emissions from nitric acid production the emission data of this year's submission differs from last year's. The recalculation difference is presented in the following table. For detailed information on recalculation see the corresponding subchapters.

Table 84: Recalculation difference with respect to previous submission for Category 2 Industry 1990-2000

	2. Industrial Processes	**2. Industrial Processes**	A. Mineral Products	B. Chemical Industry	D. Other Production	**2. Industrial Processes**	A. Mineral Products	B. Chemical Industry	C. Metal Production	**2. Industrial Processes** (2 B 2 Nitric Acid Production)
Year	Total Diff. [Gg CO_2 equi]	CO_2 [Gg Diff.]				CH_4 [Mg Diff.]				N_2O [Gg Diff.]
1990	**723.35**	**1.96**	0.00	0.00	1.96	**-0.30**	0.00	0.00	-0.30	**2.33**
1991	**740.83**	**6.01**	0.00	0.00	6.01	**-0.70**	0.00	0.00	-0.70	**2.37**
1992	**401.24**	**1.05**	0.00	0.00	1.05	**-0.35**	0.00	0.00	-0.35	**1.29**
1993	**619.59**	**1.05**	0.00	0.00	1.05	**-0.10**	0.00	0.00	-0.10	**2.00**
1994	**648.63**	**1.12**	0.00	0.00	1.12	**0.00**	0.00	0.00	0.00	**2.09**
1995	**686.80**	**1.05**	0.00	0.00	1.05	**0.11**	0.00	0.00	0.11	**2.21**
1996	**699.73**	**1.05**	0.00	0.00	1.05	**-0.17**	0.00	0.00	-0.17	**2.25**
1997	**690.25**	**1.15**	0.00	0.00	1.15	**-1.46**	-1.63	0.00	0.17	**2.22**
1998	**726.56**	**8.90**	0.00	0.00	8.90	**-5.06**	-5.42	0.00	0.36	**2.32**
1999	**751.49**	**9.92**	0.00	0.00	9.92	**-5.72**	-6.00	0.00	0.27	**2.39**
2000	**772.85**	**1.02**	4.03	-8.28	5.26	**-11.32**	-6.77	-5.10	0.55	**2.49**

4.1.7 Completeness

Table 85 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 85: Overview of subcategories of Category Industry: 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	NE		

	IPCC Category		SNAP	Status		
				CO_2	CH_4	N_2O
2 A 4	Soda Ash Production and Use	040619	Soda Ash Production and Use	NE		
2 A 5	Asphalt Roofing	040610	Roof covering with asphalt materials	NE	✓	
2 A 6	Road Paving with Asphalt	040611	Road paving with asphalt	NE(1)		
2 A 7	*Other*					
2 A 7 a		040613	Glass (decarbonising)	✓		
2 A 7 b		040617	Other (including asbestos products manufacturing) 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	NE	
2 B 5	Other	040407 040408	NPK fertilisers Urea	✓	✓	
2 C	**METAL PRODUCTION**					
2 C 1	Iron and Steel Production(3)	040201 040202 040206 040203 040209	Coke oven Blast furnace charging Basic oxygen furnace steel plant Pig iron tapping Sinter and palletising plants	✓	IE(4)	
2 C 2	Ferroalloys Production	040302	Ferro alloys	NE	NE	
2 C 3	Aluminium Production	040301	Aluminium production (electrolysis) – except SF_6	✓ / NO(5)	✓ / NO(5)	
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*	040207 040208 040309	Electric furnace steel plant Rolling mills Processes in non-ferrous metal industries		✓ ✓ ✓	
2 D	**OTHER PRODUCTION**					
2 D 1	Pulp and Paper	040601 040602 040603 040604	Chipboard Paper pulp (Kraft process) Paper pulp (Acid Sulphite process) Paper pulp (Neutral Sulphite Semi-Chemical process)			
2 D 2	Food and Drink	040605 040606 040607 040608	Bread Wine Beer Spirits	✓		
				HFCs, PFCs, SF_6		

	IPCC Category	SNAP		Status		
				CO_2	CH_4	N_2O
2 E	**PRODUCTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE**	0408	Production of halocarbons and sulphur hexaflouride	NO[6]		
2 F	**CONSUMPTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE** [7]					
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*					
2 F 8 a	Research and other use			✓		
2 F 8 b	Stock or not identifiable			NE		
2 F 8 c	Heat pumps			✓		

[1] Direct greenhouse gas emissions from this IPCC-category are not estimated. Only NMVOC emissions from this category have been estimated (for further information see Austria's Informative Inventory Report 2003, Submission under the UNECE/CLRTAP Convention)
[2] There is no adipic acid production in Austria.
[3] All emissions of the iron and steel industry are included (process emissions and emissions due to combustion).
[4] included in *2 C 5 Other - Rolling Mills*
[5] Primary aluminium production was terminated in 1992.
[6] There is no production of halocarbons or SF_6 in Austria.
[7] No corresponding SNAP category is presented here as the actual estimation is based on IPCC Categories.

4.1.8 Planned Improvements

It is planned to estimate emissions from *2 B 4 Carbide Production, 2 A 3 Limestone and Dolomite Use* and *2 A 4 Use Soda Ash Production and Use* for the submission 2004.

For emissions of fluorinated gases a study to update emissions is planned for 2004/2005.

4.2 Mineral Products (CRF Source Category 2 A)

4.2.1 Cement Production (2 A 1)

4.2.1.1 Source Category Description

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 years except 1993. In 2001 CO_2 emissions from cement production contributed 2.73% to total greenhouse gas emissions in Austria (see Table 82).

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 86 presents CO_2 emissions in total and split into combustion and process-related emissions from the production of cement for the period from 1990 to 2001.

This year, emissions from cement production have been split into the two different types of emissions for the first time. Only process emissions should be considered in this category, emissions due to combustion should be reported in IPCC Category 1 Energy. However, in the CRF they are reported all together under category *2 A 1 Cement Production* because it is not possible to spit CO_2 emissions from combustion according to individual fuels[13] (including waste) as there are no fuel-specific or fuel-substitute specific emissions factors for the cement industry available. Therefore the IPPC-category *2 A 1* in the Austrian inventory contains total CO_2 emissions from cement production.

Table 86: CO_2 emissions from cement production in total and split into combustion- and process related emissions 1990–2001

Year	Total CO_2 emissions from Cement Production [Gg]	Process specific CO_2 emissions [Gg]	CO_2 emission due to combustion [Gg]
1990	3 088.07	2 067.58	1 020.49
1991	3 042.76	2 007.49	1 035.26
1992	3 212.18	2 221.22	990.96
1993	3 070.16	2 026.41	1 043.75
1994	3 191.15	2 102.26	1 088.89
1995	2 498.40	1 631.33	867.07
1996	2 495.54	1 634.25	861.30
1997	2 642.55	1 760.92	881.63
1998	2 382.01	1 579.62	802.39
1999	2 380.60	1 587.56	793.04
2000	2 346.95	1 553.91	793.04
2001	2 346.95	1 553.91	793.04

[13] Fuels used are: about 40% coal and coke, 40% oil, 5% gas and 15% waste (used tyres, waste oil, waste solvents, waste fiber and also waste plastics)

CO_2 emissions (see Table 86) have been quite constant from 1990 to 1994, then dropped by 21.7% compared to the previous year. As can be seen in Figure 14 this was 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 2001 was minus 24%.

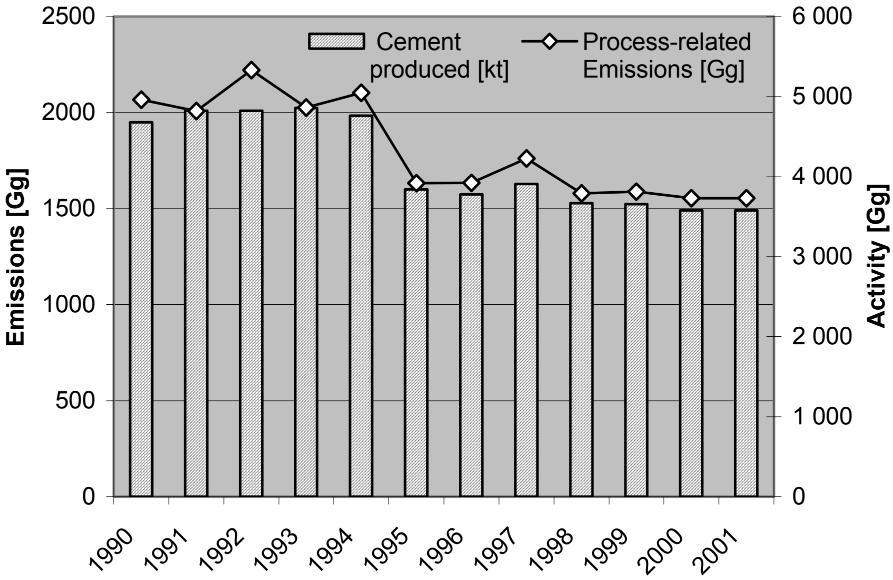


Figure 14: Cement produced and process-related emissions from Cement Production 1990-2001

4.2.1.2 Methodological Issues

Information about CO_2 emissions from cement production was taken from three studies of emissions from the Austrian cement production industry [HACKL, MAUSCHITZ, 1995, 1997 and 2001]. The studies cover the years 1988 to 1999. For the years 2000 and 2001 the emission factor of 1999 was used, activity data for 2000 was available but for 2001 the value of 2000 was also used due to lack of more up to date activity data.

The data presented in this study include emission data for emissions from combustion processes and from calcination processes (process specific emissions) separately.

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.

Emission factors

Emission factors for total CO_2 emissions (from combustion and calcination) for each plant were calculated from emission and activity data provided by the study mentioned above. Table 87 presents the calculated mean values of the plant specific emission factors for each year of the period from 1990 to 1999.

Table 87: Calculated mean values of plant specific emission factors 1990–2001

Year	IEF CO_2 from combustion		IEF process–specific CO_2	
	[g/t_{Ce}]	[g/t_{Cl}]	[g/t_{Ce}]	[g/t_{Cl}]
1990	229 171	290 340	441 847	559 783
1991	215 510	285 817	416 365	552 198
1992	242 272	305 808	460 613	581 410
1993	213 154	281 518	417 128	550 911
1994	228 632	287 221	441 404	554 519
1995	225 835	295 933	424 889	556 772
1996	227 912	295 374	432 447	560 450
1997	225 534	284 094	450 468	567 432
1998	218 749	283 303	430 640	557 723
1999	216 790	277 925	433 984	556 367
2000	221 484	277 925	433 984	556 367
2001	221 484	277 925	433 984	556 367

CO_2 emissions from the raw meal calcination were calculated as follows:

$$M_{(CO2\ calc)} = \sum_k (m_{(raw\ meal)})_k \bullet x_{(CaCO3)k} \bullet (44{,}0088/100{,}0892)$$

Whereas:

- m mass stream [kg/a]
- x mass portion
- k for the k^{th} cement plant

No cement kiln dust (CKD) correction factor was considered because cement kiln dust is returned back into the raw material.

Emission factors related to ton clinker and ton cement were calculated as follows:

$$EF_{(clinker)} = \sum_k m_{i,k} / \sum_k m_{(clinker)k} \quad \text{with } m_{i,k} = c_{i,k} \bullet V_{(waste\ gas)k}$$

$$EF_{(cement)} = \sum_k m_{i,k} / \sum_k m_{(cement)k} \quad \text{with } m_{i,k} = c_{i,k} \bullet V_{(waste\ gas)k}$$

Whereas:

- c medium concentration of pollutant in the waste gas (mean value from single measurements) [kg/m³]
- V plant specific, dry waste gas volume flow [m^3/a]
- i for the i^{th} pollutant

Combustion related emissions were calculated by subtracting process specific emissions (calculated as explained above) from total CO_2 emissions, that were obtained from plant specific CO_2 concentrations in the waste gas and waste gas flows.

Table 88 presents the calculated emission factors for total CO_2 emissions from cement production as reported in the studies [HACKL, MAUSCHITZ, 1995, 1997 and 2001]. These emission factors were used for the CRF for the period from 1990 to 2000. For the years 2000 and 2001 it was assumed that the emission factor from 1999 has not changed.

Table 88: Calculated emission factors for the period 1990–2000

Year	IEF for overall CO_2 emissions from cement production [t/t_{Ce}]
1990	0.67
1991	0.63
1992	0.70
1993	0.63
1994	0.67
1995	0.65
1996	0.66
1997	0.68
1998	0.65
1999	0.65
2000	0.65
2001	0.65

Activity data

Activity data for clinker and cement for the period from 1990 to 1999 were taken from the studies [HACKL, MAUSCHITZ, 1995, 1997 and 2001]. These activity data represent production data directly from individual plants (Good Practice recommended by IPPC, Tier 2 Method). For 2000 the activity data for cement was obtained from the *Association of the Cement Industry*, for 2001 the value of 2000 was used and for clinker production the value of 1999 was used for the years onwards due to lack of more up to date activity data.

Table 89 presents the activity data for clinker and cement production for the period from 1990 to 2001.

Table 89: Activity data - Clinker and cement production 1990–2001

Year	Clinker [t/a]	Cement [t/a]
1990	3 693 539	4 679 409
1991	3 635 462	4 821 480
1992	3 820 397	4 822 304
1993	3 678 293	4 858 012
1994	3 791 131	4 762 651
1995	2 929 973	3 839 415
1996	2 915 956	3 779 074
1997	3 103 312	3 909 083
1998	2 832 262	3 668 076
1999	2 853 437	3 658 102
2000	2 853 437	3 580 570
2001	2 853 437	3 580 570

4.2.1.3 Planned Improvements

Activity data for 2000 and 2001 will be updated as soon as new data becomes available.

4.2.1.4 Recalculation

Due to a transcript error the value reported last year for CO_2 emissions from cement production 2000 was incorrect. In this year's submission the value has been corrected. The recalculation difference resulting from this correction is presented below.

Table 90: Recalculation Difference with respect to previous submission for 2 A 1 Cement Production

Year	CO_2 Emissions -Recalculation Difference [Gg]
2000	+4.03

4.2.2 Lime Production (2 A 2)

4.2.2.1 Source Category Description

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 of the years 1990 to 1995 and to the trend of emissions of the total greenhouse gas inventory 1991. In the year 2001 emissions from this category contributed 0.34% to the total amount of greenhouse gas emissions in Austria (see Table 82).

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

Only CO_2 emissions generated during the calcination step of lime manufacturing (no CO_2 emissions from combustion) were considered under Category *2 A 2*.

Table 91 presents activity data for this category (lime produced) as well as CO_2 emissions from lime production for the period from 1990 to 2001.

Table 91: Activity data and CO_2 emissions for Lime production 1990–2001

Year	Lime Produced [t/a]	CO_2 emissions [Gg]
1990	420 062	317.52
1991	388 929	299.40
1992	350 649	286.53
1993	372 095	291.11
1994	357 495	287.50
1995	377 733	303.77
1996	377 733*	303.77
1997	269 160	303.77
1998	288 200	303.77

Year	Lime Produced [t/a]	CO_2 emissions [Gg]
1999	284 725	295.55
2000	340 152	295.55
2001	340 152*	295.55

*NOTE: The activity value of 1995 was also used for 1996 and the value of 2000 was used for the year 2001 due to lack of activity data for these years.

As can be seen in Figure 15, the overall trend for CO_2 emissions from this category was decreasing emissions, in the year 2001 emissions were 19% less than in 1990. As emissions were calculated using a constant emission factor, emissions follow the production of lime (see Table 91).

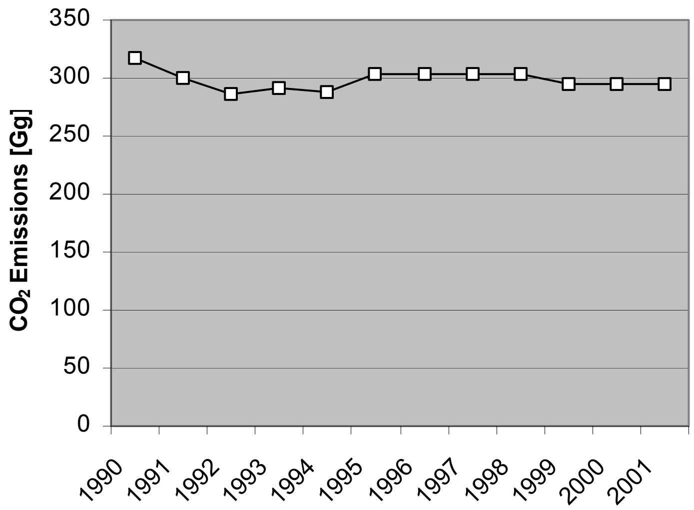


Figure 15: Emissions from Lime Production 1990-2001

4.2.2.2 Methodological Issues

The estimation of CO_2 emissions from lime production was carried out in accordance with the IPCC Good Practice:

$$\text{Emissions [t]} = \text{Emission factor [kg } CO_2/\ t_{time}] \times \text{Lime production [t]}$$

Emission factor

The used emission factors were in accordance with IPCC Good Practice:

EF (high calcium quicklime) = 785 kg CO_2 / t
EF (dolomite quicklime) = 913 kg CO_2 / t

IPCC default value for production rate of high calcium/ dolomite lime: 85/ 14.
These assumptions lead to an implied emission factor of 804.20 kg CO_2 / t lime produced. Due to an artefact the reported emission factors differ from that value for some years, this will be corrected for next year's submission.

Activity data

Data on lime production was taken from national statistics (STATISTIK AUSTRIA). For the years 1996 and 2001 no statistical data was available, that's why the value of the year before was used for these years.

In these statistics the total amount of lime is broken down into different types of lime. According to information from the *Association of the Stone & Ceramic Industry* not all lime that is worked up in Austria is also calcinated in Austria, some is imported calcined and then only grinded and sold. Therefore only the amount of "non-slaked high-calcium and dolomite lime" as reported in the statistical data were considered for the calculation. "Slaked high calcium and dolomite lime" and "hydraulic lime" were not considered.

Activity data for lime production for the period from 1990 to 2001 is presented in Table 91.

4.2.2.3 Planned Improvements

It is planned to obtain more detailed data on the amount of lime actually calcined in Austria per type of lime (high-calcium / dolomite lime and hydraulic lime) from the *Association of the Stone & Ceramic Industry*.

4.2.3 Asphalt Roofing (2 A 5)

4.2.3.1 Source Category Description

Key Source: No

In this category CH_4 emissions from the production and laying of asphalt roofing are considered. CO_2 emissions can be disregarded.

Figure 16 presents CH_4 emissions from asphalt roofing for the period from 1990 to 2001.

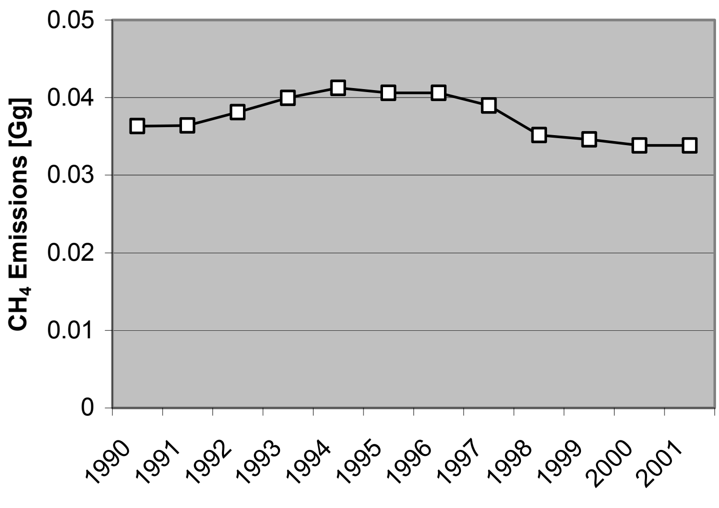


Figure 16: CH_4 emissions from Asphalt Roofing 1990-2001

As can be seen in the figure, CH_4 emissions reached a maximum in 1994. In the 2001 emissions from this category were 7% below the level of the base year. As a constant emission factor was used for estimating these emissions, the emissions followed the changes in production of roofing paper.

4.2.3.2 Methodological Issues

Estimation of CH_4 emissions from asphalt roofing was carried out applying an emission factor in g of m² produced asphalt roofing (CORINAIR simpler methodology).

$$\text{Emission [Mg]} = (\text{Emission factor } [g_{CH4}/m^2_{\text{asphalt roofing}}] \times \text{Activity } [m^2])/1000000$$

Emission factor

An emission factor of 1.3 g CH_4 /m² of produced asphalt roofing was applied [BUWAL, 1995]. The consumption of bitumen was assumed to be 1.2 kg/m² of asphalt roofing.

Activity data

Activity data were taken from national statistics (STATISTIK AUSTRIA). For 1996 and 2001 no activity value was available from these statistics, that's why the value of the year before was used for these years.

Table 92 presents activity data for asphalt roofing as well as emissions from this category for the period from 1990 to 2001.

Table 92: Activity data (Roofing Paper produced) and CH_4 emissions for Asphalt Roofing 1990-2001

Year	Roofing Paper [m²]	CH_4 emissions [Gg]
1990	27 945 000	0.03633
1991	28 007 000	0.03641
1992	29 311 000	0.03810
1993	30 731 000	0.03995
1994	31 745 000	0.04127
1995	31 229 000	0.04060
1996	31 229 000	0.04060
1997	29 976 436	0.03897
1998	27 060 715	0.03518
1999	26 616 092	0.03460
2000	26 020 734	0.03383
2001	26 020 734	0.03383

4.2.3.3 Recalculation

Activity data from the years 1997 to 2000 were updated using statistical data because in the last submission the value of 1995 was used for these years. Table 93 presents the recalculation difference resulting from this update of activity data.

Table 93: Recalculation Difference with respect to last year's submission for CH_4 emissions from Asphalt Roofing

Year	Difference [Gg]
1990	0.0
1991	0.0
1992	0.0
1993	0.0
1994	0.0
1995	0.0
1996	0.0
1997	- 0.00163
1998	- 0.00542
1999	- 0.00600
2000	- 0.00677

4.2.4 Mineral Products – Other (2 A 7)

4.2.4.1 Source Category Description

In this category glass and magnesia sinter production are addressed.

4.2.4.2 Glass Production

Emission: CO_2

Key Source: No

This category includes CO_2 emissions from the production of glass (decarbonising step). During production of glass, CO_2 is generated through decomposition of carbonates.

Figure 17 and Table 94 present CO_2 emissions from glass production for the period from 1990 to 2001.

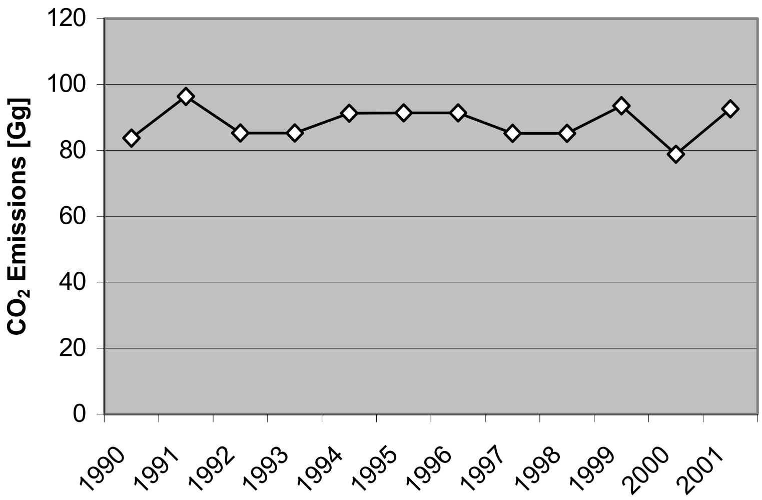


Figure 17: CO_2 emissions from Glass Production 1990-2001

As can be seen in the figure, CO_2 emissions from glass production varied during the period, no clear trend can be observed. However, in 2001 emissions from this category were 11% above the level of 1990.

Methodological Issues

Estimation of CO_2 emissions was accomplished by applying an emission factor:

$$\text{Emission [Gg]} = (\text{Emission factor } [kg_{CO2}/Mg_{activity}] \times \text{Activity [Mg]})/1\,000\,000$$

Emission factor

For glass production an emission factor of 210 kg CO_2 per Mg glass was applied. This value is based on information of one glass production company and was applied on total production figures in Austria.

Activity data

Activity data for the production of glass for 1990 were derived from national statistics (STATISTIK AUSTRIA), for the other years they were reported from the *Association of the Glass Industry* directly to the UBAVIE.

Table 94 presents activity data for production of glass and CO_2 emissions for this category for the period from 1990 to 2001.

Table 94: Activity data (Glass produced) and CO_2 emissions for Glass Production 1990-2001

Year	Glass [t/a]	CO_2 emissions [Gg]
1990	398 515	83.69
1991	458 666	96.32
1992	405 863	85.23
1993	406 222	85.31
1994	434 873	91.32

Year	Glass [t/a]	CO_2 emissions [Gg]
1995	435 094	91.37
1996	435 094	91.37
1997	405 760	85.21
1998	405 760	85.21
1999	445 069	93.46
2000	375 348	78.82
2001	440 865	92.58

4.2.4.3 Magnesia Sinter Production

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 in the years 1990 to 1999 and to the trend from the base year to the years 1991 to 2001. In 2001 it contributed 0.39% to the total amount of greenhouse gas emissions in Austria (see Table 82).

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.

Figure 18 and Table 95 present CO_2 emissions from production of magnesia sinter for the period from 1990 to 2000.

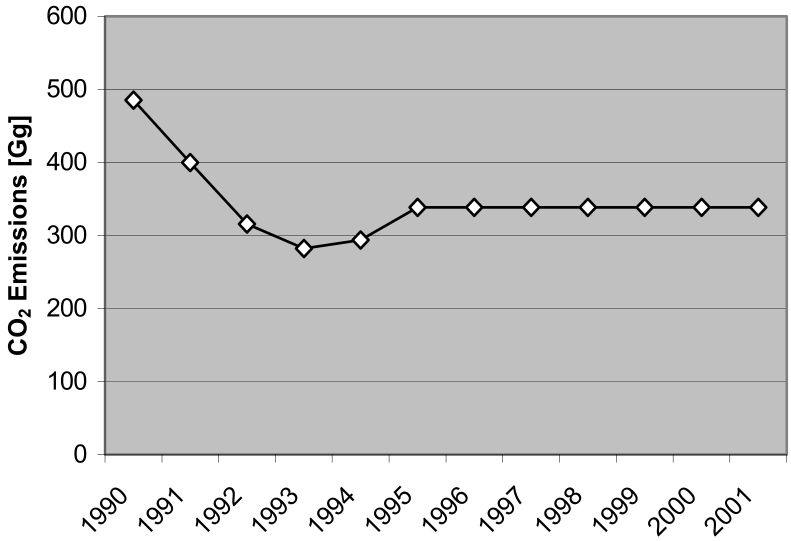


Figure 18: CO_2 emissions from Magnesia Sinter Production 1990-2001

As can be seen in the figure, CO_2 emissions from magnesia sinter plants reached a minimum in 1993. In 1995 emissions were 30% less than in 1990. No information on the overall trend from 1990 to 2001 can be given as for the years 1996 onwards the value of 1995 was used.

Methodological Issues

Estimation of CO_2 emissions was accomplished by applying an emission factor:

$$\text{Emission [Gg]} = (\text{Emission factor } [kg_{CO2}/Mg_{activity}] \times \text{Activity [Mg]})/1000000$$

Emission factor

The emission factor of 1 100 kg CO_2 emission per Mg magnesia sinter that was applied was verified by a company that produces magnesia sinter in Austria.

Activity data

Activity data for the production of magnesia sinter for the years 1990 to 1995 were taken from national statistics (STATISTIK AUSTRIA). For the other years the value from 1995 was used after contact with the producer as due to a change in methodology in the national statistics these value was not available for the years after 1995.

Table 95 presents activity data for production of magnesia sinter and CO_2 emissions from this category for the period from 1990 to 2001.

Table 95: Activity data (magnesia sintered) and CO_2 emissions from Magnesia Sinter Production 1990-2001

Year	Magnesia Sintered [t]	CO2 Emissions [Gg]
1990	441 167	485.28
1991	363 201	399.52
1992	286 945	315.64
1993	256 616	282.28
1994	267 169	293.89
1995	307 768	338.54
1996	307 768	338.54
1997	307 768	338.54
1998	307 768	338.54
1999	307 768	338.54
2000	307 768	338.54
2001	307 768	338.54

Planned Improvements

Update of activity data.

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 were 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 2001. It is not rated as key source with respect to its contribution to the total inventories trend. In 2001 it contributed 0.51% to the total amount of greenhouse gas emissions in Austria (see Table 82).

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.

Figure 19 and Table 96 present CO_2 and CH_4 emissions from ammonia production as well as production of ammonia for the period from 1990 to 2001.

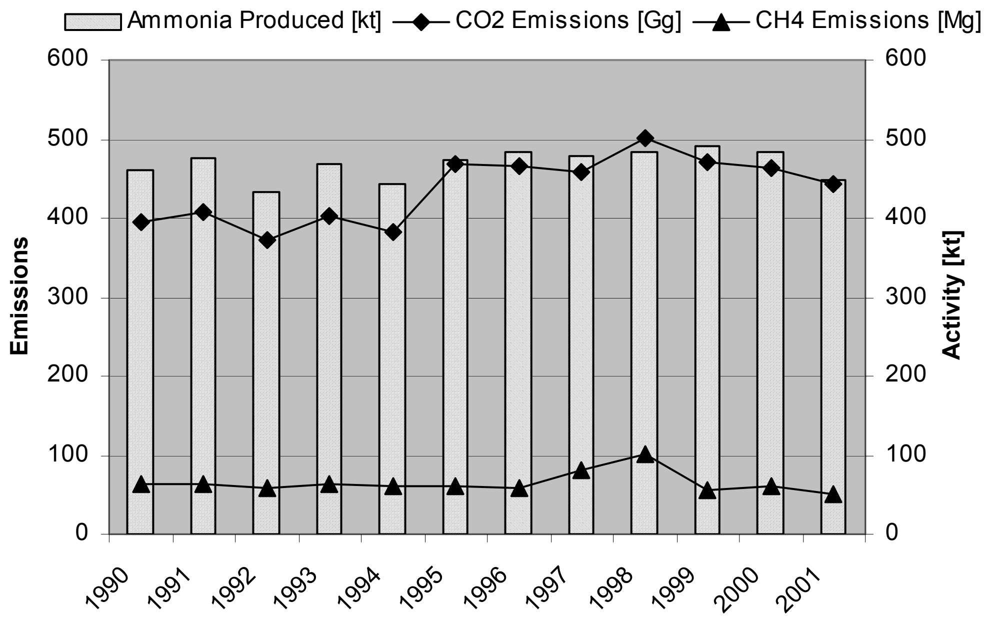


Figure 19: Activity data (ammonia produced) and emissions from Ammonia Production 1990-2001

As can be seen in the figure, 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 1995. Since then emissions were decreasing again. In 2001 CO_2 emissions increased by 12% whereas CH_4 emissions decreased by 18%.

4.3.1.2 Methodological Issues

Activity data since 1990 and emission data from 1994 onwards were reported directly to the UBAVIE 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 96). 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.

The 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.

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.

Table 96: Activity data, emissions and implied emission factors for CO_2 and CH_4 emissions from ammonia production 1990–2001

Year	Ammonia Produced [t]	CO_2 Emissions [Gg]	CH_4 Emissions [Gg]	IEF CO2 [kg/t]	IEF CH4 [g/t]
1990	461 000	396.00	0.062	859.00	157.16
1991	475 000	408.03	0.064	859.00	157.16
1992	432 000	371.09	0.058	859.00	157.16
1993	469 000	402.87	0.063	859.00	157.16
1994	444 000	381.40	0.060	859.00	157.16
1995	473 000	468.32	0.061	990.11	130.68
1996	484 772	465.33	0.059	959.90	127.01
1997	479 698	457.10	0.081	952.90	177.42
1998	484 449	501.24	0.102	1 034.66	203.49
1999	490 493	472.12	0.055	962.54	116.07
2000	482 333	463.00	0.060	959.92	129.59
2001	448 176	442.00	0.051	986.22	115.38

4.3.1.3 Recalculation

Activity and emission data for the year 2000 was updated, therefore data of that year previously reported differs from the new data, the recalculation difference is presented in the following table:

Table 97: Recalculation Difference with respect to previous submission for Ammonia Production

Year	CH_4 Emissions [Gg]	CO_2 Emissions [Gg]
2000	+ 0.0052	- 9.12

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.

In Austria there is only one producer of HNO_3.

Table 98 and Figure 20 present N_2O and CO_2 emissions from production of nitric acid for the period from 1990 to 2001.

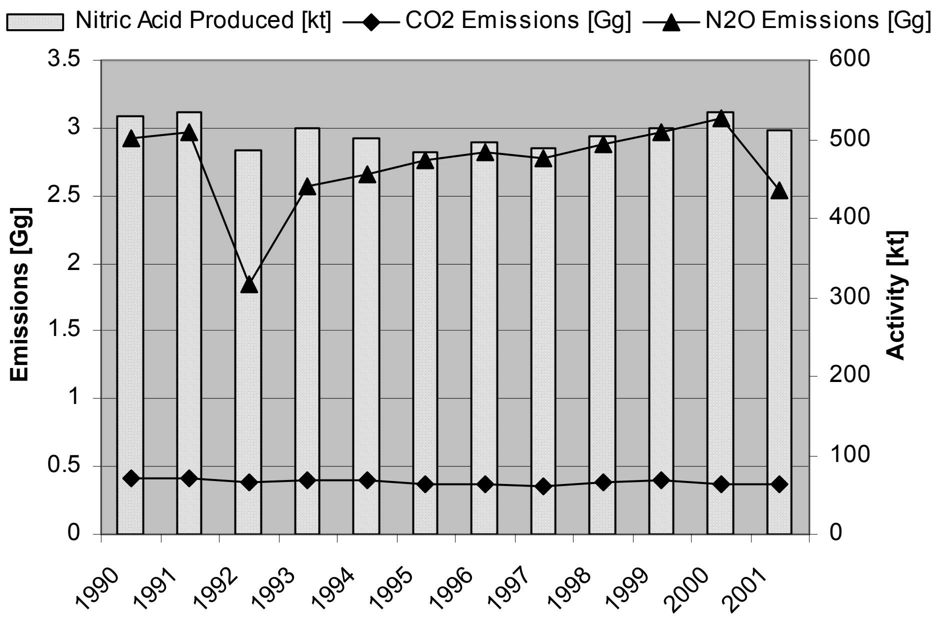


Figure 20: Activity data (nitric acid produced) and emissions from Nitric Acid Production 1990-2001

As can be seen in the figure, N_2O emissions fluctuated during the period from 1990 to 2001, they increased from 1993 to 2000 and decreased by 17% from 2000 to 2001. This drop in emissions in the last year of the inventory was due to efforts made by the company to reduce their N_2O emissions. In the year 2001 N_2O emissions were 13% lower than in 1990.

For the years 1995 to 2000 N_2O emissions followed closely the trend of nitric acid production. Before 1995 there have been some changes in the plant stock used for production of nitric acid, therefore the emissions did not follow the nitric acid production trend as closely as for the years after. The presented emission values of 1992 and 1993 do not cover the whole production of nitric acid of that year, explaining the deviation in emissions related to production values for these years.

CO_2 emissions also varied over the period from 1990-2001 following the trend of nitric acid production closely until 1999. Specific emissions decreased in 2000/2001 due to efforts made by the plant owner to reduce greenhouse gas emissions (also see implied emission factors in Table 98). In 2001 emissions were 12% lower than in 1990.

4.3.2.2 Methodological Issues

Activity and emission data of N_2O emissions and CO_2 emissions from the years 1994 onwards have been reported directly to the UBAVIE 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 98: Activity data, emissions and implied emission factors for CO_2 and CH_4 emissions from Nitric Acid Production 1990-2001

Year	Nitric Acid Produced [kt]	CO_2 Emissions [Gg]	N_2O Emissions [Gg]	IEF CO_2 [kg/t]	IEF N_2O [kg/t]
1990	530.00	0.41	2.93	0.78	5.52
1991	535.00	0.42	2.98	0.78	5.56
1992	485.00	0.38	1.84*	0.78	--*
1993	513.00	0.40	2.58*	0.78	--*
1994	502.00	0.39	2.66	0.78	5.29
1995	484.00	0.37	2.76	0.76	5.70
1996	495.74	0.38	2.81	0.76	5.68
1997	489.38	0.36	2.78	0.73	5.67
1998	504.98	0.38	2.89	0.75	5.72
1999	512.80	0.40	2.97	0.78	5.80
2000	533.72	0.37	3.07	0.69	5.75
2001	510.80	0.36	2.54	0.71	4.97

* The presented emission values do not cover the whole production of nitric acid, that's why no IEF is shown here. For next year's submission these values will be corrected.

4.3.2.3 Recalculation

For the year 2000 activity and emission data have been updated, therefore the reported emission value for CO_2 emission for the year 2000 reported last year differs from that that was reported this year.

The presented emission values of 1992 and 1993 do not cover the whole production of nitric acid, for next year's submission these values will be corrected.

The time series for N_2O emissions has been revised by the plant operator. The emissions reported now are about five times higher than those reported in the years before. The ERT had already noted that the implied emission factor is very low (see paragraph 132 and 140b of the [CR 2001].

The previously reported time series was based on emission factors that were determined by measurement of the waste gas flow and analysing its N_2O content. The measurement was performed for each of the three plants (low pressure and medium pressure plants) that were operating at that time and were repeated three times within less than six hours (for one plant less than two hours even). For analysing the waste gas a gas chromatograph with IR detection was used. This method was not validated for analysing N_2O emissions from this source. The GC/IR method is not specific enough and often interferences are observed.

As N_2O concentrations in the waste gas flow vary over time, spot data collected are not representative and furthermore the used method for measuring the concentration was not validated for this type of problem. For the low pressure plants the concentration of N_2O was below the detection limit of the used method, therefore the detection limit was used to extrapolate emissions. Thus the resulting emission factor had a large uncertainty.

It has to be noted, that the measurements were not intended to give exact results, they were performed by the company to get an idea about the order of magnitude of their N_2O emissions.

For the new measurements an accredited laboratory was assigned to analyse the waste gas flow. The measurements go back to 1998 and were performed every day on each of the two plants that are now in service. For analysing the waste gas a validated method was used (Infrared Analyzer Model Uras 14). As the new emission factors are based on a large number of measurements they are more reliable than the old ones.

For the reasons explained above, the new time series as reported by the plant operator was included in the Austrian greenhouse gas inventory as this is considered to reduce uncertainties.

Detailed background data on both the old and the new measurements as well as on all changes made to the plants have been made available by the plant operator to the UBAVIE.

Table 99: Recalculation Difference with respect to last year's submission for N_2O and CO_2 emissions from Nitric Acid Production

Year	N_2O Emissions Difference [Gg]	CO_2 Emissions Difference [Gg]
1990	2.33	0.00
1991	2.37	0.00
1992	1.29	0.00
1993	2.00	0.00
1994	2.09	0.00
1995	2.21	0.00
1996	2.25	0.00
1997	2.22	0.00
1998	2.32	0.00
1999	2.39	0.00
2000	2.49	-0.03

4.3.3 Chemical Industry – Other: Production of Fertilizers and Urea (2 B 5)

4.3.3.1 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 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.

Figure 21 and Figure 22 present CH_4 and CO_2 emissions for *Urea Production* and *Fertilizer Production*, respectively for the period from 1990 to 2001.

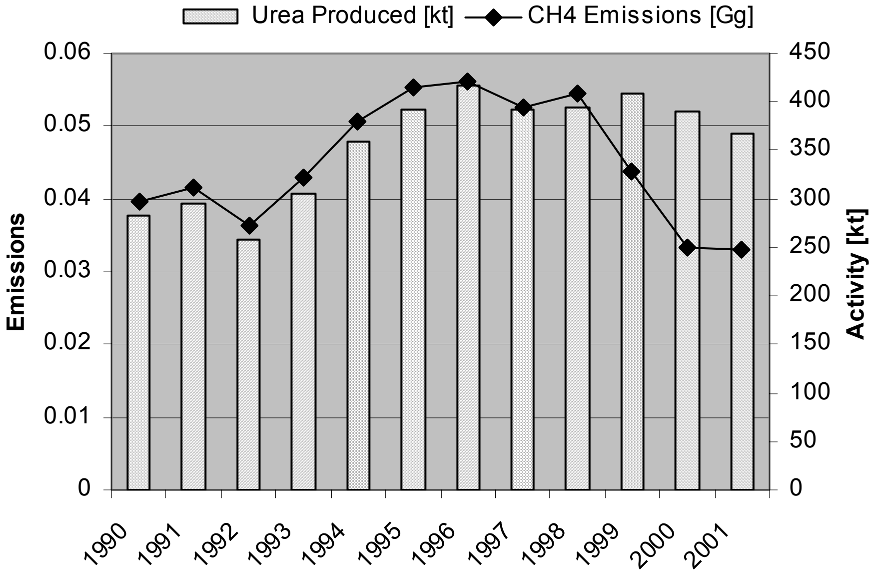


Figure 21: Activity data and emissions for Chemical Industry – Other (Urea Production)

As can be seen in the figure, CH_4 emissions from urea production followed the trend of urea produced until 1998. Since then specific emissions decreased due to changes in process control of the waste gas. In 2001 emissions from this category were 17% lower than in 1990.

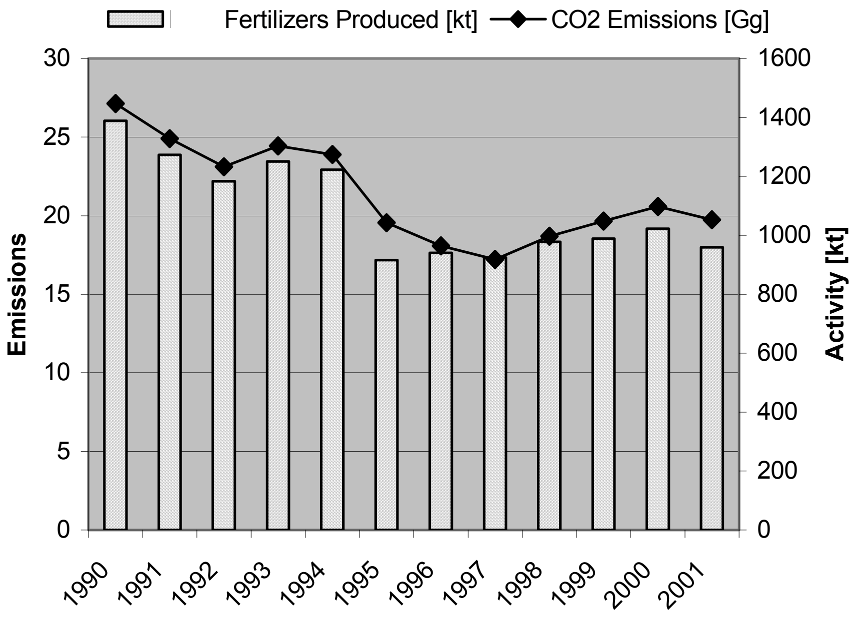


Figure 22: Activity data and emissions for Chemical Industry – Other (Fertilizer Production)

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 2001 emissions from this category were 31% lower than in 1990.

4.3.3.2 Methodological Issues

Emission data for 1994 to 2001 were directly reported by industry and thus represent plant-specific data. With the emission and activity data from 1994 an emission factor for 1994 was calculated and applied for the years 1993 to 1990.

CO_2 emissions from fertilizer production were calculated by industry using a mass balance approach.

Activity data

Production data for urea were directly reported by the Austrian producer of urea and thus represent plant-specific data.

Production data for fertilizers for 1990 to 1994 were taken from national statistics (STATISTIK AUSTRIA), for 1995 to 2001 the production data were reported directly from industry.

Table 100 presents activity data, emissions and implied emission factors for CO_2 emissions from *Fertilizer Production* and CH_4 emissions from *Urea Production* for the period from 1990 to 2001.

Table 100: Activity data, emissions and implied emission factors for CO_2 emissions from NPK-fertilizer Production and CH_4 emissions from Urea Production 1990-2001

Year	Urea Produced [t]	CH_4 Emissions [Gg]	IEF CH_4 [g/t]	Fertilizers Produced [t]	CO2 Emissions [Gg]	IEF CO_2 [kg/t]
1990	282 000	0.040	140.71	1 388 621	27.14	19.55
1991	295 000	0.042	140.71	1 273 467	24.89	19.55
1992	259 000	0.036	140.71	1 182 595	23.12	19.55
1993	305 000	0.043	140.71	1 250 804	24.45	19.55
1994	360 000	0.051	140.71	1 222 578	23.90	19.55
1995	393 000	0.055	140.71	916 265	19.55	21.34
1996	417 705	0.056	134.54	940 313	18.07	19.22
1997	392 017	0.053	134.43	924 856	17.22	18.62
1998	395 288	0.055	137.87	977 212	18.68	19.12
1999	408 386	0.044	107.01	988 662	19.65	19.88
2000	390 185	0.033	85.60	1 022 983	20.59	20.13
2001	367 218	0.033	89.86	959 698	19.75	20.58

4.3.3.3 Recalculation

Activity and emission data for the year 2000 was updated, therefore data of that year previously reported differs from the new data, the recalculation difference is presented in the following table:

Table 101: Recalculation Difference with respect to previous submission for Chemical Industries-Other

Year	CH_4 Emissions from Urea Production -Recalculation Difference [Gg]	CO_2 Emissions from fertilizer Production -Recalculation Difference [Gg]
2000	-0.0103	+ 0.94

4.3.3.4 Time Series Consistency

The time series 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 2001 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

Key Source: Yes (CO_2)

Iron and Steel Industry is one of the most important key sources of the Austrian greenhouse gas inventory. It is a key source because of its contribution to the total inventory level for all years of the inventory and because of its contribution to the trend for all years except 1997 and 2001.

In the year 2001 CO_2 emissions from production of iron and steel contributed 10.76% to the total amount of greenhouse gas emissions in Austria (see Table 82).

In Austria the iron and steel (basic oxygen furnace) production is concentrated mainly at two integrated sites operated by the same company. The emission data in Table 102 contains CO_2 emissions from all sites (seven in total) operated by this company.

The total amount of CO_2 emissions included in this category contains process related CO_2 emissions from sinter plants, blast furnace charging, pig iron tapping, basic oxygen steel plants and coke oven as well as emissions from limestone used as a flux and emissions from combustion processes of sinter plants, coke oven, rolling mills and energy supply.

Figure 23 and Table 102 present total CO_2 emissions (process related and emissions due to fuel combustion) from the production of iron and steel for the period from 1990 to 2001.

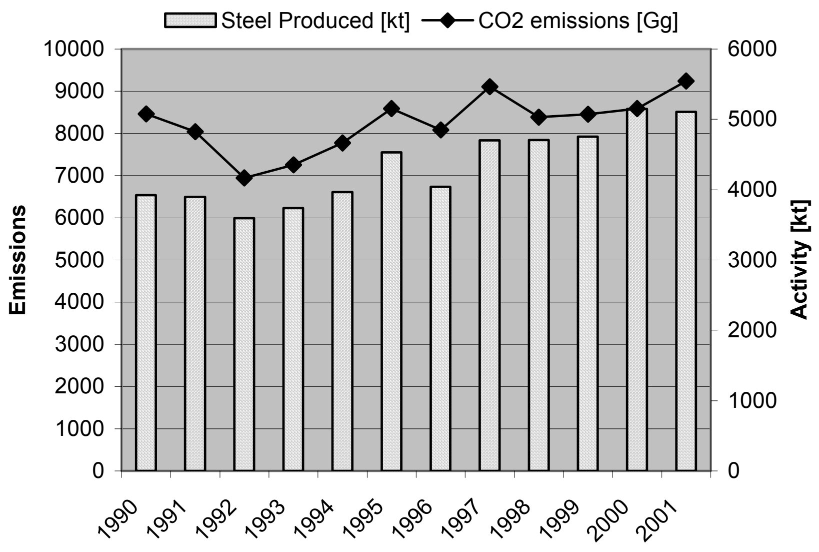


Figure 23: Total CO_2 emissions from Iron and Steel Industries 1990-2001

CO_2 emissions from *Iron and Steel Production* decreased from 1990 to 1993 and then increased steadily following the trend of steel production. In 2001 emissions were 9% above the level of 1990.

4.4.1.2 Methodological Issues

Activity and emission data were directly reported by industry and thus represent plant-specific data. With the emission and activity data an implied emission factor was calculated.

CO_2 emissions from iron and steel production of the two integrated sites were calculated separately. These CO_2 emissions and total emissions from other processes within the two integrated sites as well as emissions of the other sites were summed up and reported together as explained above.

CO_2 emissions were calculated by industry using a carbon mass balance approach. All carbon containing mass streams (inputs and outputs) of the respective processes and sites were monitored. The carbon content of these streams was measured regularly (continuous for gas streams and regular random sampling for solid in- and output streams). CO_2 emissions represent the difference of total carbon input and output mass streams. The amount of carbon that remains in the steel and in side products of the coke oven was considered in the calculation.

Because emissions from many different processes are summed up, the resulting implied emission factor varies as can be seen in Table 102. However, the implied emission factor of 2000 is significantly lower due to inconsistencies of the time series (see paragraph *Time Series Consistency*).

In Table 102 presents implied emission factors as well as total CO_2 emissions and coke, sinter and metal production.

Table 102: Activity data, emissions and implied emission factors for CO_2 emissions from Iron and Steel Production 1990–2001

Year	Coke Production [t]	Sinter Production [t]	Steel Production [t]	CO_2 emissions [Gg]	IEF CO_2 [t/t Steel]
1990	1 724 836	4 384 000	3 922 000	8 461.04	2.16
1991	1 539 527	4 412 000	3 896 000	8 040.82	2.06
1992	1 486 728	3 026 000	3 592 000	6 948.63	1.93
1993	1 401 623	2 986 000	3 736 000	7 254.29	1.94
1994	1 432 476	3 264 000	3 964 000	7 771.03	1.96
1995	1 447 886	3 565 000	4 529 000	8 585.41	1.90
1996	1 558 524	3 197 000	4 041 000	8 084.35	2.00
1997	1 566 370	3 425 000	4 700 205	9 107.32	1.94
1998	1 598 073	3 353 053	4 707 370	8 384.63	1.78
1999	1 607 903	3 371 721	4 751 994	8 456.00	1.78
2000	1 385 000	3 552 153	5 150 174	8 590.51*	1.67*
2001	1 724 836	3 527 741	5 107 717	9 245.00	1.81

For the year 2000 not all emissions of the iron and steel producing sites were considered (for further information see Chapter 4.4.1.3)

4.4.1.3 Time Series Consistency

Due to an inconsistency in the time series of the reported emissions the implied emission factor of 2000 is significantly lower than the ones of the years before or after (see Table 102): for all years except 2000 *all* emissions from the iron and steel industry including the power plants at the two main integrated sites were included. In the year 2000 emissions from the power plant at one of the integrated sites was not included in the reported emissions. They were estimated by the company to be about 600 Gg CO_2 in the year 2000. For the year 2001 emissions from this power plant were estimated to be about 700 Gg and were reported together with all other emissions as in the years before 2000.

4.4.1.4 Planned Improvements

The following improvements are planned until the next submission of the National Inventory Report:

- to estimate emissions from steel plant, blast furnace, sinter plant and coke oven separately,
- to allocate emissions due to energy combustion from *Industrial Processes* to *Energy*.

4.4.2 Aluminium Production (2 C 3)

4.4.2.1 Source Category Description

Key Source: Yes (PFCs)

This category includes emissions of PFCs from aluminium production. The two PFCs, tetra-fluoromethane (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).

This category is a key source because of its 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.

PFC emissions from primary aluminium production were only relevant for the years 1990 to 1992 (termination of primary aluminium production in Austria since 1992).

Table 103 presents PFC emissions from primary aluminium production for the period from 1990 to 1992.

Table 103: PFC emissions from primary aluminium production from 1990 to 1992

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
PFC emission [Gg CO_2-equivalent]	937	941	535	NO	NO	NO	NO	NO	NO	NO	NO	NO

4.4.2.2 Methodological Issues

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%.

The production capacity (83 000 t_{Al}/a) represents plant specific data.

By inserting these data into the formula mentioned above an emission factor of 1.56 kg CF_4 / t aluminium was calculated.

4.4.3 SF_6 Used in Aluminium and Magnesium Foundries (2 C 4)

4.4.3.1 Source Category Description

Key Source: Yes (SF_6)

This category includes emissions of SF_6 from magnesium and aluminium foundries.

This source was a key source because of its contribution to total emissions in the years 1994 to 1997 and to the trend of emissions in the trend assessment of the years 1991, 1992 and 1996 to 2001.

In 2001 SF_6 emission from aluminium and magnesium foundries contributed 0.01% to the total amount of greenhouse gas emissions in Austria compared to 0.57% in the base year (1995 for SF_6; see Table 82).

Table 104 presents SF_6 emissions from magnesium and aluminium foundries for the period from 1990 to 2001.

As can be seen in the table, 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 year 2001 the value of 2000 was used due to lack of more up to date emission data.

Table 104: SF_6 emissions from magnesium and aluminium foundries 1990–2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
SF_6 emission [Gg]	0.0106	0.0116	0.0106	0.0116	0.0156	0.0185	0.0256	0.0146	0.0069	0.0009	0.0003	0.0003

4.4.3.2 Methodological Issues

SF_6 used in aluminium foundries

Information about the amount of SF_6 used in aluminium foundries was obtained directly from the aluminium producers in Austria and thus represent plant-specific data. Actual emissions of SF_6 correspond to the annual consumption of SF_6 in aluminium foundries.

SF_6 used in magnesium foundries

Estimation of actual SF_6 emissions from magnesium foundries was carried out by applying an emission factor of 4 kg SF_6 per ton of magnesia die cast (no potential emissions occur):

$$\text{Emission [Mg]} = (\text{Emission factor } [g_{SF6}/Mg_{activity}] \times \text{Activity [Mg]})/1\,000\,000$$

This emission factor was derived from a worldwide survey of 20 producers of magnesia die cast [LEISEWITZ, 1996].

4.4.4 Metal Production - Other (2 C 5)

In this category production in electric furnace steel plants and rolling mills is addressed.

4.4.4.1 Electric Furnace Steel Plants

4.4.4.1.1 Source Category Description

Emission: CH_4

Key Source: No

This category includes CH_4 emissions from electric furnace steel plants. Table 105 and Figure 24 present these emissions for the period from 1990 to 2001.

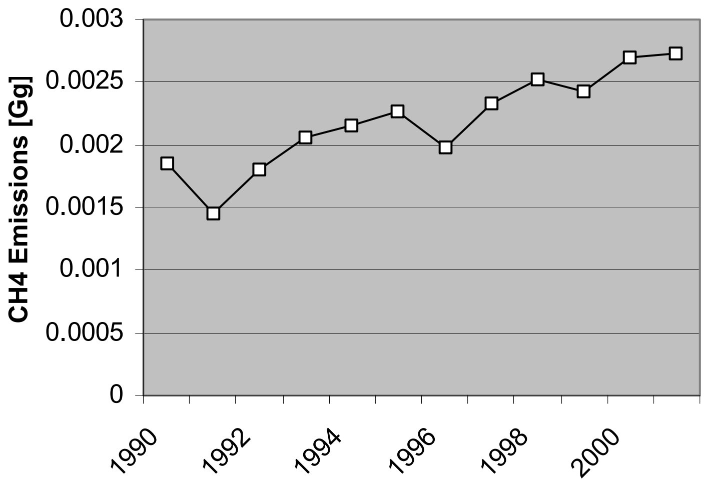


Figure 24: CH_4 emissions from Electric Steel Production 1990-2001

As can be seen from Figure 24, the trend of CH_4 emissions from the production of electric steel is increasing. In 2001 emissions were 47% higher than in 1990 due to increased production.

4.4.4.1.2 Methodological Issues

Estimation of CH_4 emissions was carried out applying an emission factor:

$$\text{Emission [Mg]} = (\text{Emission factor } [g_{CH4}/Mg_{activity}] \times \text{Activity [Mg]})/1\,000\,000$$

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 UBAVIE).

Activity data were obtained from the *Association of Mining and Steel* and thus represent plant specific data.

Table 105 presents activity data for electric steel production for the period from 1990 to 2001.

Table 105: Activity data and CH_4 emissions from Electric Steel Production 1990–2001

Year	Electric steel production [t]	CH_4 emissions [Gg]
1990	370 107	0.0019
1991	290 324	0.0015
1992	360 620	0.0018
1993	410 769	0.0021
1994	430 949	0.0022
1995	453 645	0.0023
1996	396 200	0.0020
1997	465 578	0.0023
1998	502 913	0.0025
1999	485 929	0.0024
2000	540 539	0.0027
2001	545 695	0.0027

4.4.4.1.3 Recalculation

There is a difference in the reported emission values compared to the ones reported this year because a new time series of activity data was used (previously the value of 1994 was used for all years, now values for all reporting years have been collected).

Table 106: Recalculation difference of CH_4 emissions from electric furnace steel plants compared to last year's submission

Year	Difference [Gg]
1990	-0.00030
1991	-0.00070
1992	-0.00035
1993	-0.00010
1994	0.00000
1995	0.00011
1996	-0.00017
1997	0.00017
1998	0.00036
1999	0.00027
2000	0.00055

4.4.4.2 Rolling Mills

4.4.4.2.1 Source Category Description

Emission: CH_4

Key Source: No

This category includes CH_4 emissions from rolling mills.

Table 107 and Figure 25 present CH_4 emissions from this category for the period from 1990 to 2001.

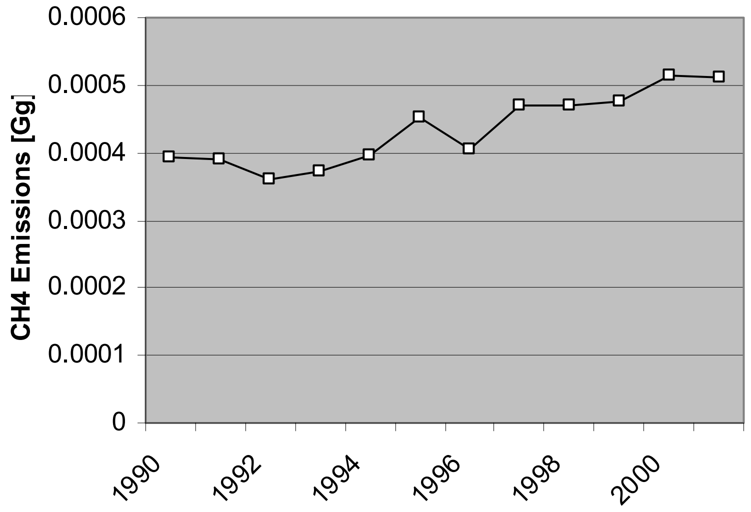


Figure 25: CH_4 emissions from Rolling Mills 1990-2001

As can be seen from Figure 25, CH_4 emissions increased steadily over the period, by the year 2001 they were 30% higher than in the base year due to increased steel production.

4.4.4.2.2 Methodological Issues

Estimation of CH_4 emissions was carried out applying an emission factor of 0.1 g CH_4 /Mg steel:

$$\text{Emission [Mg]} = (\text{Emission factor } [g_{CH4}/Mg_{activity}] \text{ x Activity [Mg]})/1\,000\,000$$

The emission factor for VOC emissions from rolling mills 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 UBAVIE).

The activity data were plant specific data and were directly reported by the iron and steel industry.

Table 107 presents activity data (steel produced) as well as CH_4 emissions arising from rolling mills for the period from 1990 to 2001.

Table 107: Activity data and CH_4 emissions from Rolling Mills 1990-2001

Year	Steel Produced [t]	CH_4 emissions [Gg]
1990	3 922 000	0.00039
1991	3 896 000	0.00039
1992	3 592 000	0.00036
1993	3 736 000	0.00037
1994	3 964 000	0.00040
1995	4 529 000	0.00045
1996	4 041 000	0.00040
1997	4 700 205	0.00047
1998	4 707 370	0.00047
1999	4 751 994	0.00048
2000	5 150 174	0.00052
2001	5 107 717	0.00051

4.5 Other Production (CRF Source Category 2 D)

In this category production of pulp and paper and food and drink are addressed. Emissions from *2 D 1 Pulp and Paper* are included in *1 A 2 f* because emissions mainly arise from combustion activities.

4.5.1 Food and Drink (2 D 2)

4.5.1.1 Source Category Description

Emission: CO_2

Key Source: No

This category includes CO_2 emissions from the production of bread, wine, sprits and beer.

Table 109 and Figure 26 present CO_2 emissions from *Food and Drink Production* for the period from 1990 to 2001.

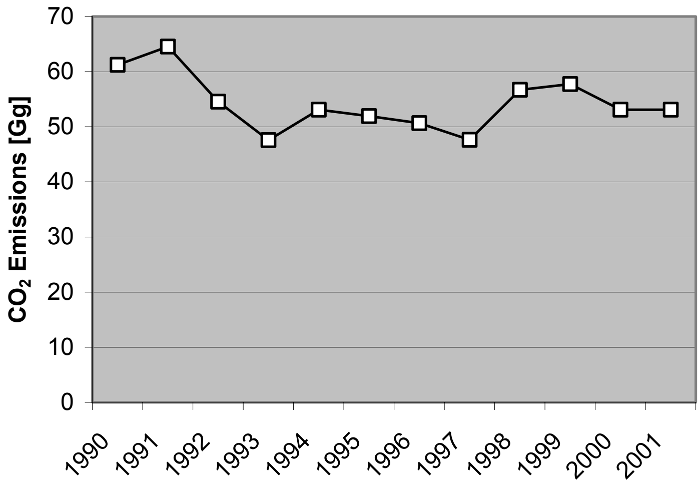


Figure 26: CO_2 emissions from Food and Drink Production 1990-2001

As can be seen in the figure, CO_2 emissions varied during the period, but the overall trend was decreasing CO_2 emissions. From 1990 to 2001 CO_2 emissions from this category decreased by 13%.

4.5.1.2 Methodological Issues

Emissions were calculated by multiplying the annual production with an emission factor.

The following emission factors[14] were applied:

Bread: 7 kg_{CO2}/Mg_{bread}

Wine: 10 kg_{CO2}/hl_{wine}

Beer: 0,5 kg_{CO2}/hl_{beer}

Spirits: 80 kg_{CO2}/hl_{spirit}

All emission factors were taken from [BUWAL, 1995] because of the very similar structures and standards of industry in Austria and Switzerland.

Activity values were taken from national statistics (STATISTIK AUSTRIA), for the year 2001 no activity data was available, that's why the value of 2000 was also used for 2001. Table 108 presents activity data for bread, wine, beer and spirits production for the period from 1990 to 2001.

Table 108: Activity data of Food and Drink Production 1990–2001

Year	Spirits [hl]	Beer [hl]	Wine [hl]	Bread [t]	Total [t]
1990	289 134	9 799 090	3 166 290	215 992	1 541 443
1991	338 189	9 971 470	3 093 259	221 149	1 561 441
1992	274 182	10 176 200	2 588 215	229 858	1 533 718
1993	279 831	9 788 520	1 865 479	233 729	1 427 112

[14] There are no emission factors in the CRF sectoral background data table 2(I), because it is not resonable to give one emission factor for all the food and drink industry (different units of emission factors). However, activity data was summed up and reported in the CRF (also see Table 108).

Year	Spirits [hl]	Beer [hl]	Wine [hl]	Bread [t]	Total [t]
1994	249 777	9 934 764	2 646 635	241 691	1 524 809
1995	289 676	9 473 950	2 228 969	241 601	1 440 861
1996	289 676	9 370 693	2 110 332	241 601	1 418 671
1997	289 676	9 303 437	1 801 747	256 055	1 395 541
1998	289 676	8 836 673	2 703 170	296 695	1 479 647
1999	289 676	8 884 269	2 803 383	294 843	1 492 576
2000	289 676	8 725 404	2 338 410	305 845	1 441 194
2001	289 676	8 725 404	2 338 410	305 845	1 441 194

Table 109: CO_2 emissions from Food and Drink Production 1990–2001

Year	CO_2 Emissions [Gg]				
	Spirits	Beer	Wine	Bread	Total
1990	23.13	4.90	31.66	1.51	61.21
1991	27.06	4.99	30.93	1.55	64.52
1992	21.93	5.09	25.88	1.61	54.51
1993	22.39	4.89	18.65	1.64	47.57
1994	19.98	4.97	26.47	1.69	53.11
1995	23.17	4.74	22.29	1.69	51.89
1996	23.17	4.69	21.10	1.69	50.65
1997	23.17	4.65	18.02	1.79	47.64
1998	23.17	4.42	27.03	2.08	56.70
1999	23.17	4.44	28.03	2.06	57.71
2000	23.17	4.36	23.38	2.14	53.06
2001	23.17	4.36	23.38	2.14	53.06

4.5.1.3 Recalculations

There is a difference in the reported emission values compared to the ones reported this year because activity data were updated.
For bread previously the value of 1994 was used for all years, now values for all reporting years have been collected.
Also for spirits the whole time series has been changed, however due to a change of the methodology in the national statistics the last activity value available is the one of 1995. This value was also used for the years onwards.
For wine activity data since 1998 has been updated, for beer the values of 1990, 1991, 1994, 1999 and 2000.
The recalculation difference resulting from these changes with respect to the emissions that were reported in last year's submission are presented in Table 110.

Table 110: Recalculation Difference with respect to last year's submission for CO_2 emissions from Food and Drink Production 1990–2001

Year	Difference [Gg]
1990	1.96
1991	6.01
1992	1.05
1993	1.05
1994	1.12
1995	1.05
1996	1.05
1997	1.15
1998	8.90
1999	9.92
2000	5.26

4.6 Consumption of Halocarbons and SF_6 (CRF Source Category 2 F)

4.6.1 Source Category Description

NOTE: There was no new data on emissions of F-gases available, that's why the figures of 2000 were also used for 2001.

This category includes the following emission sources: refrigeration and air conditioning equipment, foam blowing, fire extinguishers, aerosols/metered dose inhalers, semiconductor manufacture, electrical equipment and other sources (noise insulation windows, tyres and research; heat pumps).

Potential emissions are only reported as sums under category *2 F*, estimation of actual emissions see the respective sub-categories.

Emission Trends

For the source *Consumption of Halocarbons and SF_6* greenhouse gas emissions increased by 33.59% compared to base year emissions (1995 for PFCs, HFCs and SF_6). In 2001 emissions were almost six 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*). Emissions by subsector and gas are presented in Table 111.

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*.

Emissions of heat pumps were included in *ODS Substitutes*.

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).

4.6.2 Methodological Issues

The basic 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

Table 111: Emissions of IPCC Category 2 F by subsector 1990-2001

CRF-Sector	Description	Unit	GHG	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GWP
2 F 6	Semiconductor Manufacture	t	HFC-23	0.17	0.26	0.38	0.50	0.61	0.04	0.16	0.08	0.08	0.09	0.09	0.09	*11 700*
		t	CF4	3.33	3.82	4.31	4.80	5.01	0.78	0.66	0.90	0.90	1.50	1.47	1.47	*6 500*
		t	C2F6	0.50	0.96	1.40	1.84	2.29	1.15	1.14	1.35	1.63	1.69	1.70	1.70	*9 200*
		t	SF6	4.17	7.23	9.88	12.54	15.19	17.84	13.66	20.37	17.97	16.03	13.56	13.56	*23 900*
2 F 6	**Semiconductor Manufacture**	**Gg**	**CO2 equivale**	**127.87**	**209.55**	**281.50**	**353.53**	**423.78**	**442.49**	**343.06**	**506.03**	**451.27**	**409.40**	**350.38**	**350.38**	
2 F 8	Other / Heat Pumps	t	HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1300*
2 F 1	Refrigeration and Air Conditioning Equipment	t	HFC-32	0.00	0.00	0.00	0.00	0.02	0.07	0.17	0.35	0.60	0.91	1.75	1.75	*650*
		t	HFC-125	0.00	0.00	0.00	0.00	0.03	1.44	5.70	11.05	14.79	16.19	21.90	21.90	*2 800*
		t	HFC-134a	1.35	2.13	3.15	4.60	6.73	23.33	41.30	62.68	90.25	103.90	134.30	134.30	*1 300*
		t	HFC-152a	0.00	0.00	0.00	0.00	0.00	0.06	0.33	0.57	0.76	0.69	0.79	0.79	*140*
		t	HFC-143a	0.00	0.00	0.00	0.00	0.00	0.38	2.51	5.62	8.14	9.47	13.57	13.57	*3 800*
2 F 2	Foam Blowing	t	HFC-134a	0.00	0.00	0.00	0.00	0.00	391.00	416.50	446.25	477.42	498.10	518.76	518.76	*1 300*
		t	HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	451.44	451.44	*140*
2 F 3	Fire Extinguishers	t	HFC-23	0.00	0.00	0.00	0.03	0.07	0.12	0.18	0.24	0.31	0.39	0.46	0.46	*11 700*
		t	HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.07	0.11	0.17	0.17	*2 900*
2 F 1/2/	**ODS Substitutes**	**Gg**	**CO2 equivale**	**1.76**	**2.77**	**4.10**	**6.33**	**9.70**	**545.56**	**622.92**	**717.12**	**814.66**	**869.43**	**1 032.18**	**1 032.18**	
2 F 7	Electrical Equipment	t	SF6	1.57	2.22	2.25	2.32	3.13	2.65	2.39	2.32	3.16	3.55	4.08	4.08	*23 900*
3 F 7	**Electrical Equipment**	**Gg**	**CO2 equivale**	**37.56**	**53.11**	**53.74**	**55.53**	**74.73**	**63.42**	**57.22**	**55.33**	**75.57**	**84.87**	**97.59**	**97.59**	
2 F 8	Other / Research	t	SF6	5.32	7.52	7.62	7.97	9.30	10.12	10.54	10.74	11.95	10.03	10.36	10.36	*23 900*
2 F 8	**Other Sources of SF6**	**Gg**	**CO2 equivale**	**127.15**	**179.73**	**182.12**	**190.48**	**222.27**	**241.87**	**251.91**	**256.69**	**285.68**	**239.76**	**247.56**	**247.56**	
2 F	**Consumption of Halocarbons and SF6**	**Gg**	**CO2 equivale**	**294.34**	**445.16**	**521.45**	**605.88**	**730.48**	**1 293.33**	**1 275.11**	**1 535.17**	**1 627.17**	**1 603.46**	**1 727.71**	**1 727.71**	

4.6.2.1 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 household, industrial and commercial refrigerators, heat pumps, cold storage warehouses, automobiles with mobile air condition and imported mobile refrigeration systems were obtained from Associations of Industry.

HFC-125, HFC-143a and HFC-32 were not in use as individual gases but are parts of the blends used for stationary refrigeration where actual emissions normally accord with the respective equipment installation stock.

4.6.2.2 2 F 2 Foam Blowing and XPS/PU Plates

Production data and information about the used blowing agent were obtained from Associations of Industry (construction industry).

The actual emissions were calculated from the total consumption of XPS/PU plates in Austria - about 75% of the XPS/ PU plates are imported. Based on expert judgement it was assumed that for plates of common thickness (40 to 60 mm) about 5 kg blowing agent per m³ plate are used. About 30% of that amount (that are 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. These diffusion losses were calculated using the half-life-time with the following formula:

$$T_{1/2} \approx 0{,}8 \times 10^{-6} \times d^2/D$$

Where: d = thickness of the plates [cm]

D = Diffusion coefficient [cm²/s]

$T_{1/2}$ = half-life-time [days]

For HFC R134a a diffusion coefficient of $2{,}9 \times 10^{-9}$ cm²/s and for HFC R152a a diffusion coefficient of $0{,}21 \times 10^{-6}$ cm²/s was assumed.

The consumption per capita of XPS/ PU plates in Austria is higher than in all other European countries.

4.6.2.3 2 F 3 Fire Extinguishers

From 1992 to 1995 1.000 t of R 3110 for the use in fire extinguishers in Austria was sold. It was assumed that actual emissions are 1% of potential emissions.

HFC-23 and HFC-227ea in fire extinguishers were first introduced to the Austrian market in 1995. It was assumed that the actual emissions correspond to 1,5% of the annual potential emissions. Potential emissions correspond to the sum of consumption data of all years before.

Consumption data were obtained directly from the producers of fire extinguishers.

4.6.2.4 2 F 4 Aerosols/Metered Dose Inhalers

NO

There was no consumption of Halocarbons and SF_6 under this category in Austria.

4.6.2.5 2 F 5 Solvents concerning Halocarbons

NO

There was no consumption of halocarbons and SF_6 as solvents in Austria.

4.6.2.6 2 F 6 Semiconductor Manufacture (HFCs, PFCs, SF_6)

SF_6 is used for etching in semiconductor manufacture and for insulation purposes for high frequency measurements.

All consumption data and data about actual emissions of SF_6 from semiconductor manufacture were based upon direct information from industry.

All consumption data and data about emissions of PFCs and HFCs from semiconductor manufacture were based upon direct information from industry.

The actual emissions correspond to approximately 8% (CF_4), respectively 1% (C_2F_6) of the total consumption. For HFCs it was assumed that about 90% of total consumption is emitted. Potential emissions were not relevant.

4.6.2.7 2 F 7 Electrical Equipment (SF_6)

Based on information from energy supplier and industry it was estimated that in 1998 about 100 tons SF_6 were used for electrical transmission and distribution purposes. From these 100 tons about 97% can be assigned to the high voltage sector and about 3% can be assigned to the middle voltage sector.

With the following assumptions the SF_6 emissions were calculated:

- Consumption of SF_6 means first filling of equipment installations and covering of losses.
- There are no emissions during first filling on site. When equipment installation is opened for servicing or if there is leakage, emissions are below 1% of total filled SF_6 (expert judgement).
- The potential emissions correspond to the respective equipment installation stock.

4.6.2.8 2 F 8 Other Sources of SF_6 (noise insulate glass, tyres and research)

Activity data were based upon direct information 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 were the annual congestion losses based on annual production data plus the leakage's losses (1%) of the total stock of insulate glasses filled with SF_6. The potential emissions correspond to the total SF_6 included in insulate glasses (about 50 g SF_6/m^2), minus the amount of SF_6 which escaped before by diffusion.

For estimation of actual emissions from SF_6 filled tyres it was assumed that the total amount of gas contained in a tyre is emitted within three years (1/3 of total amount each year).

Also SF_6 emissions from electron microscopes and shoes were considered in this category.

4.6.3 Planned Improvements

New data on emissions of F-gases will become available in the year 2004 because the new order which regulates the use of F-gases also includes a reporting obligation of companies dealing with those substances. This data will be included in the submission 2004 or 2005 at the latest.

5 SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3)

NOTE: As there have been no changes in methodology for this chapter, and because the emissions reported for 2001 equal the values for 2000, this chapter is identical to the corresponding one in the NIR 2002.

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 are also addressed in this category.

Emission Trends

In the year 2000 this category had a contribution of 0.8% to total greenhouse gas emissions (not considering CO_2 from LUCF). The trend of GHG emissions from 1990 to 2000 shows in Austria a decrease of 16.8% for this sector (see Table 112) due to change in activity data.

Table 112: Trend in greenhouse gas emissions of Category 3 Solvent and Other Product Use 1990–2000

GHG	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1990–2000 Trend
	CO_2 equivalent [Gg]											
TOTAL	**755**	**669**	**614**	**593**	**594**	**613**	**612**	**638**	**628**	**628**	**628**	**–16.8%**
CO_2	523	436	381	361	361	381	379	406	396	396	396	–24.3%
N_2O	233	233	233	233	233	233	233	233	233	233	233	0.0%

Key sources

CO_2 emissions originating from *Solvent and Other Product Use* were identified a key source in all level and trend assessments.

Table 113: 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	ALL

LA90 = Level Assessment 1990
LA00 = Level Assessment 2000
TA00 = Trend Assessment Base Year -2000

Quality Assurance and Quality Control (QA/QC)

For the Austrian Inventory there is an internal quality management system, comprising the whole emission inventory (see Chapter 1.3.).

Inquiries from industry show inconsistencies with the statistical data – see *Planned Improvements* at the end of this chapter and in chapter 5.3.

Uncertainty Assessment

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.

For further information concerning uncertainty assessment see chapter 1.4.

Recalculations

No recalculations were done in this category.

Methodology

Table 114 shows the IPCC categories and the corresponding SNAP categories for which the actual calculations are made.

Table 114: IPCC category 3 and corresponding SNAP categories

IPCC-Category	SNAP-Category	Description
3 A	**0601**	**PAINT APPLICATION**
	060101	Paint application: manufacture of automobiles
	060102	Paint application: car repairing
	060107	Paint application: wood
	060108	Other industrial paint application
	060109	Other non industrial paint application
3 B	**0602**	**DEGREASING AND DRY CLEANING**
3 C	**0603**	**CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING**
	060307	Paints manufacturing
	060312	Textile finishing
3 D	**0604**	**OTHER**
		Use of N_2O
	060501	Anaesthesia
	060505	Fire Extinguishers
	060506	Aerosol Cans
	060508	Other
		Other Use of Solvents and Related Activities
	060403	Printing industry
	060405	Application of glues and adhesives

5.2 Source Categories

3 A Paint Application - 3 B Degreasing and Dry Cleaning - 3 C Chemical Products, Manufacture and Processing - 3 D Other – Other Use of Solvents and Related Activities

Methodology

Estimation of CO_2 emissions include the following steps:

Step 1: Estimation of the consumption of each product group of the statistical data set.

Step 2: Estimation of the solvent content of each product group of the statistical data set.

Step 3: Estimation of the NMVOC content of solvents.

Step 4: Estimation of the carbon content of NMVOC.

Step 5: Calculation of CO_2 emissions

Emission factors

Steps 3–5 of the above mentioned methodology are performed as follows:

The NMVOC content of each of the substances is estimated by expert judgement. It is assumed to be on average 85% for all solvents.

The carbon content of NMVOC is also estimated by expert judgement and is assumed to be on average 85% for total NMVOC.

Calculate CO_2 emissions with formula:

$$CO_2[Gg] = \text{carbon content } [Gg] \times 44 / 12$$

Activity data

Steps 1–2 of the above mentioned methodology are performed by using a national study [SCHÖRNER & SCHÖNSTEIN, 1999] As there is no standard IPCC methodology in the GPG for calculating emissions from solvent use a revised version of the CORINAIR detailed methodology is applied.

CORINAIR detailed methodology:

> *This method is based on a mass balance per solvent. The sum of all solvent mass balances equals the NMVOC emission due to solvent use. In formula the solvent mass balance is:*
>
> *consumption = production + import - export - destruction/disposal - hold-up*

The simplified formula without consideration of destruction/disposal and hold-up is:

> consumption = production + import - export

The data used to perform step 1 are from STATISTIK AUSTRIA. The number of solvent containing substances is 83 organic compounds in 65 product categories. Each compound or product category has a specific solvent content, which has to be estimated by expert judgement. Unfortunately statistical data are not consistent because of different categories of the production- and import/export-statistics. Changes in the meaning of product categories lead to further inconsistencies of time series.

It has to be noted that a sectoral approach of the category *Solvent and Other Product Use* is difficult when using the top down methodology. For the sectoral approach some additional information from industry and manufacturers is gathered, which is also used for verification purposes.

Table 115 shows the total solvent use and respective CO_2 emissions.

Table 115: Total solvent consumption

Year	Solvent-Consumption [Gg]	CO_2 emissions from Solvent Use [Gg]
1990	197.29	522.65
1991	164.75	436.44
1992	143.99	381.45
1993	136.22	360.87
1994	136.42	361.41
1995	143.68	380.64
1996	143.10	379.09
1997	153.05	405.46
1998	149.34	395.64
1999 (1)	149.34	395.64
2000 (1)	149.34	395.64
2001 (1)	149.34	395.64

(1) Preliminary estimate: Value of 1998

3 D Other – Use of N_2O

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 in a widespread use, the uncertainty of emission estimations 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 estimation is based upon expert judgement and industry inquiries.

Other

No other occurrences of N_2O emissions were considered.

5.3 Planned Improvements

Verification of the results obtained by inquiries from industry shows that there are some inconsistencies with the statistical data.

The assumed NMVOC factor of 85% for all solvents is generally too high and in reality not constant over the time series because NMVOC contents of the substance groups have become lower over time in order to comply with the new solvent directives. It is recommended to estimate the NMVOC content for each product group separately.

Because of methodological changes and inconsistencies of the statistical data the actual top down method will be improved by combining it with a bottom up approach which is based on inquiries of industry and manufacturers.

6 AGRICULTURE (CRF SECTOR 4)

6.1 Sector Overview

This chapter includes information about the estimation of greenhouse gas emissions of the sector *Agriculture* in Austria 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.

In the sector Agriculture only greenhouse gas emissions of CH_4 and N_2O are estimated. Anthropogenic CO_2 emissions from *Agricultural Soils* resulting from *Cropland Management* and *Grazing Land Management* are not yet included in the Austrian inventory for this submission.

An inventory improvement program has been launched in 2001 with the aim to fully implement the 1996 Revised IPCC Guidelines as well as the Good Practice Guidance. Key issues of the implemented improvements of this sector are described in the corresponding *Recalculations* chapters of each subchapter (Chapters 6.2.4, 6.3.4, 6.4.4, 6.5.3).

To give an overview of Austria's farm structure some information is provided below (according to the 1999 Farm Structure Survey – full survey) [GRÜNER BERICHT 1999, (2001)]:

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%).

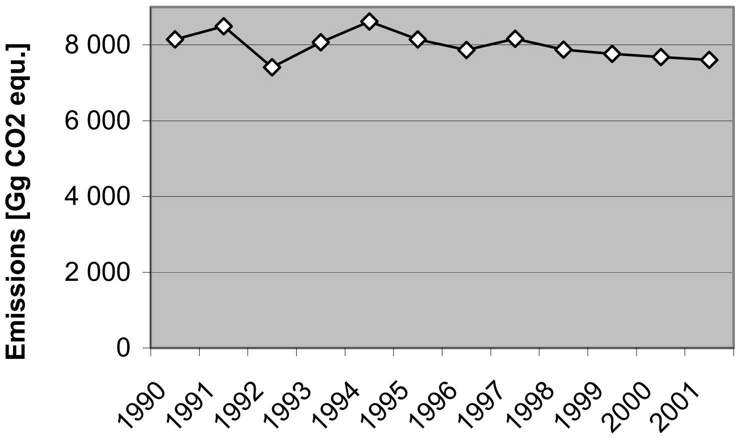
The agricultural area comprises 3.4 million hectares that is a share of ~ 41% of the total territory (forestry ~46%, other area ~13%). The shares of the different agricultural activities are as follows:

- 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 2001 the sector Agriculture contributed 8.9% to the total of Austria's greenhouse gas emissions (not considering CO_2 emissions from LUCF). The trend of GHG emissions from 1990 to 2001 shows a decrease of 6.6% for this sector (see Figure 27 and Table 117) due to a decrease in activity data.

Figure 27: Trend of total GHG emissions from Agriculture



The fluctuations in the time series shown in Figure 27 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 8.2% since the base year mainly due to lower emissions from *Enteric Fermentation*, whereas N_2O emissions only decreased by 4.8%. The trend is also presented in the following table:

Table 116: Emissions of greenhouse gases and their trend from 1990-2001 from Category 4 Agriculture

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CH_4	210.64	207.69	199.70	206.78	206.29	206.18	203.52	201.46	201.52	197.96	195.17	193.38	- 8.2%
N_2O	12.00	13.33	10.38	12.03	13.83	12.32	11.59	12.67	11.75	11.63	11.55	11.42	- 4.8%

Emission trends per sector

Table 117 presents total GHG emissions and trend 1990-2001 from *Agriculture* by subcategories as well as the contribution to the overall inventory emissions. Important sub- sectors are *4 A Enteric Fermentation* (3.7%) and *4 D Agricultural Soils* (3.3%) followed by *4 B Manure Management* (1.9%).

Table 117: Total GHG emissions (CO2 equivalent) and trend 1990 - 2001 by subcategories of Agriculture

Sector	GHG emissions [Gg CO_2 equivalent]												Share in Austrian Total 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
4	**8 142**	**8 495**	**7 411**	**8 070**	**8 619**	**8 148**	**7 867**	**8 159**	**7 876**	**7 764**	**7 680**	**7 602**	**8.9%**	**-6.6%**
4 A	3 555	3 507	3 353	3 354	3 343	3 348	3 309	3 265	3 254	3 229	3 196	3 150	3.7%	-11.4%
4 B	1 615	1 592	1 549	1 740	1 737	1 735	1 707	1 704	1 716	1 655	1 619	1 618	1.9%	0.2%
4 D	2 970	3 394	2 506	2 973	3 535	3 062	2 848	3 188	2 903	2 877	2 862	2 831	3.3%	-4.7%
4 F	3	3	3	3	3	3	3	3	3	3	3	3	0.0%	-2.2%

As can be seen in Figure 28 and Table 117 the trend concerning emissions from all categories is falling with exception of *4 B Manure Management* with slightly increasing emissions. Category *4 A Enteric Fermentation* had the strongest negative trend with minus 11.4%. 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). Fluctuations of emissions from *4 D Agricultural Soils* are mainly due to a decrease of the underlying activity data (sales numbers of mineral fertilizers).

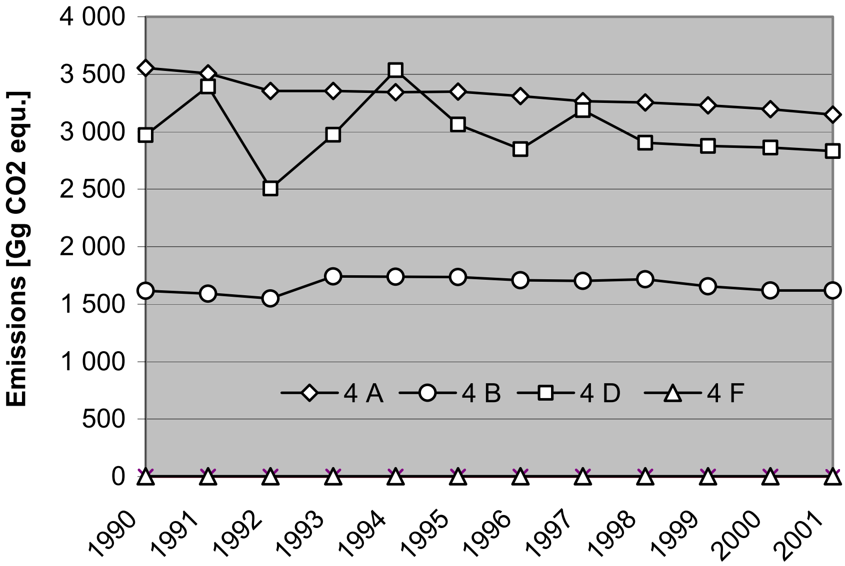


Figure 28: Emission trends of sub- sectors of Agriculture

As can be seen in Table 118, 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 (0.04% in 2001).

Table 118: Total greenhouse gas emissions and share of subcategories of Agriculture, 1990 and 2001

	GHG Emissions [%]	
	1990	2001
4 AGRICULTURE	**100.00%**	**100.00%**
4 A Enteric Fermentation	43.66%	41.44%
4 B Manure Management	19.83%	21.29%
4 D Agricultural Soils	36.47%	37.24%
4 F Field Burning Of Agricultural Wastes	0.03%	0.04%

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 119.

Compared to last years key source analysis additionally N_2O from 4 B 1 and CH_4 from 4 B 8 has become a key source due to recalculations (see subchapter Recalculations). CH_4 emissions from *Agricultural Soils* was a key source last year but this year no methane emissions were reported for this category (see Chapter 6.2.4).

Table 119: 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	BY, all LA, TA 91, 01
4 B 1	Cattle	CH_4	BY, all LA, TA 91, 95, 97, 01
4 B 8	Swine	CH_4	LA 90, LA 92 – 01, TA 93 - 98
4 D	Agricultural Soils	N_2O	all except TA 95, 97

* LA 90 = Level Assessment 1990
LA 90 - 01 = Level Assessment 1990 - 2001
TA 90 = Trend Assessment 1990

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 estimating emissions of category *4 F Field Burning of Agricultural Wastes* CORINAIR simple methodology was used.

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 120 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 120: 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]	--
4B1a	Dairy Cattle			+/- 65%[1]	- 50% to + 100%[2]
4B1b	Non-dairy Cattle			+/- 75%[1]	- 50% to + 100%[2]
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 158)
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

New methods caused different values in comparison to the 2002 submission. More details are given in the "recalculation" chapter of each sub- sector. The changes were made taking fully into account the comments of the ERT (see the reports on the Centralized[15] Review 2001, general comment paragraph 150 and the In-Country Review 2001[16], general comment paragraph 175).

Most of the results were provided as studies by scientific institutes. The following reports have been prepared:

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

As these studies are not published, a detailed description of the applied methods is given in the NIR.

---

[15] http://unfccc.int/resource/webdocs/iri(3)/2001/aut.pdf

[16] http://unfccc.int/resource/webdocs/iri(2)/2001/aut.pdf

6.1.7 Completeness

Table 121 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 121: 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**	✓	**NO**
4 A 1	Cattle	--	--	✓	NO
4 A 1 a	Dairy Cattle	100401	Dairy cows	✓	NO
4 A 1 b	Non- Dairy Cattle	100402	Other cattle	✓	NO
4 A 2	Buffalo	100414	Buffalos	NO	NO
4 A 3	Sheep	100403	Ovines	✓	NO
4 A 4	Goats	100407	Goats	✓	NO
4 A 5	Camels and Lamas	100413	Camels	✓	NO
4 A 6	Horses	100405	Horses	✓	NO
4 A 7	Mules and Asses	100406	Mules and asses	IE(1)	NO
4 A 8	Swine	100404	Fattening pigs	✓	NO
4 A 9	Poultry	100408 100410	Laying hens Other poultry (ducks, gooses, etc.)	NE	NO
4 A 10	Other	100411 100415	Fur Animals Other animals	NE	NO
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	✓	✓
4 B 3	Sheep	100505	Ovines	✓	✓
4 B 4	Goats	100511	Goats	✓	✓
4 B 5	Camels and Lamas	100513	Camels	✓	✓
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 100509	Laying hens Other poultry (ducks, gooses,…)	✓	✓
4 B 10	Anaerobic	100901	Anaerobic	NO	NO

IPCC Category		SNAP		CH_4	N_2O
4 B 11	Liquid Systems	100902	Liquid Systems	NO	✓
4 B 12	Solid Storage and Dry Lot	100903	Solid Storage and Dry Lot	NO	IE(3)
4 B 13	Other	100904	Other management	NO	IE(3)
4 B 13	Other	100510	Fur animals	NO	IE(3)
4 B 13	Other	100915	Other animals	NO	IE(3)
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	100205 100206	Grassland Fallows	NO	✓
4 D 2	Animal Production	--	--	NO	✓
4 D 3	Indirect Emissions	--	--	NO	✓
4 D 4	Other	--	--	NO	NO
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
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
(3) included in categories *4 B 1 – 4 B 9*

Emissions from *4 A 9 Poultry* and *4 A 10 Other* were not estimated because no default emission factors are provided in the IPCC Guidelines.

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 by *Enteric Fermentation*. In 2001 78% of the agricultural CH_4 emissions were caused by this source category.

6.2.1 Source Category Description

CH_4 emissions amounted to 169.3 Gg in the "Kyoto" base year and have decreased by 11% to 150 000 in 2001. Almost all emissions (95% in 1990 and 94% in 2001) are caused by cattle farming. The contribution of *Dairy Cattle* to all emissions from cattle decreased from 49% in 1990 to 43% in 2001.

Table 122: Greenhouse gas emissions from Enteric Fermentation by sub categories 1990-2001

Livestock Category	CH_4 emissions [Gg]												Share 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
4 A (TOTAL)	**169.3**	**167.0**	**159.7**	**159.7**	**159.2**	**159.4**	**157.6**	**155.5**	**155.0**	**153.8**	**152.2**	**150.0**	**100%**	**-11.4%**
4 A 1a Dairy	79.76	77.55	74.81	73.90	72.56	64.48	64.81	68.10	70.10	68.28	61.77	60.47	40.3%	-24.2%
4 A 1 b Non Dairy	80.43	80.12	75.49	76.00	76.85	84.90	82.65	77.17	74.62	75.77	80.93	79.97	53.3%	-0.6%
4 A 3 Sheep	2.48	2.61	2.50	2.67	2.74	2.92	3.05	3.07	2.89	2.82	2.71	2.56	1.7%	3.4%
4 A 4 Goats	0.19	0.20	0.20	0.24	0.25	0.27	0.27	0.29	0.27	0.29	0.28	0.30	0.2%	59.2%
4 A 6 Horses	0.89	1.04	1.11	1.17	1.20	1.30	1.32	1.34	1.36	1.47	1.49	1.53	1.0%	72.8%
4 A 8 Swine	5.53	5.46	5.58	5.73	5.59	5.56	5.50	5.52	5.72	5.15	5.02	5.16	3.4%	-6.7%

The overall reduction is caused mainly by a decrease in the 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 subcategories.

The IPCC doesn't provide methodologies for the categories *Poultry* and *Other Animals*. Emissions from these categories were not estimated.

Activity data

The Austrian official statistics [STATISTIK AUSTRIA, 2001] provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year. The activity data used is presented in the following table. The inherent uncertainty is estimated to be about 5% [FREIBAUER & KALTSCHMITT, 2001].

Table 123: Domestic livestock population and its trend 1990-2001

IPCC Categories	Population size [1000 heads] *												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Dairy	905	876	842	828	810	706	698	720	729	698	621	598	-33.9%
Non dairy	1 679	1 658	1 559	1 421	1 519	1 619	1 574	1 478	1 443	1 455	1 534	1 520	-9.5%
Mother Cows (suckling cows >2yr)	47	57	60	69	90	210	212	171	154	177	253	258	448.9%
Cattle > 2yr	146	151	145	158	149	153	154	162	157	159	160	148	1.4%
Young Cattle <1yr	925	894	832	706	707	691	670	630	635	631	655	659	-28.8%
Young Cattle 1-2yr	561	555	521	573	573	564	537	514	496	488	466	455	-18.9%
Sheep	310	326	312	334	342	365	381	384	361	352	339	320	3.4%
Horses	49	58	61	65	67	72	73	74	75	82	83	85	72.8%
Swine	3 688	3 638	3 720	3 820	3 729	3 706	3 664	3 680	3 810	3 433	3 348	3 440	-6.7%
Fattening Pig >50kg	534	525	547	1 355	1 323	1 312	1 262	1 268	1 375	1 251	1 212	1 264	n.a.
Swine for breeding > 50kg	372	364	375	396	395	401	399	398	386	344	334	350	-5.9%
Young Swine <50kg	2 784	2 749	2 798	2 069	2 011	1 992	2 003	2 013	2 049	1 838	1 802	1 826	n.a.
Poultry	13 821	14 397	13 684	14 508	14 179	13 959	12 980	14 760	14 307	14 498	11 787	12 572	-9.0%
Chicken	13 139	13 479	12 872	13 589	13 266	13 157	12 215	13 950	13 540	13 798	11 077	11 905	-9.4%
Other Poultry	682	918	812	920	913	802	765	811	767	700	709	666	-2.0%
Other	0	0	0	37	38	40	42	56	50	39	38	0	0

* Differences to totals are due to rounding
n.a.: not applicable because counting methodology changed in the time period from 1990-2001

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. For swine the time series of population size of the sub categories are not consistent as a change in the counting methodology occurred in 1993. However, this sub category data for swine is not used for estimating emissions.

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). Furthermore, in 1993 for the first time there was a collection of wild animals in enclosures.

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 and reliable.

Information about the extent of organic farming in Austria was provided in the Austrian INVEKOS[17] 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 STAT 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 1980-1996) 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 124 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.

[17] INVEKOS (**In**tegriertes **Ve**rwaltungs- und **Ko**ntrollsystem*, 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.

Table 124: 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%
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 2001 emissions from *Enteric Fermentation - Cattle* contributed 3.43% to total greenhouse gas emissions in Austria.

CH_4 Emissions were calculated using the IPCC Tier 2 method. Activity data were obtained from national statistics and are presented in Table 123.

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).

$$EF = (GE * Y_m * 365\ days/yr) / 55.65\ \text{MJ/kg}$$

<u>Y_m *Methane conversion rate*</u>

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 when applying 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 125).

Table 125: 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
Gross energy intake [MJ GE day^{-1}]	214.96	227.63	240.22	252.75

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 127. For dairy cattle there was a ~15% increase of GE intake between 1990 and 2001 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[18] worked out animal diets as shown in Table 126. 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 1980-2001, methane emissions from enteric fermentation of *Non-Dairy Cattle* are calculated with a constant gross energy intake for the whole time series.

[18] Dr. Andreas Steinwidder, head of department animal production of the Federal Research Institute for Agriculture in Alpine Regions (BAL Gumpenstein)

Table 126: 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 20 % hay 30 % grass silage	15 % green feeding 20 % hay 30 % grass silage 35 % maize silage	20 % green feeding 15 % hay 30 % grass silage 35 % maize silage	40 % green feeding 20 % hay 30 % grass 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 20 % hay 30 % grass silage	35 % green feeding 20 % hay 45 % grass silage	40 % green feeding 15 % hay 45 % grass silage	40 % green feeding 15 % hay 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 127: Annual milk yield, Gross Energy Intake and Emission Factors of Dairy Cattle 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Milk Yield [kg/cow*yr]	3791	3848	3907	3991	4076	4217	4346	4510	4548	4716	4977	5200
Gross Energy Intake [MJ GE/head*day]	224	225	226	227	228	232	236	240	244	249	253	257
Emission Factor [kg CH4/head*yr]	88	89	89	89	90	91	93	95	96	98	100	101

Table 128: Emission Factors and Gross Energy Intake of Non- Dairy Cattle 1990-2001

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) and Swine (4 A 8)

Key Source: No

As presented in Table 122, CH_4 emissions from *Sheep, Goats, Horses* and *Swine* are only minor emission sources of category *4 A Enteric Fermentation*. Together they contributed 5% to total emissions from this category in 2001. The most important sub source is *Swine*, with a contribution of 2.7%, followed by *Sheep* (1.3%), *Horses* (0.8%) and finally *Goats* with 0.2% (figures are also presented in Table 122).

Emissions from this category were estimated using the IPCC Tier 1 methodology. Default emission factors were taken from the IPCC Guidelines and are presented in the following table:

Table 129: 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	8	4 A 6 Horses	18
4 A 4 Goats	5	4 A 8 Swine	1.5

* Source: IPCC Reference Manual p.4.10

Activity data were obtained from national statistics and are presented in Table 123. For all swine categories an emission factor of 1.5 kg/head*yr was used.

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, i.e. between 153 Gg and 178 Gg in the year 1990 and between 138 Gg and 162 Gg in the year 2001.

The Monte Carlo uncertainty method used has the advantage, compared to the default propagation method, that it produces better results if the uncertainty is in a higher range [WINIWARTER & ORTHOFER, 2000].

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 130: Uncertainties of emission estimates for Enteric Fermentation (mean values for 1990-2001).

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
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

IPCC Category	Farming Type	Standard deviation (σ) in %
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 130 presents the standard deviations for CH_4 emissions from animal categories. The uncertainty is defined as +/- 2 σ.

6.2.4 Recalculations

Last year's submission was compiled using CORINAIR default EF's, the methodology used was not in line with the IPCC GPG as *4 A 1 Cattle* is a key source and only a simple methodology was used to estimate emissions (also see [ICR 2001], paragraph 201).

This year emissions were calculated according to IPCC guidelines. The IPCC Tier 2 methodology was applied for *Cattle* which is a key source. Specific emission factors that are calculated from the energy intake for different cattle farming practices are used. The less detailed Tier 1 methodology was applied for all other animal categories. Emissions from organic and conventional farming practices were calculated separately.

For *Swine* now the whole swine population was considered, whereas in last year's estimate 'young swine < 20kg' was not considered. For *Horses* the activity value for 2000 was updated.

Table 131: Difference to last year's submission of CH_4 emissions from subcategories of Category 4 A

IPCC Category	**[Gg CH_4]**										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4A ENTERIC FERMENTATION	14.86	15.73	15.36	18.00	18.64	24.27	24.89	24.28	24.30	25.86	28.56
4A1 Cattle	13.16	14.06	13.63	16.50	17.19	22.85	23.46	22.85	22.85	24.56	27.26
4A1a Dairy Cattle	-3.46	-3.06	-2.62	-2.28	-1.96	-0.52	0.64	1.82	3.06	4.08	4.64
4A1b Non-Dairy Cattle	16.62	17.12	16.26	18.78	19.15	23.37	22.82	21.03	19.79	20.49	22.62
4A6 Horses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
4A8 Swine	1.70	1.67	1.72	1.50	1.45	1.42	1.43	1.43	1.45	1.29	1.28

Due to the recalculations, CH_4 emissions from *Enteric Fermentation* are now significantly higher, where the increase is not consistent over the time series as in the new methodology the increase of the milk yield of dairy cattle was considered. Thus emissions in the base year are 10% higher whereas in the year 2000 they are 23% higher.

6.2.5 Planned Improvements

A new time series for milk yield (1995-2001) was issued by STATISTIK AUSTRIA. These values will be considered in the submission 2004.

6.3 Manure Management (CRF Source Category 4 B)

This chapter describes the estimation of CH_4 and N_2O emissions by animal manure. In 2001 22% of the agricultural CH_4 emissions and 20% of the agricultural N_2O emissions were caused by this source category.

6.3.1 Source Category Description

From 1990 to 2001 the CH_4 emissions from Manure Management increased by 4.9% to 43.31 Gg. This is mainly because of the increase of the livestock of swine.

Table 132: CH_4 Emissions from Manure Management 1990-2001

Livestock Category	CH_4 emissions [Gg]												Share 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
4 B (TOTAL)	**41.29**	**40.63**	**39.94**	**47.00**	**47.03**	**46.67**	**45.85**	**45.90**	**46.50**	**44.10**	**42.88**	**43.31**	**100%**	**4.9%**
4 B 1a Dairy	15.76	15.26	14.71	14.51	14.23	12.51	12.49	13.00	13.29	12.83	11.54	11.23	25.9%	-28.8%
4 B 1 b Non Dairy	10.27	10.29	9.74	9.11	9.75	11.05	10.85	10.21	9.88	10.11	10.98	10.80	24.9%	5.2%
4 B 3 Sheep	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0. 06	0.1%	3.4%
4 B 4 Goats	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.04%	59.2%
4 B 6 Horses	0.07	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.12	0.12	0.3%	72.8%
4 B 8 Swine	14.05	13.81	14.28	22.08	21.77	21.83	21.31	21.35	22.02	19.84	19.25	20.12	46.5%	43.2%
4 B 9 Poultry	1.08	1.12	1.07	1.13	1.11	1.09	1.01	1.15	1.12	1.13	0.92	0.98	2.3%	-9.0%
4 B 13 Other	0	0	0	0. 01	0.01	0. 01	0.01	0.01	0.01	0.01	0.01	0	0%	--

From 1990 to 2001 the N_2O emissions from *Manure Management* decreased by 5.2% to 2.29 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 133: N_2O Emissions from Manure Management 1990-2001

Livestock Category	N_2O emissions [Gg]												Share 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
4 B (TOTAL)	**2.41**	**2.38**	**2.29**	**2.43**	**2.42**	**2.44**	**2.40**	**2.39**	**2.39**	**2.35**	**2.32**	**2.29**	**100%**	**-5.2%**
Dairy Cattle	1.13	1.09	1.05	1.04	1.02	0.91	0.91	0.96	0.99	0.96	0.87	0.84	36.8%	-25.4%
Non-Dairy Cattle	1.01	1.01	0.95	0.97	0.99	1.12	1.09	1.02	0.98	1.00	1.08	1.07	46.7%	6.2%
Sheep	0.0093	0.0097	0.0093	0.0100	0.0102	0.0109	0.0114	0.0115	0.0108	0.0105	0.0101	0.0096	0.4%	3.4%
Goats	0.0002	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0004	0.0004	0.03%	59.2%

Livestock Category	N_2O emissions [Gg]												Share 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
Horses	0.0008	0.0009	0.0010	0.0010	0.0010	0.0011	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.1%	72.8%
Swine	0.18	0.18	0.19	0.31	0.31	0.31	0.30	0.30	0.31	0.28	0.28	0.29	12.6%	56.0%
Poultry	0.08	0.09	0.08	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.07	0.08	3.4%	-8.6%

6.3.2 Methodological Issues

The Austrian inventory uses the IPPC-Tier 2 methodology to estimate CH_4 emissions from manure management of cattle and swine manure 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, 2001] provides national data of annual livestock numbers on a very detailed level (see Table 123). 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 include 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

6.3.2.1.1 Cattle (4 B 1)

Key Source: Yes (CH_4 level 0.54%, N_2O level 0.69%)

B0i 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 IPCC default MCF values for "cool climate regions" presented in IPCC Guidelines' Reference Manual (table 4-8) were used. IPCC had revised the methane conversion factor (MCF) for liquid systems from 10% to 39%. The 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]. The survey was carried out from 1989 to 1992 and was first published in 1992 (Table 134). Following expert judgements a differentiation between conventional and organic systems would be connected with very high uncertainties. Thus, Austria's manure management systems distribution is estimated with data collected by [KONRAD, 1995] for the whole period of 1990-2001.

Table 134: 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 134). 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].

The average gross energy intake of Austrian dairy cattle was calculated from the average milk yield of Austrian cows like presented in the study mentioned above.

[GRUBER & STEINWIDDER 1996] calculated manure production of *Diary Cattle* dependent from the annual milk yield. Using this information a time series of manure production was calculated from the average annual milk yields of Austrian dairy cattle.

The VS content of 75 kg/ t manure was taken from [SCHECHTNER, 1991]. VS content in the manure multiplied by manure production gives Austrian specific values for VS excretion per dairy cow and day (Table 135, Table 137, Table 139).

Table 135: Examples for calculation of VS excretion of Austrian dairy cows

Year	milk yield[1] [kg cow^{-1} $year^{-1}$]	manure production[2] [t cow^{-1} yr^{-1}]	VS content in manure[3] [kg (t $manure)^{-1}$]	VS excretion [kg cow^{-1} day^{-1}]
1980	3 518	17.18	75	3.53
1994	4 076	17.75	75	3.65
1997	4 510	18.26	75	3.75
2000	4 977	18.78	75	3.86

1)….BMLuF 2001
2)…calculated after Gruber & Steinwidder 1996
3)…after Schechtner 1991

VS excretion of Austrian diary cows for the period 1990-2001 were calculated like presented above using the time series of average annual milk yields of Austrian dairy cattle.

Table 136:VS excretion of Austrian diary cows for the period 1990-2001

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Milk Yield [kg/cow*yr]	3 791	3 848	3 907	3 991	4 076	4 217	4 346	4 510	4 548	4 716	4 977	5 200
VS	3.62	3.62	3.63	3.64	3.65	3.68	3.72	3.75	3.79	3.82	3.86	3.90

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 differentiate between organic and conventional production systems. Nutrition expert Dr. Steinwidder worked out country-specific feed rations under organic and conventional management (see Table 126). As no major changes in diets of *Non-Dairy Cattle* occurred in the period from 1990-2001, 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:

$$VS\ [kg\ dm\ day^{-1}] = Intake\ [MJ\ day^{-1}] * (1kg\ (18.45\ MJ)^{-1}) * (1 - DE\%/100) * (1- ASH\%/100)$$

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 137 presents data for the calculation of VS excretion of the livestock categories *Non-Dairy Cattle*.

Table 137: 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%.

6.3.2.1.2 Swine (4 B 8)

Key Source: Yes (CH_4, level assessment for 2001 0.49%)

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 138: 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]	---
nursery and growing pigs	81.38[1]	18.62[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. As already mentioned above, 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].

Table 139. 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

6.3.2.1.3 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 very limited data availability.

Default emission factors were taken from the IPCC guidelines (Table 4-5 of the reference manual). Default emission factors are multiplied with annual livestock populations in Austria to estimate CH_4 emissions from these sources.

Table 140: 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	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* (1.39 kg CH_4 per head per year).

6.3.2.2 Estimation of N_2O Emissions

All emissions of N_2O taking place before the manure is added to soils are to be 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 134 and Table 138).

N excretion

For *Goats, Sheep, Horses, Chicken, Other Poultry* and *Other Animal* default values for N excretion was 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 141).

Table 141: N excretion of Austrian dairy cows for the period 1990-2001

Year	Milk yield *[kg yr^{-1}]*	Nitrogen excretion *[kg/animal/yr]*	Year	Milk yield *[kg yr^{-1}]*	Nitrogen excretion *[kg/animal/yr]*
1990	3 791[1]	55.59	1996	4 346[1]	58.37
1991	3 848[2]	55.74	1997	4 510[1]	59.45
1992	3 907[1]	55.89	1998	4 548[1]	60.53
1993	3 991[1]	56.05	1999	4 716[1]	61.62
1994	4 076[1]	56.20	2000	4 977[1]	62.70
1995	4 217[1]	57.28	2001	5 252[3]	62.75

[1] BMLuF 2001
[2] BMLuF 1992
[3] extrapolated

N excretion rates for the livestock categories of *Non-Dairy Cattle* were derived from different sources (Table 142). 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 142).

Table 142: 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[6]
Other Poultry	2.0[7]
Other Animals	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 DEFAULT
(7) CORINAIR

Livestock numbers per category can be found in Table 123, manure management system distribution for cattle and swine can be found in Table 134 and Table 138. For the other categories it is presented in the following table (Table 143).

Table 143: 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 Man-agement Sys-tem [%]
Sheep	2	0	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 144. 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 120.

6.3.4 Recalculations

CH_4

For last year's calculations country specific emission factors were used. In correspondence to the issues raised by the ERT (e.g. paragraphs 175 to 177 of report on the Centralized Review 2001 [CR 2001]) a new methodology has been applied. For *Cattle* and *Swine* the Tier 2 methodology to estimate CH_4 emissions was used as these are key sources. *Sheep, Goats, Horses* and *Other Soliped, Chicken, Other Poultry* and *Other Animals* are no key sources in Austria. CH_4 emissions from *Manure Management* of these livestock categories are estimated with the Tier 1 approach using IPCC default emission factors.

Due to the recalculations CH_4 emissions from *Manure Management* (4 B) are significantly higher. In the base year 1990 by 50% and in 2000 by 79%. Emissions from the sub categories *Sheep, Goats, Horses* and *Poultry* are constantly lower (13-15%) compared to emission estimates applying the previously used country specific emission factors. For the key sources *Cattle* and *Swine*, where now a more detailed methodology has been applied, emissions are higher: for *Cattle* emissions increased by 72% in 1990 and by 88% in 2000 as now the increase of the milk yield for dairy cattle was considered. For *Swine* now the whole swine population was considered, whereas in last year's estimate 'young swine < 20kg' was not considered. The increase reason for a very different recalculation difference over the time series (28% in 1990 and 79% in 2000) is due to an inconsistency in the time series of swine population, the counting system for the subcategories of swine changed in 1992/1993 (see Chapter 6.2.2/ Activity Data) and the applied emission factors for the subcategories are significantly different.

Table 145: 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
4B MANURE MANAGEMENT	13.82	13.56	13.46	19.69	20.10	20.23	19.98	20.01	20.22	19.20	18.88
4B1 Cattle	10.94	10.80	10.42	9.94	10.41	10.46	10.51	10.60	10.64	10.62	10.53
4B1a Dairy	7.89	7.64	7.38	7.31	7.18	6.37	6.42	6.74	6.95	6.76	6.14
4B1b Non- Dairy	3.04	3.16	3.04	2.63	3.22	4.08	4.08	3.85	3.68	3.85	4.38
4B3 Sheep	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
4B6 Horses	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
4B8 Swine	3.07	2.96	3.22	9.95	9.89	9.97	9.66	9.62	9.79	8.79	8.52
4B9 Poultry	-0.17	-0.17	-0.16	-0.17	-0.17	-0.17	-0.16	-0.18	-0.18	-0.17	-0.14
4B13 Other	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

N_2O

N_2O emissions from *Manure Management* were not reported in last year's submission. In the report on the In- Country Review 2001 ([ICR 2001], paragraphs 189 and 203) the ERT encouraged Austria to estimate these emissions.

For the estimation of N_2O emissions from manure management systems a Tier 1 approach has been used. 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 – CS where available) 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.

Table 146: 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
4B MANURE MANAGEMENT	2.41	2.38	2.29	2.43	2.42	2.44	2.40	2.39	2.39	2.35	2.32
Cattle	2.13	2.10	2.01	2.01	2.01	2.03	2.01	1.98	1.97	1.97	1.96
Dairy	1.13	1.09	1.05	1.04	1.02	0.91	0.91	0.96	0.99	0.96	0.87
Non-Dairy	1.01	1.01	0.95	0.97	0.99	1.12	1.09	1.02	0.98	1.00	1.08
Sheep	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Swine	0.18	0.18	0.19	0.31	0.31	0.31	0.30	0.30	0.31	0.28	0.28
Poultry	0.08	0.09	0.08	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.07

6.3.5 Planned Improvements

Studies on Austria's distribution of manure management systems are planned.

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 (see Table 119).

80% of total N_2O emissions from *Agriculture* (59% 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 3.3% (11.42 Gg) to Austria's total greenhouse gas emissions in the year 2001. This is 37% of total GHG emissions of the sector *Agriculture*.

The trend of N_2O emissions from this category is decreasing: in 2001 emissions were 4.7% below 1990 levels.

Table 147 presents N_2O emissions of *Agricultural Soils* by subcategory as well as their trends and their share in total N_2O emissions.

Table 147: Greenhouse gas emissions from Category 4 D, 1990-2001

Source	N_2O emissions [Gg]												Share 2001	Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
4 D total	**9.58**	**10.95**	**8.08**	**9.59**	**11.40**	**9.88**	**9.19**	**10.28**	**9.36**	**9.28**	**9.23**	**9.13**	**100%**	**-4.7%**
4 D 1 Direct Soil Emissions	**5.30**	**6.16**	**4.46**	**5.30**	**6.46**	**5.48**	**5.00**	**5.69**	**5.18**	**5.13**	**5.07**	**5.04**	**55.2%**	**-5.0%**
Synth. Fertilizers	2.68	3.45	1.74	2.36	3.39	2.44	2.15	2.74	2.16	2.16	2.30	2.30	25.2%	-14.5%
Animal Waste applied to soils	1.84	1.84	1.78	1.99	1.98	1.99	1.97	1.98	1.97	1.93	1.88	1.85	20.3%	0.9%
N- fixing Crops	0.33	0.36	0.46	0.45	0.45	0.32	0.34	0.40	0.43	0.39	0.37	0.36	3.9%	10.0%
Crop Residue	0.43	0.48	0.46	0.47	0.61	0.69	0.51	0.53	0.58	0.61	0.48	0.49	5.4%	14.7%
Sewage Sludge	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.3%	37.5%
4 D 2 An. Prod. Grazing animals	**0.64**	**0.66**	**0.64**	**0.70**	**0.72**	**0.74**	**0.74**	**0.75**	**0.73**	**0.73**	**0.71**	**0.67**	**7.3%**	**4.7%**
4 D 3 Indirect Soil Emissions	**3.63**	**4.13**	**2.98**	**3.59**	**4.23**	**3.66**	**3.45**	**3.84**	**3.46**	**3.42**	**3.46**	**3.42**	**37.5%**	**-5.8%**
Athm. Deposition	0.38	0.39	0.35	0.40	0.41	0.40	0.39	0.40	0.39	0.39	0.38	0.38	4.2%	-0.8%
Nitrogen Leaching (and Run- off)	3.25	3.73	2.63	3.19	3.82	3.26	3.06	3.44	3.07	3.04	3.08	3.04	33.3%	-6.4%

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 148)

Table 148: Emissions Factors for Agricultural Soils

Category	Emission Factor [t N]	Source
Direct Soil Emissions		
Synthetic Fertilizers (mineral fert.)	0.0125	IPCC
Animal Waste applied to soils		
N- fixing Crops		
Crop Residue		
Sewage Sludge		
Animal Production Grazing animals	0.02/ t N_{exGRAZ}	IPCC
Indirect Soil Emissions		
Athmospheric Deposition	0.010/ t of volatized nitrogen	IPCC
Nitrogen Leaching (and Run- off)	0.0025/ t N- loss by leaching	IPCC

Activity Data

Data for necessary input parameters (activity data) were taken from the following sources:

Table 149: Data sources for nitrogen input to Agricultural Soils

Category	Data Sources
Direct Soil Emissions	
Synthetic Fertilizers (mineral fert.)	fertilizer consumption: [ELECTRONIC DATA HANDBOOK, 2001]; urea application in Austria: Sales data RWA, 2002(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: [GRÜNER BERICHT, 1999](1) , Land use [ha]: Ministerial Reports, [ELECTRONIC DATA HANDBOOK, 2001]
Crop Residue	Harvested amount of different agricultural crops: [ELECTRONIC DATA HANDBOOK, 2001]
Sewage Sludge	Water Quality Report 2000 [PHILIPPITSCH ET AL., 2001] and Re-port on sewage sludge [SCHARF ET AL., 1997]
Animal Production Grazing animals	calculations and expert judgement by Dr. Barbara Amon following [GRUBER & STEINWIDDER, 1996]
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)

1 http://www.awi.bmlf.gv.at (Bundesanstalt für Agrarwirtschaft des BMLFUF)

2 RWA: Raiffeisen Ware Austria

Detailed data about the use of different kinds of fertilizer 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 time series for fertilizer consumption is presented in Table 150. From the different synthetic nitrogen or combined fertilizers applied in Austria, only between 2 and 6% are urea fertilizers.

Table 150: Mineral fertiliser N consumption in Austria 1990-2001

Year	Nutrient Consumption [t N/yr]	of which Urea	Fraction Urea from total N fertiliser consumption [%]	Data Source
1990	140 379	3 965	2.8	estimated, GB[1]
1991	180 388	3 965	2.2	GB
1992	91 154	3 886	4.3	GB
1993	123 634	3 478	2.8	GB
1994	177 266	4 917	2.9	GB
1995	127 963	5 198	4.1	RWA[2]
1996	112 641	4 600	4.1	RWA
1997	143 818	6 440	4.5	RWA
1998	113 301	6 440	5.7	RWA
1999	113 409	6 808	6.0	RWA
2000	120 541	6 900	5.7	RWA
2001	120 541	6 900	5.7	RWA

1 [GRÜNER BERICHT, 1999]
2 Raiffeisen Ware Austria, sales company

The yearly numbers of the legume cropping areas were taken from official statistics [GRÜNER BERICHT, 1999].

Table 151: Cropped area legume production, 1990-2001

Areas [ha]												
Legume	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
peas	40 619	37 880	43 706	44 028	38 839	19 133	30 782	50 913	58 637	46 007	41 114	38 567
soja beans	9 271	14 733	52 795	54 064	46 632	13 669	13 315	15 217	20 031	18 541	15 537	16 336
horse/field beans	13 131	14 377	14 014	1 064	10 081	6 886	4 574	2 783	2 043	2 333	2 952	2 952
clover hey, lucerne,..	57 875	65 467	64 379	68 124	72 388	71 024	72 052	75 976	76 245	75 028	74 266	72 196

Harvest data were taken from [GRÜNER BERICHT, 2001], partly adopted from [JONAS & NIELSEN, 2002] and are presented in Table 152.

Table 152: Harvest Data, 1990-2001

Harvest [1000 t]												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
corn	5 290	5 045	4 323	4 206	4 436	4 452	4 493	5 009	4 771	4 806	4 490	4 708
wheat	1 404	1 375	1 325	1 018	1 255	1 301	1 240	1 352	1 342	1 416	1 313	1 508
rye	396	350	278	292	319	314	156	207	236	218	183	214
barley	1 521	1 427	1 342	1 100	1 184	1 065	1 083	1 258	1 212	1 153	855	1 012
oats	244	226	185	191	172	162	153	197	164	152	118	128
maize (corn)	1 620	1 571	1 118	1 524	1 421	1 474	1 736	1 842	1 646	1 700	1 852	1 652
potato	794	790	738	886	594	724	769	677	647	712	695	668
sugar beet	2 494	2 522	2 605	2 994	2 561	2 886	3 131	3 012	3 314	3 217	2 634	2 912
fodder beet	171	173	119	129	103	85	62	59	72	70	47	47
silo- green maize	4 289	4 252	3 523	4 220	4 152	3 996	3 918	3 940	3 865	3 729	3 531	3 531
clover-hey	717	797	587	628	743	823	858	962	1 014	1 025		1 025
rape	102	128	126	125	217	268	121	129	128	193	125	125
sunflower	57	72	79	104	92	61	44	44	57	64	54	54
soja bean	18	37	81	103	105	31	27	34	51	50	33	33
horse- /fodderbean	41	37	31	29	27	17	10	6	5	6	7	7
peas	145	133	137	107	134	60	93	162	178	140	97	97
vegetables	273	277	227	230	246	302	297	349	313	399	361	392
oil pumpkin	3	4	4	3	3	5	8	8	11	6	6	6

Data about the annual amount of sewage sludge produced and agriculturally applied were taken from [PHILIPPITSCH ET AL., 2001] and [SCHARF ET AL., 1997]. Data were reported for 1991, 1993, 1995 and 1998; for the years 1992 and 1994 interpolated values were used, whereas for the years 1996, 1997, 1999–2001 the value of the year before or for 1990 the value of the year after was used.

Table 153: Amount of sewage sludge (dry matter) produced in Austria, 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
produced [t dm]	161 936	161 936	200 000	300 000	350 000	390 500	390 500	390 500	392 909	392 909	392 909	392 909
agriculturally applied [t dm]	31 507	31 507	30 000	45 000	38 500	42 955	42 955	42 955	43 220	43 220	43 220	43 220
agriculturally applied [%]	19.5	19.5	15	15	11	11	11	11	11	11	11	11

6.4.2.1 Direct Soil Emissions (4 D 1)

Direct Soil Emissions is the most important subcategory of *4 D Agricultural Soils*. 55.2% (5.04 Gg in 2001) of emissions of *Agricultural Soils* arise from this subcategory (see Table 147).

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.

The following sub- sources were considered:

- 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
- Application of sewage sludge on agricultural soils

Nitrogen input from all sources was added and the direct N_2O emissions from agricultural soils 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 of nitrogen input from these sources are 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 on 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.

6.4.2.1.1 Nitrogen input through application of mineral fertilizers

The method applied for calculation of the emissions is IPCC Tier 1a (GPG, Equation 4.22), but with specific consideration of nitrogen that is lost during application ($Frac_{GASF}$).

$$F_{SN} = N_{FERT} * (1- Frac_{GASF})$$

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 150
$Frac_{GASF}$	=	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.

6.4.2.1.2 Nitrogen input through application of animal manure

The method applied for calculation of the emissions is IPCC Tier 1b, but with country-specific data and with specific consideration of nitrogen that is lost during application ($Frac_{GASF}$). 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.

$$F_{AW} = N_{exLFS} * (1 – Frac_{GASM})$$

F_{AW}	=	Nitrogen from animal waste that is left for spreading on agricultural soils annually [t N], corrected for losses occurring during manure management and NH_3/NO_x volatilisation lost during spreading of manure onto soils
N_{exLFS}	=	Annual amount of nitrogen in animal excreta left for spreading on agricultural soils, corrected for losses during manure management (This value was adopted from the calculations of the category *Manure Management*. It does not include nitrogen from grazing animals) [t N]
$Frac_{GASM}$	=	Fraction of nitrogen in excreted animal waste that is volatilised as NH_3 and NO_x during application to agricultural soils (=spreading) [t/t]

Frac$_{GASM}$

For Frac$_{GASM}$ the IPCC default value was not used (0.2). Instead, NH_3 volatilisation losses occurring during application of animal waste to agricultural soils were calculated following CORINAIR- EMEP methodology. For comparison reasons an equivalent loss fraction, derived as quotient between volatilisation losses (NH_3) and the nitrogen left for spreading, for 1990 yielded a value of 0.18. Adding 0.01 to account for NO_x losses, a similar figure (0.19) as recommended by IPCC methodology (0.20) was estimated for volatilisation losses during spreading of animal waste on agricultural lands. This confirms that consistency of calculations was not disturbed by the application of a more detailed emission calculation method.

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. In Table 154 the nitrogen left for spreading for the years 1990-2001 per animal type is presented. The data are based on calculations (Dr. Barbara Amon, university of agriculture after expert judgement [GRUBER & STEIWIDDER, 1996].

Table 154: Animal manure left for spreading on agricultural soils per animal category 1990-2001

Nitrogen left for spreading [tons N per year]												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
dairy cattle	40 892	39 705	38 254	37 745	37 015	32 907	33 107	34 825	35 868	34 970	31 662	30 364
suckling cows	1 852	2 258	2 382	2 729	3 544	8 288	8 376	6 715	6 075	6 957	9 954	10 149
cattle 1-2 a	18 366	18 190	17 065	18 763	18 771	18 482	17 599	16 849	16 249	15 991	15 277	14 924
cattle < 1 a	12 559	12 137	11 289	9 578	9 592	9 386	9 101	8 564	8 621	8 560	8 896	8 945
cattle > 2 a	7 442	7 691	7 418	8 035	7 568	7 785	7 829	8 224	8 007	8 106	8 128	7 533
sows	8 019	7 878	8 109	8 570	8 547	8 689	8 627	8 608	8 360	7 441	7 234	7 579
fattening pigs	6 447	6 338	6 609	16 366	15 978	15 848	15 244	15 323	16 605	15 104	14 636	15 267
chicken	8 083	8 292	7 919	8 360	8 161	8 094	7 515	8 582	8 330	8 488	6 815	7 324
other Poultry	1 054	1 420	1 255	1 422	1 412	1 240	1 182	1 254	1 186	1 083	1 097	1 030
sheep	6 137	6 458	6 178	6 611	6 775	7 233	7 542	7 597	7 145	6 976	6 718	6 346
goats	739	810	780	936	985	1 074	1 079	1 155	1 074	1 148	1 111	1 177
horses/soliped	2 342	2 752	2 923	3 091	3 178	3 451	3 487	3 531	3 587	3 884	3 952	4 047
other animals	0	0	0	735	747	798	822	1 114	997	774	762	0
total	**113932**	**113929**	**110181**	**122940**	**122274**	**123276**	**121510**	**122340**	**122104**	**119481**	**116242**	**114685**

6.4.2.1.3 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:

$$F_{BN} = LCA * B_{Fix} / 1000$$

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 1990-2001 can be found in Table 151.

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 Federal Environmental Agency [GÖTZ, 1998]; these values are constant over the time series.

6.4.2.1.4 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 152)
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 [GRÜNER BERICHT, 2001], partly adopted from [JONAS, 2002] and are presented in Table 152.

The other parameters used are presented in the following table:

Table 155: 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	0.0063
Rye	0.86	1.4	0.005	0.7	0.0063
Barley	0.86	1.1	0.005	0.7	0.0063
Oats	0.86	1.5	0.005	0.7	0.0063
Maize (corn)	0.50	1.4	0.005	0.0	0
Potato	0.30	0.3	0.005	0.0	0.0063
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

6.4.2.1.5 Nitrogen input through use of sewage sludge

The contribution of sewage sludge is very small. In 1990 nitrogen from sewage sludge contributed less than 0.5% of all nitrogen inputs to soils in Austria.

The estimation of annually applied sewage sludge is based on the figures reported in the Austrian water protection report [PHILIPPITSCH et al., 2001] which provides 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]
SsluN	=	Nitrogen content in dry matter [%] – 3.9%
$SSlu_{agric}$	=	Annual amount of sewage sludge agriculturally applied [t/t] - see Table 153

6.4.2.2 Animal Production (4 D 2)

According to IPCC, N_2O emissions that result from nitrogen input through excretions of grazing animals (directly dropped onto the soil) should be calculated under *Manure Management* but are reported under *Agricultural Soils*. The calculation procedure follows the IPCC guidelines.

$$F_{GRAZ} = N_{exGRAZ} * EF_{GRAZ}$$

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 156
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 156: Nitrogen excreted during grazing (N_{exGRAZ}) in Austria, 1990-2001

Nitrogen excreted during grazing [t N]											
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
20 487	21 119	20 451	22 339	22 743	23 580	23 639	23 857	23 161	23 087	22 584	21 449

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 calculation is based on the recommendations of the IPCC guidelines.

6.4.2.3.1 N_2O emissions through atmospheric nitrogen deposition

The calculation of the emissions according to IPCC guidelines was slightly adapted to the available input values. Instead of deriving the animal waste volatilisation losses from N_{ex} (total nitrogen produced in animal waste management systems), the sum of gaseous losses (NH_3 and NO_x emissions) derived from N_{lfs} (nitrogen left for spreading produced in all animal waste management systems except "pasture range & paddock") was used.

Thus the original formula from the IPCC guidebook:

$$F_{AD} = [(N_{FERT} * Frac_{GASF}) + (N_{ex} * Frac_{GASM})] * EF_{AD}$$

is adapted to:

$$F_{AD} = [(N_{FERT} * Frac_{GASF}) + (NH_3+NO_x \text{ from spreaded manure})] * EF_{AD}$$

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 150.
$Frac_{GASF}$	=	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 141, Table 142
$Frac_{GASM}$	=	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]

Ammonia emissions from animal waste application for Cattle and Swine were calculated using 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 154) is emitted as NO_X- N.

6.4.2.3.2 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 is:

$$E\text{-}N_2O_{LL} = (F_{FERT} + N_{exLFS} + N_{exGRAZ} + F_{SSlu}) * Frac_{LEACH} * EF\text{-}N_2O_{LL}$$

$E\text{-}N_2O_{LL}$	=	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 150
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 154
N_{exGRAZ}	=	Annual amount of animal manure nitrogen produced by grazing animals and directly dropped on agricultural soils during grazing [t N] – see Table 156
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 was calculated according to the formula presented in the subsection *Nitrogen input through the use of sewage sludge.*

Table 157: Annual nitrogen input from sewage sludge applied on agricultural soils (F_{SSlu}) in Austria, 1990-2001

Annual nitrogen input from sewage sludge applied on agricultural soils [t N]											
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1 229	1 229	1 170	1 755	1 502	1 654	1 675	1 675	1 686	1 686	1 686	1 686

6.4.3 Uncertainties

The uncertainties are presented in Table 158 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 158: Uncertainties of N_2O emissions from agricultural soils

Category	Uncertainty
Direct soil emissions	
Mineral fertilizer application	+/- 27%
Animal waste application	+/- 25%
Crop residues	+/- 25%
Biological N fixation	+/- 50%
Sewage sludge application	+/- 25%

Category	Uncertainty
Animal production	
Emissions from animal production (grazing)	+/- 58%
Indirect emissions	
Leaching	+/- 25%
Atmospheric deposition	+/- 57%
Total	**+/- 24%**

6.4.4 Recalculations

In last year's calculations Swiss EFs based on expert judgement without further background-information were used for calculating emissions from *Agricultural Soils (4 D)*. Emissions were calculated on level 1 (sector overview table) only. The submission 2003 includes for the first time data for the sub sector level. Therefore no comparison on the sub sector level can be presented.

The ERT noted that the previously applied methodology is not in line with the IPCC Guidelines (see paragraph 174 [ICR 2001]). Furthermore Austria has been encouraged to estimate also sub- sector emissions (paragraph 163 [ICR 2001] and 164 [CR 2001]).

In correspondence to the issues raised by the ERT now emissions were calculated according to the IPCC tier 1 method on sub sector level. Emission sources considered include direct emissions from nitrogen inputs to soils (mineral and organic fertilizers, crop residues, sewage sludge application, biological fixation) as well as indirect emissions (from atmospheric nitrogen deposition and nitrogen leaching) plus emissions from nitrogen input through grazing animal excreta.

As a result of the recalculation of N_2O emissions from Agricultural Soils, the emission reported this year are about three times higher than those reported in last year's submission. The recalculation difference is presented in the following table:

Table 159: Difference to submission 2002 of N_2O emissions from Category 4 D Agricultural Soils

IPCC Category	**[Gg N_2O]**										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4D AGRICULTURAL SOILS	6.28	7.63	4.76	6.26	8.11	6.62	5.92	7.02	6.13	6.08	6.05

Last year CH_4 emissions were reported from this category. This year these emissions were not reported anymore as in the IPCC and CORINAIR guidebook only rice paddies (and there are no rice paddies in Austria) are considered as a source of CH_4 emissions from this category and because other countries also do not report CH_4 emissions from this category.

Table 160: Difference to submission 2002 of CH_4 emissions from Category 4 D Agricultural Soils

IPCC Category	**[Gg CH_4]**										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4D AGRICULTURAL SOILS	-35.48	-35.56	-35.63	-35.71	-35.30	-34.89	-34.93	-34.97	-34.60	-34.24	-34.17

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, which explains the strong reduction. Therefore the contribution of emissions from the category *Field Burning of Agricultural Waste* to the total emissions is very low.

In the year 2001 total emissions from this category amounted to 2.9 Gg CO_2 equivalent, this is a share of 0.04% in total GHG emissions from agriculture. Emissions for the years from 1990 to 2001 are presented in Table 161.

Table 161: Greenhouse gas emissions and their trend from 1990-2001 from Category 4 F Field Burning of Agricultural Waste 1990-2001

Gas	GHG emissions [Gg CO_2 Equi.]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CH_4	1.57	1.57	1.57	1.56	1.56	1.54	1.54	1.52	1.52	1.51	1.51	1.51	-3.5%
N_2O	1.42	1.42	1.42	1.42	1.42	1.42	1.41	1.41	1.41	1.41	1.41	1.41	-0.7%
Total	2.99	2.99	2.99	2.98	2.98	2.96	2.95	2.93	2.93	2.92	2.92	2.92	-2.1%

6.5.2 Methodological Issues

A simple method (Emission = Activity x Emission Factor) using country specific emission factors was used.

6.5.2.1 Cereals/ Wheat (4 F 1 a)

N_2O emissions 4 F 1 a Cereals/ Wheat are estimated to be constant over the period from 1990 to 2001 and to amount 0.0038 Gg. CH_4 emissions from the same category are also estimated to be constant and to amount to 0.05 Gg.

The applied emission factors are based upon expert judgement (UBAVIE): 8.9 kg CH_4 /ha and 0.595 kg N_2O/ha respectively. For CH_4 emissions the IEF are lower than IPCC default values, whereas those for N_2O are higher.

According to an expert judgement from Dr. Johannes Schima from the *Presidential Conference of Austrian Agricultural Chambers*, about 6 000 ha of straw fields are burnt every year. This value was used for all years.

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 1991-2002 [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 hectar viniculture area.

Table 162: *Activity data for 4 F Field Burning of Agricultural Waste 1990–2001*

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

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.

6.5.3 Recalculations

Emissions from sub category *4 F 5 Other* were recalculated using updated activity data and new emission factors:

- Previously one estimated value for the viniculture area in Austria was used for all years, for this year's inventory the time series has been updated using the Statistical Year-books 1991-2002 [STATISTIK AUSTRIA]. However, not for all years an updated value is available[19].
- Based on expert judgement the amount of residual wood per hectare viniculture area and the share of annually burnt wood have been updated.
- The emission factors (CH_4 and N_2O) have been updated.

[19] Only for 1990, 1993, 1995, 1997 and 1999 an updated figure is available, for the years in between the last available value was used (e.g. for 1991 and 1992 the value of 1990 was used).

Table 163: Recalculations with respect to previous submission from sub category 4 F 5 Other 1990-2000

Diff. [Gg]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4	-0.136	-0.136	-0.136	-0.1364	-0.1364	-0.137	-0.137	-0.1381	-0.1381	-0.1386	-0.1386
N_2O	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042	-0.0042

There were no recalculations in subcategory *4 F 1 a*.

6.5.4 Planned Improvements

It is planned to use IPCC default emission factors for *4 F 1 a Cereals/ Wheat* in the future.

7 LAND USE CHANGE AND FORESTRY (CRF SECTOR 5)

NOTE: As there have been no changes in methodology for this chapter, and because the emissions/removals reported for 2001 equal the values for 2000, this chapter is identical to the corresponding one in the NIR 2002.

7.1 Source Category Description

3,9 Mio ha (46%) of Austria are forest land [FBVA, 1997]. 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].

Table 164 shows the IPCC categories and the corresponding SNAP categories for which the actual calculations are made.

Table 164: IPCC categories and the corresponding SNAP categories for IPCC Category 5

IPCC-Category	SNAP / SPLIT-Category	Description
5 A 2		**Temperate Forests**
5 A 2	112102 Deciduous	Temperate forests
5 A 2	112102 Evergreen	Temperate forests

Other IPCC categories are IE, NE or NO. The quantitatively most relevant sub-categories of *5 B Forest and Grassland Conversion* and *5 C Abandonment of Managed Lands* are included in the figures for category *5 A Changes in Forest and Other Woody Biomass Stocks* (see chapter 4.5.2).

Emission trends

In the period 1961 to 1996 changes in the Austrian forest biomass (*IPCC Category 5 A*) led to a mean annual net carbon sink of 2.527 kt carbon (from 1.014 kt C to 3.689 kt C with an uncertainty of ±748 kt C). 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]. Between 1990 and 1996 a decrease in the net sink of category *5 A* was detected (mean: 2.371 kt C; range: 1.469 to 3.683 kt C), and so the offset of category *5 A* to the total GHG emissions in the individual years of this period was between 6,7 and 16,6% (mean value: 11,2%).

The time series of accurate and measured values for individual years ends with the year 1996. For the years after 1996 the means for the last period (1992 to 1996) of the National Forest Inventory (NFI) have been reported (the rationale in behind this procedure is given in chapter 4.5.2). Therefore, the reported annual data for category *5 A* are constant after 1996. A revision of the data for these years will be carried out when the results of the follow-up NFI will be available, which will be in 2003.

Details on the methodology, uncertainty assessment, quality assurance, quality control and verification are given in chapter 4.5.2

7.2 Changes in Forest and Other Woody Biomass Stocks (5 A)

7.2.1 Methodological Issues

A national method is applied which follows to some extent the IPCC methodology. However, it gives more accurate and appropriate figures for the Austrian forests.

The main basis of the estimates are measured data on 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 NFI [SCHIELER et al., 1995], [FBVA, 1997], [WINKLER, 1997]. The NFI was carried out in the periods 1961-70, 1971-80, 1981-85, 1986-90, 1992-96. Recently, the follow-up NFI is running – the new data will be available in 2003. 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, 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 1964-1998]. 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 in the forests. Therefore, the figures for "Total biomass increment in Commercial Harvest" include also the biomass increments due to abandonment of managed land and regrowth by forests. The NFI harvest data include also all possible reasons for biomass losses in the forests. This means, that the figures for "Total biomass removed in Commercial Harvest" include in addition: e.g. traditional (non-commercial) fuel wood consumption, biomass losses by forest conversion, forest fires[20] and losses due to other damages. Therefore, to provide accurate and representative figures for the entire commercial forests of Austria and to avoid double accounting as well as further conflicting matters with the categories *5 B Forest and Grassland Conversion* and *5 C Abandonment of Managed Lands*, these figures are reported as a total in category *5 A Changes in Forest and Other Woody Biomass Stocks*.

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[21] 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 and the wood balance [BITTERMANN and GERHOLD 1995], [BMLF 1964-1998]. For increment a representative Austrian set of tree ring cores [HASENAUER et al. 1999a, b] is used to calculate the relative indices. The means of these estimated annual

[20] 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 in Austria.

[21] Values for the relative variation in the individual years of the time series

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*. 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 are used to convert the measured m^3 stem wood over bark 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 for individual age classes (compiled in [KÖRNER et al., 1993]) and literature values on C contents for individual tree compartments and species (Table 165). 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 165: 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 1996. For the years after 1996 the means for the last inventory period (1992/96) and therefore constant values have been reported. An extrapolation of trends for increment and harvest from the 2nd but last inventory period (1986/90) to the 90ies led to figures which had to be strongly revised downwards after the last inventory (1992/96). One of the main reasons was that increment did not increase as in the years before. A use of means for increment and for harvest, which are based on the last NFI results, for years after the last NFI provides more probable 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. A revision of these means and constant figures for the years after 1996 will be carried out when the results of the follow-up forest inventory will be available, which will be in 2003[22].

Other sub-categories under *5 A* were not estimated or are not occurring. The area of temperate forest plantations (category *5 A 2 c*) is very small in Austria (< 2.000 ha). Therefore, the C stock changes at these plantations are negligible. There are not sufficient data to estimate accurately the emissions and removals from other wooded land like vineyards, or-

[22] The last recalculation was carried out for the year-2000-submission for the period 1990 to 1998. The rationale was the inclusion of the results of the latest NFI (1992/96) and a development of a more detailed approach compared to the estimates before.

chards, parks, forest nurseries and Christmas tree cultures. This is also the case for the emissions and removals from grasslands. However, it is assumed that figures for this category are also of minor relevance for the Austrian GHG balance. Estimates on the subcategory *5 A 2 d Harvested Wood* will be made in the near future.

7.2.2 QA/QC, Verification, Uncertainty Assessment

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* is embedded in the overall QA/QC-system of the Austrian GHG inventory (see chapter 1.4):

The calculation of the uncertainty of the reported data for category *5 A* took 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[23]
- and the uncertainty of each conversion and expansion factor.

The estimates of the uncertainty includes 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 166, 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 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.

The absolute uncertainty of the Austrian annual net carbon balance of category *5 A* is ±748 kt C. This corresponds to varying relative uncertainties between ±20% and ±74% (mean ±30%) for the individual years of the time period 1960 to 1996 depending on the individual annual net C sequestration of category *5 A*.

In the near future a further estimate on the uncertainties of the carbon figures of category *5 A* which uses Monte Carlo simulations will be available.

[23] 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

Table 166: Relative uncertainties of the used data for the calculations [WEISS et al. 2000]

	Relative uncertainties in %				
	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			

7.3 Forest and Grassland Conversion (5 B), Abandonment of Managed Lands (5 C)

Categories *5 B* and *5 C* are indirectly included in the figures of category *5 A* as far as changes of tree biomass of the Austrian forests are concerned (afforestation, reforestation in the sense of IPCC, abandonment of managed lands and regrowth of forests and deforestation; see also above). Under Austrian ecological conditions abandonment of managed lands is usually followed by regrowth of forests. Therefore, the quantitatively more important activities under the categories 5B and 5C and their impact on the biomass C stock changes are covered by the figures of sector 5A. Grassland conversions (category *5 B 4*) as well as abandonment of managed land and regrowth by grasslands (category *5 C 4*) also occur in Austria, but data which would allow to estimate accurately the emissions/removals from these sub-categories are lacking. It is assumed that activities under these two sub-categories are of minor relevance for the Austrian GHG balance and mainly lead to changes in the soil carbon pools, whereas the related changes in the biomass carbon pools are assumed to be much less significant. Changes of soil carbon pools related to all activities of the categories *5 B* and *5 C* would be included in category *5 D* if these data were already available (see below).

Hence, the non-reporting of specific figures for the categories *5 B* and *5 C* does not represent a data gap but avoids double-accounting. In addition, the relative uncertainty of these specific figures for the categories *5 B* and *5 C* would be considerably higher than those of category *5 A* because the Austrian NFI (as most forest inventories) is designed to provide accurate figures on a nation-wide basis. Each estimate of respective figures for a sub-category, e.g. previous and new forest areas (afforestation, reforestation, deforestation), is related with much higher relative uncertainties or would even need a completely different approach to obtain accurate figures. This is very much a question of costs and resources for measurement and of weighing up the necessary efforts against the gain of information (particularly as figures for these categories are already included in other categories). However, it should be noted that in the future measurement, calculation and reporting of figures for specific parts of the categories 5B and 5C might be necessary under the Kyoto-Protocol (Article 3.3). Such preliminary Austrian estimates for Article 3.3 were given in a supporting submission for the Kyoto-negotiations (UNFCCC 2000).

7.4 CO_2 Emissions and Removals from Soil (5 D)

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).

CO_2 emissions or removals from soils are not reported at the moment. The changes in the carbon content of the soils are very small and slow and 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 to provide measured figures for the carbon stock changes in this category.

8 WASTE (CRF SECTOR 6)

8.1 Sector Overview

This chapter includes information 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* (*Sludge Spreading* and *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 167 presents the greenhouse gas emissions for the period from 1990 to 2001 for the IPCC Category *6 Waste*.

The overall greenhouse gas emissions from waste management and treatment activities during the year 2001 correspond to 4 650 Gg CO_2 equivalent. This represents about 5.9% of the total greenhouse gas emissions in Austria in 2001 compared with 9.1% in the base year.

As can be seen in Table 167 the trend for the years 1990 to 2001 concerning greenhouse gas emissions from the waste sector was decreasing. In 2001 the greenhouse gas emissions from the waste sector were 19.2% below the level of the base year.

Table 167: Emissions of greenhouse gases and their trend from 1990-2001 from category 6 Waste

Gas	GHG emissions [Gg CO_2 equivalent]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	20.7	18.5	7.5	8.5	9.8	10.1	10.4	10.7	11.0	11.3	11.3	11.3	*-45.5%*
CH_4	5 689.1	5 591.3	5 534.9	5 422.2	5 318.9	5 207.6	5 118.4	4 973.1	4 810.2	4 746.2	4 658.2	4 615.1	*-18.9%*
N_2O	22.0	22.4	22.8	22.7	23.0	23.4	23.8	23.7	24.4	23.8	23.9	23.9	*+8.6%*
Total	**5 731.8**	**5 632.1**	**5 565.3**	**5 453.4**	**5 351.7**	**5 241.1**	**5 152.6**	**5 007.5**	**4 845.6**	**4 781.4**	**4 693.3**	**4 650.3**	***-19.2%***

Emission trends by greenhouse gas

Table 167 presents the greenhouse gas emissions from the sector *Waste* for the base year (1990) and for 2001 as well as their share in greenhouse gas emissions from this sector.

Table 168: Greenhouse gas emissions from the Waste sector in the base year and in 2001.

Greenhouse gas emissions	Base year*	2001	Base year	2001
	CO_2 equivalent [Gg]		[%]	
Total	**5 731.8**	**4 650.3**	**100%**	**100%**
CO_2	20.7	11.3	0.4%	0.2%
CH_4	5 689.1	4 615.1	99.3%	99.2%
N_2O	22.0	23.9	0.4%	0.5%

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

The major greenhouse gas emissions from this sector are CH_4 emissions, which represent 99.2% of all emissions from this sector in 2001 compared with 99.3% in 1990, followed by CO_2 (0.2% 2001 respectively 0.4% 1990) and N_2O (0.5% 2001 respectively 0.4% 1990).

CO_2 emissions

As can be seen from Table 167 CO_2 emissions from sector *6 Waste* decreased remarkably: in 2001 CO_2 emissions from this sector amounted to 11.3 Gg CO_2 equivalent, this was 45.5% below the level of the base year.

CO_2 emissions originate from *Waste Incineration* (*Municipal Solid Waste, Waste Oil and Incineration of Corpses*), the amount of waste being incinerated has also decreased during the period.

CH_4 emissions

As can be seen from Table 167 also the trend of CH_4 emissions arising from the sector *Waste* was decreasing emissions. In 2001 they amounted to 4 615 Gg CO_2 equivalent, this was 18.9% below the level of the base year.

CH_4 emissions originate from most subcategories within the sector but the main source is *Solid Waste Disposal on Land* (landfill gas). As a result of waste management policies the amount of landfilled waste has decreased during the period.

N_2O emissions

N_2O emissions from the waste sector increased over the considered period (see Table 167). In 2001 the N_2O emissions from the Waste sector amounted to 23.9 Gg CO_2 equivalent. This was 8.6% above the level of the base year.

N_2O emissions originate from *Wastewater Handling* (*Domestic and Commercial Wastewater* and *Industrial Wastewater*) and *Waste Incineration* (*Municipal Solid Waste* and *Waste Oil*).

Emission trends by sources

Table 169 presents the greenhouse gas emissions for the period from 1990 to 2001 from the different subcategories within the IPCC *Category 6 Waste*.

Table 169: Total greenhouse gas emissions and trend from 1990–2001 by subcategories of Category 6 Waste

	GHG emissions [Gg CO_2 equivalent]											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
6 A	4 928.7	4 827.8	4 767.7	4 652.1	4 547.4	4 435.4	4 345.8	4 200.0	4 036.9	3 972.4	3 883.6	3 842.3
6 B	310.1	313.7	317.9	320.7	322.5	323.5	324.4	324.7	325.7	325.6	326.3	324.6
6 C	20.8	18.6	7.6	8.5	9.8	10.1	10.4	10.7	11.0	11.3	11.3	11.3
6 D	472.1	472.1	472.1	472.1	472.1	472.1	472.1	472.1	472.1	472.1	472.1	472.1
Total	**5 731.8**	**5 632.1**	**5 565.3**	**5 453.4**	**5 351.7**	**5 241.1**	**5 152.6**	**5 007.5**	**4 845.6**	**4 781.4**	**4 93.3**	**4 650.3**

The dominant subcategory in this sector was *6 A Solid Waste Disposal on Land* which greenhouse gas emissions represent 82.6% of the total greenhouse gas emissions from this sector in 2001 compared with 86.0% in 1990.

6 A Solid Waste Disposal on Land

For *Solid Waste Disposal on Land* greenhouse gas emissions decreased by 22.5% from 1990 to 2001. This was mainly due to decreasing CH_4 emissions from landfills because the recovery rate of landfill gas increased over the period. .

6 B Wastewater Handling

For *Wastewater Handling* the greenhouse gas emissions increased by 4.6% from 1990 to 2001. This was mainly due to increasing CH_4 emissions from handling of industrial and domestic/commercial wastewater.

6 C Waste Incineration

For *Waste Incineration* greenhouse gas emissions decreased by 45.8% from 1990 to 2001. This was mainly due to decreasing CO_2 emissions from incineration of municipal solid waste due to lower amounts of waste being incinerated.

6 D Other

This category addresses *Sludge Spreading* and *Compost Production*. The reported greenhouse gas emissions from these subcategory are constant over the period as the activity data was assumed to be constant.

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 170 presents the source categories in the level of aggregation for the key source analysis.

Table 170: Key sources of Category 6 Waste

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment
6 A 1	Managed Waste disposal	CH_4	all except TA92
6 D 1	SNAP 091003 Sludge spreading	CH_4	all TA

all = all Level and Trend Assessments
TA92 = Trend Assessment base year – 1992

8.1.3 Methodology

The general method for estimating emissions for the waste sector, as recommended by the IPCC, is multiplying activity data for each subcategory with an emission factor. In some cases, however, country-specific methods were used. In those cases detailed information on the applied methods is provided in the corresponding subchapter.

8.1.4 Recalculations

Recalculations have been made only for subcategory *6 A 1 Managed Waste Disposal on Land (*see Table 175).

8.1.5 Completeness

Table 171 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 171: 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	✓	NO
6 A 2 Unmanaged Waste Disposal	090402 Unmanaged Waste Disposal	NO	NO	NO
6 B WASTEWATER HANDLING				
6 B 1 Industrial Wastewater	091001 Waste water treatment in industry	NO	✓	✓
6 B 2 Domestic and Commercial Wastewater	091002 Waste water treatment in residential/commercial sect.	NO	✓	✓
6 C WASTE INCINERATION	090901 Incineration of corpses 090201 Incineration of municipal waste 090208 Incineration of waste oil	✓ ✓ ✓	NO ✓ ✓	NO ✓ ✓
6 D OTHER WASTE	091003 Sludge spreading 091005 Compost production	NO NO	✓ ✓	NO NO

There are no unmanaged waste disposal sites in Austria, 100% of the solid waste disposal sites are managed sites.

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 100% of waste disposal sites are managed sites (landfills).

CH_4 emissions from managed waste disposal on land (landfills) contributed in the year 2001 4.5% to the total amount of 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. According to expert judgement since 1983 the amount of the collected and burnt landfill gas increased exponentially. While for example the amount of the collected landfill gas was about 2% in 1990, this amount reached 21%in the year 2001.

Table 172 presents CH_4 emissions from managed waste disposal on land for the period from 1990 to 2001.

As can be seen in the table, the trend of the CH_4 emissions during the period was decreasing. From 1990 to 2001 the CH_4 emissions decreased by 22% according to increasing amount of the collected landfill-gas.

Table 172: Greenhouse gas emissions from Category 6 A 1 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4 emissions [Gg]	235	230	227	222	217	211	207	200	192	189	184	183

8.2.1.2 Methodological Issues

For calculating the emissions of solid waste disposal on land the directly deposited waste is separated into two categories: "residual waste" and "non residual waste".

For "residual waste" activity data were available for each year, whereas, because of lack of data, for "non residual waste" the same figure was used for all years.

8.2.1.2.1 Residual waste

Waste from households and similar establishments originates in private households, administrative facilities of commerce, industry and public administration, kindergartens, schools, hospitals, small enterprises, agriculture, market places and other generation points if these are 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")***;

"Residual waste" is that waste from households and similar establishments, which is directly deposited at landfills without any treatment.

The detailed calculation of the CH_4 emissions from "residual waste" is shown in Table 173.

First the overall amount of generated landfill gas per ton waste was calculated, taking the DOC-content (200kg C/Mg Waste) of the waste and the average temperature at the landfill (30°C) into account. 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 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 173: 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) [K] Bio-degradable organic carbon content of directly deposited residual waste (estimated in [HACKL & MAUSCHITZ, 1999]) [200kgC/Mg waste]
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 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

Calculation of	Formula		Explanation
	is summed up		
G…Emitted gas [m³]	$G=G_T$ *(1-j)	G_T………. j…………	Total incidental gas in the year t Collecting factor; estimated for 1999: j = 0.2
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=20% (HACKL, MAUSCHITZ 1999) Density of methane, ρ=0.65kg/m^3

8.2.1.2.2 Non Residual Waste

"Non Residual Waste" is directly deposited waste other than residual waste and comprises:

- bulk waste
- construction waste
- mixed industrial waste
- road sweepings
- sewage sludge
- rakings
- residual matter from waste treatment

For the calculation the methodology of Marticorena was used, with the assumption that the composition and quantity of deposited non residual waste was constant. The deposited non residual waste was split up into three groups and the incidental quantity of gas was calculated for each group.

1. Well bio-degradable waste (half-life period: 1-20 years)
2. Hardly bio-degradable waste (half-life period: 20-100 years)
3. Very hardly bio-degradable waste (half-life period: >>100 years)

After calculating the total emitted gas of each group the values were summed up, multiplied with 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 174.

Table 174: Calculation of the CH_4 emissions of directly deposited waste except residual waste

Calculation of	Formula		Explanation
Methodology of Marticorena to calculate the formation potential for 100 years	$M=M_0e^{-(kt)}$	M………… M_0……….. k…………. $t_{1/2}$………..	Incidental quantity of gas [m³] Formation potential of landfill gas [m³]* Velocity constant k=-ln(0.5)/$t_{1/2}$ Half life (calculated for each group, weighted by the quantity of the depos-

Calculation of	Formula		Explanation
			ited waste [BAUMELER, 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_1^3………..	Summation of the 3 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; estimated for 1999: j=0.2 => 1-j…Fraction of emitted gas
		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=20%
		ρ…………	Density of CH_4, ρ=0.72kg/m³ (0°C;1 atm)

*For each of the 3 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

Because of the consideration of the emissions from the last 31 years the quantities of "residual waste" as of 1960 are needed. Thus the activity data from the year 1950 to 1989 were taken from a study [HACKL & MAUSCHITZ, 1999].

The quantities of residual waste from 1990 until 1997 were taken from the current BAWP [BMUJF-BWAP, 1998].

The quantities as of 1998 were taken from the UBAVIE database for solid waste disposals "Deponiedatenbank". 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 UBAVIE (*Deponiedatenbank* – "Austrian disposal database"). Emissions from 1998 to 2001 have been recalculated on the basis of these data.

Contrary to data for "residual waste", there are no actual values for "non residual waste" for each year. In 1995, the quantity of "non residual waste" was estimated to be 2 905 000 t/a [BAUMELER et al., 1998]. This value was assumed to be constant for all years.

Emission factors

Activity data and the implied emission factors are presented in Table 14.

Table 14: Activity data and implied emission factors for "*Residual waste" and "Non Residual Waste" 1990–2001*

Year	Residual Waste [Mg/a]	IEF CH_4 Residual Waste [kg /Mg]	Non Residual Waste [Mg/a]	IEF CH_4 Non Residual Waste [kg /Mg]
1990	1 210 400	59.6	2 905 000	56.0
1991	1 093 900	64.7	2 905 000	54.8
1992	985 000	70.7	2 905 000	54.2
1993	834 400	80.4	2 905 000	53.2
1994	675 700	95.1	2 905 000	52.4
1995	624 400	98.1	2 905 000	51.6
1996	661 900	88.8	2 905 000	51.0
1997	694 600	80.4	2 905 000	49.6
1998	1 007 294	53.5	2 905 000	47.6
1999	1 040 001	51.2	2 905 000	46.8
2000	1 052 061	49.8	2 905 000	45.6
2001	1 052 061	49.5	2 905 000	45.1

The implied emission factor for residual waste and non residual waste is declining because of the increasing amount of collected and burnt landfill gas.

8.2.1.3 Recalculations

- For the years 1990 to 1997 all activity data were taken from the current *Bundes-Abfallwirtschaftsplan* (Federal Waste Management Plan) and remained unchanged. According to an order for landfills [Deponieverordnung (BGBl. Nr 164/1996 §29)], that was legalised in 1997, all operators of landfill sites have to report their activity data directly to UBAVIE (*Deponiedatenbank* - Austrian disposal database). Emissions from 1998 to 2001 have been recalculated on the basis of these data.
- In the previous inventories for the calculations the standard density of CH_4 at a temperature of 0°C was taken. In this inventory the density of CH_4 has been corrected as proposed by the expert review team (see paragraph 221 of the [CR 2001]). Not the standard density, but the density at a temperature of 30°C has been taken into account. As a result CH_4 emissions decreased by 9% for the whole time series.

Table 175: Recalculations with respect to previous submission from Category Managed Waste Disposal on Land 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH_4 [Gg Difference]	24	24	23	23	22	22	21	21	18	21	26

8.2.1.4 Planned Improvements

The following improvements are planned until the next submission of the National Inventory Report:

- Review of the methodology of estimating emissions (including emission factors)
- Update of activity data for "Non Residual Waste"
- Revise the time series of "Residual Waste"
- Update the rate of the collected landfill-gas

8.3 Wastewater Handling (CRF Source Category 6 B)

The anaerobic degradation of organic substances in wastewater treatment systems produces CH_4. These emissions from sludge storage were calculated volumes – were taken into consideration [STEINLECHNER et al., 1994]. In addition N_2O emission produced during the wastewater treatment process (denitrification) have been estimated.

8.3.1 Industrial Wastewater (6 B 1)

8.3.1.1 Source Category Description

Key Source: No

Emissions: *CH_4, N_2O*

Table 176 shows the CH_4 and N_2O emissions from industrial wastewater handling for the period from 1990 to 2001.

As can be seen from the table CH_4 and N_2O emissions slightly increased from 1990 to 2001. During this period the CH_4 emissions increased by 5% and N_2O emissions by 13%.

Table 176: Greenhouse gas emissions from Category Waste Waterhandling 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4 emissions [Gg]	4.669	4.719	4.780	4.827	4.851	4.861	4.868	4.876	4.880	4.888	4.899	4.872
N_2O emissions [Gg]	0.016	0.017	0.017	0.017	0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.018

8.3.1.2 Methodological Issues

CH_4 emissions were calculated by multiplying a national emission factor (unit: emissions/inhabitant) with the number of inhabitants.

N_2O emissions were calculated in accordance with the IPCC methodology with the assumption that industry introduces additionally 30% of the nitrogen from the human metabolism into the wastewater system [ORTHOFER et al., 1995]. Furthermore it was estimated in this study that about 10% of the nitrogen that enters wastewater treatment plants is denitrificated and that only 1% of the total nitrogen in the denitrification process is emitted as N_2O. This was taken into account when applying the following formula for estimating the N_2O emissions from this category:

$$N_2O\ Emissions = 0.3 * 0.1 * 0.01 * P * Frac_{NPR} * Inhabitants * F$$

Where:

P… annual protein intake per capita [kg protein/ person/ a][24]

$Frac_{NPR}$ ... Fraction of nitrogen in protein (IPCC default value – 0.16 kg N/kg protein)

Inhabitants … number of inhabitants in Austria

F … Factor (44/28) [1.57 kg N_2O/ kg N]

[24] Daily protein intake per capita taken from FAO statistics: http://apps.fao.org/page/collections?subset=nutrition

Emission factors

The calculation of the emission factors for methane emissions based on the year 1993 is shown in Table 177 and was taken from a study [STEINLECHNER et al., 1994]. For the following years these factors were assumed to be constant and were multiplied by the current number of inhabitants.

First the amount of generated methane per unit of wastewater is determined for each of the three different types of treatments (mechanical/ biological/ further) separately. These factors were multiplied with the corresponding capacities of the Austrian wastewater treatment plants and then summed up, resulting in the total CH_4 emissions for the subsector *Commercial and Domestic Wastewater* of the year 1993. Emissions from *Industrial Wastewater* were calculated separately, its wastewater was treated like biological treated wastewater.

The emission factor for *Industrial* and *Domestic and Commercial Wastewater Treatment* respectively were obtained by dividing the corresponding emissions of 1993 by the population of this year.

The detailed calculation steps of the emission factors for methane are shown in Table 177.

Table 177: Calculation of the emission factors for methane emissions (based on 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
The sustained emissions were divided by the inhabitants of the year 1993 (7.991.000), which results in the two activity factors: EF (Industrial wastewater handling): EF (Domestic and commercial wastewater handling):	 604.05 g CH_4 /inhabitant 171.94 g CH_4 /inhabitant

Main difference between the Austrian method and the one of IPCC

The main difference is that the Austrian emission factor is calculated per inhabitant and not per kg DOC. Therefore the amount of produced biogas was estimated together for industrial and domestic and commercial wastewater, based on the amount of organic waste. It was not calculated on the bases of BOD (biochemical oxygen demand) and COD (chemical oxygen demand).

Activity data

The number of inhabitants was provided by STATISTIK AUSTRIA.

Table 178 presents the number of inhabitants in Austria as well as the amount of protein in sewage as reported by FAO for the period from 1990 to 2001. It was assumed that the value for protein in sewage of 1999 was still valid for the years 2000 and 2001.

Table 178: Number of inhabitants and protein per inhabitant in sewage 1990–2001.

Year	Inhabitants	Protein [g/ day/ inhabitant]
1990	7 729 000	102
1991	7 813 000	103
1992	7 914 000	104
1993	7 991 000	102
1994	8 030 000	103
1995	8 047 000	105
1996	8 059 000	107
1997	8 072 000	106
1998	8 078 000	109
1999	8 092 000	106
2000	8 107 000	106
2001	8 065 000	106

8.3.1.3 Planned Improvements

For the next submission of the National Inventory Report it is planned to provide a new estimation of the methane recovery rate and to review the methodology of estimating emissions (including emission factors).

8.3.2 Domestic and Commercial Wastewater (6 B 2)

8.3.2.1 Source Category Description

Key Source: No

Emissions: CH_4, N_2O

Table 179 presents CH_4 and N_2O emissions from domestic and commercial wastewater handling for the period from 1990 to 2001.

As can be seen from the table, the trend during the period was increasing CH_4 and N_2O emissions. From 1990 to 2000 the CH_4 emissions increased by 5% and the N_2O emissions by 9%. Due to decreasing number of inhabitants CH_4 and N_2O emissions decreased from 2000 to 2001.

Table 179: Greenhouse gas emissions from Category Domestic and Commercial Wastewater 6 B 2 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4 emissions [Gg]	9.058	9.156	9.275	9.365	9.411	9.431	9.445	9.460	9.467	9.483	9.501	9.452
N_2O emissions [Gg]	0.054	0.055	0.056	0.056	0.057	0.058	0.059	0.059	0.060	0.059	0.059	0.059

8.3.2.2 Methodological Issues

CH_4 emissions were calculated by multiplying a national emission factor (unit: g emissions/inhabitant) with the number of inhabitants.

N_2O emissions were calculated in accordance with IPCC methodology [ORTHOFER et al., 1995]. According to this study about 75% of the domestic and commercial sewage in Austria is treated in sewage plants. Furthermore it was estimated in this study that about 10% of the nitrogen that enters wastewater treatment plants is denitrificated and that only 1% of the total nitrogen in the denitrification process is emitted as N_2O. This was taken into account when applying the following formula for estimating the N_2O emissions from this category:

$$N_2O\ Emissions = 0.75 * 0.1 * 0.01 * P * Frac_{NPR} * Inhabitants * F$$

Where:

P… annual protein intake per capita [kg protein/ person/ a][25]

$Frac_{NPR}$ ... 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]

Emission factors

See subchapter 6 B 1 Wastewater Handling – Industrial wastewater.

Activity data

The number of inhabitants was provided by STATISTIK AUSTRIA. The number of inhabitants during the period from 1990 to 2001 as well as the daily protein intake per capita are presented in Table 178.

8.3.2.3 Planned Improvements

For the next submission of the National Inventory Report it is planned to provide a new estimation of the methane recovery rate and to review the methodology of estimating emissions (including emission factors).

[25] Daily protein intake per capita taken from FAO statistics: http://apps.fao.org/page/collections?subset=nutrition

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, waste oil and non-biogenic waste are included as well as CO_2, CH_4 and N_2O emissions from waste incineration. All CO_2 emissions from Category *6 Waste* are caused by waste incineration.

Emissions from Category *Open Burning Of Agricultural Waste* is included in Chapter 0.

In Austria waste oil is incinerated in especially designed so called "USK-facilities". The emissions of waste oil combustion for energy use (e.g. in cement industry) are reported under *CRF sector 1 A Fuel Combustion*.

In general municipal, industrial and hazardous waste are combusted in district heating plants or in industrial sites and the energy is used. Therefore their emissions are reported in *CRF sector 1 A Fuel Combustion*. There is only one waste incineration plant which has been operated until 1991 with a capacity of 22 000 tons of waste per year without using the energy. This plant has been rebuilt as a district heating plant starting operation in 1996. Therefore the emissions of this plant are reported under *CRF sector 1 A Fuel Combustion* from 1996 onwards.

Table 180: Greenhouse gas emissions from Category 6 C.

Gas	GHG emissions [Gg]												Trend 1990-2001
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
CO_2	21	18	8	9	10	10	10	11	11	11	11	11	-45.5%
CH_4	0.0023	0.0023	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-100.0%
N_2O	0.0003	0.0003	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-77.4%

Completeness

Table 181 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 181: 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	✓	NE	✓

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 a 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 182: 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	-	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 were taken from [UBAVIE IB-650, 2001].

Table 183: Activity data for IPCC Category 6 C Waste Incineration.

Year	Municipal Waste [Mg]	Waste Oil [Mg]
1990	22 000	2 200
1991	22 000	1 500
1992	0	1 800
1993	0	2 100
1994	0	2 500
1995	0	2 600
1996	0	2 700
1997	0	2 800
1998	0	2 900

Year	Municipal Waste [Mg]	Waste Oil [Mg]
1999	0	3 000
2000	0	3 000
2001	0	3 000

For incineration of corpses the activity data as presented in Table 184 were taken from STATISTIK AUSTRIA. It was assumed that 12% of the total number of corpses were incinerated every year.

Table 184: Number of incinerated corpses 1990–2001

Year	Total number of corpses	Number of incinerated corpses
1990	82 952	9 954
1991	83 428	10 011
1992	83 162	9 979
1993	82 517	9 902
1994	80 684	9 682
1995	81 171	9 741
1996	80 790	9 695
1997	79 432	9 532
1998	78 339	9 401
1999	78 200	9 384
2000	76 780	9 214
2001	76 780	9 214

8.4.3 Recalculations

In the previous submission emissions from waste incineration in district heating plants were reported under category *6 C Waste Incineration.* According to the GPG, chapter 5.3.1.3 and the recommendations of the in-country review team (see paragraph 212 of the [CR 2001]) they are now reported as 'other fuels' under category *1 A 1 a Public Electricity and Heat Production*.

The activity data for incineration of corpses were updated according to the actual death statistics published by STATISTIK AUSTRIA.

8.4.4 Planned Improvements

Until the next submission of the National Inventory Report it is planned to review the methodology of estimating emissions (including emission factors) and to update activity data.

8.5 Other Waste (CRF Source Category 6 D)

8.5.1 Source Category Description

In this category sludge spreading and compost production are addressed.

8.5.2 Sludge Spreading

Key Source: Yes (CH_4, LA90 - LA01)

Emission: CH_4

For this category three kinds of sludge were considered:

- Stabilized sludge from mechanical-biological waste water treatment, if not included in other categories
- Residues of canalisation and wastewater treatment except sludge
- Wastewater resulting from water utilization

In 2001 CH_4 emissions from sludge spreading was a key source. It contributed 0.5% to the total amount of greenhouse gas emissions in Austria.

Table 185 presents the CH_4 emissions from this category for the period from 1990 to 2001.

As can be seen in the table, the reported CH_4 emissions were constant throughout the period according to the estimation of a constant amount of sludge being spread yearly.

Table 185: Greenhouse gas emissions from Category Sludge Spreading 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4 emissions [Gg]	20	20	20	20	20	20	20	20	20	20	20	20

8.5.2.1 Methodological Issues

Activity data and methodology were taken from a study [STEINLECHNER et al., 1994]. The amount of spread sludge was assumed to be constant throughout the period.

First the amount of total generated gas was calculated by multiplying the quantity of sludge (250 000 t) by its gas production potential (200 m^3/ t). The amount of generated gas (50 mio m^3/ a) was multiplied with the share of CH_4 in the generated gas which was assumed to be 55% as in all other categories. This resulted in a value of 20 Gg CH_4 emitted from this source in the year 1990. As the amount of spread sludge was assumed to be constant throughout the period, this value was reported for all years.

8.5.2.2 Planned Improvements

The following improvements are planned until the next submission of the National Inventory Report:

- Sludge Spreading will be reported in Category *6 B Wastewater Handling*
- Review of the methodology of estimating emissions (including emission factors)
- Update of activity data

8.5.3 Compost Production

Key Source: No

Emission: CH_4

This category includes CH_4 emissions from compost production, which are presented in Table 186 for the period from 1990 to 2001.

As can be seen from the table, the reported CH_4 emissions were constant throughout the period according to the assumption of a constant amount of compost being produced yearly.

Table 186: Greenhouse gas emissions from Category Compost Production 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CO_2 emissions [Gg]	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48

8.5.3.1 Methodological Issues

CH_4 emissions were calculated by multiplying an emission factor by the quantity of treated waste (mechanical biological treated residual waste and composted waste).

The calculated value, based on data of the year 1995 was applied for all years.

Emission factors

The quantity of emitted CH_4 for mechanical biological treated residual waste and composted waste, using the mean carbon flow is taken from a study [BAUMELER et al., 1998]. Therein the CH_4 emissions for residual waste amount to 0.38 Gg and 2.1 Gg for composted waste respectively. By adding up these emissions and dividing them by the quantity of treated waste the emission factor for the year 1995 (1 945 g CH_4 /t of waste) was obtained.

Activity data

To obtain activity data, the quantity of mechanical biological treated residual waste (345 000 t/a) and composted waste (930 000 t/a) are summed up (1 275 000 t/a). These data are taken from a national study [BAUMELER et al., 1998].

8.5.3.2 Planned Improvements

For the next submission of the National Inventory Report it is planned to update activity data and to review the methodology of estimating emissions (including emission factors).

9 RECALCULATIONS AND IMPROVEMENTS

This chapter quantifies the changes in emissions for all six greenhouse gases compared to the previous submission – UNFCCC 2002 (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 must be collected from different sources, for instance statistic divisions, 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:
    - Uncertainty must be decreased.
    - 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.
    - National methodology is no longer appropriate.

For detailed information on recalculations and their justifications see the corresponding subchapters of Chapters *3 Energy – 8 Waste*.

9.2 Implication for Emission Levels

9.2.1 Recalculation of CO_2 Emissions by Categories

Explanations are provided in the relating subchapters.

Table 187: Recalculation Difference of CO_2 Emissions.

IPCC Categories		CO_2 [Gg]; Differences with respect to UNFCCC 2002										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	TOTAL W/O SINKS	-2 184.6	-2 578.9	-1 894.8	-1 410.0	-2 251.5	-1 388.6	1 243.0	-803.2	869.7	-1 004.1	-1 174.2
1	ENERGY	-2 169.1	-2 563.4	-1 811.7	-1 326.2	-2 147.3	-1 273.8	1 347.8	-694.5	959.4	-937.1	-1 080.6
1 A	FUEL COMBUSTION ACTIVITIES	-2 169.1	-2 563.4	-1 811.7	-1 326.2	-2 147.3	-1 273.8	1 347.8	-694.5	959.4	-937.1	-1 173.1
1 A 1	Energy Industries	-1 170.7	-1 444.4	-1 079.2	-410.8	-395.3	-698.3	-295.5	-675.6	-636.4	-18.5	99.0
1 A 2	Manufacturing Indus-tries and Construction	-1 522.8	-405.3	-635.8	214.9	843.7	183.6	-828.9	-237.6	-1 089.1	-1 225.2	-1 545.7
1 A 3	Transport	794.7	770.3	732.5	564.3	-232.2	660.0	2 317.7	865.9	1 981.4	501.1	543.5
1 A 4	Other Sectors	-270.3	-1 484.0	-829.2	-1 694.6	-2 363.4	-1 419.2	154.5	-647.3	703.5	-194.5	-269.9
1 B	FUGITIVE EMISSIONS FROM FUELS											92.5
1 B 2	Oil and natural gas											92.5
2	INDUSTRIAL PROCESSES	2.0	6.0	1.1	1.0	1.1	1.0	1.0	1.1	8.9	9.9	1.0
2 A	MINERAL PRODUCTS											4.0
2 A 1	Cement Production											4.0
2 B	Chemical Industry											-8.3
2 D	Other Production	2.0	6.0	1.1	1.0	1.1	1.0	1.0	1.1	8.9	9.9	5.3
3	SOLVENT AND OTHER PRODUCT USE											
4	AGRICULTURE											
5	LAND USE CHANGE AND FORESTRY											
6	WASTE	-17.5	-21.5	-84.1	-84.9	-105.4	-115.8	-105.9	-109.9	-98.6	-76.9	-94.7
6 C	WASTE INCINERATION	-17.5	-21.5	-84.1	-84.9	-105.4	-115.8	-105.9	-109.9	-98.6	-76.9	-94.7
7	OTHER											
I B	International Bunkers	-55.3	-107.0	-95.0	-2.5	-15.7	-4.1	-4.1	3.6	-50.1	-1.6	3.1
Bio	CO_2 Emissions from Bio-mass	-3 033.7	-1 438.9	-1 644.4	-1 505.4	-2 245.3	-2 855.5	-2 219.8	-1 834.7	-1 950.0	-1 283.7	-869.2

Blank fields indicate that no recalculation of emissions has been carried out.

9.2.2 Recalculation of CH_4 Emissions by Categories

Explanations are provided in the relating subchapters.

Table 188: Recalculation Difference of CH_4 Emissions.

IPCC Categories		CH_4 [Gg]; Differences with respect to UNFCCC 2002										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	Total without sinks	-29.84	-25.07	-25.43	-17.51	-16.31	-10.20	-7.75	-12.50	-9.55	-11.32	-12.73
1	ENERGY	1.40	5.14	5.07	3.62	2.84	2.22	3.90	-0.93	-0.83	-0.43	-0.07
1 A	FUEL COMBUSTION ACTIVITIES	1.40	5.14	5.07	3.62	2.84	2.22	3.90	-0.93	-0.83	-0.43	-0.07
1 A 1	Energy Industries	0.00	0.00	0.03	0.04	0.05	0.06	0.07	0.07	0.06	0.06	0.09
1 A 2	Manufacturing Industries and Construction	0.02	0.06	0.05	0.03	0.26	0.23	0.18	0.19	0.19	0.20	0.20
1 A 3	Transport	-0.32	-0.36	-0.20	-0.11	-0.06	-0.05	-0.01	0.00	0.07	0.03	0.05
1 A 4	Other Sectors	1.70	5.43	5.19	3.65	2.59	1.98	3.66	-1.18	-1.15	-0.72	-0.42
1 B	FUGITIVE EMISSIONS FROM FUELS											0.00
1 B 1	Solid Fuels											0.00
2	INDUSTRIAL PROCESSES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01
2 A	MINERAL PRODUCTS		0.00	0.00		0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01
2 B	Chemical Industry											-0.01
2 C	Metal Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SOLVENT AND OTHER PRODUCT USE											
4	AGRICULTURE	-6.94	-6.40	-6.95	1.84	3.31	9.48	9.81	9.18	9.78	10.68	13.13
4 A	Enteric Fermentation	14.86	15.73	15.36	18.00	18.64	24.27	24.89	24.28	24.30	25.86	28.56
4 B	Manure Management	13.82	13.56	13.46	19.69	20.10	20.23	19.98	20.01	20.22	19.20	18.88
4 D	Agricultural Soils	-35.48	-35.56	-35.63	-35.71	-35.30	-34.89	-34.93	-34.97	-34.60	-34.24	-34.17
4 F	Field Burning of Agricultural Residues	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14
5	LAND USE CHANGE AND FORESTRY											
6	WASTE	-24.30	-23.81	-23.54	-22.97	-22.46	-21.91	-21.46	-20.75	-18.49	-21.56	-25.78
6 A	Solid Waste Disposal on Land	-24.27	-23.78	-23.48	-22.91	-22.39	-21.84	-21.40	-20.68	-18.42	-21.50	-25.72
6 B	Waste-water Handling											0.01
6 C	Waste Incineration	-0.03	-0.04	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.07
7	OTHER											
I B	International Bunkers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 the relating subchapters.

Table 189: Recalculation Difference of N_2O Emissions

IPCC Categories		N_2O [Gg]; Differences with respect to UNFCCC 2002										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	Total without sinks	11.28	13.01	9.12	11.57	13.56	12.24	11.59	12.56	11.91	11.72	11.74
1	ENERGY	0.27	0.63	0.78	0.90	0.95	0.99	1.03	0.94	1.08	0.91	0.89
1 A	FUEL COMBUSTION ACTIVITIES	0.27	0.63	0.78	0.90	0.95	0.99	1.03	0.94	1.08	0.91	0.89
1 A 1	Energy Industries	0.00	-0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.01
1 A 2	Manufacturing Industries and Construction	-0.07	-0.05	-0.05	-0.03	-0.09	-0.10	-0.12	-0.10	-0.09	-0.07	-0.06
1 A 3	Transport	0.58	0.86	1.00	1.10	1.22	1.25	1.22	1.10	1.21	1.01	0.97
1 A 4	Other Sectors	-0.23	-0.17	-0.16	-0.19	-0.19	-0.18	-0.09	-0.08	-0.05	-0.03	-0.02
1 B	FUGITIVE EMISSIONS FROM FUELS											
2	INDUSTRIAL PROCESSES	2.33	2.37	1.29	2.00	2.09	2.21	2.25	2.22	2.32	2.39	2.49
2 B	Chemical Industry	2.33	2.37	1.29	2.00	2.09	2.21	2.25	2.22	2.32	2.39	2.49
3	SOLVENT AND OTHER PRODUCT USE											
4	AGRICULTURE	8.69	10.01	7.05	8.69	10.52	9.05	8.32	9.40	8.52	8.43	8.36
4 B	Manure Management	2.41	2.38	2.29	2.43	2.42	2.44	2.40	2.39	2.39	2.35	2.32
4 D	Agricultural Soils	6.28	7.63	4.76	6.26	8.11	6.62	5.92	7.02	6.13	6.08	6.05
4 F	Field Burning of Agricultural Residues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	LAND USE CHANGE AND FORESTRY											
6	WASTE	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
6 C	Waste Incineration	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
7	OTHER											
I B	International Bunkers	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05

Blank fields indicate that no recalculation of emissions has been carried out.

9.2.4 Recalculation of HFC, PFC and SF_6 Emissions by Categories

No recalculations where done for HFCs and PFCs. SF_6 emissions were recalculated for the year 1993 because there was a transfer mistake in last year's submission that has been corrected in this year's submission (see

Table 192).

9.2.5 Recalculation of National Total GHG Emissions

Table 190 compares national total GHG emissions of UNFCCC submission 2003 with UNFCCC submission 2002. Due to the recalculations national total GHG emissions are now higher: for the base year they are 0.88% more and for the year 2000 2.75%.

Table 190: Recalculation Difference of National Total CO_2 Equivalent Emissions

Year	National Total GHG emissions without LUCF		
	UNFCCC 2002 [Gg CO_2 equiv]	UNFCCC 2003 [Gg CO_2 equiv]	Recalculation Difference [%]
Base year	77 639	78 325	0.88%
1990	77 388	78 073	0.89%
1991	81 314	82 241	1.14%
1992	74 893	75 291	0.53%
1993	74 770	76 580	2.42%
1994	76 159	77 768	2.11%
1995	78 606	80 797	2.79%
1996	79 951	84 624	5.85%
1997	81 319	84 146	3.48%
1998	79 458	83 819	5.49%
1999	79 731	82 123	3.00%
2000	79 754	81 951	2.75%

Table 191 presents recalculations for CO_2 and CH_4. The recalculation differences for CO_2 emissions are mainly due a revision of the time series of the energy balance (see Chapter Energy).

Table 192 presents N_2O and fluorinated gases. N_2O estimates increased remarkably more than compensating the decrease of emission estimates of CO_2 and CH_4 and finally resulting in an overall increase of GHG emissions compared to last year's submission. They are now about 1.5 times higher, this is mainly due a whole new approach for estimating emissions from *Agriculture* (*4 B Manure Management* and *4 D Agricultural Soils*) and due the revision of the time series for N_2O emissions from nitric acid production. For explanations and justifications see the corresponding subchapters of Chapter *Agriculture* and Chapter *Industry*.

For F-gases no recalculations were done, but there was one value that was wrong in last year's submission due to a transcription error that has been corrected in this year's submission.

Table 191: Recalculation Difference of National CO_2 and CH_4 Emissions.

Year	CO_2 [Gg]			CH_4 [Gg]		
	UNFCCC 2002	UNFCCC 2003	Recalculation Difference [%]	UNFCCC 2002	UNFCCC 2003	Recalculation Difference [%]
1990*	62 297	60 113	-3.51%	538.01	508.17	-5.55%
1991	66 174	63 595	-3.90%	527.54	502.46	-4.75%
1992	60 349	58 455	-3.14%	514.93	489.50	-4.94%
1993	60 717	59 307	-2.32%	508.82	491.31	-3.44%
1994	61 995	59 744	-3.63%	500.52	484.21	-3.26%
1995	64 015	62 627	-2.17%	489.93	479.73	-2.08%
1996	65 386	66 629	1.90%	481.82	474.07	-1.61%
1997	67 012	66 208	-1.20%	470.07	457.57	-2.66%
1998	65 464	66 333	1.33%	459.15	449.60	-2.08%
1999	66 025	65 020	-1.52%	454.16	442.84	-2.49%
2000	66 102	64 928	-1.78%	447.70	434.97	-2.84%

* 1990 is the base year for CO_2 and CH_4

Table 192: Recalculation Difference of National N_2O and HFC,PFC,SF_6 Emissions

Year	N_2O [Gg]			HFC, PFC, SF_6 [Gg CO_2-equivalent]		
	UNFCCC 2002	UNFCCC 2003	Recalculation Difference [%]	UNFCCC 2002	UNFCCC 2003	Recalculation Difference [%]
1990*	7.44	18.72	151.52%	1 484.60	1 484.60	0.00%
1991	7.74	20.75	168.10%	1 663.08	1 663.08	0.00%
1992	7.81	16.92	116.82%	1 310.13	1 310.13	0.00%
1993	8.02	19.59	144.35%	882.88	883.12	0.03%
1994	8.23	21.78	164.80%	1 103.32	1 103.32	0.00%
1995*	8.28	20.51	147.85%	1 736.44	1 736.44	0.00%
1996	8.26	19.85	140.31%	1 885.75	1 885.75	0.00%
1997	8.23	20.79	152.55%	1 884.35	1 884.35	0.00%
1998	8.26	20.17	144.12%	1 791.37	1 791.37	0.00%
1999	8.21	19.93	142.83%	1 625.69	1 625.69	0.00%
2000	8.11	19.85	144.65%	1 735.36	1 735.36	0.00%

* 1990 is the base year for N_2O, for fluorinated gases the base year is 1995

9.3 Implications for Emission Trends

As can be seen in Table 190 and Figure 29, Austria's greenhouse gas emissions as reported in the UNFCCC submission 2003 are higher than the values reported last year due to recalculations: for the base year they are 0.88% higher and for the year 2000 2.75%. This results in an stronger upward trend: last year the trend from the base year to 2000 was plus 2.5% whereas now it is 4.6%.

The reasons for the stronger upward trend are a stronger increase of CO_2 emissions, a smaller decrease of CH_4 emissions, and a large contribution from the increase in N_2O emissions.

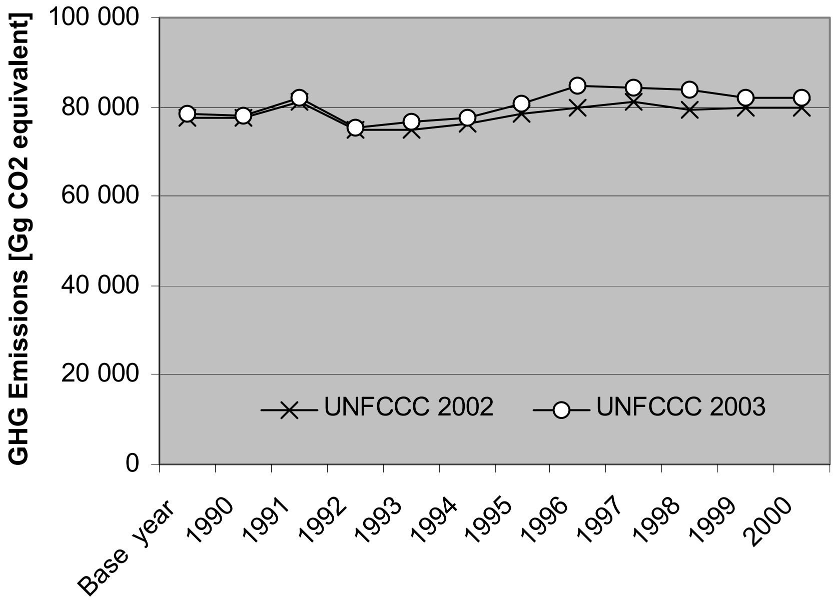


Figure 29: Emission estimate of the submission 2002 and recalculated values of the submission 2003

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 und the Kyoto Protocol.

Linkages

The improvement programme is driven by the results of the various review process, 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 Federal Environment Agency.

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 Federal Environment Agency 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
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
UBAVIE	Umweltbundesamt Wien Austrian Federal Environment Agency, Vienna
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/1997/7]

"NO" (not occurring)	for emissions by sources and removals by sinks of greenhouse gases that do not occur for a particular gas or source/sink category 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, using the completeness table of the common reporting format, why emissions could not be 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 common reporting format 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 Party should indicate, using the completeness table of the common reporting format, where in the inventory the emissions or removals from the displaced source/sink category have been included and the Party should give the reasons for this inclusion deviating 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 19 [FCCC/CP/1997/7];
"0"	for emissions by sources and removals by sinks of greenhouse gases which are estimated to be less than one half the unit being used to record the inventory table, and which therefore appear as zero after rounding. The amount should still be included in the national totals and any relevant subtotals. In the sectoral background tables of the common reporting format Parties should provide data as detailed as methods allow.

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}

REFERENCES

- BAUMELER, A.; BRUNNER, H.P.; FEHRINGER, R.; SCHACHERMAYER, E. (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft. Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs.
- BARBER, M.A.; (1996): (Alcan International Limited) Alcans`s P-FKW Emission Reduction Program. A Case Study, Lecture at the U.S. EPA Workshop on P-FKW`s, Washington DC, May 8th-9th 1996.
- BITTERMANN, W.; GERHOLD, S. (1995): Wirtschaftliche Aspekte und Holzbilanz. In: Östereichisches Statistisches Zentralamt, Forstliche Bundesversuchsanstalt (eds.): Ökobilanz Wald. Statistik Austria, Wien, 99-110.
- BMLF (1964-1998): Österreichische Waldberichte; Jahresberichte über die Forstwirtschaft. Edited annually by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.
- BMUJF–BAWP (1998): Bundes-Abfallwirtschaftsplan, Bundesabfallbericht 1998. Bundesministerium für Umwelt, Jugend und Familie, Wien.
- BMLFUW, (2002): Tabellen zum Grünen Bericht 2000. Tabelle 3.1.15: Entwicklung der Biobetriebe 1980 bis 2000., Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft - Bundesanstalt für Agrarwirtschaft. 2002. http://www.awi.bmlf.gv.at/gb/tabellen/Tab_3.1.15.xls
- BMUJF (1994): N_2O-Emissionen in Österreich. Endbericht zum Forschungsauftrag des BMUJF GZ 01 2943/2-I/7/94 vom 18.Mai 1994. Bundesministerium für Umwelt, Jugend und Familie, Wien.
- BMUJF (1994) CH_4-Emissionen in Österreich, Reihe Dokumentation, Band 6. Bundesministerium für Umwelt, Jugend und Familie, Wien.
- BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.
- BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.
- BUWAL (1995): Emissionsfaktoren für stationäre Quellen. Bundesamt für Umwelt, Wald und Landschaft, Bern.
- CHARLES, D.; JONES, B.M.R.; SALWAY, A.G.; EGGLESTON, H.S.; MILNE, R. (1998): Treatment of Uncertainties for National Estimates of Greenhouse Gas Emissions, AEA Technology: Culham, UK.; AEAT-2688-1.
- CR (2001): Report on the Individual Review of the Greenhouse Gas Inventory of Austria submitted in 2001 (Centralized review) FCCC/WEB/IRI(3)/2001/AUT[26]. UNFCCC Secretariat, Bonn.
- DÖHLER, H., DÄMMGEN, U., BERG, W., BERGSCHMIDT, A., BRUNSCH, R., EURICH-MENDEN, B., LÜTTICH, M., OSTERBURG, B. (2001). Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien und Prognose der Ammoniak-Emissionen der deutschen Landwirtschaft und Szenarien zu deren Minderung bis zum Jahre 2010. Final Report for Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft and Umweltbundesamt.

[26] http://unfccc.int/resource/webdocs/iri(3)/2001/aut.pdf

- EIDGENÖSSISCHE FORSCHUNGSANSTALT FÜR AGRARÖKOLOGIE UND LANDBAU ZÜRICH-RECKENHOLZ, INSTITUT FÜR UMWELTSCHUTZ UND LANDWIRTSCHAFT LIEBEFELD (eds.) (1997). Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Schriftenreihe FAL 26. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich.
- ELECTRONIC DATA HANDBOOK (2001), Bundesanstalt für Agrarwirtschaft (Federal Institute of Agricultural Economics). http://www.awi.bmlf.gv.at/docs/3.offer/statistic/dhb/dhbunten.htm.
- FAO AGR. STATISTICAL SYSTEM, (2001): FAO Agricultural Statistical System. http://apps.fao.org/page/-collections?-subset-=agriculture.
- FREIBAUER, A. & KALTSCHMITT, M. (2001). Biogenic greenhouse gas emissions from agriculture in Europe. European Summary Report (Project Report Task 3) of the EU-Concerted Action FAIR3-CT96-1877 "Biogenic Emissions of Greenhouse Gases Caused by Arable and Animal Agriculture".
- EMEP/CORINAIR Guidebook (1999): Atmospheric Emission Inventory Guidebook, Second Edition, Prepared by the EMEP Task Force on Emission Inventories, Edited by Stephen Richardson Task Force Secretary.
- FBVA (1992): Österreichische Waldbodenzustandsinventur. Mitteilungen der Forstlichen Bundesversuchsanstalt Wien, Vol. 168/I, Vol. 168/II, Federal Forest Research Centre, Wien.
- FBVA (1997): Waldinventur 1992/96. CD-Rom, Federal Forest Research Centre, Wien.
- GIBBS, M. (ICF Inc.); JACOBS, C. (US EPA); (1996): Reducing P-FKW Emissions from Primary Aluminium Production in the USA, from: Light Metal Age, February 1996.
- GRUBER & STEINWIDDER, (1996): Einfluß der Fütterung auf die Stickstoff- und Phosphorausscheidung landwirtschaftlicher Nutztiere – Modellkalkulationen auf Basis einer Literaturübersicht in: Die Bodenkultur – Austrian Journal of Agricultural Research, 47. Band / Heft 4 / Dezember 1996 / ISBN 0006-5471, WUV-Universitätsverlag, Wien.
- GRÜNER BERICHT (2001): Grüner Bericht 1999 online, Bundesamt für Agrarwirtschaft. 2001. http://www.awi.bmlf.gv.at/docs/3.offer/statistic/gb/tabellen/Tab_3.1.04.xls.
- GÖTZ, B. (1998): Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Umweltbundesamt, Wien, UBA BE-087a. July 1998.
- HACKL, A.; MAUSCHITZ, G. (1995/1997/2001): Emissionen der österreichischen Zementindustrie.
- HACKL, A.; MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.
- HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K.; RUNNING, S.W. (1999a): Forest growth response to changing climate between 1961 and 1990. Forest Ecology and Management 122, 209-219.
- HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K.; RUNNING, S.W. (1999b): Climate variations and tree growth between 1961 and 1995 in Austria. In: KARJALAINEN, T.; SPIECKER, H.; LAROUSSINI, O. (eds.): Causes and consequences of accelerating tree growth in Europe. European Forest Institute Joensuu, Proceedings No. 27, 75-86.
- HAUSBERGER, S. (1998): GLOBEMI - Globale Modellbildung für Emissions- und

Verbrauchsszenarien im Verkehrssektor; Institute for Internal Combustion and Thermodynamics. University of Technology Graz; Volume 71; Graz.

- ICR (2001): Report on the Individual Review of the Greenhouse Gas Inventory of Austria submitted in 2001 (In-country review) FCCC/WEB/IRI(2)/2001/AUT[27]. UNFCCC Secretariat, Bonn.
- IPCC-GPG (2000): Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Report). Edited by J. Penman, D. Kruger, I. Galbally, T. Hiraishi, B. Nyenzi, S. Emmanuel, L. Buendia, R. Hoppaus, T. Martinsen, J. Meijer, K. Miwa and K. Tanabe, Japan.
- IPCC Guidelines (1997): Revised 1996 IPCC Guidelines for Natinal Greenhouse Gas Inventories, Vol. 1: Reporting Instructions, Vol. 2: Workbook, Vol. 3: Reference Manual. Intergovernmental Panel on Climate Change, Edited by J.T. Houghton, L.G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander, Genf.
- JONAS , M. & NIELSEN, S. (2002): The Austrian Carbon Database (ACDb) Study. International Institute for Applied Systems Research Laxenburg, Report IR-01-064, 133 pp. http://www.iiasa.ac.at/Research/FOR/acdb.html#top
- KALIVODA, M. et al (2002): Air Traffic Emission Calculation for Austria 1990-2000, study commissioned by UBAVIE[28], Vienna.
- KIRNER & SCHNEEBERGER (1999): Strukturanalyse der Betriebe mit der ÖPUL-Maßnahme "Verzicht auf bestimmte ertragssteigernde Betriebsmittel (Betrieb)". Der Förderungsdienst 47(6).
- KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht, WUV Universitätsverlag, Wien.
- KOLLMANN F. 1982: Technologie des Holzes und der Holzwerkstoffe. 1. Band, 2. Aufl., Springer-Verlag, Berlin, Heidelberg, New York.
- KÖRNER, C.; SCHILCHER, B.; PELAEZ-RIEDL, S. (1993): Vegetation und Treibhausproblematik: Eine Beurteilung der Situation in Österreich unter besonderer Berücksichtigung der Kohlenstoff-Bilanz. In: ÖAW (eds.): Anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – mögliche Maßnahmen in Österreich. Dokumentation, Austrian Academy of Sciences, Wien, 6.1-6.46.
- LEISEWITZ (1996): Aktuelle und künftige Emissionen treibhauswirksamer flourierter Verbindungen in Deutschland. Dr. Schwarz und Dr. Leisewitz, UBA Berlin.
- LOHMANN, U. (1987): Holzhandbuch. 3. Aufl., DRW-Verlag, Leinfelden-Echterdingen.
- LÖHR, L. (1990): Faustzahlen für die Landwirtschaft.
- MEET (1999): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium.
- ORTHOFER, R., KNOFLACHER, M., ZÜGER, J. (1995): N_2O Emissionen in Österreich.
- OZONBERICHT (1997): Ozonbericht, Bundesministerium für Umwelt. http://www.bmu.gv.at/u_luft/bodennah_ozon/ozonbericht_1997/ozon91.htm.
- PHILIPPITSCH, R., GRATH, J., SCHIMON, W. GMEINER, C. DEUTSCH, K. GRUBER, D. TOMEK, H. BONANI, M. LASSNIG M. (2001): Wassergüte in Österreich. Jahresbe-

[27] http://unfccc.int/resource/webdocs/iri(2)/2001/aut.pdf

[28] Study has not been published but can be made available upon request.

richt 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBL.-Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.

- PISCHINGER, R. (2000): Emissionen des Off-Road-Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz
- RYPDAL, K. (1999): Evaluation of uncertainty in the Norwegian emission inventory, Norwegian Pollution Control Authority, Oslo, Norway, Report 99:01.
- S&A (2001): Synthesis & Assessment report on the greenhouse gas inventories submitted in 2001 - FCCC/WEB/SAI/2001[29] p134-144. UNFCCC Secretariat, Bonn.
- SCHIELER, K.; BÜCHSENMEISTER, R.; SCHADAUER, K. (1995): Österreichische Forstinventur – Ergebnisse 1986/90. Bericht 92, Federal Forest Research Centre, Wien.
- SCHIELER, K. & HAUK, E. (2001): Instruktion für die Feldarbeit - Österreichische Waldinventur 2000/2002, Fassung 2001. Federal Forest Research Centre, Wien.
- SCHÖRNER, G. & SCHÖNSTEIN, R. (1999): Studie über die Luftschadstoffinventur für die SNAP Kategorie 06 "Lösungsmittel" sowie Ergänzung zur Studie über die Luftschadstoffinventur[30], Wien.
- STANZEL, G., JUNGMEIER, J., SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research Graz.
- SCHARF, S., M. SCHNEIDER and G. ZETHNER (1997). Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. UBA Monographien Band 95, Umweltbundesamt, Wien.
- SCHECHTNER, (1991): Wirtschaftsdünger - Richtige Gewinnung und Anwendung, Sonderausgabe des Förderungsdienst 1991, BMLF, Wien.
- STAT. ZENTRALAMT (1991): Ergebnisse der Landwirtschaftlichen Statistik im Jahre 1991, Beiträge zur Österreichischen Statistik Heft 1.062, Österreichisches Statistisches Zentralamt, Wien.
- STAT. ZENTRALAMT (1993): Ergebnisse der Landwirtschaftlichen Statistik im Jahre 1993, Beiträge zur Österreichischen Statistik Heft 1.137. Österreichisches Statistisches Zentralamt, Wien.
- STAT. ZENTRALAMT (1995): Ergebnisse der Landwirtschaftlichen Statistik im Jahre 1995, Beiträge zur Österreichischen Statistik Heft 1.205. Österreichisches Statistisches Zentralamt, Wien.
- STATISTIK AUSTRIA[31]: Statistisches Jahrbuch Österreich 1992-2002; Industrie und Gewerbestatistik (1. Teil) 1990-1995; Konjunkturerhebung im Produzierenden Bereich (Band 3) 1997-2000;

---

[29] http://unfccc.int/resource/webdocs/sai/2001.pdf

[30] Study has not been published but can be made available upon request.

[31] STATISTIK AUSTRIA (or Statistics Austria): collects national information on the demographic, social and economical structure and development of Austria and provides information and expert services, in particular statistical analyses, as well as statistical data partly free-of-charge (e.g. published in the "The Statistical Yearbook" = a comprehensive reference book on official statistics or in separate technical papers.) Homepage: http://www.statistik.at/

- STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J.; WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemissionen. Report des Joanneum Research: Institut für Umweltgeologie und Ökosystemforschung.
- TABERAUX, A. (1996): Relationship between Operating Parameters and Emissions, Lecture at the U.S. EPA Workshop on P-FKW`s, Washington DC, May 8th-9th 1996.
- UBAVIE (2001): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999, IB-614[32], Wien.
- UBAVIE (2001): Österreichische Emissionsinventur für POPs 1985-1999, IB-650[33], Wien.
- WEISS, P.; SCHIELER, K.; SCHADAUER, K.; RADUNSKY, K.; ENGLISCH, M. (2000): Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Monographie 106, Federal Environment Agency, Wien.
- WINIWARTER, W. & ORTHOFER, R. (2000): Unsicherheit der Emissionsinventur für Treibhausgase in Österreich.
- WINIWARTER, W.; RYPDAL, K.. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria, Accepted for publication in Atmospheric Environment.
- WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports - Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5-74.
- WINDSPERGER, A., TURI, K. (1997): Emissionserhebung der Industrie für 1993 und 1994. Technische Universität Wien, Forschungsinstitut für Chemie und Umwelt, Wien.

[32] Study has not been published but can be made available upon request

[33] Study has not been published but can be made available upon request

DATA SOURCES BY SECTOR

All Sectors

- EMEP/CORINAIR Guidebook (1999): Atmospheric Emission Inventory Guidebook, Second Edition, Prepared by the EMEP Task Force on Emission Inventories.
- IPCC-GPG (2000): Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Report). Japan.
- IPCC-Rev. 1996 Guidelines (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 3: Reference Manual. Intergovernmental Panel on Climate Change, Genf.

Energy

- BMUJF (1994) CH_4-Emissionen in Österreich, Reihe Dokumentation, Band 6. Bundesministerium für Umwelt, Jugend und Familie, Wien.
- BMUJF (1994): N_2O-Emissionen in Österreich. Endbericht zum Forschungsauftrag des BMUJF GZ 01 2943/2-I/7/94 vom 18.Mai 1994. Bundesministerium für Umwelt, Jugend und Familie, Wien.
- BMWA–EB (1990): Energiebericht der Österreichischen Bundesregierung. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.
- BMWA–EB (1996): Energiebericht der Österreichischen Bundesregierung. Bundesministerium für wirtschaftliche Angelegenheiten, Wien.
- STANZEL, G., JUNGMEIER, J., SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie- und Emissionsbilanzen im Bereich Raumwärmeversorgung, Joanneum Research Graz.
- UBAVIE (2001): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur Stand 1999, IB-614[34], Wien.

Transport

- HAUSBERGER, S. (1998): GLOBEMI - Globale Modellbildung für Emissions- und Verbrauchsszenarien im Verkehrssektor; Institute for Internal Combustion and Thermodynamics. University of Technology Graz; Volume 71; Graz.
- KALIVODA, M. et al (2002): Air Traffic Emission Calculation for Austria 1990-2000, study commissioned by UBAVIE[35], Vienna.
- MEET (1999): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium.
- PISCHINGER, R. (2000): Emissionen des Off-Road-Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz.

[34] Study has not been published but can be made available upon request

[35] Study has not been published but can be made available upon request

Industry

Activity Data

- STATISTIK AUSTRIA: Statistisches Jahrbuch Österreich 1992-2002; Industrie und Gewerbestatistik (1. Teil) 1990-1995; Konjunkturerhebung im Produzierenden Bereich (Band 3) 1997-2000; Statistik Austria, Wien.

Emission Data

Electric Steel Production:

- WINDSPERGER, A., TURI, K. (1997): Emissionserhebung der Industrie für 1993 und 1994. Technische Universität Wien, Forschungsinstitut für Chemie und Umwelt, Wien.

Cement Production:

- HACKL, A.; MAUSCHITZ, G. (1995/1997/2001): Emissionen aus Anlagen der österreichischen Zementindustrie.

SF_6 used in Aluminum and Magnesium Foundries:

- LEISEWITZ (1996): Aktuelle und künftige Emissionen treibhauswirksamer flourierter Verbindungen in Deutschland. Dr. Schwarz und Dr. Leisewitz, UBA Berlin.

Emission Factors

Asphalt Roofing/ Food and Drink:

- BUWAL (1995): Emissionsfaktoren für stationäre Quellen. Bundesamt für Umwelt, Wald und Landschaft, Bern.

Aluminium Production:

- BARBER, M.A.; (1996): (Alcan International Limited) Alcans`s P-FKW Emission Reduction Program. A Case Study, Lecture at the U.S. EPA Workshop on P-FKW`s, Washington DC, May 8th-9th 1996.
- GIBBS, M. (ICF Inc.); JACOBS, C. (US EPA); (1996): Reducing P-FKW Emissions from Primary Aluminium Production in the USA, from: Light Metal Age, February 1996.
- TABERAUX, A.; (1996): Relationship between Operating Parameters and Emissions, Lecture at the U.S. EPA Workshop on P-FKW`s, Washington DC, May 8th-9th 1996.

Solvent and Other Product Use

Activity Data

- STATISTIK AUSTRIA: Statistisches Jahrbuch Österreich 1992-2002; Industrie und Gewerbestatistik (1. Teil) 1990-1995; Konjunkturerhebung im Produzierenden Bereich (Band 3) 1997-2000; Statistik Austria, Wien.

Emission Data

- SCHÖRNER, G., SCHÖNSTEIN, R. (1999): Studie über die Luftschadstoffinventur für die SNAP Kategorie 06 "Lösungsmittel" sowie Ergänzung zur Studie über die Luftschadstoffinventur, Wien.[36]

---

[36] Study has not been published but can be made available upon request

Agriculture

Emission estimation for *4 A*, *4 B* and *4 D* were carried out by scientific institutes, results were provided as unpublished studies that can be made available upon request:

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

As these studies are not published, a detailed description of the applied methods is given in the NIR. In the following data sources used in the studies mentioned above are summarized.

- BMLFUW, (2002): Tabellen zum Grünen Bericht 2000. Tabelle 3.1.15: Entwicklung der Biobetriebe 1980 bis 2000., Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft - Bundesanstalt für Agrarwirtschaft. 2002. http://www.awi.bmlf.gv.at/gb/tabellen/Tab_3.1.15.xls
- ELECTRONIC DATA HANDBOOK (2001), Bundesanstalt für Agrarwirtschaft (Federal Institute of Agricultural Economics). http://www.awi.bmlf.gv.at/docs/3.offer/statistic/dhb/dhbunten.htm.
- FAO AGR. STATISTICAL SYSTEM, (2001): FAO Agricultural Statistical System. http://apps.fao.org/page/-collections?-subset-=agriculture.
- FREIBAUER, A. & KALTSCHMITT, M. (2001). Biogenic greenhouse gas emissions from agriculture in Europe. European Summary Report (Project Report Task 3) of the EU-Concerted Action FAIR3-CT96-1877 "Biogenic Emissions of Greenhouse Gases Caused by Arable and Animal Agriculture".
- GRUBER & STEINWIDDER, (1996): Einfluß der Fütterung auf die Stickstoff- und Phosphorausscheidung landwirtschaftlicher Nutztiere – Modellkalkulationen auf Basis einer Literaturübersicht in: Die Bodenkultur – Austrian Journal of Agricultural Research, 47. Band / Heft 4 / Dezember 1996 / ISBN 0006-5471, WUV-Universitätsverlag, Wien.
- GRÜNER BERICHT (2001): Grüner Bericht 1999 online, Bundesamt für Agrarwirtschaft. 2001. http://www.awi.bmlf.gv.at/docs/3.offer/statistic/gb/tabellen/Tab_3.1.04.xls.
- GÖTZ, B. (1998): Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Umweltbundesamt, Wien, UBA BE-087a. July 1998.
- STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J.; WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemisisonen. Report des Joanneum Research: Institut für Umweltgeologie und Ökosystemforschung
- JONAS , M. & NIELSEN, S. (2002): The Austrian Carbon Database (ACDb) Study. International Institute for Applied Systems Research Laxenburg, Report IR-01-064, 133 pp. http://www.iiasa.ac.at/Research/FOR/acdb.html#top
- KIRNER & SCHNEEBERGER, (1999): Strukturanalyse der Betriebe mit der ÖPUL-Maßnahme "Verzicht auf bestimmte ertragssteigernde Betriebsmittel (Betrieb)". Der Förderungsdienst 47(6).

- KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht, WUV Universitätsverlag, Wien.
- LÖHR, L. (1990): Faustzahlen für die Landwirtschaft.
- OZONBERICHT (1997): Ozonbericht, Bundesministerium für Umwelt. http://www.bmu.gv.at/u_luft/bodennah_ozon/ozonbericht_1997/ozon91.htm.
- PHILIPPITSCH, R., GRATH, J., SCHIMON, W. Gmeiner, C. Deutsch, K. Gruber, D. Tomek, H. Bonani, M. Lassnig M. (2001): Wassergüte in Österreich. Jahresbericht 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBL.-Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.
- SCHARF, S., M. SCHNEIDER and G. ZETHNER (1997). Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. UBA Monographien Band 95, Umweltbundesamt, Wien.
- SCHECHTNER, (1991): Wirtschaftsdünger - Richtige Gewinnung und Anwendung, Sonderausgabe des Förderungsdienst 1991, BMLF, Wien.
- STAT. ZENTRALAMT (1991): Ergebnisse der Landwirtschaftlichen Statistik im Jahre 1991, Beiträge zur Österreichischen Statistik Heft 1.062, Österreichisches Statistisches Zentralamt, Wien.
- STAT. ZENTRALAMT (1993): Ergebnisse der Landwirtschaftlichen Statistik im Jahre 1993, Beiträge zur Österreichischen Statistik Heft 1.137. Österreichisches Statistisches Zentralamt, Wien.
- STAT. ZENTRALAMT (1995): Ergebnisse der Landwirtschaftlichen Statistik im Jahre 1995, Beiträge zur Österreichischen Statistik Heft 1.205. Österreichisches Statistisches Zentralamt, Wien.
- STATISTIK AUSTRIA: Statistisches Jahrbuch Österreich 1992-2002; Statistik Austria, Wien.

LUCF

- FBVA (1992): Österreichische Waldbodenzustandsinventur. Mitteilungen der Forstlichen Bundesversuchsanstalt Wien, Vol. 168/I, Vol. 168/II, Federal Forest Research Centre, Wien.
- FBVA (1997): Waldinventur 1992/96. CD-Rom, Federal Forest Research Centre, Wien.
- BITTERMANN, W.; GERHOLD, S. (1995): Wirtschaftliche Aspekte und Holzbilanz. In: Östereichisches Statistisches Zentralamt, Forstliche Bundesversuchsanstalt (eds.): Ökobilanz Wald. Statistik Austria, Wien, 99-110.
- BMLF (1964-1998): Österreichische Waldberichte; Jahresberichte über die Forstwirtschaft. Edited annually by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Wien.
- HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K.; RUNNING, S.W. (1999a): Forest growth response to changing climate between 1961 and 1990. Forest Ecology and Management 122, 209-219.
- HASENAUER, H.; NEMANI, R.R.; SCHADAUER, K.; RUNNING, S.W. (1999b): Climate variations and tree growth between 1961 and 1995 in Austria. In: KARJALAINEN, T.; SPIECKER, H.; LAROUSSINI, O. (eds.): Causes and consequences of accelerating tree

growth in Europe. European Forest Institute Joensuu, Proceedings No. 27, 75-86.

- KOLLMANN F. 1982: Technologie des Holzes und der Holzwerkstoffe. 1. Band, 2. Aufl., Springer-Verlag, Berlin, Heidelberg, New York.
- LOHMANN, U. 1987: Holzhandbuch. 3. Aufl., DRW-Verlag, Leinfelden-Echterdingen.
- KÖRNER, C.; SCHILCHER, B.; PELAEZ-RIEDL, S. (1993): Vegetation und Treibhausproblematik: Eine Beurteilung der Situation in Österreich unter besonderer Berücksichtigung der Kohlenstoff-Bilanz. In: ÖAW (eds.): Anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – mögliche Maßnahmen in Österreich. Dokumentation, Austrian Academy of Sciences, Wien, 6.1-6.46.
- SCHIELER, K.; HAUK, E. (2001): Instruktion für die Feldarbeit - Österreichische Waldinventur 2000/2002, Fassung 2001. Federal Forest Research Centre, Wien.
- WEISS, P.; SCHIELER, K.; SCHADAUER, K.; RADUNSKY, K.; ENGLISCH, M. (2000): Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Monographie 106, Federal Environment Agency, Wien.
- WINKLER, N. (1997): Country report for Austria. In: Study on European Forestry Information and Communication System Reports - Reports on Forest Inventory and Survey Systems, Volume 1, Office for Official Publications of the European Communities, Luxembourg, 5-74.
- SCHIELER, K.; BÜCHSENMEISTER, R.; SCHADAUER, K. (1995): Österreichische Forstinventur – Ergebnisse 1986/90. Bericht 92, Federal Forest Research Centre, Wien.

Waste

- BAUMELER, A.; BRUNNER, H.P.; FEHRINGER, R.; SCHACHERMAYER, E. (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft. Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs.
- BMUJF–BAWP (1998): Bundes-Abfallwirtschaftsplan, Bundesabfallbericht 1998. Bundesministerium für Umwelt, Jugend und Familie, Wien.
- BUWAL (1995): Emissionsfaktoren für stationäre Quellen. Bundesamt für Umwelt, Wald und Landschaft, Bern.
- HACKL, A.; MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.
- ORTHOFER, R., KNOFLACHER, M., ZÜGER, J. (1995): N_2O Emissionen in Österreich.
- STEINLECHNER, E.; BERGHOLD, H.; CATE, F.M.; JUNGMEIER, G.; SPITZER, J.; WUTZL, C. (1994): Möglichkeiten zur Vermeidung und Nutzung anthropogener Methanemisisonen. Report des Johanneum Research: Institut für Umweltgeologie und Ökosystemforschung.
- UBAVIE (2001): Österreichische Emissionsinventur für POPs 1985-1999, IB-650[37], Wien.

[37] Study has not been published but can be made available upon request