National Inventory Report 2005 Norway

Greenhouse Gas Emissions 1990-2003 reported
according to the UNFCCC guidelines

TA-2097/2005
ISBN 82-7655-258-7

Preface

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and entered into force in 1994. According to Articles 4 and 12 of the Convention, Parties are required to develop and submit to the UNFCCC national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol on an annual basis.

To comply with the above requirement, Norway has prepared the present National Inventory Report (NIR) for the year 2005. The report and the associated Common Reporting Format (CRF) tables have been prepared accordance with the UNFCCC Reporting Guidelines on Annual Inventories as adopted by the COP by its Decision 18/CP. 8. The methodologies used in the calculation of emissions are based on the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC Guidelines) and the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* prepared by the Intergovernmental Panel on Climate Change (IPCC).

The Norwegian Pollution Control Authority (SFT), a directorate under the Norwegian Ministry of Environment, is responsible for the reporting. Statistics Norway (SN) has been the principle contributor to the preparation of the report.

Oslo, April 2005

Ingrid Bjotveit
Director, Department of Industry
The Norwegian Pollution Control Authority (SFT)

Contents

E.S. Executive Summary …..……9

1. Introduction 16
1.1. Background 16
1.2. Institutional arrangement for inventory preparation 17
1.3. The process of inventory preparation 19
1.3.1. Introduction 19
1.3.2. Data collection, processing and archiving 19
1.4. Methodologies and data sources used 20
1.4.1. Introduction 20
1.4.2. The Norwegian emission model 20
1.4.3. Data sources 21
1.5. Key source categories 22
1.6. Quality assurance and quality control (QA/QC) 24
1.6.1. Introduction 24
1.6.2. QA Procedures 24
1.6.3. General QC procedures 25
1.6.4. Source category-specific QC procedures 27
1.6.5. Verification studies 27
1.6.6. Documentation, archiving and reporting 28
1.6.7. Confidentiality issues 28
1.7. Uncertainty evaluation 28
1.8. General assessment of the completeness 29
1.9. Planned and implemented improvements 30
1.9.1. Issues addressed in reviews of the inventory 30
1.9.2. Implemented improvements 30
1.9.3. Planned improvements 31

2. Trends in Greenhouse Gas Emissions 33
2.1. Emission trends for aggregated greenhouse gas emissions 33
2.2. Emission trends by gas 34
2.2.1. Carbon dioxide (CO_2) 35
2.2.2. Methane (CH_4) 38
2.2.3. Nitrous oxide (N_2O) 40
2.2.4. Perfluorcarbons (PFCs) 42
2.2.5. Sulphur hexafluoride (SF_6) 43
2.2.6. Hydroflorocarbons (HFCs) 44
2.3. Emission trends by source 45
2.3.1. Energy 47
2.3.2. Industrial processes 50
2.3.3. Solvent and other product use 52
2.3.4. Agriculture 53
2.3.5. Waste 53
2.4. Land Use Change and Forestry 55
2.5. Emission trends for indirect greenhouse gases and SO_2 57

3. Energy 60
3.1. Overview 60
3.2. Stationary Fuel Combustion: Gaseous Fuels – CO_2 – 1A1, 1A2, 1A4 (Key Source) 61
3.2.1. Description 61
3.2.2. Methodological issues 61
3.2.3. Activity data 62
3.2.4. Emission factors 63

3.2.5. Uncertainties 65
3.2.6. Source specific QA/QC and verification 65
3.2.7. Recalculations 65
3.2.8. Planned improvements 66
3.3. Stationary Fuel Combustion: Liquid Fuels – CO2 – 1A1, 1A2, 1A4 (Key Source) 66
3.3.1. Description 66
3.3.2. Methodological issues 66
3.3.3. Activity data 66
3.3.4. Emission Factors 67
3.3.5. Uncertainties 67
3.3.6. QA/QC and verification 68
3.3.7. Recalculations 68
3.3.8. Planned improvements 68
3.4. Stationary Fuel Combustion: Solid Fuels, Biomass, Other fuels – CO_2 – 1A1, 1A2, 1A4 (Non-Key Source) 68
3.5. Stationary Fuel Combustion: All Fuels – CH_4, N_2O – 1A1, 1A2, 1A4 (Non-Key Source) 70
3.6. Civil Aviation: Liquid Fuels – CO_2 – 1A3a (Key Source) 72
3.6.1. Description 72
3.6.2. Methodological issues 72
3.6.3. Activity data 72
3.6.4. Emission factors 72
3.6.5. Uncertainties 72
3.6.6. Source specific QA/QC and verification 73
3.6.7. Recalculations 73
3.6.8. Planned improvements 73
3.7. Civil Aviation – CH_4, N_2O – 1A3a (Non-Key Source) 73
3.8. Road Transportation: Liquid Fuels – CO_2, N_2O – 1A3b (Key Source) 75
3.8.1. Description 75
3.8.2. Methodological issues 75
3.8.3. Activity data 77
3.8.4. Emission factors 78
3.8.5. Emissions from evaporation and cold starts 78
3.8.6. Uncertainties 79
3.8.7. QA/QC and verification 79
3.8.8. Recalculations 79
3.8.9. Planned improvements 80
3.9. Road Transportation: Liquid Fuels – CH_4 – 1A3b (Non-Key Source) 80
3.10. Railways: All Fuels – All Components – 1A3c (Non-Key Source) 81
3.10.1. Methodological issues 81
3.10.2. Activity data 81
3.10.3. Emission factors 81
3.10.4. Uncertainties 81
3.10.5. Source specific QA/QC and verification 81
3.11. Navigation: Liquid Fuels – CO_2 –1A3d (Key Source) 81
3.11.1. Description 81
3.11.2. Methodological issues 82
3.11.3. Activity data 82
3.11.4. Emission factors 82
3.11.5. Uncertainties 82
3.11.6. Source specific QA/QC and verification 83
3.11.7. Recalculations 83
3.11.8. Planned improvements 83
3.12. Navigation: All Fuels – CH_4, N_2O –1A3d (Non-Key Source) 83
3.13. Other Transportation: All Fuels – CO_2, CH_4, N_2O – 1A3e (Non-Key Source) 84
3.13.1. Methodological issues 84

3.13.2. Activity data 84
3.13.3. Emission factors 84
3.13.4. Description 84
3.13.5. Methodological issues 84
3.13.6. Activity data 84
3.13.7. Emission factors 85
3.13.8. Uncertainties 85
3.14. Other Sectors: All Fuels – CO_2, CH_4, N_2O – 1A5 (Non-Key Source) 85
3.15. Fugitive Emissions from Coal Mining and Handling – 1B1a – CH_4 (Key Source) 86
3.15.1. Description 86
3.15.2. Methodological issues 87
3.15.3. Activity data 87
3.15.4. Emission factor 87
3.15.5. Uncertainties 87
3.15.6. Source specific QA/QC and verification 88
3.15.7. Recalculations 88
3.15.8. Planned Improvements 88
3.16. Fugitive Emissions from Oil and Natural Gas – 2B 88
3.16.1. Overview 88
3.16.2. Fugitive Emissions from Oil – CO_2, CH_4 - 1.B.2.a (Key Source) 89
3.16.3. Fugitive Emissions from Natural Gas – 1.B.2.b (Non Key Source) 92
3.16.4. Fugitive Emissions from Venting and Flaring – CO_2 , CH_4 - 1.B.2.c – (Key Source) 93
3.17. CO2 capture and storage at the oil and gas production field Sleipner West (Key Category) 96
3.17.1. Description 96
3.17.2. Methodological issues 97
3.17.3. Uncertainties 98
3.17.4. Source specific QA/QC and verification 98
3.18. International bunker fuels 98
3.18.1. Methodological Issues 99
3.18.2. Precursors 99
3.19. Cross-cutting issues 100
3.19.1. Sectoral versus reference approach 100
3.19.2. Feedstocks and non-energy use of fuels 101
3.19.3. Indirect CO_2 emissions from CH_4 and NMVOC 101

4. Industrial Processes 102
4.1. Overview 102
4.2. Mineral Products – 2A 102
4.2.1. Cement Production – CO_2 - 2A1 (Key Source) 103
4.2.2. Lime Production – 2A2 (Non Key Source) 104
4.2.3. Limestone and Dolomite Use 2A3 (Non Key Source) 104
4.3. Chemical Industry – 2B 105
4.3.1. Ammonia Production – CO_2 - 2B1 (Non Key Source) 105
4.3.2. Production of Nitric Acid –N_2O - 2B2 (Key source) 106
4.3.3. Silicon Carbide – 2B4 (Non Key Source) 107
4.3.4. Production of Calcium Carbide – 2B4 (Non Key Source) 108
4.3.5. Production of Methanol - 2B5 (Non Key Source) 109
4.3.6. Production of Plastic 2B5 (Non Key Source) 109
4.3.7. Production of Explosives - 2B5 (Non Key Source) 110
4.4. Metal Production – 2C 110
4.4.1. Production of Iron and Steel – 2C1 (Non Key Source) 110
4.4.2. Production of Ferroalloys - CO_2 - 2C2 (Key source) 111
4.4.3. Production of Primary Aluminium –CO_2 and PFC - 2C3 (Key source) 113
4.4.4. Production of Secondary Aluminium – 2C4 (Non Key Source) 117

4.4.5. Production of magnesium –SF_6 - 2C4 (Key source) ... 117
4.4.6. Production of Nickel - 2C5 (Non Key Source) ... 118
4.4.7. Manufacture of Anodes - 2C5 (Non Key Source) ... 119
4.5. Other Production – 2D ... 119
4.5.1. Food and drink - Production of Bread and Beer – 2D2 (Non Key Source) ... 119
4.5.2. Food and drink - Carbonic Acid to Breweries - 2D2 ... 120
4.5.3. Production of Bio Protein (Non Key Source) ... 120
4.6. Consumption of Halocarbons and SF_6 ... 120
4.6.1. HFCs and PFCs from Products and Processes – HFC - 2F (Key source) ... 120
4.6.2. Emissions of SF_6 from Products and Processes – 2F (Non Key Source) ... 122

5. Solvent and other product use ... 124
5.1. Overview ... 124
5.2. Solvent losses (NMVOC) ... 124
5.2.1. Description ... 124
5.2.2. Method ... 124
5.2.3. Activity data ... 125
5.2.4. Uncertainty ... 125
5.2.5. Source specific QA/QC ... 125
5.3. Other product use -3D ... 125
5.3.1. Use of N_2O in anaesthesia – 3D ... 125
5.3.2. Use of N_2O as propellant – 3D ... 126

6. Agriculture ... 127
6.1. Overview ... 127
6.2. Emissions from enteric fermentation in domestic livestock 4A– CH_4 (Key Source) ... 128
6.2.1. Description ... 128
6.2.2. Methodological issues ... 128
6.2.3. Activity data ... 128
6.2.4. Emission factors ... 129
6.2.5. Uncertainties ... 130
6.2.6. Completeness ... 130
6.2.7. Source specific QA/QC ... 130
6.2.8. Recalculations ... 130
6.2.9. Planned improvements ... 130
6.3. Emissions from manure management -4B- CH_4- , N_2O (Non Key Source) ... 130
6.3.1. Description ... 130
6.3.2. Methodological issues ... 131
6.3.3. Activity data ... 134
6.3.4. Emission factors ... 135
6.3.5. Uncertainties ... 138
6.3.6. Completeness ... 139
6.3.7. Source specific QA/QC ... 139
6.3.8. Recalculations ... 139
6.3.9. Planned improvements ... 139
6.4. Direct and indirect emissions from agricultural soils - 4D - N_2O (Key Source) ... 139
6.4.1. Description ... 139
6.4.2. Methodological issues ... 140
6.4.3. Activity data ... 142
6.4.4. Emission factors ... 144
6.4.5. Uncertainties ... 146
6.4.6. Completeness ... 147
6.4.7. Source specific QA/QC ... 147
6.4.8. Recalculations ... 148
6.4.9. Planned improvements ... 148

6.5. Emissions from agricultural residue burning (agricultural wastes)- 4F - CH_4 , N_2O (Non Key Source) 148
6.5.1. Method ... 148
6.5.2. Activity data ... 149
6.5.3. Emission factors ... 149
6.5.4. Uncertainties ... 150
6.5.5. Completeness ... 150
6.5.6. Source specific QA/QC ... 150
6.5.7. Recalculations ... 150
6.5.8. Planned improvement ... 150
6.6. Other agricultural emission sources – 4G – NH_3 (Non Key Source) ... 150
6.6.1. NH_3 emissions from treatment of straw ... 150
6.6.2. Particle emissions from the agricultural sector ... 151

7. Land-Use, Land-Use Change and Forestry (LULUCF) ... 153
7.1. Overview ... 153
7.2. IPCC Land-use, Land-Use change and forestry categories ... 156
7.2.1. Forest land ... 157
7.2.2. Cropland ... 157
7.2.3. Grassland ... 157
7.2.4. Wetlands ... 157
7.2.5. Settlements ... 157
7.2.6. Other lands ... 158
7.3. Inventory and statistical systems for LULUCF in Norway ... 158
7.3.1. The National Forest Inventory ... 158
7.3.2. Agricultural census ... 159
7.3.3. Other sources of data ... 160
7.4. Land Areas statistics and transitions ... 162
7.4.1. Choosing data according to IPCC Good Practice Guidance ... 162
7.4.2. Area distribution and land-use transfers ... 162
7.4.3. National data ... 163
7.4.4. Use of administrative data to detail the categories ... 166
7.5. Forest land - 5A ... 170
7.5.1. Forest land remaining forest land – 5A1 (Key Category) ... 170
7.5.2. Land converted to forest land – 5A2 ... 178
7.6. Cropland – 5B ... 180
7.6.1. Cropland remaining cropland – 5B1 ... 180
7.6.2. Land converted to cropland - 5B2 ... 187
7.7. Grassland – 5C ... 189
7.7.1. Grassland remaining grassland – 5C1 (Key Category) ... 189
7.7.2. Land converted to grassland – 5C2 ... 190
7.8. Wetlands – 5D ... 191
7.8.1. Wetlands remaining wetlands – 5D1 ... 191
7.8.2. Land converted to wetlands – 5D2 ... 192
7.9. Settlements – 5E ... 193
7.9.1. Settlements remaining settlements – 5E1 ... 193
7.9.2. Land converted to settlements – 5D2 ... 193
7.10. Other land – 5E ... 194
7.10.1. Other land remaining other land – 5E1 ... 194
7.10.2. Land converted to other land – 5E2 ... 195
7.11. Reporting of emissions of non-CO_2 gases ... 195
7.11.1. Introduction ... 195
7.11.2. Forests ... 195
7.11.3. Cropland ... 199
7.11.4. Grassland ... 200

7.11.5. Wetlands 200
7.12. Uncertainties 200
7.13. Source-specific QA/QC and verification 201
7.14. Recalculations 201
7.15. Planned improvements 201

8. Waste 201
8.1. Overview 201
8.2. Managed Waste Disposal on Land – CH_4 – 6A1 (Key source) 202
8.2.1. Description 202
8.2.2. Method CH_4 202
8.2.3. Activity data 204
8.2.4. Emission factor 204
8.2.5. Uncertainties 205
8.2.6. Source specific QA/QC 205
8.2.7. Recalculations 205
8.2.8. Planned improvements 206
8.3. Unmanaged Waste Disposal Sites – 6A2 (Non Key Source) 206
8.4. Wastewater handling - 6B (Non Key Sources) 206
8.4.1. Description 206
8.4.2. Method 206
8.4.3. Activity data 207
8.4.4. Emission factor 207
8.4.5. Uncertainties 208
8.4.6. Source Spesific QA/QC 208
8.4.7. Recalculations 208
8.4.8. Planned improvements 208
8.5. Waste incineration – CO_2 – 6C (Non Key Source) 209
8.5.1. Description 209
8.5.2. Method 209
8.5.3. Activity data 209
8.5.4. Emission factors 210
8.5.5. Uncertainties 210
8.5.6. Source specific QA/QC 210
8.5.7. Recalculations 210
8.5.8. Planned improvements 211

9. Recalculations 212
9.1. Overall description of recalculations 212
9.2. Specific description of the recalculations 212
9.2.1. IPCC category 1 Energy 212
9.2.2. IPCC category 2 Industrial processes 214
9.2.3. IPCC category 4 Agriculture 214
9.2.4. IPCC category 7 Land-Use, Land-Use Change and Forestry (LULUCF) 215
9.2.5. IPCC category 6 Waste 215
9.3. Implications of the recalculations 215
9.3.1. Implications for emissions levels 215
9.3.2. Implications for emission trends 216
References 218
Annex I – Key Sources
Annex II – Uncertainties
Annex III – Energy Balance
Annex IV – CRF Summary Tables

E.S Executive Summary

E.S.1. Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) requires the Parties to the Convention to develop, update and submit to the UNFCCC annual inventories of greenhouse gas emissions by sources and removals by sinks. This report documents the Norwegian National Inventory Report (NIR) 2005 for the period 1990-2003.

The report and the associated Common Reporting Format (CRF) tables have been prepared accordance with the UNFCCC Reporting Guidelines on Annual Inventories as adopted by the COP by its Decision 18/CP. 8. The methodologies used in the calculation of emissions are based on the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC Guidelines) and the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* prepared by the Intergovernmental Panel on Climate Change (IPCC). As recommended by the IPCC Guidelines country specific methods have been used where appropriate and where they provide more accurate emission data.

This report presents the national inventory of greenhouse gas (GHG) emissions and removals from 1990 to 2003. Emissions of the following greenhouse gases are covered in the report:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Perfluorocarbons (PFCs)
- Hydrofluorocarbons (HFCs)
- Sulphur hexafluoride (SF_6)

In addition, the inventory includes calculations of emissions of the precursors NOx, NMVOC and CO as well as SO_2. More comprehensive descriptions of the methodologies have been included in this report. In some cases the most detailed descriptions are added in annexes. The Common Reporting Format (CRF) tables are included in Annex 4. For the years 1990 and 1998-2003 full CRF-sets are made available. For the years 1991 to 1997, only summary tables (Summary II) are provided, due to the fact that emission figures are only available in a different electronic format than that required by the UNFCCC. However, Norway intends to submit full sets within six weeks from the 15 April deadline for the NIR. The emissions figures for the years 1991 to 1997 have been calculated using the same methodology as for the 1990 and 1998-2003 figures.

The COP, by its decision 13/CP.9, completed the tables of the common reporting format for reporting on the Land Use, Land Use Change and Forestry (LULUCF) sector and it was decided these should be employed for the 2005 submission, as part of a trial period. A study has been conducted in Norway with the aim to provide estimates of emissions and removals from the LULUCF-sector using the IPCC Good Practice Guidance, as well as to provide documentation of the implementation of the GPG for Norway. The work is carried out by the Norwegian Institute of Land Inventory (NIJOS), Center for International Climate and Environmental Research (Cicero) and Statistics Norway (SN). The report from the study will be published in June/July 2005 (Cicero 2005). The methodology and calculations in this report are extracted from this study. As the results so far are preliminary, and no experience, has been gained from using this new reporting format, the data must be considered preliminary.

The 2004 GHG inventory submission of Norway was subject to a centralized review by an expert review team (ERT) in October 2004. The main findings were that the Norwegian inventory is largely complete. However, areas of improvement were identified. The most important being the provisions of complete series of CRF-tables (including recalculations tables), the use of notation keys, and the

provision of greater transparency on country-specific methods and Emission Factors in the NIR. The ERT also recommends that Norway formalize its quality assurance/quality control (QA/QC) plan.

The present report seeks to address the elements identified in the review to the extent that it has been possible. In particular, the various sectors are described in more detail now than in NIR 2004. A full set of CRF-tables will be submitted shortly. The use of notation keys is now more extensive than in previous submissions. Norway has initiated a project with the aim to formalize the QA/QC plan. This will be described in detail in NIR 2006. The model for calculating methane from landfills has been revised, and is described in more detail in this submission. CO_2 capture and storage, which is of relevance for Norway, is also described in more detail in this report. Several other projects have been initiated in 2005, to accommodate for the ERTs comments in future NIRs.

E.S.2 Trends in emissions and removals

In 2003, the total emissions of greenhouse gases in Norway amounted to 54,8 million tonnes CO_2– equivalents. 79 per cent of this was CO_2, while methane and nitrous oxide contributed 9 and 10 per cent, respectively. PFCs, HFCs and SF_6 together accounted for approximately 2 per cent of total emissions.

Table 1 and Table 2 show the overall trend in the total emissions by gas during the period 1990-2003. From 1990 to 2003 the emissions increased by approximately 9 per cent, increasing by 2 per cent between 2002 and 2003, alone. Norway experienced economic growth during the period since 1990, which explains the general growth until 2003.

Table 1. Emissions and removals of greenhouse gases for the years 1990-200. Source: SN/SFT

		Year													
Gas	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
CO_2	Mtonnes	34,4	33,5	33,8	35,4	37,3	37,2	40,4	40,6	40,8	41,6	41,1	42,7	41,2	43,2
CH_4	ktonnes	245,7	247,3	250,4	252,5	256,3	256,7	258,2	260,9	253,4	248,9	253,2	252,1	243,8	240,8
N_2O	ktonnes	16,3	15,9	13,7	14,9	15,2	15,5	15,8	15,6	16,5	17,1	16,8	16,8	17,5	17,2
CF_4	tonnes	479,1	368,9	294,1	290,1	250,6	229,1	214,2	200,8	184,8	163,9	131,1	151,7	163,0	102,3
C_2F_6	tonnes	19,6	13,7	11,4	10,3	8,9	7,9	5,1	7,7	7,1	6,2	5,1	6,2	6,6	4,2
PFK 218	tonnes	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,0
SF_6	tonnes	92	87	30	31	37	26	24	25	31	37	40	34	11	10
HFK 134a	tonnes	0,0	0,1	0,2	2,3	7,1	13,3	22,4	34,1	49,7	65,3	79,4	93,4	111,6	83,9
HFK 125	tonnes	0,0	0,0	0,0	0,0	1,3	6,7	15,3	27,2	41,2	55,6	72,6	92,2	115,3	75,7
HFK 143a	tonnes	0,0	0,0	0,0	0,0	0,7	5,8	14,7	26,0	39,6	56,0	77,1	102,0	131,9	74,6
HFK 32	tonnes	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,4	0,7	1,0	1,5	3,3
HFK 23	tonnes	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,4	0,8	0,8	0,8	0,8	0,9	0,2
HFK 152a	tonnes	0,0	0,1	0,1	0,1	0,1	0,1	0,2	0,3	0,7	0,8	1,1	1,4	1,7	1,6
HFK 227ea	tonnes	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,3	0,4	0,5	0,5	0,8	2,2	1,0
Total	**Mt CO2-eq.**	**50,1**	**48,3**	**46,0**	**48,0**	**50,0**	**49,6**	**52,8**	**52,9**	**53,3**	**54,3**	**53,8**	**55,3**	**53,5**	**54,8**

Preliminary figures of the GHG emissions in 2004 indicate a continued increase, amounting to 1 per cent increase in 2004 compared to 2003.
The CO_2 emission's share of the Norwegian total GHG emissions has increased from 69 per cent in 1990 to 79 per cent in 2003. The increased proportion of CO2 and the reduction of other gases are due to growth in the CO2 emissions as well as a reduction in emissions of the other gases because of environmental measures implemented and/or technological improvements.

Table 2. Emissions in Mtonnes CO2-equivalents 1990, 2002, 2003 and change 1990-2003 and 2002-2003

Emissions in Mtonnes CO_2 -eq.				Change	Change
	1990	2002	2003	1990-2003	2002-2003
CO2	34,41	41,24	43,22	26 %	5 %
CH4	5,16	5,12	5,06	-2 %	-1 %
N2O	5,06	5,42	5,33	5 %	-2 %
PFCs	3,29	1,12	0,69	-79 %	-38 %
SF6	2,20	0,25	0,23	-89 %	-8 %
HFCs	0,00	0,37	0,24	-	-34 %
SUM	**50,13**	**53,52**	**54,77**	**9 %**	**2 %**

The growth in CO_2-emissions from 2002 to 2003 can mainly be explained by increased offshore oil and gas production and increased sales of mineral oil for heating because of high prices on electricity, due to dry and cold conditions creating scarcity of hydropower. Other factors which contributed are growth in the sales of auto diesel for cars as well as of marine fuels in domestic navigation.

The emissions of PFCs showed a strong decrease of about 38 per cent from 2002 to 2003. PFC-emissions originate primarily from the production of aluminium. At the same time CO_2-emissions from aluminium production increased, offsetting the decrease from this sector by about 50 per cent. Emissions of N_2O decreased with 2 per cent between 2002 and 2003, first and foremost because of reduced emissions due to technological improvements, from production of fertiliser. SF_6-emissions were also reduced by 8 per cent from 2002 to 2003, mainly because of technological improvements and the closure of a production plant for primary magnesium in 2002. HFC-emissions decreased with as much as 34 per cent, which may be an effect of the tax on import of HFC that entered into force 1 January 2003.

E.S.3 Source and sink category emission estimates and trends

Figure 1 shows the percentage change in emissions of greenhouse gases from 1990 to 2003 for the various UNFCCC sectors, compared to emissions in 1990. The development for each of the sectors since 1990 with regard to greenhouse gas emissions, and the most important sources, are briefly described in the following.

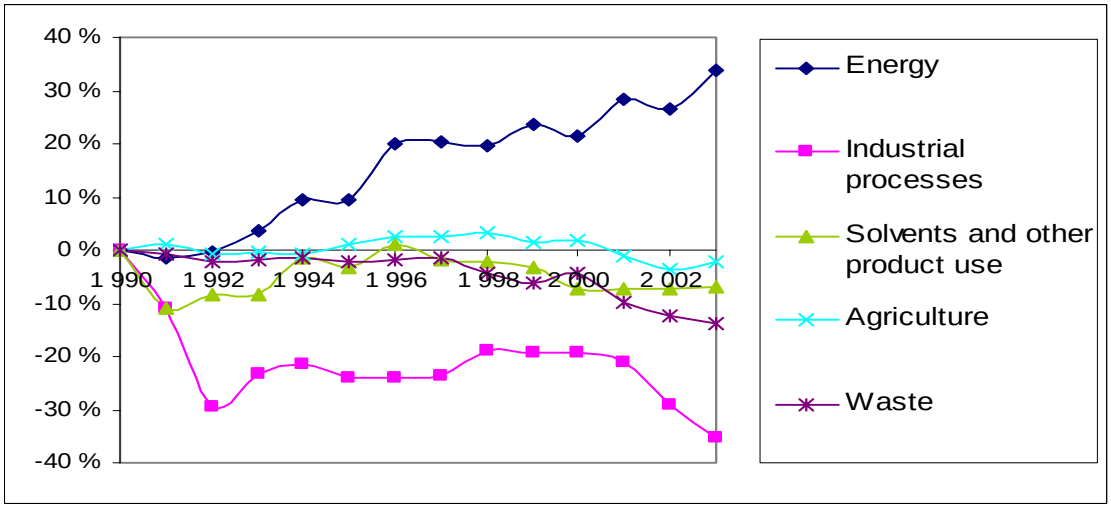


Figure 1. Figure 1 Changes in greenhouse gas emissions by UNFCCC sector 1990-2003 compared to 1990. Source: SN/SFT

Figure 2 shows the various sections share of total GHG emissions in Norway in 2003. The Energy sector accounts for almost 72 per cent of the total Norwegian greenhouse gas emissions. Road traffic and offshore gas turbines (electricity generation and pumping of natural gas) are the largest single contributors, while coastal navigation and energy commodities used for the production of raw materials are other major sources. During most of the 1990s and until 2003 energy related emissions have been increasing, mainly due to higher activity in the offshore- and transport sectors.

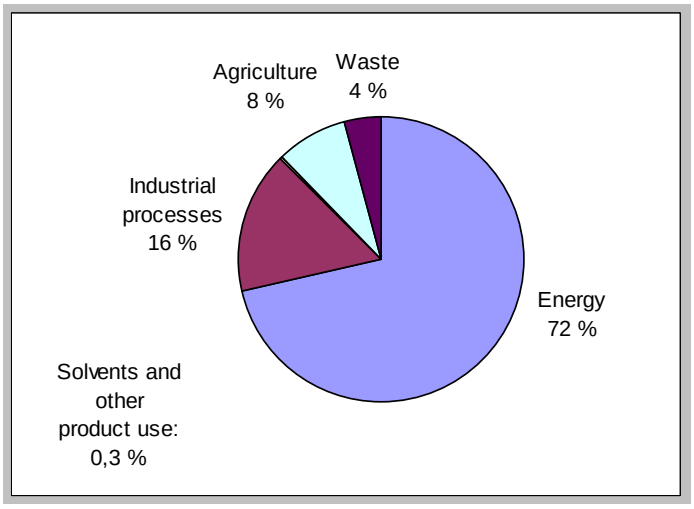


Figure 2. Figure 2 Emissions by UNFCCC sector in 2003. Source: SFT/SN

From 1990 to 2003 the increase in emissions from the energy sector was 34 per cent. Emissions from oil and gas operations offshore increased by 72 per cent from 1990 to 2003. Their relative contribution to the total national GHG emissions increased from 13 per cent in 1990 to 20 per cent in 2003. The remaining emissions in the energy sector (including the two Norwegian gas terminals onshore) have experienced an increase of 23 per cent.

The second most important sector with regard to the size of emissions of greenhouse gases in Norway is industrial processes. This sector accounts for 16 per cent of the total national emissions of

greenhouse gases. Production of raw materials is the main source of process-related industrial emissions of both CO_2 and other greenhouse gases such as N_2O (fertiliser production), SF_6 (magnesium foundries) and PFCs (aluminium production). Between 1990 and 2003 the sector has experienced an overall decrease of 35 per cent. This is mainly due to reduced PFC emissions from production of aluminium and SF_6 from production of magnesium.

The contribution of the agricultural sector to the total emissions of greenhouse gases is 8 per cent. This sector has experienced a small reduction over the period 1990-2003, which amounts to 2 per cent. Agricultural practices mainly result in emissions of methane and nitrous oxide, as well as indirect emissions of CO_2. The largest sources in this sector are N_2O from soil processes and CH_4 from enteric fermentation.

The waste sector contributes about 4 per cent of total Norwegian greenhouse gas emissions. Due to changes made in the model for calculating methane from landfills, the waste sectors contribution to the total GHG emissions has been reduced from 7 per cent to 4 per cent. There has been a reduction of emissions from the waste sector since 1996/-97, amounting to about 14 per cent compared to the level in 1990. Waste volumes have increased quite significantly over the period, but this has been counteracted by increased recycling of waste and increased burning of methane from landfills.

Solvent and other product use accounts for only 0.3 per cent of the total emissions of greenhouse gases in the country. This contribution has been more or less unchanged since 1990.

The average net sequestration from the land-use, land-use change and forestry sector was about 22.5 Mtonnes of CO_2 in 2003, which would offset 41 per cent of the total greenhouse gas emissions in Norway that year. The sequestration increased by approximately 47 per cent from 1990 to 2003, while the increase from 2002 to 2003 was only ca. 0.6 per cent. Forest covers around one fourth of the mainland area of Norway and is the most important land-use category. Forest is also the most important contributor to carbon stock changes. In 2003 the land-use category forest land remaining forest land was the single contributor to the total amount of sequestration with approximately 25 Mtonnes CO_2. All other land-use categories showed net emissions, which totalled 2.5 Mtonnes CO_2. The total net removal in forest living biomass for the period 1990-2003 calculated with this new methodology deviates only by about 6 per cent from the sequestration reported previously to UNFCCC using a lower tier method based on annual increment, losses and biomass expansion factors.

In 2003, CO_2 emissions from ships and aircraft in international traffic bunkered in Norway amounted to a total of 2.5 million tonnes, which corresponds to about 6 per cent of the total Norwegian CO_2 emissions. These emissions are not included in the national totals, but reported separately as required by the UNFCCC reporting guidelines. CO_2 emissions from marine and aviation bunkers showed a growth of about 80 per cent during the period 1990 to 1997. This increasing trend was reversed in 1998, and from 1997 to 2003 emissions were reduced by 33 per cent. Compared to 1990, the emissions were 21 per cent higher in 2003.

E.S.4 Precursors and SO_2

Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) are not greenhouse gases, but they have an indirect effect on the climate through their influence on greenhouse gases; in particular ozone. Sulphur dioxide (SO_2) has also an indirect impact on climate, as it increases the level of aerosols with a subsequent cooling effect. Therefore, emissions of these gases are, to some limited extent included in the inventory.

NO_x emissions decreased, overall from 1990 to 2002, primarily because of stricter emission regulations with regard to road traffic, which counteracted increased emissions from oil and gas production and from navigation. However, the NO_x emissions increased again, by 4 per cent in 2003, compared to 2002. The increase was mainly due to increased emissions from oil and gas production

and from navigation. The total decrease from 1990 to 2003 is less than 2%. The emissions of NMVOC experienced an increase of 2 per cent in the same period, mainly because of the rise in oil production. However, the emissions have decreased by 30 per cent from 2001 to 2003. This decrease has been possible, due to implemented measures to increased recycling of oil vapour offshore at loading and storage terminals. Emissions of CO have decreased by 41 per cent over the period 1990-2003. The explanation is primarily new emissions standards for motor vehicles. With regard to emissions of SO_2, they were reduced by 56 per cent from 1990 to 2003. This can mainly be explained by a reduction in sulphur content of all oil products and lower process emissions from ferroalloy and aluminium production and refineries.

E.S.5 Emissions trends compared to value added

Emissions of greenhouse gases have increased more than value added (constant basic prices) for the first time in a number of years.

The Norwegian authorities have a goal that the economy will continue to grow but at the same time there will be a reduction in the environmental consequences due to these economic activities. A reduction in emissions intensity can be obtained either by having the various industries become more environmentally effective (i.e., pollute less per NOK value added), or by a structural change in the economy where less polluting industries become increasingly more important at the expense of more polluting industries.

In previous years most industries showed a positive development. Even though total levels of pollution did not go down, there was less pollution in relation to value added created. In 2003 this was not the case. Emissions of both greenhouse gases and acidification precursors increased in relation to the previous year, and they increased more than value added. Whether this is a change in the overall trend is not yet certain. Changes in emissions intensity have also gone in undesirable directions for short periods earlier, as demonstrated in Figure 3. However, the long-term trend has been gradually decreasing for the emissions intensity for greenhouse gases. Some of the primary reasons for the emissions increase in 2003 were higher natural gas production and an increase in road transportation and coastal shipping. Another important factor was that the winter of 2003 was cold with little precipitation. This lead to scarcity of water for hydro power production and high prices of electricity, in turn leading to higher use of substitutes like mineral oils for heating.

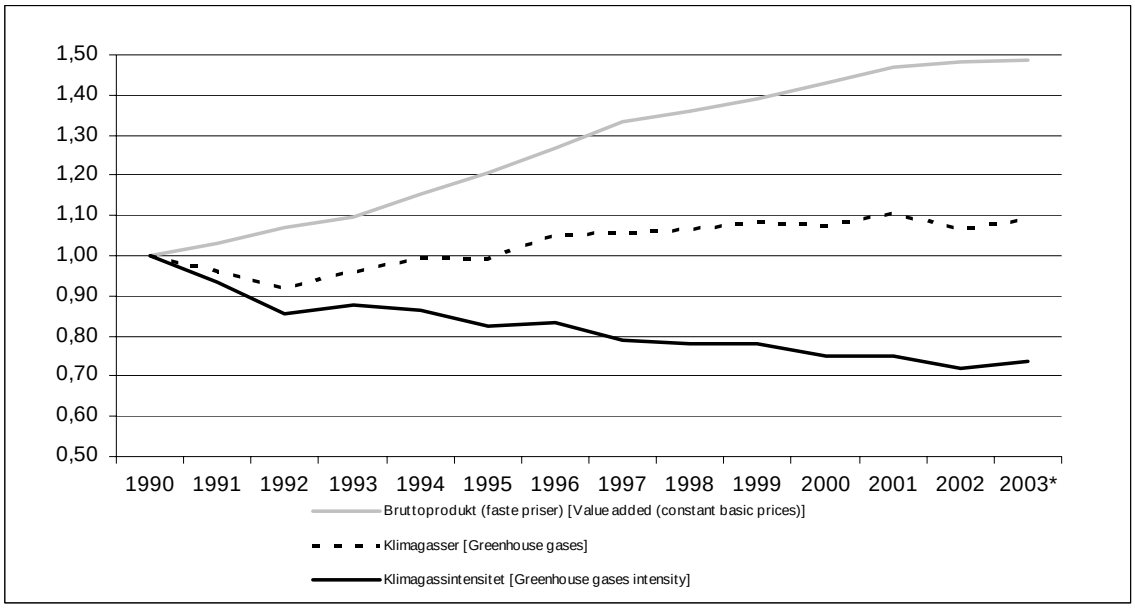


Figure 3. Development of value added (constant basic prices), greenhouse gases and greenhouse gases intensity 1990-2003 compared to the situation in 1990. Source: SN

1. Introduction

1.1. Background

The 1992 United Nation Framework Convention on Climate Change (UNFCCC) was ratified by Norway on 9 July 1993 and entered into force on 21 March 1994. One of the commitments of the Convention is that Parties are required to report their national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using methodologies agreed upon by the Conference of the Parties to the Convention (COP).

With the adoption of the Kyoto Protocol in 1997, Norway is faced with the requirement to limit its total greenhouse gas emissions to 1 per cent above the 1990 level during the commitment period 2008-2012. On 30 May 2002 Norway ratified the Kyoto Protocol, which entered into force on 16 February this year.

In compliance with its reporting requirements, Norway has submitted to the UNFCCC national emission inventory reports on an annual basis since 1993. Furthermore, since the introduction of annual technical reviews of the national inventories by independent experts in 2000, Norway has undergone four desk reviews, in 2000, 2001 and 2003 respectively, and a centralized review in 2004. In addition, an in-depth country review was held in Oslo in October 2002. Issues commented upon by the reviewers have been included in this report as far as possible.

The present report together with the associated Common Reporting Format (CRF) tables is Norway's contribution to the 2005 round of reporting under the Convention, and it covers emissions and removals for the period 1990-2003. The report is prepared in accordance with the UNFCCC Reporting Guidelines on Annual Inventories as adopted by the COP by its Decision 18/CP. 8. The methodologies used in the calculation of emissions are based on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Guidance) prepared by the Intergovernmental Panel on Climate Change (IPCC). As recommended by the IPCC Guidelines country specific methods have been used where appropriate and where they provide more accurate emission data.

With regard to the Land-Use, Land-Use Change and Forestry sector (LULUCF), the IPCC finalised the "Good Practice Guidance" report last year. The removals and emissions of greenhouse gases from this sector in Norway have been calculated during a project which started last year and will be finalised in the near future. This report contains descriptions of the methodologies used as well as CRF-tables with updated LULUCF figures calculated according to IPCC Good Practice Guidance. The CRF-tables on LULUCF are contained in Annex.

The greenhouse gases or groups of gases included in the national inventory are the following:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulphur hexafluoride (SF_6).

Aggregated emissions and removals of greenhouse gases expressed in CO_2-equivalents are also reported. We have used Global Warming Potentials (GWP) calculated on a 100-year time horizon, as provided by the IPCC in the Second Assessment Report. The report also contains calculations of emissions of the precursors and indirect greenhouse gases NOx, NMVOC, CO and SO_2, which should be included according to the reporting guidelines. However, we have not included detailed descriptions of the calculation methodologies for these gases (included in the report SN/SFT 2005 to be published and submitted to the UNFCCC secretariat later this year). The agreed methodologies for emission reporting are those described in the documents on reporting guidelines on annual inventories, which are published and updated periodically by the UNFCCC secretariat.

1.2. Institutional arrangement for inventory preparation

The Norwegian Pollution Control Authority (SFT) is the single national entity designated to be responsible for the national inventory of greenhouse gases in Norway, which includes annual reporting to the UNFCCC and responsibility for making sure that all relevant material is archived. In addition, SFT is responsible for the approval of emission data, models and emission factors for all sources, as well as the supply of:

- Estimated/measured emission data from large industrial plants based on individual company reports submitted to SFT on a regular basis;
- Emissions of CH_4 from landfills estimated by a model operated by SFT;
- Import and export data of HFCs, PFCs and SF_6.

Statistics Norway (SN) is the other main actor in the reporting of national greenhouse gas emissions to the UNFCCC. SN performs most of the emission calculations described in the report and is responsible for the main emission model. Furthermore, Statistics Norway is responsible for:

- Collection of activity data;
- Operation and further development of models for emission estimation;
- Emission calculations;
- Ensuring consistency between LULUCF and non-LULUCF categories;
- Filling in the CRF tables;
- Archiving of calculation data including CRF-tables.

The Norwegian Institute on Land Inventory (NIJOS) is responsible for the calculations of emissions and removals from land-use, land-use change and forestry (LULUCF), as well as providing descriptions of the methodologies used. Their detailed responsibilities in this respect will be appointed later this year.

Figure 4 illustrates the flow of information and allocation of responsibilities between the two institutions.

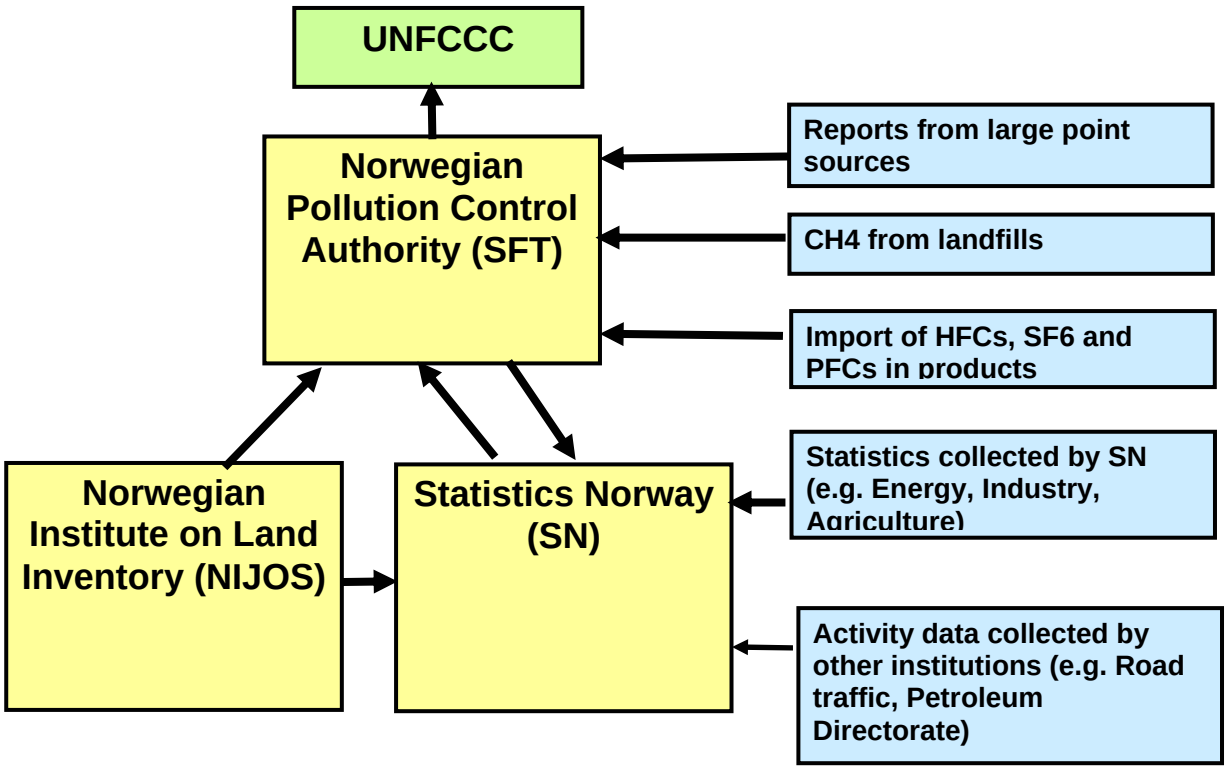


Figure 4. Information flow and distribution of responsibilities in the Norwegian emission inventory system for reporting to the UNFCCC.

Activity data are collected either internally at SN (e.g. data on energy use, industrial production, animals etc) or SFT (e.g. data on large point sources, methane from landfills, HFCs, PFCs and SF_6 in products) or reported from external sources such as the Norwegian Institute on Land Inventory (NIJOS), the Norwegian Petroleum Directorate (OD), the Public Road Administration (VD). Emission figures are derived from models operating at Statistics Norway with the exception of methane emissions from landfills, which are estimated by SFT. In the modelling activities SN makes use of the data collected by SFT on emission factors, emissions from industrial enterprises and on imports and exports of HFCs, PFCs and SF_6.

SFT is responsible for quality control of the data they deliver to the SN model; however Statistics Norway makes a consistency check in addition (See Section 1.6 on QA/QC). SN is responsible for quality control of the activity data and the emission figures from the model, which SFT also takes part in.

A formal procedure on the cooperation between SN and SFT on preparation of the inventory has been established at SFT. The procedure covers calculation of preliminary emissions figures (last year), calculations of final[1] emission figures (second last year) and updating of historical time series. On the basis of this procedure, the following timetable for the different steps of the process is followed:

[1] What we call "final" emission figures may be recalculated at a later stage

Table 3. Procedure for the cooperation between SFT and SN on preparation on annual inventories

Task	Responsible institution	Deadline
Publication of final[1] emission figures (two years before present year)	SN/SFT[2]	13 February
Documentation of methodology	SN	1 March
Completion of CRF-tables	SN	15 March
Publication of preliminary emission figures (preceding year)	SN/SFT[2]	2 April
Submission of the National Inventory Report	SFT	15 April

1.3. The process of inventory preparation

1.3.1. Introduction

The Norwegian emission reporting system depends largely on the efficient operation of a general emission inventory model and a series of more detailed satellite models which cover specific emission sources (e.g. road traffic, air traffic, landfills, solvents, HFCs, SF_6, PFCs).
These models are operated by Statistics Norway, with only one exception; the SFT model calculating emissions from landfills.

Data and information on point sources are recorded at SFT under the Norwegian Pollutant Release and Transfer Register (PRTR) (http://www.sft.no/bmi/). This register, nationally known as INKOSYS, was introduced in 1978 as an internal tool for the authorities. It was upgraded in 1992, and has been under continuous development over the last years in order to harmonise with the PRTR adopted by the OECD in 1996. Each polluting industrial installation or enterprise is subjected to licensing and is obliged to produce an annual report to the pollution control authorities. The report provides activity data, emission figures and information about the particular source and it addresses compliance with current environmental standards. SFT supplies SN with data from INKOSYS relevant for the preparation of the national emission inventory.

1.3.2. Data collection, processing and archiving

SN collects the majority of data necessary to run the general emission model. These are as follows: activity levels, emission factors, aggregated results from the side models and emission figures for point sources.

The collected data are subjected to the Quality Assurance and Quality Control (QA/QC) routines described in Section 1.6 as well as source specific routines as described under each source chapter. They are subsequently processed by Statistics Norway into a format appropriate to enter the emission models. The models are designed in a manner that accommodates both the estimation methodologies reflecting Norwegian conditions and those recommended internationally. The model output includes emission figures in the required CRF format.

[2] The preliminary and final emission figures are published in a joint SN/SFT press release

The input data used in the model runs, the versions of the models used and the model output are all stored at SN. Relevant information including dates and procedures followed are also recorded.

The main emission model has undergone substantial restructuring and modifications the past years in order to enable efficient and timely processing, especially in terms of automatic control, treatment of long time series and recording of all changes performed during the inventory preparations.

1.4. Methodologies and data sources used

1.4.1. Introduction

The estimation methods of the greenhouse gases included, i.e. CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, are harmonised with the current IPCC Guidelines for National Greenhouse Gas Inventories and are in accordance with the IPCC Good Practice Guidance. National specific estimation methodologies have been used when they better illustrate Norwegian conditions as recommended in the Good Practice Guidance. The methodology, emission factors, activity data and measurements used in the Norwegian inventory model are described for the different sectors in this report as thorough as has been possible. As asked for in the UNFCCC reporting guidelines, the report includes calculations of emissions of the precursors and indirect greenhouse gases NO_x, SO_2, VOC and CO. Documentation of the calculation methodologies of these gases are contained in the report SN/SFT 2005, which is under preparation with expected finalisation later this year (the report will be submitted to the UNFCCC-secretariat).

Since 2000, methodologies for the estimation of emissions from aviation and shipping have been updated and described in two separate reports (SN 2001a – "Emissions to Air from Fishing Fleet and Sea Traffic between Norwegian Harbours" and SN 2002 – "Emissions to Air from Norwegian Air Traffic"). In addition, smaller refinements have been made also for other sources. These are noted in the CRF tables addressing the issue of recalculations.

1.4.2. The Norwegian emission model

The general emission model is based on the equation:

$$Emissions\ (E) = Activity\ level\ (A) \cdot Emission\ Factor\ (EF)$$

The model includes the greenhouse gases CO_2, CH_4 and N_2O and in addition the precursors and indirect greenhouse gases NO_X, SO_2, NMVOC and CO, as well as some other gases such as heavy metals and particles. For emissions from combustion, the activity data concern energy use. In the Norwegian energy accounts, the use of different forms of energy is allocated to industries (economic sectors). In order to calculate emissions to air, energy use must also be allocated to technical sources (e.g. equipment). After energy use has been allocated in this way, the energy accounts may be viewed as a cube in which the three axes are fuels, industries, and sources.

The energy use data are combined with a corresponding matrix of emission factors. In principle, there should be one emission factor for each combination of fuel, industry, source, and pollutant. As mentioned earlier, the factors may be viewed as a four-dimensional cube with pollutants as the additional dimension. However, in a matrix with a cell for each combination, most of the cells would be empty (no consumption). In addition, the same emission factor would apply to many cells.

Emissions of some pollutants from major manufacturing plants (point sources) are available from measurements or other plant-specific calculations. When such measured data are available it is possible to replace the estimated values by the measured ones:

$$Emissions\ (E) = (A - A_{PS}) \cdot EF + E_{PS}$$

A_{PS} and E_{PS} are the activity and the measured emissions at the point sources, respectively.

Non-combustion emissions are generally calculated in the same way, by combining appropriate activity data with emission factors. Some emissions may be obtained from current reports and investigations, and some are measured directly as described in chapters 4-8. The emissions are fitted into the general model using the parameters industry, source, and pollutant. The fuel parameter is not relevant here. The source sector categories are based on EMEP/NFR and UNFCCC/CRF categories, with further subdivisions where more detailed methods are available.

The model uses approximately 130 industries (economic sectors). The classification is common with the Energy Accounts, and is almost identical to that used in the National Accounts, which is aggregated from the European NACE (rev. 1) classification (Statistics Norway 1994). The allocation of energy use and emissions to industries is the basis for combining inventory results with economic data in economic/environmental accounts (NAMEA - Sørensen et al 2001) and with economic models. The large number of sectors is an advantage in dealing with important emissions from manufacturing industries. The disadvantage is an unnecessary disaggregation of sectors with very small emissions. To make the standard sectors more appropriate for calculation of emissions, a few changes have been made, e.g. "Private households" is defined as a sector.

Emissions from road traffic, methane from landfills and emissions of HFC, PFC and SF_6 from products are calculated by side models, and are incorporated into the main model along with emissions from point sources collected by SFT.

The Norwegian Institute of Land Inventory (NIJOS) is responsible for calculating the emissions and removals of greenhouse gases from the LULUCF-sector, in cooperation with SN. The calculations are mainly based on information from the National Forest Inventory (NFI), which NIJOS is responsible for. The NFI is a sample plot inventory with the aim of providing data on natural resources and environment for forest land in Norway. The inventory comprises all types of land below the coniferous forest limit, but a more comprehensive description is made only for forest land.

The calculations of greenhouse gas emissions measured as CO_2 equivalents are based on data on global warming potentials (GWP) for the different GHG, calculated for a time horizon of 100 years, from IPCC Second Assessment Report from 1995, as required by the UNFCCC reporting guidelines.

The emission estimation methodologies are being developed continuously. SN and SFT have carried out several studies on specific emission sources, e.g. emissions from road, sea, and air transport, emissions from landfills as well as emissions of HFCs and SF_6. Usually, such projects are connected to an evaluation of emission reduction measures. An important element in SN's work is to increase the environmental relevance of the statistical system. As far as possible, data collection relevant to the emission inventories is integrated into other surveys and statistics.

1.4.3. Data sources

The data sources used in the Norwegian inventorying activities are outlined in the following:

- *Activity levels* – these normally originate from official statistical sources available internally in SN and other material available from external sources (see also Section 1.2). When such information is not available, research reports are used or extrapolations are made from expert judgements.
- *Emission factors* – these originate from reports on Norwegian conditions and are either estimated from measurements or elaborated in special investigations. However, international

default data are used in cases where emission factors are highly uncertain (e.g. N_2O from agriculture, and CH_4 and N_2O from stationary combustion) or when the source is insignificant in relation to other sources.

- *Aggregated results from the side models* – The operation of these side models requires various sets of additional parameters pertinent to the emission source at hand. These data sets are as far as possible defined in official registers, public statistics and surveys, but some are based on assumptions.
- *Emission figures for point sources* – For large industrial plants these are figures reported to the SFT by the plants' responsible (based on measurements or calculations at the plants).

1.5. Key source categories

According to the IPCC definition, key sources are those that add up to 90% of the total uncertainty in level and/or trend. In the Norwegian Emission Inventory key source categories are identified by means of a Tier 2 method, as recommended by the IPCC Good Practice Guidance (IPCC 2001). A description of the methodology is presented in Annex 1.

A key source analysis was performed in April 2005. The table below lists the 22 identified key sources arranged primarily according to contribution to the uncertainty in level. It was performed at the level of IPCC source categories and each greenhouse gas from each source category was considered separately with respect to total GWP weighted emissions. The advantage in using a Tier 2 methodology is that uncertainties are taken into account and the ranking shows where uncertainties can be reduced. The UNFCCC secretariat performed a Tier 1 key source analysis on the basis of the 2004 NIR and identified four additional sources (19 key sources were identified for the 2004 NIR). In this year's analysis, one of them is identified as a key source (N_2O from nitric acid production) from the Tier 2 analysis. We have chosen to also include cement production as key source in terms of the absolute level of emissions (Tier 1). The contributions to the total level from the other two sources identified last year by the UNFCCC secretariat, ammonia and carbide production are quite small this year (0.2 and 0.3 % respectively), so they are not among the defined key sources.

Table 4. Summary of identified key sources.

IPCC Source category		Gas	Level assessment		Trend assessment	Method (Tier)
			1990	2003	1990-2003	2003
4D1	Direct soil emissions	N_2O	42,56 %	40,22 %	19,50 %	Tier 1a
1A3b	Road Transportation	CO_2	8,20 %	9,75 %	3,90 %	Tier 2
4D3	Indirect emissions	N_2O	9,98 %	9,55 %	4,10 %	Tier 1a
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO_2	2,99 %	5,43 %	8,64 %	Tier 2 / 3
4D2	Animal production	N_2O	5,23 %	5,16 %	1,56 %	Tier 1a
1A3b	Road Transportation	N_2O		4,01 %	13,21 %	Tier 2
6A	Solid Waste Disposal on Land	CH_4	4,59 %	3,72 %	4,47 %	Tier 2
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO_2	1,95 %	2,39 %	1,24 %	Tier 2
4A1	Cattle	CH_4	1,89 %	1,74 %	1,04 %	Tier 1
2C3	Aluminium Production	PFCs	6,92 %	1,44 %	22,73 %	Tier 2
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO_2	1,40 %	1,40 %		Tier 2
1A3d	Navigation	CO_2	1,04 %	1,31 %	0,76 %	Tier 2
1B2c	Venting and Flaring	CH_4		0,97 %	1,57 %	Tier 2
1A3a	Civil Aviation	CO_2	0,71 %	0,97 %	0,83 %	Tier 2
2C2	Ferroalloys Production	CO_2	1,01 %	0,85 %	0,88 %	Tier 2
2C3	Aluminium Production	CO_2		0,72 %		Tier 2
1B2c	Venting and Flaring	CO_2	0,84 %	0,70 %	0,72 %	Tier 2
2C4	SF_6 Used in Aluminium and Magnesium Foundries	SF_6			2,09 %	Tier 2
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs			1,88 %	Tier 2
2B2	Nitric Acid Production	N_2O	0,75 %		0,73 %	Tier 2
1B2a	Oil (incl. oil refineries, gasoline distribution)	CH_4			0,61 %	Tier 2
2A1	Cement Production*	CO_2	0.92 %	1.07 %	0.96 %	Tier 2

* Identified as key source because of large contribution to the total emissions (Tier 1)

The key source analysis gives generally the same result as in the previous NIR. However, improvements of the methods have led to some changes:

- Estimates of CH_4 emissions from landfills (6A) have been reduced, with reduced level assessments as a consequence. However, the reduction has not been uniform over the period. Thus, the trend assessment has increased.
- Estimates of N_2O from agriculture (4D) have been reduced, which has resulted in reduced level assessments.
- Due to the reductions of level assessments in the previous points, further source categories have been included in order to reach the 90 percent threshold. The new key sources are:
    - 1B2c - Fugitive emissions of CO_2 from venting and flaring
    - 1B2a - Fugitive emissions of CH_4 from oil (incl. oil refineries, gasoline distribution)
    - 2B2 – Emissions of N_2O from nitric acid production

In addition, we have identified the following key categories:

Table 5. Summary of identified key categories

IPCC Category		Gas	Level assessment		Trend assessment 1990-2003	Method (Tier) 2003
			1990	2003		
5A1	Forest land remaining forest land, living biomass, other	CO_2	6.61 %	10.29%	19.97	Tier 3
5C1	Grassland remaining grassland, soils, histosols	CO_2	7.82	7.39	2.47	Tier 2*
5A3	Forest land remaining forest land, dead biomass, other	CO_2	7.04	5.70	2.04	Tier 3
5A4	Forest land remaining forest land, soils	CO_2	1.89	1.95	1.33	Tier 3
5A2	Forest land remaining forest land, soils, drained organic soils	CO_2	1.19	1.19	0.66	Tier 1
5B5	Cropland remaining cropland, histosols, soils	CO_2	0.87	0.83	-	Tier 2
**	CO_2 capture and storage	CO_2				CS (Tier 2)**

* Country specific emission factors
** No methodology or category is defined in IPCC Guidelines

We have defined CO_2 capture and storage as key category since there is presently no methodology as such defined in the IPCC guidelines and since these operations are unique worldwide.

1.6. Quality assurance and quality control (QA/QC)

1.6.1. Introduction

Several quality assurance and quality control procedures for the preparation of the national emission inventory have been established in Norway during the past years. Statistics Norway made its first emission inventory for some gases in 1983 for the calculation year 1973. The emission estimation methodologies and the QA/QC procedures have been developed continuously since then. Norway has not yet implemented a formal quality assurance/quality control or verification plan. However, a project has recently been initiated with the aim to decide on elements to be included in a QA/QC plan in order to comply with the UNFCCC Guidelines on reporting and review. The established QA/QC procedures include the following:

- SFT is the single national entity designated to be responsible for the national inventory of greenhouse gases in Norway, which includes coordination of the QA/QC procedures.
- SN is responsible for the quality control system with regard to technical activities of the inventory preparation
- A Tier 1 general inventory level QC procedures, as listed in Table 8.1 of the IPCC Good Practice Guidance is performed each year
- Source category-specific QC procedures are performed for all key sources and some non-key sources; with regard to emission factors, activity data and uncertainty estimates (Tier 2)

1.6.2. QA Procedures

According to the IPCC Good practice guidance, good practice for QA procedures requires an objective review to assess the quality of the inventory and to identify areas where improvements could be made. Furthermore, it is good practice to use QA reviewers that have not been involved in preparing the

inventory. In Norway, SFT is responsible for reviewing the inventory with regard to quality and areas for improvement. For most sources it is a person within the SFT who has not been involved in the calculations and the quality controls who performs the QA for the particular source. Thus, we have performed a basic expert peer review (Tier 1). Whether to also to perform more extensive external peer reviews and/or audits (Tier 2) will be discussed as a part of the elaboration of steps and procedures to be included in a QA/QC plan.

There is no formalised procedure of verification of emission data in Norway. However, Norway has performed several studies comparing inventories from different countries; see Section 1.6.5 below. Verification of emission data is another element to be assessed during the elaboration of a QA/QC and verification plan.

Each of the institutions SN, SFT and NIJOS (for LULUCF) have established procedures with regard to documentation and archiving of the information which have been used to produce the national emissions inventory estimates. We believe that the transparency of the inventory has been improved last year and this year compared to previous years since we have incorporated information on methodologies used in the inventory report. However, we will consider a joint, formalised procedure with regard to archiving when developing the QA/QC plan.

1.6.3. General QC procedures

The Norwegian emission inventory is produced in several steps. Preliminary estimates are first produced three months after the end of the inventory year (for SO_2 six months later). These data are based on preliminary statistics and indicators and data that have been subjected to a less thorough quality control. The "final" update takes place about one year after the inventory year. At this stage, final statistics are available for all sources and also regional emission data are calculated. Recalculations of the inventory are performed annually caused by methodological changes and refinements. In itself, this stepwise procedure is a part of the QA/QC-procedure since all differences in data are recorded and verified by SFT before publication of the emission figures (see Section 1.2).

For each of the steps described above, general quality control procedures are performed, but with different levels of detail and thoroughness as mentioned. The national emission model was revised in 2002 in order to facilitate the QC of the input data rather than the emission data only. Input data include emissions reported from large plants, activity data, emission factors and other estimation parameters.

In the following we will go through the procedures listed in Table 8.1 of the Good Practice Guidance; the Tier 1 General Inventory Level QC Procedures, and comment briefly on how these checks are performed for the Norwegian greenhouse gas emission inventory.

<u>Check that assumptions and criteria for the selection of activity data and emissions factors are documented</u>
Thorough checks of emission factors and activity data and their documentation have been performed for existing emission sources. When new sources appear (for example a new industrial plant) or existing sources for the first time are recognised as a source, SFT delivers all relevant information to SN. This information is then thoroughly checked by two members of the inventory team at SN. All changes in methodologies or data are documented and kept up to date.

<u>Check for transcription errors in data input and references</u>
Activity data are often statistical data. Official statistical data undergo a systematic revision process, which may be manual or, increasingly frequently, computerised. The revision significantly reduces the number of errors in the statistics used as input to the inventory.

<u>Check that emissions are calculated correctly</u>

When possible, estimates based on different methodologies are compared. An important example is the metal production sector where CO_2 estimates reported by the plants are compared with estimates based on the Good Practice methodology corrected for national circumstances. In this case, both production based and reducing agent based calculations are performed to verify the reported value. SFT and SN control and verify emission data reported to SFT by industrial enterprises, registered in INKOSYS. First SFT checks the data received from these plants, and if errors are discovered, they may then ask the plants' responsible to submit new data. Subsequently, SN makes, where possible, comparable emission calculations based on activity data sampled in official statistics and deviations are explained through contact with the plants.

Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used

All parameter values are compared with values used in previous years and with any preliminary figures available. Whenever large deviations are detected, the value of the parameter in question is first checked for typing errors or unit errors. Changes in emissions from large plants are compared with changes in activity level. If necessary, the primary data suppliers (e.g. NIJOS, OD, VD, various plants etc) are contacted for explanations and possibly corrections.

Check the integrity of database files

Control checks of whether appropriate data processing steps and data relationships are correctly represented are made for each step of the process. Furthermore, it is verified that data fields are properly labelled and have correct design specifications and that adequate documentation of database and model structure and operation are archived. SN has started a process on updating the documentation of the model, which will be finalised later this year.

Check for consistency in data between source categories

Emission data for the last year are compared with data for the previous year to check the consistency and explain any changes in the data behaviour. For example, in 2003 SN/SFT calculated emission data for 2002 for the first time. These data were compared with the 2001 figures for detection of any considerable deviations. Large deviations may often be correct, caused for instance by the shutdown of large industrial plants or the launch of new ones.

Check that the movement for inventory data among processing steps is correct

SN has established automated procedures to check that inventory data fed into the model does not deviate too much from the figures for earlier years, and that the calculations within the model are correctly made. Checks are also made that emissions data are correctly transcribed between different intermediate products. The model is constructed so that it gives error messages if factors are lacking, which makes it quite robust to miscalculations.

Check that uncertainties in emissions and removals are estimated correctly

The last overall uncertainty calculations were made in 2000 (see further information in Section 1.6 on Uncertainty). It was then checked that calculated uncertainties were complete and correctly calculated. Calculations of probability distribution were also performed using Monte Carlo analyses.

Undertake review of internal documentation

For some sources expert judgements dating some years back are employed with regard to activity data/emission factors. In most of the cases these judgements have not been reviewed since then, and may not be properly documented, which may be a weakness of the inventory. The procedures have improved the last few years, and the requirements for internal documentation to support estimates are now quite strict; all expert judgements and assumptions made by the SN staff must be documented. This should enable duplication of emissions and uncertainty estimates. The new model at SN has improved the process of archiving inventory data, supporting data and inventory records, which does facilitate review. The model runs are stored and may be reconstructed, and all input data from SFT as well as notes with explanations on changes in emissions are stored. This is a continuous process of improvement at SN.

Check methodological data changes resulting in recalculations
Emission time series are recalculated every year in order to account for methodological changes. The recalculated emission data for a year is compared with the corresponding figures estimated the year before. For example, CO_2 data calculated for 1990 in 2004 are compared with the 1990 CO_2 data calculated in 2005. It is our intention to explain all major differences as far as possible. Changes may be due to revisions in energy data, new plants, correcting for former errors, new emission methodologies or there may be caused by new errors. These checks lead to corrections and re-runs of the emission model.

Undertake completeness checks
Estimates are reported for all source categories and for all years as far as we know, apart from a few known data gaps, which are listed in the Section on completeness (Section 1.8.). There may of course, exist sources of greenhouse gases which are not covered. However, we are quite certain that emissions from potentially additional sources are very small or negligible.

Compare estimates to previous estimates
Internal checks of time series for all emission sources are performed every year when an emission calculation for a new year is done. It is then examined whether any detected inconsistencies are due to data or/and methodology changes. For example, in 2003 SN/SFT calculated emission data for 2002 for the first time. These data were compared with the 2001 figures for detection of any considerable deviations. Large deviations may often be correct, caused for instance by the shutdown of large industrial plants or the launch of new ones.

1.6.4. Source category-specific QC procedures

SN and SFT have carried out several studies on specific emission sources, e.g. emissions from road, sea, and air transport, emissions from landfills as well as emissions of HFCs and SF_6. These projects are repeated in regular intervals when new information is available. During the studies, emission factors have been assessed and amended in order to represent the best estimates for national circumstances, and a rational for the choice of emission factor is provided. The emission factors are often compared with factors from literature. Furthermore, activity data have been closely examined and quality controlled and so has the uncertainty estimates.

The QC procedures with regard to emissions data, activity data and uncertainty estimates for the different emission sources are described in the QA/QC-chapters of the relevant source-categories. The source category-specific analyses have primarily been performed for key sources on a case-by-case basis, which is described as being good practice. The QA/QC process for many of the sources could be improved. As stated earlier, the QA/QC-procedures will be considered in detail later this year.

1.6.5. Verification studies

In general, the final inventory data provided by SN are checked and verified by SFT. However, there is, as mentioned, no formal verification procedure in Norway. In the following, some other verification studies which have been performed are briefly described.

Emission estimates for a source are often compared with estimates performed with a different methodology. In particular, Norway has conducted a study on verification of the Norwegian emission inventory (SFT/SN 2000). The main goals of that work were to investigate the possibility of using statistical data as indicators for comparing emission figures between countries on a general basis, and to test the method on the Norwegian national emission estimates. In the report Norwegian emission data are compared with national data for Canada, Sweden and New Zealand. It was concluded that no large errors in the Norwegian emission inventory were detected. The process of verification did, however, reveal several smaller reporting errors; emissions that had been reported in other categories than they should have been. These errors have been corrected in later reports to the UNFCCC. We do

realise that this method of verification only considers consistency compared with what other countries report. It is not a verification of the scientific value of the inventory data themselves.

In 2002, a project funded by the Nordic Council of Ministers was carried out, where emissions of greenhouse gases from the agricultural sector in the national emission inventories were compared with the emissions derived from the IPCC default methodology and the IPCC default factors (for details, see Chapter 6 on Agriculture).

1.6.6. Documentation, archiving and reporting

SFT has the overall responsibility with regard to archiving. Each of the participating institutions SN, SFT and NIJOS (LUCF) have established procedures with regard to documentation and archiving of the information which have been used to produce the national emissions inventory estimates. For example, all input data used in model runs, the versions of the models used and the model output, as well as dates and procedures followed are archived at SN. With regard to LULUCF, the Norwegian Institute of Land Inventory (NIJOS) will be in charge of archiving all data from the calculations of emissions and removals from this sector. A joint, formalised procedure with regard to archiving will be considered as part the project of developing the QA/QC plan.

1.6.7. Confidentiality issues

All data contained in the Norwegian emission inventory are publicly available, both activity data and emission factors.

1.7. Uncertainty evaluation

The uncertainty in the Norwegian emission inventory has been investigated systematically in two reports so far (SFT/SN 1999a and SN 2000). We consider the results from these reports to still be valid. We will consider the need for new uncertainty estimates together with other issues where updates are necessary as part of the work plan before the next NIR.

The emission estimates for the greenhouse gases in the Norwegian inventory may be ranked roughly in order of increasing uncertainty as follows:

$$CO_2 \approx SF_6 < HFC < CF_4/C_2F_6 \approx CH_4 < N_2O$$

In the report SN 2000 the uncertainty in level for the total Norwegian GHG emissions in 1990 is estimated at 21 per cent. An uncertainty in level of 3 per cent was estimated for CO_2, while estimations of other gases have much higher uncertainties. Calculations of emissions of N_2O are most uncertain; the uncertainty in level is estimated to be more than 150 per cent. The estimated uncertainty in trend is 4 per cent for the period 1990 to 2000. Using a simpler method of analysis (Good Practice Guidance Tier 1), the uncertainty in level was found to be 11-17 per cent (SFT 1999a).

In the 1999 report a qualitative evaluation of the uncertainty in the Norwegian greenhouse gas inventory of each gas was carried out concerning emissions factors, activity data and direct measured emissions. Emissions of CH_4 from landfills, N_2O from agriculture and PFCs from production of aluminium are found to have highest uncertainty. This result is in accordance with what was found in the 2000 report, where uncertainties in level and trend were estimated using models based on simulations (Good Practice Guidance Tier 2).

The major elements of the most recent work on emission uncertainties in Norway (SN, 2000) are summarised in the tables presented in Annex 6. These tables list the standard deviation and probability density of the activity data and emission factors found under the various IPCC source categories, as

well as the estimated uncertainties in emission level and in trend for the greenhouse gases under consideration.

This year, an updated Tier 2 key source analysis on the greenhouse gas inventory was performed. The steps taken to find key sources with respect to level and trend were the determination of uncertainties in input parameters (AD = activity data and EF = emission factors). Uncertainty data were obtained from SN (2000) with some modifications. The highest uncertainties from SN (2000) could not be used directly, as they would have totally dominated the analysis. More information about the modifications made and the uncertainty values used in the key source analysis are given in Annex 1.

1.8. General assessment of the completeness

An assessment of the completeness of the emission inventory should, according to the IPCC Good Practice Guidance, address the issues of spatial, temporal and sectoral coverage along with all underlying source categories and activities. Confidentiality is an additional element of relevance, which has been addressed in Section 1.6.4.

In terms of spatial coverage, the emission reporting under the UNFCCC covers all activities within Norway's jurisdiction.

In the case of temporal coverage, the major point to be addressed is that CRF tables are reported for the years 1990, 1998, 1999, 2000, 2001, 2002 and 2003. For the years 1991 to 1997 we have only included Summary II CRF tables. Complete set of emission figures do exist, but are only available in another electronic format than the one presently required by the UNFCCC. It is our intention to submit complete sets of CRF tables for all years within six weeks after the 15 April dead line. We will then use the new reporting format, which hopefully will make the reporting work less time consuming.

With regard to sectoral coverage, the Norwegian GHG emission inventory includes estimates from all known relevant sources or sinks. There are, however, a few exceptions of minor sources/sinks which are not covered. These are:

- Emissions of CH_4 from agricultural waste, after it is applied to soils. We are not sure what should be included here. In the IPCC Guidelines it is written that "Agricultural soils may also emit CH_4", but no calculation methodology is proposed. We hope this is clarified in the new IPCC Guidelines.

- Carbon stock change of harvested wood products The IPCC default method is used, where harvested wood is counted as emissions the year the harvest takes places.

- Within the land-use, land-use change and forestry sector, calculations for the following categories have not been performed in the LULUCF-study and are lacking in the report:

    - Land converted to cropland, dead organic matter;
    - Settlements remaining settlements;
    - Land converted to settlements, dead organic matter and soils;
    - Other land remaining other land;
    - Land converted to other land.

The reason for not including the above activities in the present submission is lack of data and/or exclusion from the list of priorities in the national inventorying work because of the source's insignificant contribution to the national total. However, as the national inventory system is being improved, several of the above sources/sinks are expected to be addressed in the near future.

Although notation keys have been used more extensively than in any earlier submission, full coverage has not been possible due to time constraints in the emission inventory work.

Emissions from the use of feedstock are in accordance with Good Practice Guidance and generally accounted for in the industrial processes sector in the Norwegian inventory. By-products from processes like CO gas that is sold and combusted are accounted for and reported under the energy sector.

1.9. Planned and implemented improvements

1.9.1. Issues addressed in reviews of the inventory

The Norwegian NIRs have undergone four desk reviews/centralized reviews, in 2000, 2001, 2003 and 2004 respectively. In addition, the Norwegian emission inventory system was inspected by an expert review team (ERT), which visited SFT in October 2002 (in-country review). We find the comments and recommendations from the review teams very useful and valuable, and try to improve the inventory accordingly. Below we have listed the main issues addressed by the review team during the last centralised review in 2004.

The expert review team concluded that the Norwegian inventory is largely complete and largely consistent with the UNFCCC reporting guidelines. We were commended for our effort to include improvements identified by the in-country review in 2002. According to the ERT, the submission covers most source categories, but Norway has identified and explained the reasons for some gaps in sectoral coverage. With regard to key sources, the ERT noted that Norway generally uses recommended IPCC methods, but specific areas where the transparency of the methods used could be improved and where a higher-tier method should be used were identified (these areas are specified below).

With respect to deficiencies and areas for improvement in the Norwegian emission inventory system the ERT addressed the following main points:

- A complete time series of CRF tables, including recalculation tables, should be included;
- Notation keys should be used more consistently and extensively;
- More methodological information should be included, particularly for the country-specific methods and emission factors used ;
- Norway should formalize its quality assurance/quality control (QA/QC) plan
- The uncertainty analysis should be improved by including a discussion of the factors influencing the high uncertainty of a number of parameters;
- IPCC Good Practice Guidance for Land-use Change and Forestry should be employed;
- Norway should continue to improve the consistency of the NIR with the structure outlined in the UNFCCC reporting guidelines, particularly with respect to a discussion of the time-series consistency of recalculations performed and their impact on emission trends;
- It should be ensured that the information in the NIR and that in the CFR tables are consistent;
- The transparency of the information on CO_2 capture and storage should be improved;
- Tier 2 methodology for enteric fermentation should be employed.

1.9.2. Implemented improvements

The present report addresses the above points to the extent that that has been possible. As mentioned earlier in this section, the use of notation keys is now more extensive than before. We have included more comprehensive descriptions of the methodologies for many sources this year, e.g. for some of the sources where country-specific methods are used (for example with regard to N_2O emissions from Aerosol Propellant and N_2O from Road Transportation).

As mentioned in Section 1.6 on QA/QC, a project with the aim to formalize Norway's QA/QC plan has been initiated. In NIR 2006 the plan will be described in detail. Regarding land-use, land-use change and forestry, we have employed the new IPCC Good Practice Guidance for calculations of emissions and removals. Consistency checks, including time series consistency have been performed; this is part of the general QC procedure as described in the section on QA/QC. Furthermore, the emissions and removals from CO2 capture and storage have been describes in more detail than in NIR 2004. We have defined CO_2 storage as a key category since Norway is the only country which employs this technology as far as we know.

1.9.3. Planned improvements

General
Later this year, we will assess all parts of the Norwegian inventory of greenhouse gases and elaborate a plan for improvements. The plan will e.g. identify and prioritize sources and/or categories where a higher tier methodology should be employed, updating the uncertainty analysis etc. in order to comply with the UNFCCC reporting requirements and the IPCC Good Practice Guidance. When deciding on such a plan, we will of course take the comments from the last reviews into account. This work is particularly important now, since we have informed the UNFCCC Secretariat that Norway intends to submit a report in 2006 on the calculation of our assigned amount.

As mentioned above, a project with the aim to elaborate a formal QA/QC plan has been initiated. This report contains complete sets of CRF-tables for the years 1990 and 1998-2003, and Summary II tables for the years 1991-1997. We will, however fill in all the CRF-tables for the years 1991-1997 and submit the full sets within six weeks from the 15 April deadline for the NIR. In the following we will address planned improvements which are addressed in the sector chapters.

Energy
As indicated by the various review teams so far, the N_2O emission factors for road transportation in the national emission inventory are far too high compared to those of other European countries. In order to deal with this inadequacy in the national inventory, a project has been scheduled aiming at updating these emission factors. The project will be completed in time for next year's submission.

Comparison of CO_2 emissions from fuel combustion between the Reference and the National Approach reveals large deviations in both the energy consumption data and the CO_2 emissions in 2003. For earlier years the differences have been even larger. The energy balance data used in the CRF are the same data that Statistics Norway has reported to the IEA, but there are differences in the Reference Approach estimated by Statistics Norway and the one published by IEA. Norway intends to examine more closely the figures used in the compilation of this table with a view to detect and resolve any discrepancies in time for NIR 2006.

Industry
We have identified a need for an updating of the calculations of emissions of consumption of halocarbons and SF_6 from 2003 and onwards as a result of the introduction of taxation and refund schemes. Statistics Norway will conduct a project that will prepare new methodologies for calculation of emissions of HFCs and PFC used in products and processes. Focus will be on new and improved import/export data from customs statistics and revision of emission factors based on feedback from users and scientists. The aim of the project is to implement a fully revised and improved methodology for emissions in 2004 and onwards.

Land-use, land-use change and forestry

The study on LULUCF that was carried out pointed out several needs for improvements, which we have to consider with the aim to improve the methodology and as a part of the total plan of improvements described above.

The uncertainties are particularly large for emissions of non-CO_2 gases and CO_2 from soils. Changes in soil organic carbon are difficult to monitor due to upscaling problems, lack of time-series and lack of management data. Also lack of knowledge of the history of a piece of land causes problems. More measurements and more use of models could contribute to reductions of these uncertainties. Uncertainties are also large for the category other wooded land (tree covered land that does not meet the forest definition). In addition, reservoirs should be further investigated due to the importance of dams in Norway (hydroelectric power stations); estimates of these have not been included in the report. The study further pointed out a need for improvement of the National Forest Inventory in order to improve the estimates, e.g. measures to avoid misclassification during the field work, better interpretation of multiple land-uses of plots, more frequent assessment of plots on non-forested areas and the establishment of permanent sample plots in Finnmark County and on other wooded land.

2. Trends in Greenhouse Gas Emissions

2.1. Emission trends for aggregated greenhouse gas emissions

The total amounts of greenhouse gases emitted in Norway during the period 1990-2003 are in the following expressed in terms of contribution by gases and by sources.

Table 6 presents emission figures for all direct greenhouse gases, expressed in CO_2 equivalent along with their change indicated for both the time periods 1990-2003 and 2002-2003.

Table 6. Emissions of greenhouse gases in Norway during the period 1990-2003 (without LULUCF). Empty cells indicate emission not occurring. Units: CO2 and CO2–eq. in Mtonnes, CH4 and N2O in ktonnes and other gases in tonnes. Source: SN/SFT

		Year													
Gas	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
CO_2	Mtonnes	34.4	33.5	33.8	35.4	37.3	37.2	40.4	40.6	40.8	41.6	41.1	42.7	41.2	43.2
CH_4	ktonnes	245.7	247.3	250.4	252.5	256.3	256.7	258.2	260.9	253.4	248.9	253.2	252.1	243.8	240.8
N_2O	ktonnes	16.3	15.9	13.7	14.9	15.2	15.5	15.8	15.6	16.5	17.1	16.8	16.8	17.5	17.2
CF_4	tonnes	479.1	368.9	294.1	290.1	250.6	229.1	214.2	200.8	184.8	163.9	131.1	151.7	163.0	102.3
C_2F_6	tonnes	19.6	13.7	11.4	10.3	8.9	7.9	5.1	7.7	7.1	6.2	5.1	6.2	6.6	4.2
PFK 218	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0
SF_6	tonnes	92	87	30	31	37	26	24	25	31	37	40	34	11	10
HFK 134a	tonnes	0.0	0.1	0.2	2.3	7.1	13.3	22.4	34.1	49.7	65.3	79.4	93.4	111.6	83.9
HFK 125	tonnes	0.0	0.0	0.0	0.0	1.3	6.7	15.3	27.2	41.2	55.6	72.6	92.2	115.3	75.7
HFK 143a	tonnes	0.0	0.0	0.0	0.0	0.7	5.8	14.7	26.0	39.6	56.0	77.1	102.0	131.9	74.6
HFK 32	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7	1.0	1.5	3.3
HFK 23	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.8	0.8	0.8	0.8	0.9	0.2
HFK 152a	tonnes	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.7	0.8	1.1	1.4	1.7	1.6
HFK 227ea	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.5	0.5	0.8	2.2	1.0
Total	**Mt CO2-eq.**	**50.1**	**48.3**	**46.0**	**48.0**	**50.0**	**49.6**	**52.8**	**52.9**	**53.3**	**54.3**	**53.8**	**55.3**	**53.5**	**54.8**

	Emissions in Mtonnes CO2-eq.			**Change**	**Change**
	1990	**2002**	**2003**	**1990-2003**	**2002-2003**
CO2	34.41	41.24	43.22	26%	5%
CH4	5.16	5.12	5.06	-2%	-1%
N2O	5.06	5.42	5.33	5%	-2%
PFCs	3.29	1.12	0.69	-79%	-38%
SF6	2.20	0.25	0.23	-89%	-8%
HFCs	0.00	0.37	0.24		-34%
SUM	**50.13**	**53.52**	**54.77**	**9%**	**2%**

Total emissions show a marked decrease between 1990 and 1992 and an increase thereafter with small interruptions in 1995, 2000 and 2002. Looking at the overall trend from 1990 to 2003, we see that the emissions increased by about 9 per cent. So far, 2001 has been the year with the highest emissions recorded.

Norway has experienced economic growth since 1990, which explains the general growth in emissions. This has resulted in higher CO_2 emissions from most sources, but in particular from gas and oil extraction and to a lesser extent from the transport sector and the consumption of oil products in industry. The emissions of CH_4 and N_2O have been relatively stable over the same period. The overall increasing trend has to some degree been counteracted by decreased emissions of PFCs and SF_6 from aluminium and magnesium plants. Emissions of HFCs had an explosive increase until 2002, rising from 0.02 ktonnes CO_2 equivalents in 1990 to a total of 365 ktonnes CO_2 equivalents for all HFC components of relevance in Norway in 2002. However in 2003 emissions from HFCs declined to 240 ktonnes CO_2 , likely as a result of the implementation of a new tax on HFCs.

The downward trend in the early 1990's is primarily due to the decreased consumption of gasoline and fuel oils as well as reduced production of metals. Contributors to this development were the low economic activity during that time and the CO_2-tax, which was implemented with effect from 1991.

The dip in 2000 corresponds to an emission fall of about 1 per cent from the 1999 level. However, this feature is really an artefact caused by the fact that emissions from transport are calculated on the basis of sales rather than consumption. A mild winter season combined with changes in taxes on petrol and diesel with effect from 1 January 2000 led to a temporary reduction in stock-in-trade of those products with a subsequent reduction in the respective CO_2 emissions.

The total emissions decreased from 2001 to 2002 by about 2.5 per cent. This decline is primarily a result of close-downs and reductions in the ferroalloy- and magnesium industry, reduced flaring in the oil and gas extraction sector and reduced domestic navigation. The reduction outweighs increased emissions from road traffic and from the production of fertiliser as well as from aluminium production and from the consumption of HFCs.

Emissions in 2003 moved again upward by 2 % explained by an increase in economic activity, including transportation, but especially in the petroleum sector. A cold winter combined with low generation of hydropower due to a long dry period increased the consumption of oil for heating.

The overall increase between 1990 and 2003 is above 9 per cent. This means that Norway will have to reduce its national GHG emissions by 8 per cent in order to achieve the emission target of 1 per cent required by the Kyoto Protocol by the period 2008-2012 if the emissions stabilise at this level. Preliminary calculations of the GHG emissions in 2004 indicate an increase of more than 1 per cent since 2003. The development from 1990 to 2004 is hence an increase of almost 11 per cent, which is 10 per cent above the Kyoto commitment.

2.2. Emission trends by gas

As shown in Figure 5, CO_2 is by far the largest contributor to the total GHG emissions, followed by CH_4 and N_2O, and then the fluorinated gases PFCs, SF_6 and HFCs. In 2003 the relative contributions to the national totals from the different gases were; CO_2: 79 per cent, CH_4: 9 per cent, N_2O: 10 per cent, fluorcarbons (PFCs, SF_6 and HFCs) about 2 per cent. The fluorocarbons constituted a larger fraction of the greenhouse gas emission total in the early 1990s than that in 2003, while CO_2 represented a smaller share in 1990 than in 2003.

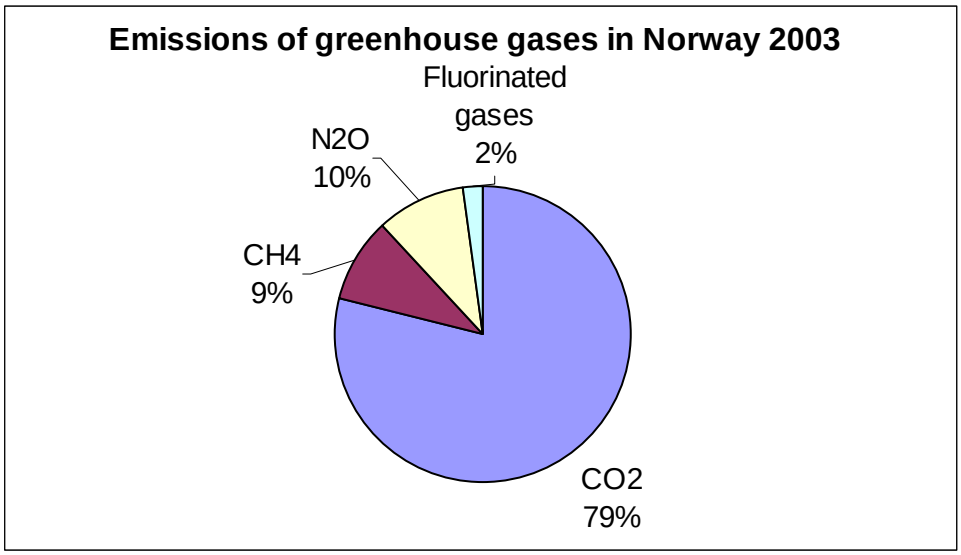


Figure 5. Distribution of emissions of greenhouse gases in Norway by gas, 2003. Source: SN/SFT

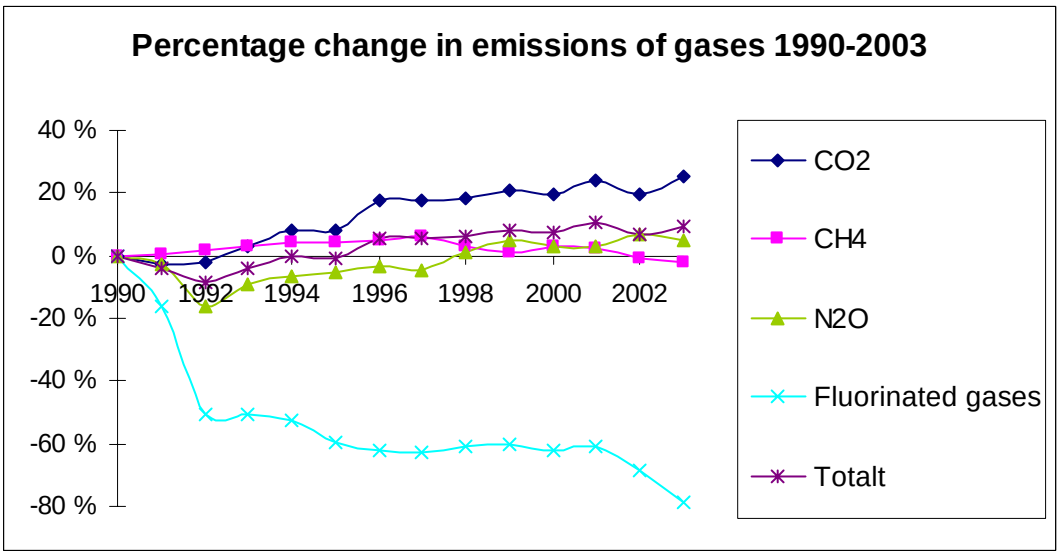


Figure 6. Changes in emissions of greenhouse gases by gas in Norway 1990-2003, compared to 1990. Source: SN/SFT

Figure 6 illustrates the change in emissions of greenhouse gases by gas in Norway 1990-2003, compared to 1990. We will describe these trends further for each of the six greenhouse gases in the following

2.2.1. Carbon dioxide (CO_2)

The Norwegian CO_2 emissions originate primarily from industrial sources related to oil and gas extraction and the production of metals, as well as from the transport sector. A relatively large share of the transport-related emissions originates from coastal navigation and the fishing fleet. Since generation of electricity is almost exclusively hydroelectric, emissions from stationary combustion are dominated by industrial sources and internal energy use.
The distribution of CO_2 emissions on the various source categories is shown in Figure 7,

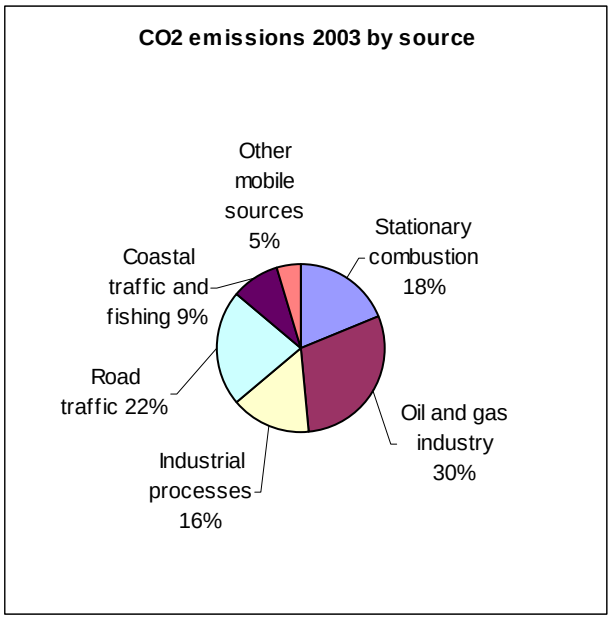


Figure 7. Distribution of CO2 emissions in Norway by source in 2003. Source SN/SFT

Table 7 lists CO_2-emissions from each source category for the whole period 1990-2003. The change in emissions from 1990 to 2003 compared to 1990 is displayed in Figure 8.
From 1990 to 2003 the total CO_2 emissions increased by 25 per cent or 8.8 Mtonne The increases in natural gas use in gas turbines in the oil and gas extraction industry have been the most important contributor to the overall CO_2 increase.

In 2003 the total Norwegian emissions of CO_2 were 41.2 Mtonnes, which is an increase of about 5 per cent from the preceding year. Table 7 shows that stationary combustion contributed with most, 1 Mtonne CO_2, to this increase. High electricity prices and a cold winter increased the use of oil for heating. A higher level of activity and a shift from oil- to gas explotation, which is more energy demanding, increased emissions by 0.6 Mtonne, the same amount as the increase from traffic on roads and at sea, including fishing.

Table 7. CO_2-emissions from different source categories for the period 1990-2003. Mtonnes. Source: SN/SFT

Emissions, Mtonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Stationary combustion	7.1	6.6	6.4	6.6	7.5	7.0	8.4	7.8	7.8	7.5	6.7	7.2	7.0	8.0
Oil and gas industry	7.4	7.3	7.8	8.1	8.8	9.0	9.8	10.3	9.8	10.3	11.5	12.5	12.2	12.8
Industrial processes	6.8	6.8	6.5	7.0	7.3	7.2	7.5	7.6	7.9	7.8	8.1	7.7	6.7	6.8
Road traffic	7.9	7.8	8.0	8.4	8.2	8.4	8.9	8.9	9.1	9.3	8.8	9.3	9.3	9.6
Coastal traffic and fishing	3.2	3.0	3.1	3.3	3.2	3.3	3.5	3.8	4.0	4.3	3.9	3.8	3.7	4.0
Other mobile sources	2.0	2.0	2.0	1.9	2.2	2.2	2.2	2.3	2.2	2.4	2.1	2.2	2.3	2.0
Total	**34.4**	**33.5**	**33.8**	**35.4**	**37.3**	**37.2**	**40.4**	**40.6**	**40.8**	**41.6**	**41.1**	**42.7**	**41.2**	**43.2**

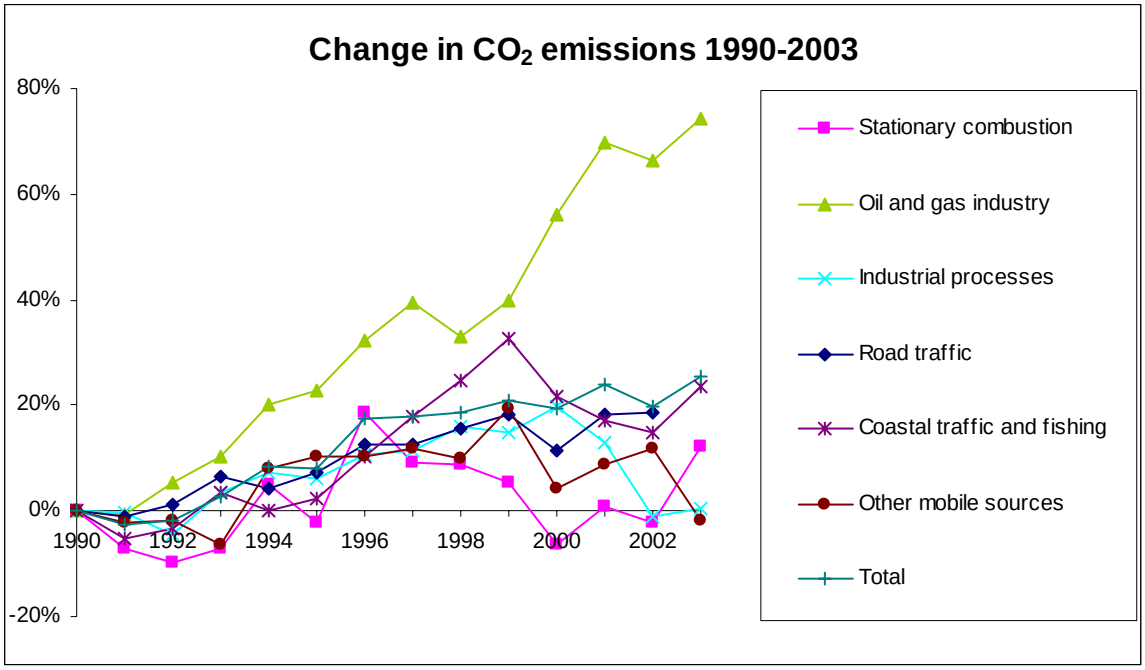


Figure 8. Changes in Norwegian CO_2 emissions 1990-2003 for major sources compared to 1990. Source: SN/SFT

Emissions from the oil- and gas industry increased by about 72 per cent since 1990 as a result of large increases in production volume of oil and gas and the export of natural gas in pipelines. However, emissions per unit produced oil/gas have been decreasing, because of technical and administrative improvements partly induced by a CO_2-taxation regime in 1991. Nevertheless, this trend has been counteracted in the last few years, due to technical factors related to a shift to older and more marginal oil-and gas fields and shift in production from oil to gas. Production of gas is more energy demanding than production of oil. From 2002 to 2003 the emissions decreased by 5 per cent.

Regarding road transportation, an increase of 21 per cent is detected in the CO_2 emission figures from 1990 to 2003. This rise is primarily attributed to the large increase (80 per cent) in the emissions from diesel vehicles over the years. Although emissions from gasoline vehicles decreased by 7 per cent

during this period, this fall was counteracted by the significant shift from gasoline to diesel vehicles. The emissions increased by about 3 per cent between 2002 and 2003.

Emissions of CO_2 from navigation (coastal traffic and fishing) have increased by 25 per cent from 1990 to 2003, mainly due to increased activity in the petroleum sector. The substantial increase in the production of Norwegian oil and gas in the North Sea during the 1990s resulted in increased traffic of supply boats to and from the oil platforms until 1999, after which the emissions have been quite stable.

Domestic civil aviation contributed to the total national GHG emissions by about 1.7 per cent in 2003. Emissions from civil aviation have increased by 40 per cent since 1990. Reduction in the number of flights resulted in an emission decline in the years 2000 - 2002. But in 2003 there was a new growth of 4 %.

CO_2 emissions from industrial processes are about at the same level as in 1990, and contribute with about 16 per cent of total CO_2 emissions. 78 per cent of the CO_2 emissions from this sector are from metal production.

The CO_2 emissions from stationary combustion are 19 per cent of total CO_2 emissions. This has increased with about 13 per cent since 1990. In the heating sector (commercial, institutional and residential), which represented in 2003 about 26 per cent of the stationary combustion figure, there has been a reduction in CO_2 emissions by 4 per cent from 1990 to 2003. This CO_2 emission reduction is mainly caused by increase in the use of electricity rather than oil. However, these emissions are very sensitive to winter temperatures and fuel prices, since many heating systems have the possibility to switch to oil when electricity prices are high. The winter temperatures were especially low in 2003, and electricity prices high because of little rain in 2002. This resulted in a strong increase in the sales of oil for heating compared to the precedent year. Consequently, CO_2-emissions from heating were about 21 per cent higher in 2003 than in 2002.

2.2.2. Methane (CH_4)

As can be seen from Figure 9, about 40 and 39 per cent of the emissions of methane in 2003 originated from waste treatment and agriculture respectively. These sources are relatively stable from year to year, and are little affected by short-term economic cycles. Methane emissions from agriculture are dominated by releases from enteric fermentation contributing 33 per cent to the total methane figure in 2003. Combustion and evaporation/leakage in the oil- and gas industry accounted for 14 per cent of the total emissions in 2003, the largest fraction of which is releases of methane (venting) during the loading and unloading operations offshore. Minor sources include emissions from petrol cars, manure management domestic heating and coal mining.

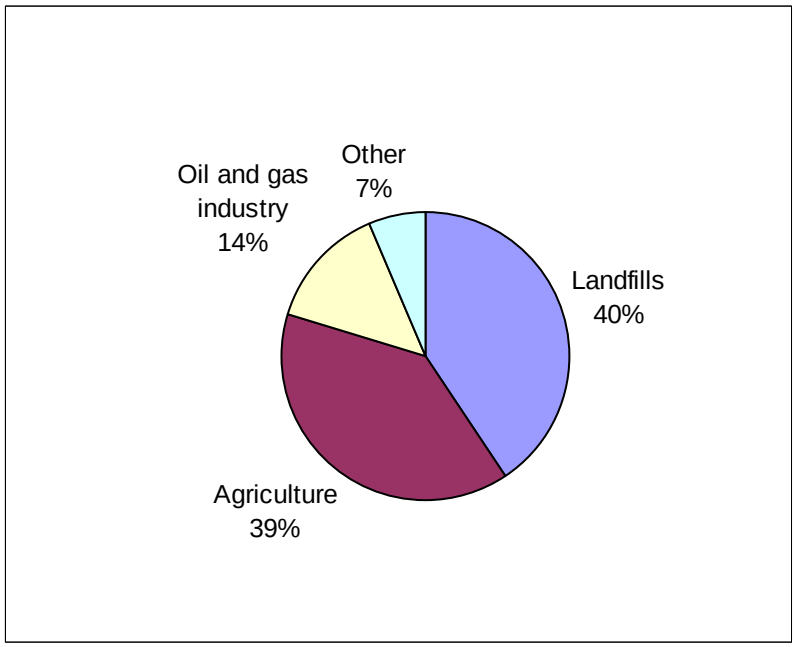


Figure 9. Distribution of Norwegian CH_4 emissions by source in 2003. Source: SN/SFT

The total methane emissions decreased by about 1 per cent from 2002 to 2003. During the period 1990-2003 the total CH_4 emissions decreased by about 2 per cent. Figure 10 shows that this decrease is primarily due to decreased emissions from waste treatment, which more than compensated for the strong growth in emissions from the oil- and gas industry.

The emission trend is characterised by a slow increase in the first half of the 1990s until 1997. From 1997 until 2003 emissions have gone down again to a level 1 % below 1990. Small annual fluctuations can be explained by emission changes in the oil- and gas industry because of changes in production volumes. Methane emissions from waste treatment were relatively stable until 1997 but then started to go down with increasing velocity, so emissions in 2003are 17 % below the 1990 level. The waste volumes have grown during the period (1990-2003), but this effect has been more than offset by increased recycling and incineration of waste and increased burning of methane from landfills. Over the period 1990-2003 the overall methane emissions from agriculture decreased by approximately 1 per cent, with small annual fluctuations. Given the high uncertainty of the key source enteric fermentation, no conclusions can be drawn for a possible trend.

Emissions from combustion and evaporation/leakage in the oil- and gas industry grew by 76 % from 1990 to 2003 and increased its share of the national CH_4 emissions from 8 % in 1990 to 14 % in 2003. Measures for mitigating the emissions have not been sufficient to compensate for the increase in activity level and change in extraction from oil to gas.

Table 8. Emissions of CH_4 in Norway 1990-2003, ktonne. Source: SN/SFT

Emissions, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Landfills	117	116	114	115	115	114	114	113	108	106	107	102	100	98
Agriculture	96	97	97	97	98	99	100	100	101	100	99	96	93	95
Oil and gas extraction	19	21	26	28	30	31	30	34	31	29	34	39	35	33
Other sources	14	13	12	13	13	13	14	14	14	14	14	15	15	16
Total	**246**	**247**	**250**	**253**	**256**	**257**	**258**	**261**	**253**	**249**	**253**	**252**	**244**	**241**

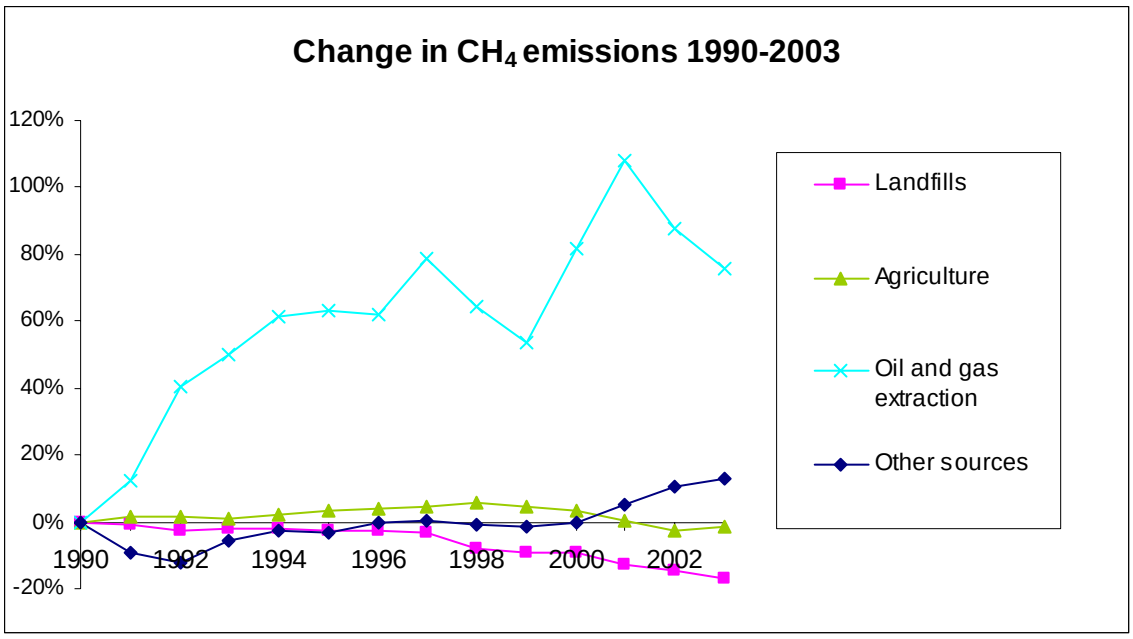


Figure 10. Changes in CH_4 emissions for major Norwegian sources between 1990 and 2002 compared to 1990. Source: SN/SFT

2.2.3. Nitrous oxide (N_2O)

Figure 11 shows that almost half of the Norwegian emissions of N_2O are of agricultural origin (48 per cent), with agricultural soils as the most prominent contributor. The second most important source is production of nitric acid from two plants, which is one of the steps in the production of fertiliser. These emissions account for 32 per cent of the total. The contribution from road traffic amounted to 13 per cent in 2003, with emissions originating from the use of catalytic converters in mobile sources. Included under "other" are emissions from e.g. fuel combustion, manure management and waste-water handling.

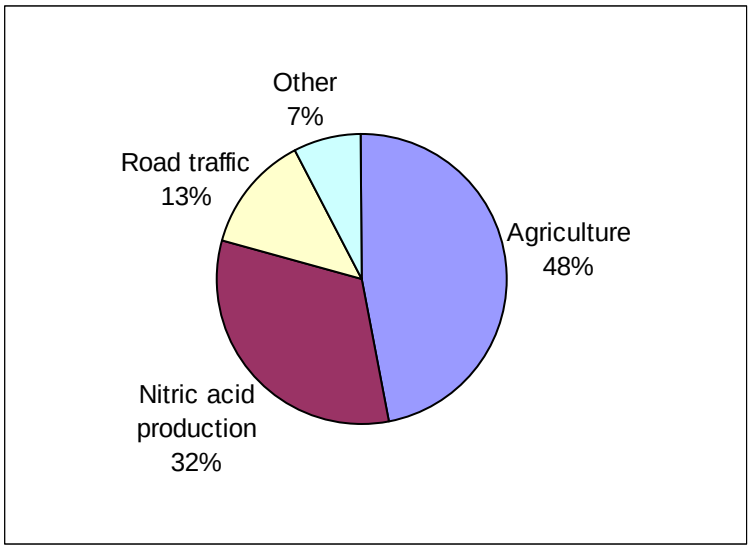


Figure 11. Distribution of Norwegian N_2O eissions by major sources in 2003. Source: SN/SFT

The overall nitrous oxide emissions increased by about 5 per cent from 1990 to 2003. Between 2002 and 2003 emissions decreased by 2 per cent. This and the details are shown in table 9 and figure 12.

Emissions of N_2O from agriculture have been rather stable through the 1990s and further on until 2003. The figures for N_2O emissions from agriculture demonstrate a reduction of 2 per cent from 1990 to 2003. Bearing in mind the very high level of uncertainty both in level and trend of the key source "agricultural soils", no conclusions can be drawn about the development in emissions from agriculture.

Changes in the production processes of nitric acid led to decreased emissions from this source in the beginning of the 1990s, while there was a moderate increase in emission in the following years due to increased production volumes. Improvements in the production process brought the emissions down again to a level 17 % lower than in 1990.

The most important factor contributing to the rise in emissions the last years is the increasing use of catalytic converters in mobile sources. Emissions of N_2O from road traffic increased about 7 times during the period 1990-2003.

Table 9. Emissions of N2O in Norway by major sources 1990-2003, ktonne. Source: SN/SFT

Emissions, ktonnes	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Agriculture	8.24	8.30	8.06	8.19	8.07	8.24	8.36	8.39	8.42	8.21	8.35	8.10	7.94	8.08
Nitric acid production	6.65	6.10	4.17	5.03	5.37	5.29	5.23	4.78	5.45	6.06	5.59	5.46	6.65	5.52
Road trafic	0.30	0.34	0.40	0.50	0.60	0.74	0.92	1.09	1.29	1.50	1.64	1.93	2.12	2.30
Other sources	1.15	1.13	1.11	1.13	1.20	1.22	1.26	1.30	1.30	1.33	1.27	1.32	0.77	1.28
Total	**16.34**	**15.87**	**13.73**	**14.85**	**15.23**	**15.48**	**15.76**	**15.55**	**16.46**	**17.09**	**16.85**	**16.81**	**17.48**	**17.18**

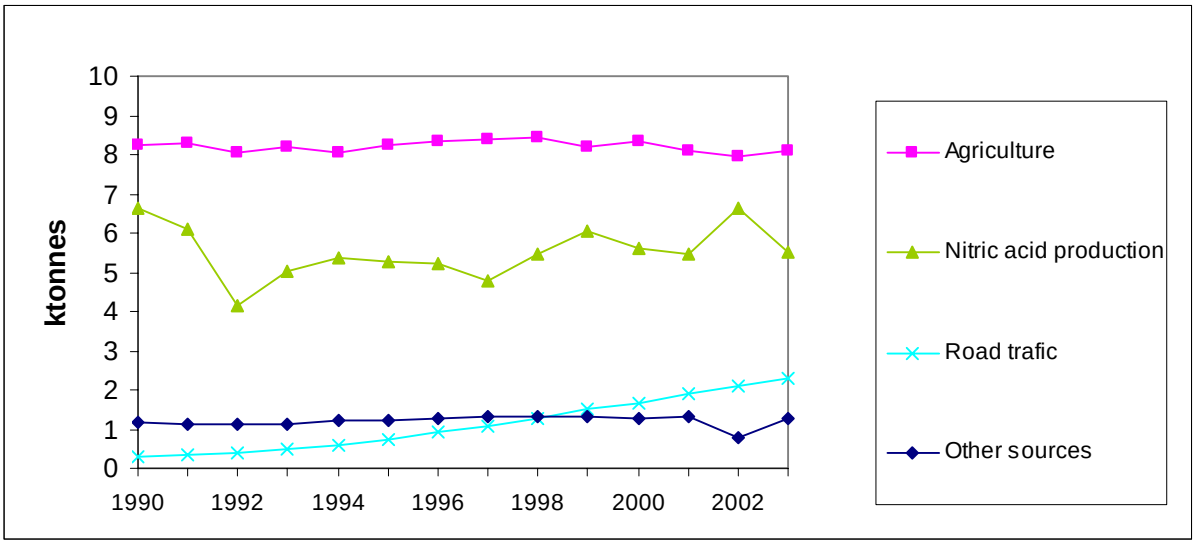


Figure 12. Changes in N_2O emissions for major Norwegian sources between 1990 and 2003. Source: SN/SFT

2.2.4. Perfluorcarbons (PFCs)

The emissions of the perfluorcarbons tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from Norwegian aluminium plants in 2003 were reported at 102 and 4 tonnes respectively, corresponding to a total of 0.7 Mtonnes of CO_2-equivalents.

The total emissions of PFCs decreased by 79 per cent in the period 1990-2003 following a steady downward trend as illustrated in Figure 13. Both CF_4 and C_2F_6 decreased by the same amount. PFCs reduction is caused by improved technology and process control, which has led to a 72 per cent decrease in the amount of PFCs emitted per tonne aluminium produced during the period 1990-2003, see Section 4.2 for further details.

PFCs may be used as substitutes for ozone-depleting substances. In Norway, only one compound is used for this purpose, namely C_3F_8 (PFC-218). The actual emissions of C_3F_8 have been calculated at only 55 kg in 2002, corresponding to almost 390 tonnes of CO_2-equivalents. Consumption of halocarbons is also described in Section 4.5.

Table 10. Emissions of PFCs in Norway 1990-2003, tonnes. Source SN/SFT

Emissions, tonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CF4	479	369	294	290	251	229	214	201	185	164	131	152	163	102
C2F6	20	14	11	10	9	8	5	8	7	6	5	6	7	4
PFK 218	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Total CO2-eq.	**3.29**	**2.52**	**2.02**	**1.98**	**1.71**	**1.56**	**1.44**	**1.38**	**1.27**	**1.12**	**0.90**	**1.04**	**1.12**	**0.69**

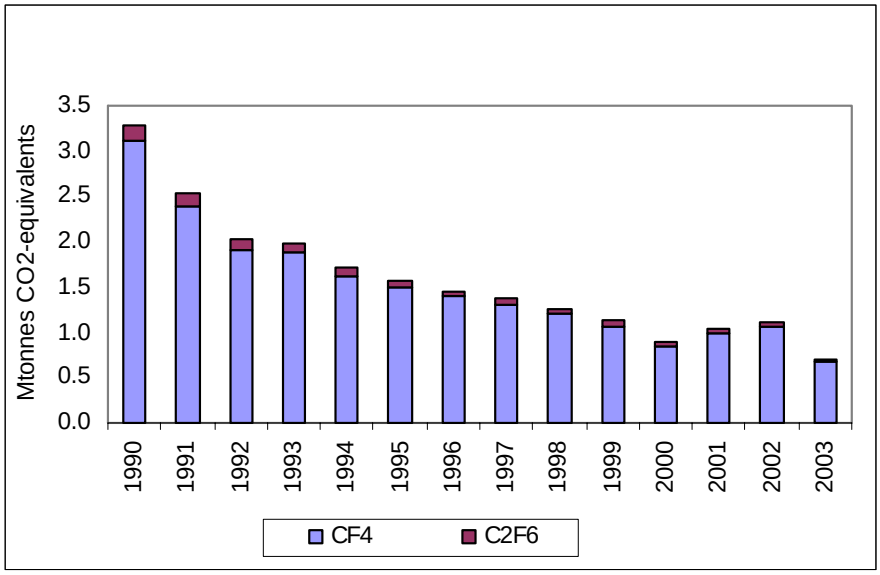


Figure 13. Emissions of PFCs in Norway 1990-2003, Mtonnes CO_2-equivalents. Source: SN/SFT

2.2.5. Sulphur hexafluoride (SF_6)

The largest source of SF_6 emissions in Norway is magnesium production, where SF_6 is used to cover the surface of liquid magnesium to prevent it from oxidising. The covering gas is emitted to air after use and no SF_6 is expected to react with the metal. The consumption of SF_6 has been reduced through the 1990s due to improvements in technology and process management. However, the process management changes from year to year and consequently also the consumption of SF_6. In 2003 the SF_6 emissions were 90 per cent lower than in 1990.

During the period 1990-1997, emissions were reduced by 75 per cent. From 1997 to 2000 emissions increased by 63 per cent due to increased production and higher shares of production of primary magnesium versus recycled metal. However, from 2000 emissions have decreased again, and emissions in 2003 were 76 per cent lower than those in 2000. Between 2001 and 2002 the reduction was as high as 71 per cent. Primary magnesium is produced by one company in Norway. The company decided to retain only the secondary production in the future, and primary production stopped in 2002. This explains the strong downward trend.

The use of SF_6 as a cover gas in the aluminium foundries lasted only during the period 1992-1996. Since1997 SF_6 has not been used in the foundries.

Table 11. SF_6 emissions in Norway 1990-2003, tonnes. Source SN/SFT

Emissions, tonnes	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Magnesium production	89.7	84.5	23.6	21.8	22.8	17.7	18.9	18.3	24.3	30.3	32.3	27.0	5.9	7.2
Aluminum production	0.0	0.0	3.1	6.0	10.0	3.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Products (GIS and other products)	2.4	2.7	2.9	3.4	4.3	4.5	4.7	6.4	6.6	6.8	7.3	6.7	4.7	2.5
Total	**92.1**	**87.2**	**29.6**	**31.2**	**37.1**	**25.8**	**24.5**	**24.7**	**30.9**	**37.1**	**39.7**	**33.7**	**10.6**	**9.7**

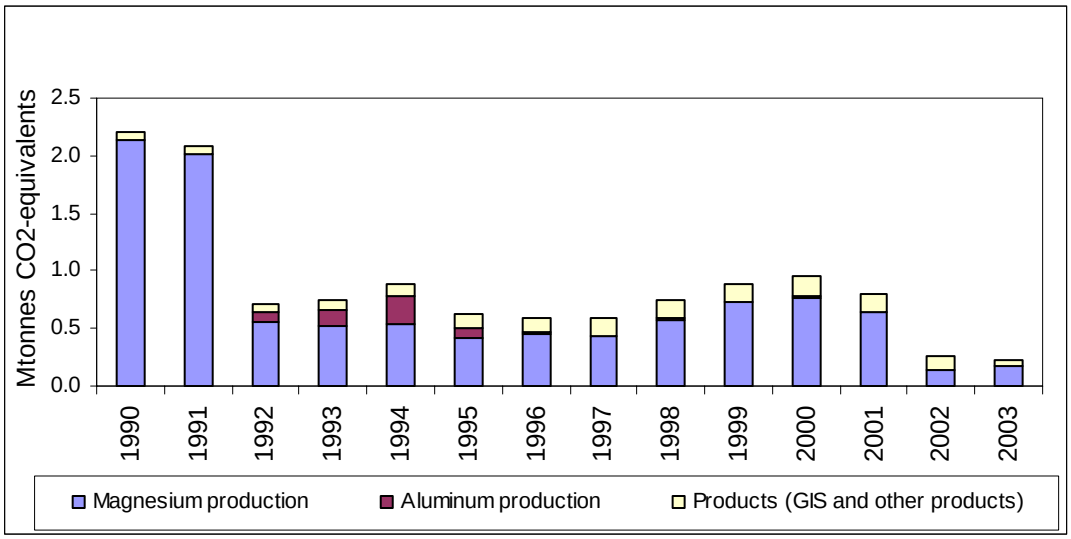


Figure 14. Emissions of SF_6 in Norway 1990-2003, Mtonnes CO_2-equivalents. Source: SN/SFT

2.2.6. Hydroflorocarbons (HFCs)

The total actual emissions from HFCs used as substitutes for ozone depleting substances amounted to 0.24 Mtonnes of CO_2-equivalents in 2003. Compared to the emissions in 2002, this represents a decrease of about 34 %. The emissions in 1990 were insignificant. The application category refrigeration and air conditioning contribute by far with the largest part of the HFCs emissions. The other categories foam and foam blowing, fire extinguishing products, and solvents and aerosol propellants contributed small amounts to the overall emissions. Tier 2 methodology was used to calculate the emissions. Figure 15 displays the development of the emissions of HFCs in the period 1990-2003. Table12 shows the actual emissions of different HFCs over the same period.

The potential emissions have also been calculated employing the Tier 1b methodology, which includes the import and export of chemicals in bulk and in products. The introduction of taxes has lead to a decrease in potential emissions due to decrease in investments in new HFC equipment and tightening of existing equipment. In the NIR report for next year, the calculation methods will be revised due to these new circumstances.

Table 12. Actual emissions of HFCs in Norway 1990-2003 calculated using the Tier 2 methodology, tonnes. Source SN/SFT

Utslipp i tonn (Tier 2)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFK 134a	-	0.0	0.2	1.8	5.4	10.2	17.2	26.2	38.2	50.2	61.1	71.8	85.8	64.6
HFK 125	-	-	-	-	0.5	2.4	5.5	9.7	14.7	19.9	25.9	32.9	41.2	27.0
HFK 143a	-	-	-	-	0.0	0.0	0.0	0.2	0.3	0.6	20.3	26.9	34.7	19.6
HFK 32	-	-	-	-	0.0	0.0	0.0	0.2	0.3	0.6	1.0	1.5	2.2	5.0
HFK 23	-	-	-	-	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0
HFK 152a	0.1	0.4	0.7	0.8	0.8	1.0	1.5	2.4	4.8	6.0	7.7	10.2	12.4	11.3
HFK 227ea	-	-	-	-	-	-	0.0	0.1	0.1	0.2	0.2	0.3	0.8	0.3

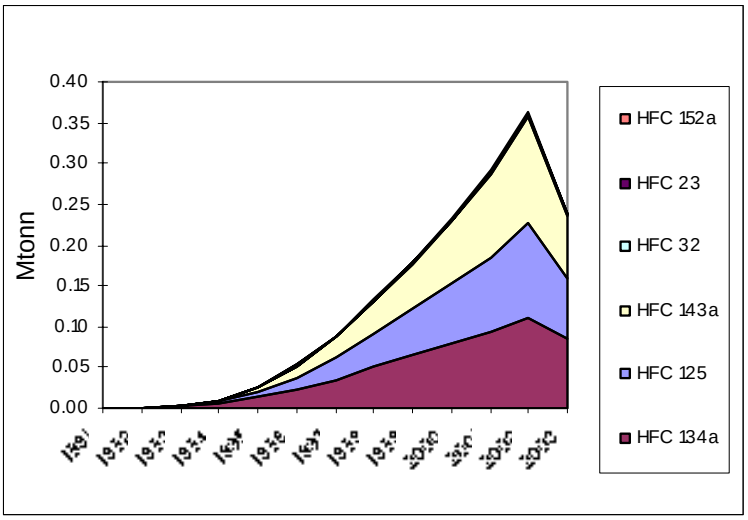


Figure 15. Actual emissions of HFCs in Norway 1990-2003, Mtonnes CO_2-equivalents. Source: SN/SFT

2.3. Emission trends by source

The largest contributor to the total greenhouse gas emissions in Norway is the energy sector, followed by industrial processes, agriculture and waste, see Figure 16.

Emissions from the energy sector account for 72 % of the national total, while industrial processes accounted for 16 per cent. Furthermore, emissions from agriculture contributed 8 per cent of the total, and the waste sector accounted for 4 per cent. The least important source is solvents and other products use, which accounted for only 0.3 per cent of the overall emissions.

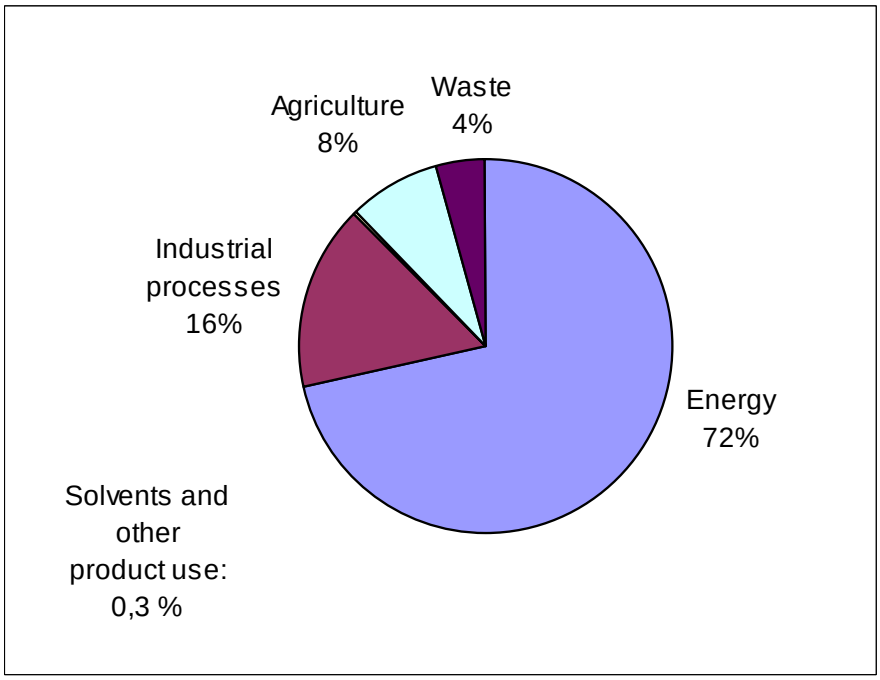


Figure 16. Emissions of greenhouse gases by UNFCCC sector in Norway in 2002. Source: SN/SFT

From 1990 to 2003 the share of the energy sector to the total emissionsl increased from 58 to 72 %. At the same time the contribution from industrial processes decreased from 27 to 16 %.

Table 13. Total emissions of greenhouse gases by sources and CO_2 removals from LULUCF in Norway 1990-2003. Mtonnes CO_2-equivalents. Source: SN/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Energy	29.3	28.9	29.2	30.4	32.1	32.0	35.1	35.2	35.0	36.2	35.6	37.6	37.1	39.2
Industrial processes	13.5	12.0	9.5	10.4	10.6	10.3	10.3	10.3	10.9	10.9	10.9	10.7	9.6	8.7
Solvents and other prod .use	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Agriculture	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.5	4.4	4.5
Waste	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.5	2.3	2.3	2.2
LULUCF														
Total - with LULUCF	**50.1**	**48.3**	**46.0**	**48.0**	**50.0**	**49.6**	**52.8**	**52.9**	**53.3**	**54.3**	**53.8**	**55.3**	**53.5**	**54.8**
Total - without LULUCF	**50.1**	**48.3**	**46.0**	**48.0**	**50.0**	**49.6**	**52.8**	**52.9**	**53.3**	**54.3**	**53.8**	**55.3**	**53.5**	**54.8**

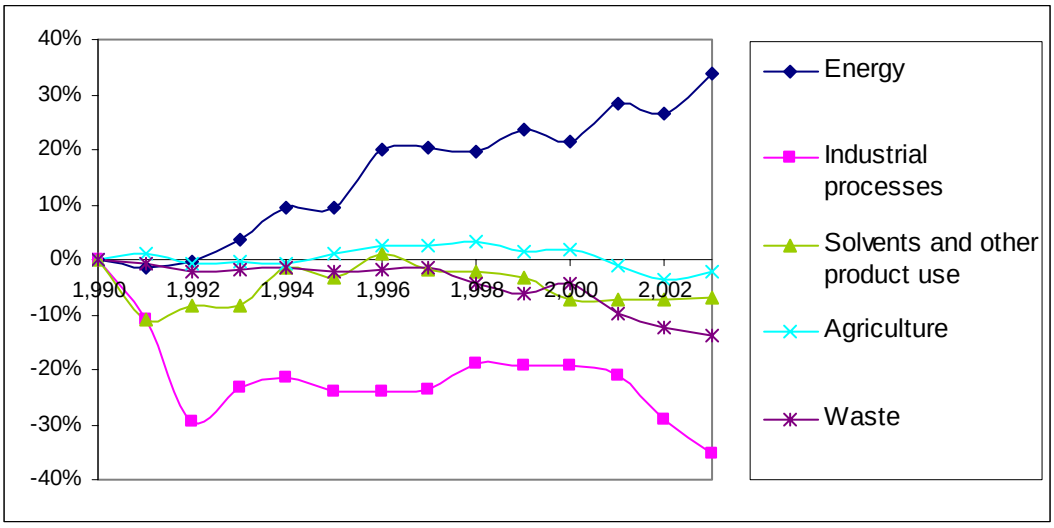


Figure 17. Changes in total greenhouse gas emissions by UNFCCC source categories during the period 1990-2003 compared to 1990. Source: SN/SFT

2.3.1. Energy

Emissions from the energy sector account for 72 % of the national total .
The transport sector is the biggest emitter of GHG wit a share of 37 %. Number two is "energy industries" with a share of 33 %. This sector is almost completely dominated by the oil-and gas extraction and related activities. The Norwegian energy sector has traditionally been characterised by large amounts of readily available hydroelectric power. This has resulted in a preference of electricity in favour of fossil fuels in heating and many manufacturing processes with corresponding lower emissions of GHGs from industry and households. Figure 18 displays the distribution of GHG emissions in 2003 on the different source categories.

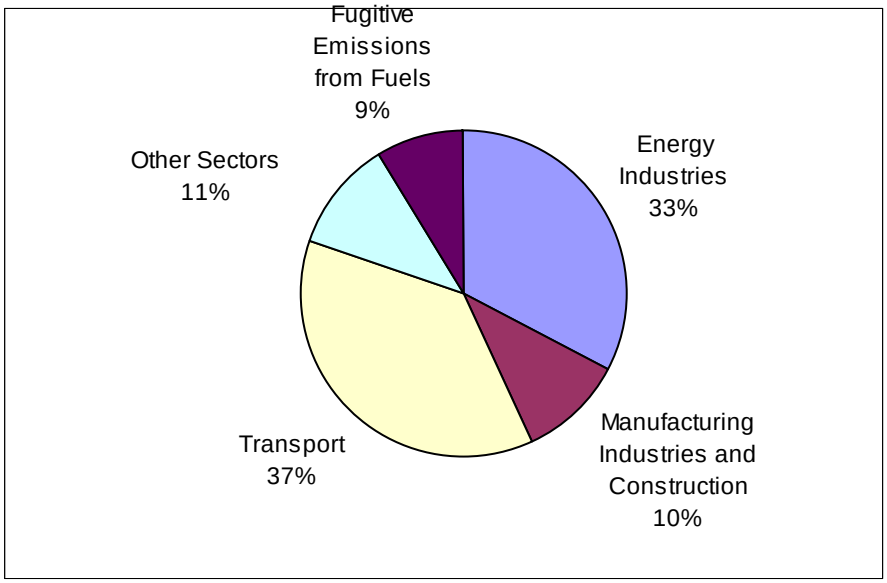


Figure 18. Greenhouse gas emissions in 2003 from the energy sector distributed on the different source categories. Source: SN/SFT

The total emissions of greenhouse gases from the energy sector over the period 1990-2003 are listed in Table 14. The emission changes detected in the various source categories in the energy sector between 1990 and 2003, compared to 1990 are illustrated in Figure 19 and discussed in the following.

Table 14. Total emissions of greenhouse gases from the energy sector in Norway 1990-2003, Mtonnes CO_2-equivalents. Source: SN/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Energy Industries	6.6	6.9	7.5	7.8	8.5	8.4	9.2	9.6	9.3	9.2	10.0	11.5	11.8
Manufacturing Ind. and Construction	3.6	3.4	3.3	3.5	4.2	3.9	4.4	4.4	4.3	4.1	3.9	4.0	3.7
Transport	11.3	11.3	11.5	12.1	12.0	12.5	13.2	13.5	13.9	14.5	13.7	14.1	13.9
Other Sectors	4.8	4.3	4.1	3.9	4.2	4.1	4.8	4.4	4.3	4.4	3.6	4.0	4.3
Fugitive Emissions from Fuels	3.0	3.0	2.9	3.0	3.2	3.2	3.5	3.4	3.3	4.0	4.4	4.0	3.4
Total	**29.3**	**28.9**	**29.2**	**30.4**	**32.1**	**32.0**	**35.1**	**35.2**	**35.0**	**36.2**	**35.6**	**37.6**	**37.1**

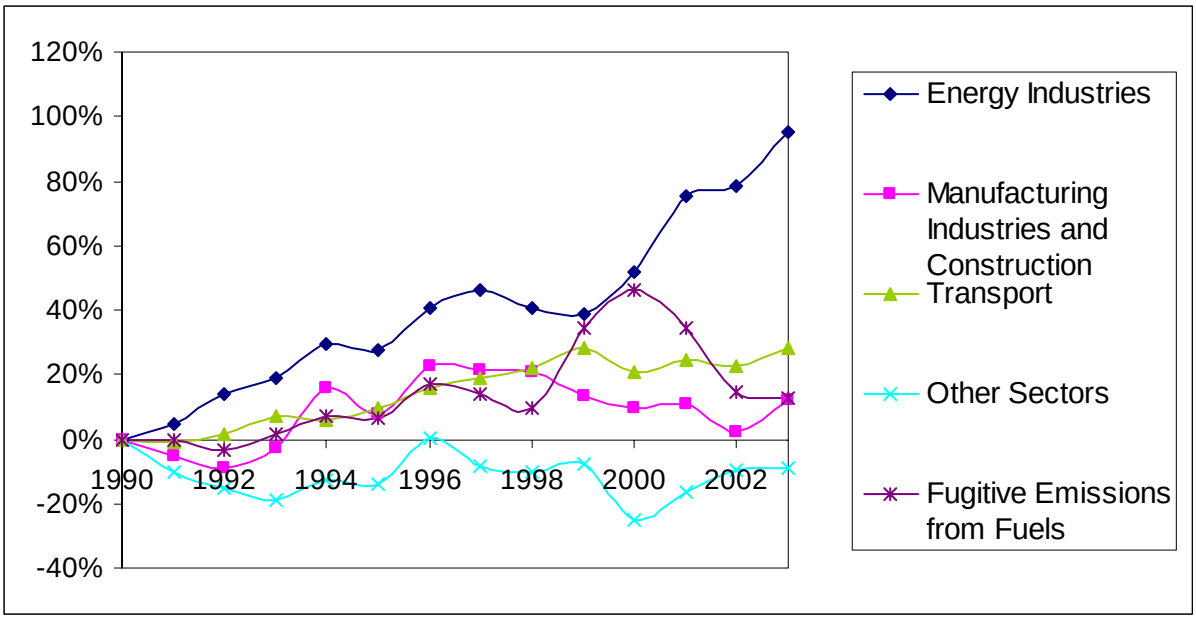


Figure 19. Changes in emission in the various source categories in the energy sector between 1990 and 2003, compared to 1990. Source: SN/SFT

During most of the 1990s energy related emissions were increasing, mainly due to higher activity in the oil and gas extraction sector and in the transport sector. In 2003 the total emission level in this sector was 34 per cent higher than those of 1990. There were short, temporary emission reductions in 1991, 2000, and 2002 follwed by new growth. The reduction in1991 was caused by a period with reduced economical activity, in 2000 by a mild winter and tax changes which resulted in reduced use of fuels for heating purposes and reduced fuel sales respectively. The decrease from 2001 to 2002 was due to reduced fugitive emissions from fuels and lower emissions from manufacturing industries and construction, which outpaced the increased emissions from energy industries and transport over the same period.

Emissions from **Energy industries** have increased by 95 per cent from 1990 to 2003, and by about 9 per cent from 2002 to 2003. The main source here is offshore oil- and gas extraction, contributing with 87 % of the emissions from Energy industries in 2003. Oil and gas extraction has played an important role in the national economy in recent decades. On the offshore oil- and gas installations, electricity and pumping power is principally produced by gas turbines and, to a lesser extent, diesel engines. Emissions from these sources are accounted for under the UNFCCC sector Manufacturing of Solid Fuels and Other Energy Industries. In 2003 the emissions from oil and gas extraction off shore contributed about 20 per cent to the total GHG emissions in Norway. In 1990 the corresponding contribution was 13 per cent and the growth detected can be explained by increased production of oil and gas. During the period 1990-2003 there was a 72 per cent increase in the total greenhouse gas emissions from energy production offshore.

Public generation of electricity is almost completely dominated by hydroelectric generation; hence insignificant emissions of greenhouse gases are reported. The only important exceptions are waste incineration plants and a small coal combustion plant (6 MW) on the island of Spitsbergen. These emissions accounts for about 3 per cent of the energy industries figure, and they doubled from 1990 to 2003.

Industrial emissions related to fuel combustion[3] originate to a large extent from the production of raw materials and semi-manufactured goods, e.g. alloys, petrochemicals, paper and minerals. Emissions

[3] Mainly emissions from use of oil or gas for heating purposes. Does not include consumption of coal as feedstock and reduction medium, which is included in the industrial process category.

from **Manufacturing industries and construction** increased by 12 per cent in the period 1990-2003, due to increased activity with the most pronounced rise being in the petrochemical industry (starting up of a new methanol production plant) and the pulp and paper industry. , There was a strong decrease of 9 % in 2002, compensated by a growth of 10 % in 2003.

Emissions from **Transport** showed an overall increase of about 28 per cent from 1990 to 2003, while the emissions increased by 5 per cent from 2002 to 2003 (see Table 15 and Figure 20). The share of transport in the total GHG emissions, have increased from 22 per cent in 1990 to 27 % in 2003. Road traffic accounts for more than 2/3 of the total mobile emissions and these emissions have increased by 22 per cent since 1990. From 2002 to 2003 the emissions rose by almost 3 per cent. Emissions from navigation increased by 29 per cent from 1990 to 2003, mainly because of increased activity related to the oil- and gas extraction sector. Emissions from civil aviation have increased by 40 per cent since 1990. Reduction in the number of flights resulted in an emission decline in the years 2000, 2001 and especially 2002. In 2003 there was a new growth of 4 %. Domestic civil aviation contributed to the total national GHG emissions by about 1.7 per cent in 2003. Due to the fact that most railways are electrified in Norway, emissions of GHG from this source are insignificant.

Table 15. Total emissions of greenhouse gases from the transport sector in Norway 1990-2003, Mtonnes CO_2-equivalents. Source: SFT/SN

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Civil Aviation	0.68	0.70	0.72	0.72	0.80	0.86	0.96	0.98	1.01	1.16	1.06	1.06	0.91	0.95
Road transportation	7.85	7.77	7.92	8.38	8.19	8.41	8.86	8.84	9.06	9.28	8.75	9.29	9.33	9.58
Railways	0.10	0.09	0.10	0.10	0.11	0.10	0.07	0.07	0.06	0.05	0.05	0.05	0.04	0.04
Navigation	1.93	1.93	1.99	2.15	1.99	2.08	2.19	2.42	2.53	2.77	2.52	2.27	2.18	2.49
Other transportation	0.54	0.53	0.51	0.50	0.58	0.62	0.64	0.65	0.64	0.64	0.65	0.66	0.66	0.65
Total Transport	**11.1**	**11.0**	**11.2**	**11.8**	**11.7**	**12.1**	**12.7**	**13.0**	**13.3**	**13.9**	**13.0**	**13.3**	**13.1**	**13.7**

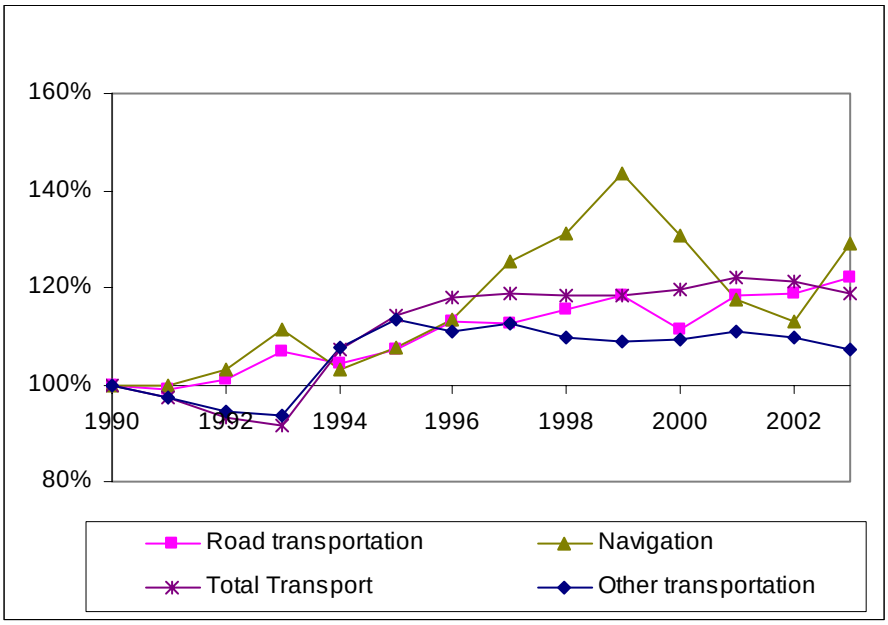


Figure 20. Changes in CO_2-emissions from different modes of transport in 1990-2003 compared to 1990. Source: SN/SFT

The category **Fuel combustion in Other Sectors,** emitting almost 4 Mt CO_2-equivalents in 2003 is dominated by emissions from agriculture, forestry and fisheries, which accounts for about half of the emissions of Other Sectors. These emissions have been rather stable throughout the period 1990-2003.

Emissions from residential sources accounted in 2003 for about 26 per cent of the total, and they have decreased by about 23 per cent since 1990 due to electrification of heating infrastructure. However, new technologies and occasional electricity shortages have at times reversed this trend during the 1990s. Recent examples of fluctations are the relatively low emissions from this source category in 2000 due to the mild winter which led subsequently to relatively low consumption of fuels for heating purposes and the increase in 2003 by 20 % of emissions from residential due to high electricity prices and a cold winter.

Emissions from commercial/institutional sources make up the last 26 % of this category. The development in emissions has been a 26 per cent increase from 1990 to 2003, and a growth of 22 per cent between 2002 and 2003.

The source category termed **Fugitive emissions from fuels** in the CRF tables with emissions in 2003 of about 3.4 Mt CO_2-equivalents, refers to emissions from oil and gas activities. These emissions originate from flaring of natural gas, leakages and venting of methane. Indirect CO_2 emissions from NMVOC emitted during the loading and unloading of oil tankers are also accounted for in this category. In order to minimise emissions from these activities, Norway has implemented various technical measures and a CO_2 tax. Nevertheless, due to large increases in production, emissions have increased by 13 per cent from 1990 to 2003. The emission level in 2003 however is 10 % lower than the one in 2001 and 16 % compared with 2001 mainly due to reduced flaring off shore and reducing spill of NMVOC during loading and onloading of oil tankers.

2.3.2. Industrial processes

Production of raw materials is the main source of process related industrial emissions for both CO_2 and other greenhouse gases such as N_2O (fertiliser production), SF_6 (magnesium foundries) and PFCs (aluminium production). The industrial process sector accounts for 15.9 per cent of the national greenhouse gas emissions. Table 16 gives figures for the total greenhouse gas emissions from the industry sector. The emissions from this source category have decreased by 35.4 per cent from 1990 to 2003 and 8.9 per cent from 2002 to 2003. The decreased emission from 1990 to 2003 is mainly due reduced PFC emissions from production of aluminium and SF_6 from production of magnesium. There was a reduction in the PFC emissions even if the production of aluminium increased by 36 per cent in the same period. The reduction in the SF_6 emissions is due to improvements in process management and that the production of magnesium was closed down in 2002.

Table 16. Total greenhouse gas emissions from the industry sector in Norway 1990-2003, Mtonnes CO_2-equivalents. Source: SN/SFT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Mineral Products	0,7	0,6	0,7	0,9	0,9	0,9	0,9	1,0	0,9	0,9	0,9	0,9	0,9	1,0
Chemical Industry	2,9	2,7	2,1	2,4	2,5	2,5	2,5	2,3	2,5	2,4	2,4	2,4	2,3	2,0
Metal Production	9,8	8,6	6,7	7,0	7,1	6,7	6,7	6,7	7,1	7,3	7,1	6,9	5,9	5,2
Other Production	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1
Production of Halocarbons and SF_6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Consumption of Halocarbons and SF_6	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,3	0,3	0,4	0,5	0,5	0,5
Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	**13,5**	**12,0**	**9,5**	**10,4**	**10,6**	**10,3**	**10,3**	**10,3**	**10,9**	**10,9**	**10,9**	**10,7**	**9,6**	**8,7**

Metal production contributes to 60 per cent of the total GHG emissions from Industrial Processes, mainly from production of ferro alloys and aluminium. Chemical Industry and Mineral Product are the two other main contributing sectors with 23 and 10 per cent, respectively, of the total GHG emissions in this sector. Figure 20 indicates the various production's contribution to greenhouse gas emissions.

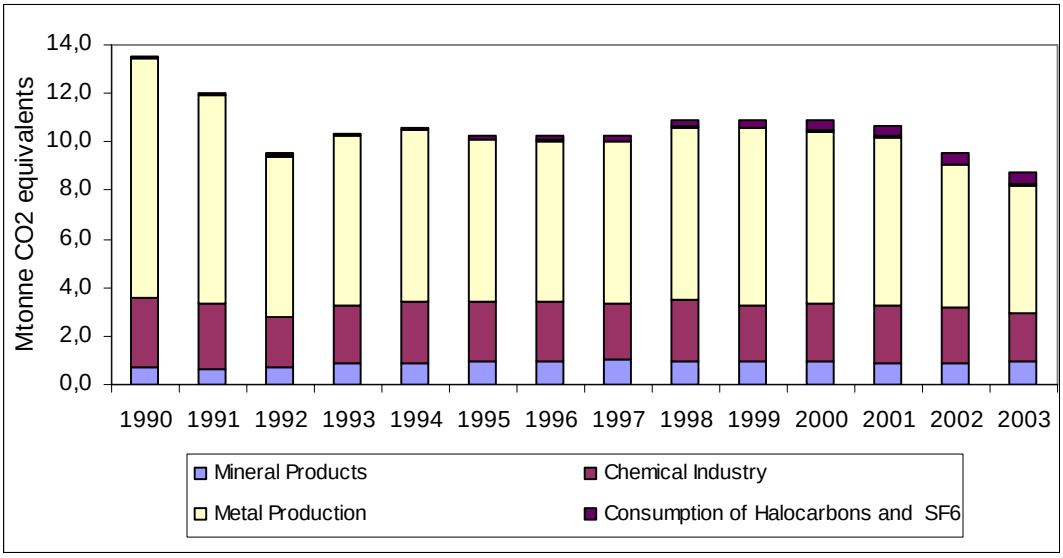


Figure 21. Total greenhouse gas emissions in the industrial source categories in Norway during the period 1990-2003. Source: SN/SFT

During the first half of the 19th century there was a large-scale industrialisation in Norway. Many industrial communities appeared around the large hydroelectric resources, particularly in the western parts of the country. Typical products were raw materials and semi-manufactured goods such as aluminium and ferroalloys. The main energy source has always been hydroelectricity. However, fossil fuels have been used as reducing agents or raw materials. Greenhouse gases are emitted as process related gases.

The main category within the industrial sector is **Metal production**, which accounted for 60 per cent of the sector's emissions in 2003. Aluminium production is the main source within the metal production category. Production of aluminium leads to emission of various components as CO_2, SO_2, NO_x, perfluorocarbons (PFCs), heavy metals and persistent organic pollutants. Both the prebaked anode and the Søderberg (old and new) production technologies are in use.

PFCs from aluminium production accounted for 1.3 per cent of the national total GHG emissions in 2003. This is a decrease from 6.6 per cent in 1990. The reduction has been achieved by improving the efficiency of the production process and by installing point feeders to reduce the numbers and duration of anode effects per cell day (AEF). For Søderberg cells, installation of point feeders has contributed significantly. This has caused a reduction of the PFC emissions per tonne aluminium produced in Norway from 3.79 kg CO_2-equivalent in 1990 to 0.59 kg CO_2-equivalent in 2003. The relative emissions of PFCs in CO_2 equivalents per tonne aluminium produced have decreased by 45 per cent from 2002 to 2003. The large reduction is mainly due to that one plant converted from Søderberg to Prebaked technology in 2003 and at at the same time the production increased.

Included in the modernisation is also an increase in production capacity. The consequence is that emissions of PFCs will go down, while emission of CO_2 will increase.

About 70 per cent of the aluminium was produced with Prebaked technology in 2003. Almost 15 per cent was produced by old Søderberg and about 15 per cent by new Søderberg technology.

Production of ferroalloys is the second most important source within the category of metal production. Norway is a major producer of ferroalloys with 14 plants in operation in 2003.
The GHG emissions (CO_2 and CH_4) from ferroalloy production accounted for 5.2 per cent of the national total GHG emissions in 1990 and have decreased to 4 per cent in 2003. The total GHG emissions from production of ferroalloy have decreased by 14 per cent from 1990 to 2003. The reduction is due to reduced activity in the sector and that plants have been closed.

The major iron producing plant was closed down in 1988, but one plant still exists. The emissions from this source account for about 5 per cent of the emissions from metal production. Other metals produced in Norway today are nickel, zinc and magnesium, one plant of each, but the emissions from theses sources are minor.

The major source of SF_6 emissions is magnesium production. There is one plant in Norway producing magnesium. The plant closed down the production of primary magnesium in 2002 but the production of cast magnesium is continuing. In the foundry, producing cast magnesium, SF_6 is used as a cover gas to prevent oxidation of magnesium. The Norwegian producers of cast magnesium has assessed whether SF_6 used a cover gas reacts with other components in the furnace. The results indicate that it is relatively inert, and it is therefore assumed that all SF_6 used as cover gas is emitted to air.

SF_6 from magnesium foundries accounted in 2003 for 0.3 per cent of the total GHG emissions in Norway. In 1990 this sector contributed with 4.3 per cent of the national total GHG emissions. The reduction is due to improvements in technology and in process management. The primary magnesium production stopped in 2002 and only secondary production is retained.

The chemical industry is the industry sector's second most important category, accounting for 23 per cent of the emissions. In Norway this category includes primarily production of fertilisers and silicon carbide. These processes release N_2O (from nitric acid production) and CO_2 (from production of ammonia and carbides). The collective emissions of N_2O and CO_2 were reduced by about 30 per cent in the period 1990-2003. The detected reduction is due to improved technology in the nitric acid production. From 2002 to 2003 emissions increased by 8 per cent, which is a result of a higher production level.

Regarding the category **Production of minerals**, cement production is by far the main source. Cement is produced in two plants in Norway, releasing CO_2 emissions from coal and waste used in direct fired furnaces, and from carbon in limestone. The latter is reported as process related emissions according to the 1996 Revised IPCC Guidelines. The GHG emissions from cement production accounted for 1.6 per cent of the total GHG emissions in 2003 and 10 per cent of the emissions in sector Industrial processes. From 1990-2003 the GHG emissions from cement production increased by 36 per cent due to increased production (46 per cent). The emission increased by 4 per cent from 2002 to 2003.

Refrigeration and air conditioning equipment is the most important application category related to emissions of hydrofluorocarbons (HFCs) under the category **Consumption of halocarbons and SF_6**. Increased application of air-conditioning systems in new cars amplifies the rapid growth in these emissions. Electrical switchgears and the use of SF_6 as trace gas are the most important source of non-process emissions of SF_6. Norway does not manufacture halocarbons or SF_6.

2.3.3. Solvent and other product use

Use of solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which is regarded as an indirect greenhouse gas. The NMVOC emissions will over a period of time in the atmosphere oxidise to CO_2.

Indirect CO_2 emissions from solvents and N_2O from anaesthesia and propellant represented approximately 0.3 per cent of the total GHG emissions in 2003 and 0.4 per cent in 1990.
The share has been more or less unchanged since 1990.

2.3.4. Agriculture

Emissions from agriculture were relatively stable between 1990 and 2003, with emission levels of around 4.6 million tonnes CO_2-equivalents. The largest sources for agricultural greenhouse gas emissions are N_2O from agricultural soils and CH_4 from enteric fermentation from cattle, sheep, reindeer and other animals. These source categories, which also are key sources, account for about 53 and 37 per cent of the total emissions from the agricultural sector. The remaining emissions in this sector constitute mostly of CH_4 and N_2O from manure management (about 9 per cent).

Greenhouse gas emissions from agriculture comprise direct emissions of methane and nitrous oxide and oxidised emissions of CO_2. The greenhouse gas emissions from this sector accounted for 8 per cent of the overall Norwegian greenhouse gas emissions in 2003. Between 1990 and 2003 there has been a 2 per cent decrease attributed to reduced emitted amounts of N_2O from agricultural soils and CH_4 from enteric fermentation. Between 2002 and 2003 emissions increased, by about 2 per cent, because of increased emissions from agricultural soils.

Over the period 1990-2003 the nitrous oxide emissions from agriculture decreased by about 2 per cent. The reduction originates primarily from the source direct soil emissions, and may be explained by reductions in the amount of N in agricultural products, which in turn decreases the N_2O emissions from crop residues. The methane emissions also went down by 2% in the same period. These figures reflect the stability of the production in the agricultural sector, as well as the absence of improvements in technology resulting in lower emissions of greenhouse gases.

However it is important to bear in mind the high levels of incertainty in both level and trend for both key sources in the interpretation of the figures.

Table 17. Total greenhouse gas emissions from agriculture in Norway 1990-2003, ktonnes CO_2-equivalents. Source: SN/SFT

Emissions, Mtonnes CO_2 –equv	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Enteric fermentation	1.71	1.74	1.74	1.72	1.74	1.76	1.78	1.78	1.80	1.78	1.75	1.71	1.69	1.68
Manure management	0.43	0.45	0.45	0.44	0.45	0.46	0.46	0.46	0.47	0.46	0.46	0.45	0.45	0.45
Agricultural soils	2.41	2.43	2.36	2.40	2.36	2.41	2.45	2.46	2.47	2.40	2.44	2.37	2.32	2.36
Field burning of agricultural residues	0.03	0.02	0.01	0.018	0.013	0.016	0.017	0.013	0.013	0.012	0.013	0.010	0.008	0.006
Total	**4.59**	**4.64**	**4.56**	**4.58**	**4.57**	**4.64**	**4.70**	**4.71**	**4.74**	**4.66**	**4.67**	**4.54**	**4.43**	**4.50**

2.3.5. Waste

The sector includes emissions from landfills ($CH_{4)}$, wastewater handling (CH_4 and N_2O) and small scale waste incineration(CO2 and CH4). Waste incineration with utilisation of energy is treated in the Energy chapter. Solid waste disposal on land (Landfills) is the main category within the waste sector, accounting for about 92.5 per cent of the sector's total emissions. Wastewater handling and waste incineration account for approximatley 5,9 and 1,6 per cent respectively. The waste sector, with emissions of 2.4 Mtonnes CO_2-equivalents in 2003 accounted for 4.0 per cent of the total GHG emissions in Norway in 2003.

The emissions of greenhouse gases from the waste sector were relatively stable until 1996 with emission levels of around 2.6 million tonnes CO_2-equivalents. From 1997 emissions declined and in 2003 were emissions 11 % lower than in 1990. In spite of increasing amounts of waste the emissions of CH_4 from landfills has decreased because of a combination of increased recycling, incineration and burning of landfill gas.

The development of the emissions from waste is shown in table 18 and Figure 22

Table 18. Emissions from the waste sector in Norway 1990-2003, Mtonnes CO_2 –equivalents. Source:SN/SFT

Emissions CO_2 equ [Mtonnes]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Waste Incineration	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Landfills	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.2	2.2	2.2	2.1	2.0
Waste Waterhandling	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	2.7	2.7	2.6	2.6	2.7	2.6	2.7	2.6	2.5	2.5	2.5	2.4	2.4	2.4

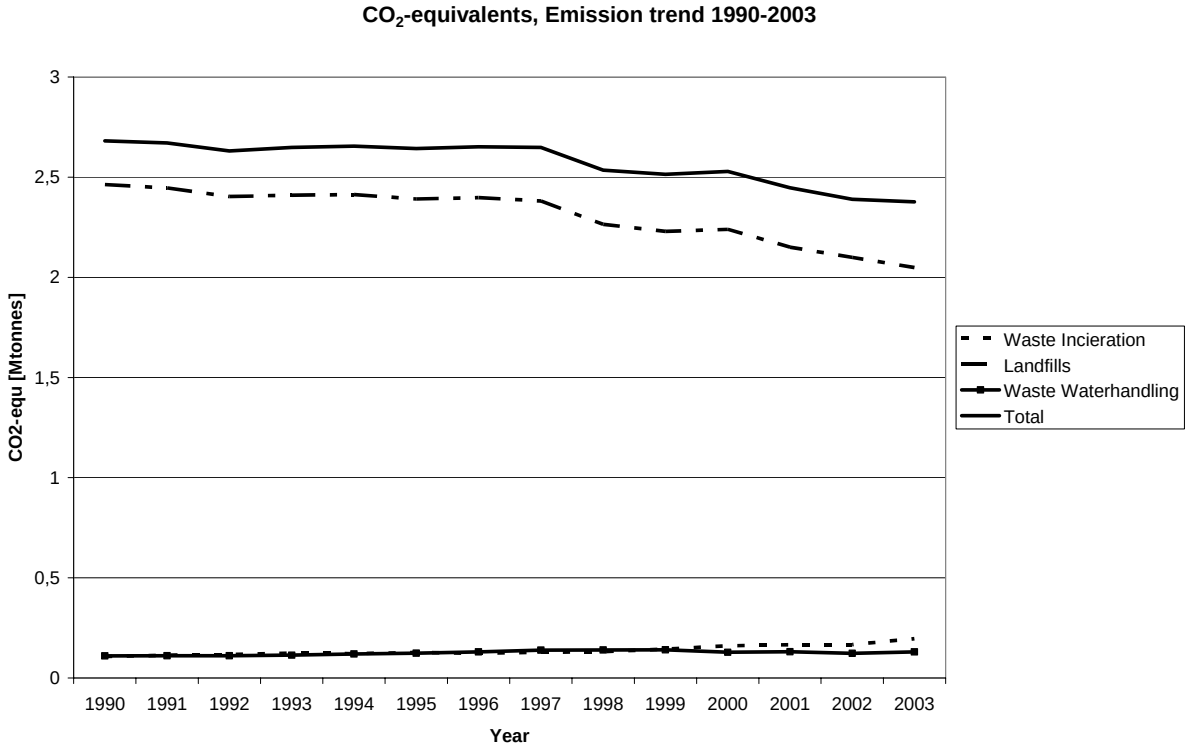


Figure 22. Total emissions of greenhouse gases in Norway from the waste sector 1990-2003, Mtonnes CO2-equivalents. Source: SN/SFT

Figure 22 shows that emissions of methane have decreased slightly since 1996 due to reduction of the amount of waste disposed at disposal sites. This reduction is the result of several measures which were

introduced in the waste sector particularly in the 1990s. With a few exceptions, it is prohibited to dispose easy degradable organic waste at landfills in Norway. In 1999 a tax was introduced on waste delivered to final disposal sites. This tax was equal to 320 NOK per tonne waste disposed at landfill sites in 2002, and increased to 327 NOK from 2003. In addition, landfills receiving biodegradable waste (waste containing degradable organic carbon (DOC)) are required to collect and treat landfill gas. In 2002 a total of 60 landfills had installed a landfill gas extraction system, and approximately 22 ktonnes of methane was recovered in 2002. In addition, the amounts of waste recycled have increased significantly since 1990.

2.4. Land Use Change and Forestry

The average annual net sequestration from the land-use, land-use change and forestry sector was about 15 Mtonnes of CO_2 for the period 1990-1996, and about 22 Mtonnes per year from 1998 to 2003. In 2003 the net sequestration was calculated at 22.5 Mtonnes of CO_2, which would offset 41 per cent of the total greenhouse gas emissions in Norway that year. The sequestration increased by approximately 47 per cent from 1990 to 2003, while the increase from 2002 to 2003 was 0.6 per cent. Figure 23 shows the land areas occupied by the different land-use categories as defined by the IPCC (IPCC 2004) in 1990 and 2001.

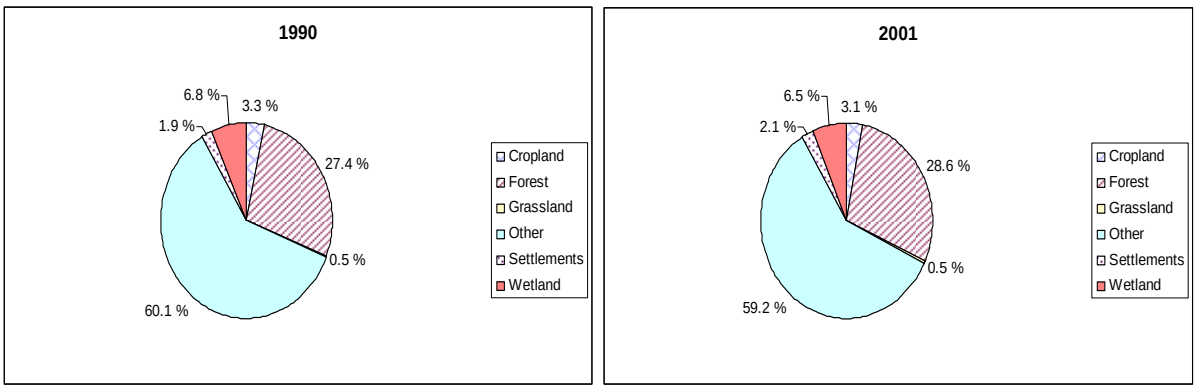


Figure 23. Land area by category in 1990 and 2001

As can be seen from the figure above, forest covers around one fourth of the mainland area of Norway and forest land is the most important land-use category. Forest land is also the most important contributor to carbon stock changes. In 2003 the land-use category forest land remaining forest land was the only category with a net sequestration, which totalled about 25 Mtonnes CO_2. From 1990 to 2003 the sequestration increased by 39 per cent. The explanation for this growth is a continued increase in standing volume and gross increment while the amount of CO_2 emissions due to harvesting and natural losses has been quite stable. Emissions of CH_4 and N_2O from forest land remaining forest land are negligible compared to the CO_2 sequestration; 0.7 and 0.05 ktonnes respectively in 2003 (corresponding to about 15 and 16 ktonnes of CO_2-equivalents). This represents a reduction from 1990 to 2003 on 19 % with respect to methane. Emissions of nitrous oxide have remained fairly constant over the period. Figure 24 illustrates the change in carbon stocks in forest living biomass, dead wood and soil organic carbon between 1990 and 2003.

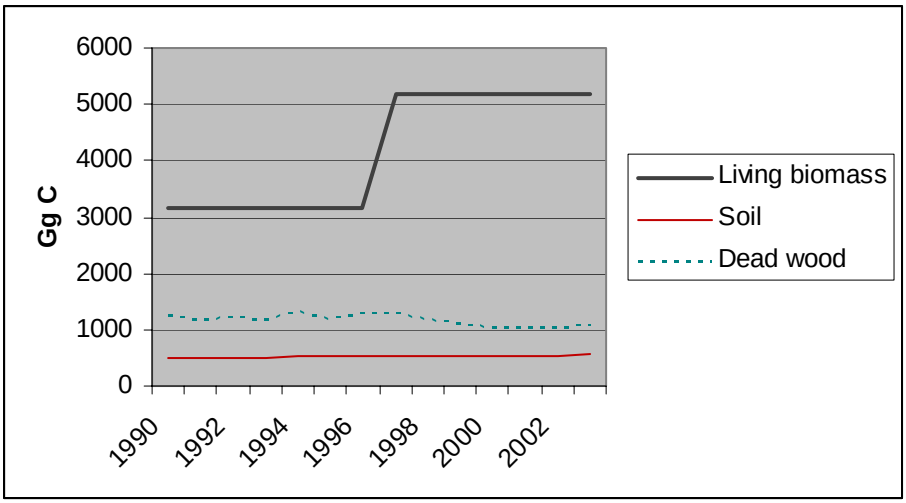


Figure 24. Carbon stock changes in forest living biomass, dead wood and soil organic carbon. 1990-2003.

All other land-use categories than forest remaining forest showed net emissions, they were calculated at a total of 2.5 Mtonnes CO_2. Of these, the most important category was grassland remaining grassland with total emissions of 1.9 Mtonnes of CO_2; while land converted to settlements (deforestation) was the second most important emissions category with 342 ktonnes of CO_2.

The total emissions from cropland, including cropland remaining cropland and lands converted to cropland, amounted to 199 ktonnes CO_2 in 2003. The emissions showed a decreasing trend from 1990 to 2003; by 60 %. Emissions from the land-use category cropland remaining cropland were about 49 ktonnes CO_2 in 2003, which is an increase of 62 per cent from 2002. However, from 1990 the emissions of CO_2 decreased by 75 per cent. The emissions from this category in 2003 represented about 2 per cent of the total emissions from the LULUCF sector. Regarding land converted to cropland, the emissions were estimated at approximately 46 ktonnes CO_2 in 2003. We have only regarded losses of carbon from conversion from forest in the calculations. Between 1990 and 2003 the emissions from land converted to cropland decreased by 46 %.

The total emissions from grassland, including grassland remaining grassland and lands converted to grassland, were estimated at 1891 ktonnes CO_2 in 2003. This is a slight increase from 1990, on 1%. Emissions from grassland remaining grassland in 2003 were estimated at 1.9 Mtonnes of CO_2, which represents 75 per cent of the total emissions from the LULUCF sector that year. The emissions are considered to be constant from 1990 to 2003 since there have not been any major changes in management of grasslands in Norway during this period. Emissions from land converted to grassland were estimated at about 21 ktonnes of CO_2 in 2003, corresponding to 1 % of the total emissions from the sector that year. In 1990 there were no emissions from this category according to the estimates performed.

Most of the wetlands in Norway are unmanaged mires, bogs and fens, as well as lakes and rivers. Managed wetlands include peat extraction and reservoirs (dams). The emissions from this land-use category were estimated at about 3 ktonnes of CO_2 in each year over the period 1990-2003, representing 0.1 % of the total emissions from the LULUCF sector. Only wetlands remaining wetlands contributed to the figure, since no data were available regarding land converted to wetlands.

The total emissions from the land-use category settlements amounted to 342 ktonnes of CO_2 in 2003. The figure comprises only conversion from land converted to settlements. Annual emissions from this category have been quite stable between 1990 and 2003 (between 326 and 352 ktonnes of CO_2).

With regard to the category other land, we assume no change in carbon stocks on other land remaining other land since this land is considered unmanaged in accordance with IPCC Good practice guidance. No calculations have been made on the conversion of land to other land. However, this will most likely be addressed in the next phase of the project and as a part of the total plan for improvements of the inventory.

2.5. Emission trends for indirect greenhouse gases and SO_2

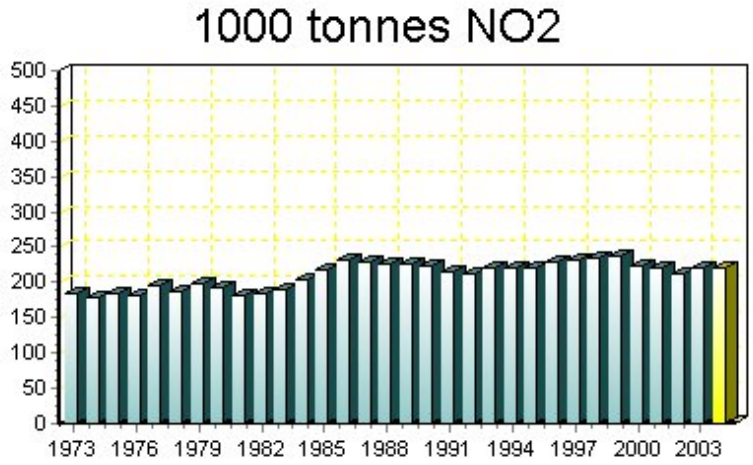
Nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) have an indirect effect on climate through their influence on greenhouse gases, especially ozone. Sulphur dioxide (SO_2), on the other hand, affects climate through increasing the level of aerosols which have in turn a cooling effect on the atmosphere. The trend of these pollutants in Norway during the period 1990-2003 is presented below.

In spite of an increase of emissions by 4 % from 2002 to 2003, ***emissions of NO_X*** were 2 per cent lower in 2003 than in 1990. Reduced emissions from road traffic due to the introduction of stricter emission regulations have been counteracted by increased emissions from oil and gas production (72% increase and navigation (21 %).

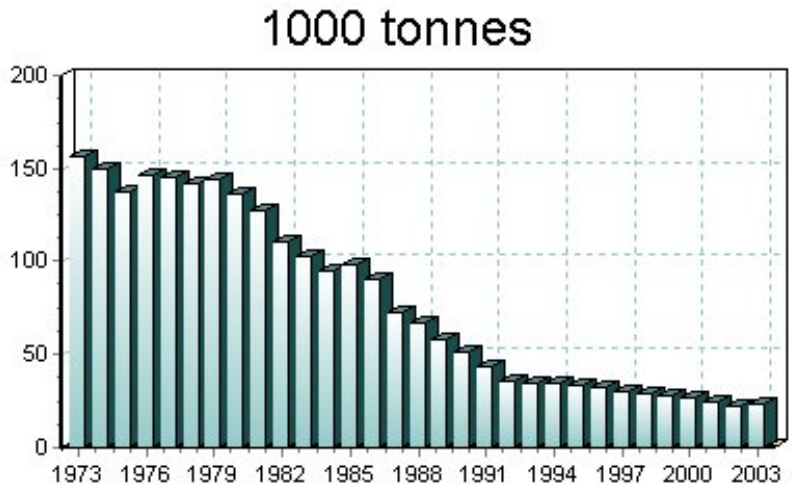
Emissions of NMVOCs increased by 33 per cent from 1990 to a top, 391,000 tonnes in 2001.
The growth in loading of crude oil overpowered the reduced emissions from road traffic and measures like installation of a vapour recovery unit at one of the oil terminals.
After 2001 the emissions have been going down significantly, to 300 000 in 2003, about 2 % above the level in 1990. Preliminary figures for 2004 indicate a further reduction. This development is due to i.a.the introduction of recovery equipment at loading and unloading of oil tankers.

From 1990 to 2003 the ***emissions of CO*** have decreased by about 45 per cent, mainly because of new emission standards for motor vehicles.

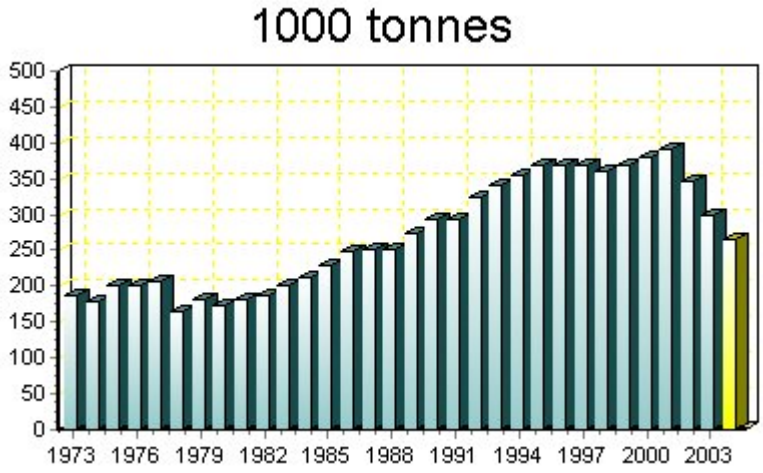
Emissions of SO_2 were reduced by 56 per cent from 1990 to 2003. This trend has mainly been caused by the reduction in the sulphur content of all oil products and by lower process emissions from the production of ferroalloys and aluminium and from the refineries.
However after 18 years with emission reductions, emissions of SO_2 grew by 5 % in 2003.



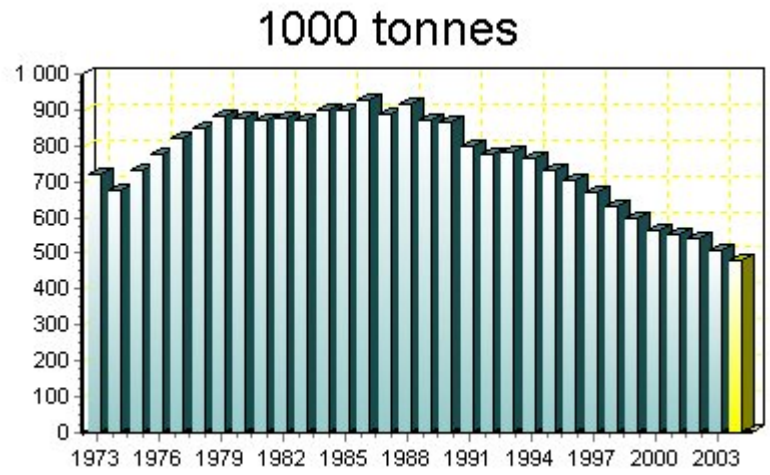
Emissions of NOx



Emissions of SO2



Emissions of NMVOC



Emmisions of CO

Figure 25. Emissions of SO_2, NOx, NMVOC and CO in Norway 1990-2002. Source: SN/SFT

3. Energy

3.1. Overview

The Energy sector accounts for more than 2/3 of Norwegian greenhouse gas emissions. In 2003 emissions from this sector contributed 71.5 % to the national GHG total. Emissions increased by 33.8 % from 1990 to 2003. From 2002 to 2003 an increase of 5.6 % is detected. Road traffic and offshore gas turbines (electricity generation and pumping of natural gas in pipelines) are the sector's largest single contributors. Other important sources are coastal navigation, energy use in the production of raw materials, as well as oil and gas operations which give rise to significant amounts of fugitive emissions. Trends in the energy sector are elaborated further in Chapter 2 Trends in greenhouse gas emissions.

As indicated in Section 1.5 of this report, the key source analysis performed for the years 2000 an 2003 has revealed that in terms of total level and/or trend uncertainty the *key sources* in the Energy sector are the following:

- Stationary Fuel Combustion, Gas – CO_2 (1A1, 1A2, 1A4)
- Stationary Fuel Combustion, Oil – CO_2 (1A1, 1A2, 1A4)
- Civil aviation – CO_2 (1A3a)
- Road Transportation – CO_2 (1A3b)
- Road Transportation – N_2O (1A3b)
- Navigation – CO_2 (1A3d)
- Fugitive emissions from Oil (incl. oil refineries, gasoline distribution) – CH_4 (1B2a)
- Fugitive emissions from Oil (incl. oil refineries, gasoline distribution) – CO_2 (1B2a)
- Venting and Flaring – CH_4 (1B2c)
- Venting and Flaring – CO_2 (1B2c)

Coal mining (1B1a) is not found to be a key source in the key source analysis. However, it is here regarded as a key source on the basis of "qualitative" criteria such as change in trend and uncertainty in the emission factors. This source is therefore described in detail in Section 3.20.

An important issue which is also elaborated in this sector concerns the capture and storage of CO_2 emissions at the offshore gas-condensate field called Sleipner West. These unique operations are discussed in detail in section 3.9.

Regarding the allocation of emissions in the Norwegian emission inventory, it is important to specify that emissions from waste incineration at district heating plants are accounted for under the energy sector, as the energy is utilised. Methane from landfills used for energy purposes is also accounted for in this sector. Emissions from flaring in the energy sectors are described in Sections 3.21. Coal and coke used as reducing agents and gas used for production of ammonia (non-energy part) are accounted for under industrial processes. Flaring outside the energy sectors is described in Chapter 8 Waste. The same applies to emissions from cigarettes, accidental fires etc. Emissions from burning of crop residues and agricultural waste are accounted for under Chapter 6 Agriculture.

The elaboration of the energy sector in the following starts with discussion on all pertinent energy sources. Key sources are described in detail, whereas non-key sources are discussed in a brief manner. Emissions from international bunker fuels are subsequently addressed separately. Finally, cross-cutting issues are elaborated. These comprise the following elements:

- Comparison between the sectoral and reference approach

- Feedstocks and non-energy use of fuels
- Indirect CO_2 emissions from CH_4 and NMVOC.

3.2. Stationary Fuel Combustion: Gaseous Fuels – CO_2 – 1A1, 1A2, 1A4 (Key Source)

3.2.1. Description

This key source refers to CO_2 emissions from combustion of gaseous fuels in the energy industries, in the manufacturing industries and construction and in sectors involving commercial/institutional and residential activities. Gaseous fuels are not used in the sub-sectors of Iron and Steel (1A2a) and Agriculture/Forestry/Fisheries (1A4c).

CO_2 emissions from the above sources constitute a key source both in level and in trend. The contribution of this key source to the total level and trend uncertainty in 2003 is estimated to be 5.4 and 8.6 per cent, respectively (see Section 1.5).

Emissions of CO_2 from the above fuel combustion activities in Norway have increased by about 45.5 per cent in the period 1990-2003. In 2003 they constituted about 55.4 per cent of the total CO_2 emissions in the Energy sector and 47.8 per cent of the national CO_2 total.

Norway produces electricity mainly from hydropower, so emissions from electricity production are small compared to most other countries. Emissions in this key source originate predominantly from the combustion of natural gas in oil and gas extraction operations offshore. At these installations, electricity and pumping power are principally produced by gas turbines and to a lesser extent, diesel engines. In 2003 the CO_2 emissions from gas combustion offshore were 85.4 per cent of the key source total. The remaining fraction is due to the use of diesel fuel oil in gas turbines and machinery. The emission of CH_4 and N_2O in these operations is negligible.

Offshore oil and gas extraction has played an important role in the national economy in recent decades. Emissions from the combustion of gaseous fuels in such operations increased by 92 per cent in the period 1990-2003 due to the increasing production of oil and gas. In 2003 they accounted for about 17 per cent of the national total GHG emissions.

3.2.2. Methodological issues

Emissions from stationary energy combustion are estimated at the sectoral level in accordance with the IPCC sectoral approach Tier 2/Tier 3. Often total fuel consumption is better known than the sectoral consumption.

The general estimation method applied is multiplication of fuel consumption by source and sector by an appropriate emission factor. However, for some major manufacturing plants (in particular offshore activities, refineries, gas terminals, cement industry, production of plastics, ammonia production), emissions of one or more compounds, reported to the Norwegian Pollution Control Authority from the plants, are used instead of figures calculated as described above. In these cases, the energy consumption of the plants in question is subtracted from the total before the general method is used to calculate the remaining emissions of the compound in question, in order to prevent double counting. An overview of the type of emissions (i.e. estimated and/or reported) used in the emission inventory for the different sectors is given in Table 19 for the greenhouse gases CO_2, CH_4 and N_2O.

Table 19. Overview of the type of emission data for energy combustion used in the national emission inventory for CO_2, CH_4 and N_2O in 2003.

	CO_2	CH_4	N_2O
A. Fuel Combustion Activities (Sectoral Approach)			
1. Energy Industries	E	E	E
a. Public Electricity and Heat Production	E/R	E	E
b. Petroleum Refining	R	E	E
c. Manufacture of Solid Fuels and Other Energy Industries	E/R	E/R	E/R
2. Manufacturing Industries and Construction			
a. Iron and Steel	E	E	E
b. Non-Ferrous Metals	E	E	E
c. Chemicals	R	E	E
d. Pulp, Paper and Print	E	E	E
e. Food Processing, Beverages and Tobacco	E	E	E
f. Other (Oil drilling, construction, other manufacturing)	E	E	E
3. Transport			
a. Civil Aviation	E	E	E
b. Road Transportation	E	E	E
c. Railways	E	E	E
d. Navigation	E	E	E
e. Other Transportation (Snow scooters, boats, motorized equipment, pipeline transport)	E	E	E
4. Other Sectors			
a. Commercial/Institutional	E	E	E
b. Residential	E	E	E
c. Agriculture/Forestry/Fisheries	E	E	E
5. Other (Military)	E	E	E

[1] R means that emission figures in the national emission inventory are based on figures reported by the plants. E means that the figures are estimated by Statistics Norway (Activity data * emission factor).

3.2.3. Activity data

The energy consumption data used in the emission calculations are taken from the annual energy balances and the energy accounts compiled by Statistics Norway. The energy accounts survey the flow of the different energy carriers within Norwegian economic activities. The energy accounts include energy carriers used as raw materials and reducing agents - these are subtracted in the data used to estimate emissions from combustion. Some emissions vary with the combustion technology; a distribution between different sources is thus required. Total use of the different oil products is based on the sales statistics for petroleum products. For other energy carriers, the total use of each energy carrier is determined by summing up reported/estimated consumption in the different sectors. A short summary of the determination of the amounts of gaseous fuels used and their distribution between emission sources is given below.

Natural gas

Most of the combustion of natural gas is related to extraction of oil and gas on the Norwegian continental shelf. The amounts of gas combusted, distributed between gas turbines and flaring, are reported annually to Statistics Norway by the Norwegian Petroleum Directorate (NPD). These figures include natural gas combusted in gas turbines on the various oil and gas fields as well as on Norway's two gas terminals onshore. The data are of high quality due to the Norwegian system of CO_2 taxation on fuel combustion. Statistics Norway's annual survey on energy use in manufacturing industries and sales figures from distributors give the remainder. Some manufacturing industries use natural gas in direct-fired furnaces; the rest is burned in boilers and, in some cases, flared.

LPG and other gases

Consumption of LPG in manufacturing industries is reported from the plants to Statistics Norway in the annual survey on energy use. Figures on use of LPG in households are based on sales figures, collected annually from the oil companies. Use in agriculture and construction is based on non-annual surveys; the figure for agriculture is held constant, whereas the figure for construction is adjusted

annually, based on employment figures. Use of refinery gas is reported to Statistics Norway from the refineries. The distribution between the sources direct-fired furnaces, flaring and boilers is based on information collected from the refineries in the early 1990's. At some industrial plants, excess gas from chemical and metallurgical industrial processes is burned, partly in direct-fired furnaces and partly in boilers. These amounts are reported to Statistics Norway. Two ferroalloy plants sell excess gas (CO gas) to some other plants, where it is combusted for energy purposes. Amounts sold are annually reported to Statistics Norway.

As mentioned above, in the case of **offshore operations** and **gas terminals**, the consumption data used in the calculations are measured continuously by field operators. This is in accordance with the strict national regulatory requirements, which include additionally a CO_2 tax on all gas used offshore (NPD 2001). Gas flared is also subjected to the same regulations.

The collection of data from the **manufacturing industries** is realized through annual surveys on energy use conducted by Statistics Norway. Such surveys supply most of the data material for the calculation of combustion emissions in these sectors. The number of energy units included in the surveys increased considerably in 1998 and resulted in about 90% coverage of the energy use in this sector for the period 1998 onwards. For the remaining companies, figures are estimated on the basis of data from the sample together with data on economic turnover, taking into account use of different energy carriers in the same industries and size groups. The change in methodology in 1998 has had minor consequences for the time series, since the energy use is mainly concentrated to a few major industrial plants, from which data were collected and taken into account both in the present and the earlier method. The data on energy use in manufacturing industries are considered to be of high quality.

Information on use of waste oil and other hazardous waste is also collected through the energy use statistics.

For the **construction industry**, the figures on use of the different energy carriers are partly taken from the annual sales statistics for petroleum products and partly projected from earlier surveys. These energy data are considered to be rather uncertain.

While in the case of manufacturing plants Statistics Norway collect annual reports on their energy use, for **other sectors** such as Commercial/institutional the available statistics on fuel consumption is very limited. Activity data for this source category are based on occasional surveys. However, the consumption in these sectors is always balanced so that the total fuel consumption (based on sales figures) is accounted for.

It is important to take into consideration here the offshore gas-condensate field **Sleipner West** which contains about 9 per cent CO_2. In order to reduce the CO_2 content in the natural gas to an acceptable level before transported to consumers onshore, approximately 1 million tonnes of CO_2 are captured and then stored in a sandstone saline aquifer not far from the gas field. The capture and storage of CO_2 emissions in th oil and gas production field of Sleipner is elaborated in Section 3.22.

3.2.4. Emission factors

Emission factors for CO_2 are independent of technology and are based on the average carbon content of fuels used in Norway (SFT, 1990; Norwegian Oil Industry Association – OLF, 1994). The standard emission factors used in the absence of more specific ones are hereafter addressed as "general" and are presented in Table 20 along with CO_2 emission factors from boilers. Subsequent discussion is concentrated on emission factors for offshore operations and gas terminals.

Table 20. Emission factors for CO_2 from combustion of gaseous fuels (in tonnes CO_2/tonne gas combusted). Source: SN/SFT

Source	Sector	Natural gas	LPG	Refinery gas	Blast furnace Gas	Fuel gas	Landfill gas
General	General	2.34	3.0	2.8	1.571	3.0	0.275
Boilers	General	-	-	-	-	-	-
	Chemical	-	-	-	-	2.5	-
	Metals	-	-	-	-	2.5	-
	Refuse disposal	-	-	-	-	-	-

Offshore operations

For all years up to 2002 emissions of CO_2 from gas combustion offshore are calculated by Statistics Norway on the basis of activity data reported by the oil companies to NPD and SFT and appropriate emission factors. For 2003 the data used in the inventory are emissions reported directly by the field operators. The latter are obliged to report these and other emissions annually to NPD and SFT.

The CO_2 emission factor used for all years leading up to 1998 and for all fields except one is one average factor based upon a survey carried out in the early 1990s (OLF 1993, 1994). From 1999 onwards the emission factors employed reflect increasingly field specific conditions. Table 21 displays the time series of such emission factors, expressed as averages.

Table 21. Emission factors for combustion of natural gas at offshore oil fields. Source: SFT/NPD

	Gas turbines offshore
	kg CO_2/Sm^3 gas burned
1990-94	2.34
1995	2.29
1996	2.30
1997	2.30
1998	2.31
1999	2.50
2000	2.48
2001	2.47
2002	2.45
2003	2.46

Gas terminals

Emission factors for the two Norwegian gas terminals are based on continuous measurements of fuel combustion. The average CO_2 emission factors for fuel gas at one gas terminal are shown in Table 22. The fuel gas used at the terminal originates from three different gas fields and the emission factors in the table reflect the average carbon content in the respective gases. Emission factors used for the other gas terminal lie within the same range. However, it should be born in mind that the emission figures

used in the inventory for gas terminals are those reported directly by the plants (see also Section 3.2.2).

Table 22. Emission factor for $CO_2$from combustion of gas at one gas terminal. Source: SFT

	Average content of CO_2 in fuel gas t CO_2 / t gas
2004	2.68
2003	2.68
2002	2.68
2001	2.68
2000	2.73
1999	2.69
1998	2.73
1997	2.77
1996	2.84
1995	2.93
1994	2.93
1993	2.79
1992	2.94
1991	2.82
1990	2.70

3.2.5. Uncertainties

An analysis of the uncertainty in both activity data and emission factors for all emission sources is given in the report by Rypdal and Zhang (SN 2000) and summary tables with the results are displayed in Annex 2. The uncertainty in the activity data is ± 4 % and in the CO_2 emissions factor ± 7 per cent. The uncertainty in the emission factor is relatively high as emissions are dominated by the oil and gas extraction operations and gas composition can vary according to field.

Generally, the total energy use is less uncertain than the energy use in each sector. For some sectors (e.g. the energy and manufacturing industries) the energy use is well known, while in households and the service sectors the energy use is more uncertain. However, the energy use in the most uncertain sectors has been adjusted in the official energy statistics so that the sum of the energy use in all sectors equals the total sales.

3.2.6. Source specific QA/QC and verification

This key source is subjected to the general QA/QC procedures described in Section 1.6. Furthermore, in the case of natural gas extraction, field-specific emission figures reported by the companies for 2003 are compared with calculations based on field-specific emission factors. Despite a few minor deviations, the comparison revealed that the overall agreement is satisfactory.

3.2.7. Recalculations

The latest recalculations performed in this key source have taken into account minor revisions made in the energy accounts for some sectors. More importantly, the major sub-sector changes which have now been accounted for are the following:

<u>1 A 1 c Manufacture of Solid Fuels and Other Energy Industries</u>

CO_2 emissions from extraction of oil and gas have been recalculated. For the year 2003 emission figures for each fields reported by all field operators are used in the emission model. For the years 1990-2002 emission estimates are based on field-specific emission factors which vary from year to year. This is an important improvement in the national inventory given that in all earlier submissions one universal emission factor was used for all fields and for all years.

1A2 Manufacturing Industries and Construction

1 A 2 a Iron and Steel

The emission figures for two plants consuming CO gas have been recalculated. In this submission reported figures have been used for these two plants; for 1990 to 2003 for one of the plants and for 1997 to 2003 for the other plant. The CO_2 is now reported under non combustion emissions.

1 A 2 c Chemicals

In the case of one plant, CO_2 figures reported to SFT for all years (1990-2003) replace figures based on emission factors and activity data.

3.2.8. Planned improvements

There are no concrete plans for further improvements in this sub-sector at the moment.

3.3. Stationary Fuel Combustion: Liquid Fuels – CO2 – 1A1, 1A2, 1A4 (Key Source)

3.3.1. Description

The key source analysis performed by Statistics Norway has shown that CO_2 emissions from the stationary combustion of liquid fuels constitute a key source in terms of level uncertainty. In fact, the contribution of this key source to the total level uncertainty in 2003 is found to be ±1.40% (see Section 1.5). Liquid fuels are consumed in all activities in the Energy sector.

Emissions of CO_2 from liquid fuel combustion in this key source increased by 9.8 % between 1990 and 2003 due to increased activity in the energy industries. In 2003 such emissions constituted about 24 % of the total CO_2 emissions in the Energy sector and 21 % of the national CO_2 total.

3.3.2. Methodological issues

As mentioned earlier, the general method to estimate emissions from this key source is to multiply energy use by source and sector by an appropriate emission factor. Consumption data are taken from the annual energy balances/energy accounts. However, for some major manufacturing plants emission figures are reported directly by the plants to SFT and are used as such in the emission inventory (see description in Section 3.2.2).

3.3.3. Activity data

The origin and processing of the energy consumption data used in the emission calculations are described in Section 3.2.2. The determination of the amounts of liquid fuels used and their distribution between emission sources follows is elaborated further in the following.

Total use of the different oil products is based on annual sales statistics for petroleum products collected by Statistics Norway. The data are considered very reliable since all major oil companies selling oil products have interest in and report to these statistics[4]. The use of sales statistics provides a given total for the use of oil products, which the use in the different sectors must sum up to. This is not the case for the other energy carriers.

Stationary use takes place in boilers and, in some manufacturing industries, in direct-fired furnaces. There is also some combustion in small ovens, mainly in private households. In addition to oil products included in the sales statistics, figures on use of waste oil are given in Statistics Norway's

[4] The statistics are corrected for direct import by other importers or companies.

industry statistics. Statistics Norway also collects additional information directly from a few companies about the use of waste oil as a fuel source.

As described earlier, activity data are based on the consumption figures reported by the Norwegian Petroleum Directorate for all platforms on the Norwegian part of the continental shelf, including the Norwegian economic part of platforms shared with the UK. Data reports include the amounts of diesel burned in turbines and direct-fired furnaces on the oil and gas fields. The data are of high quality due to the CO_2 tax on fuel combustion. The same situation applies for combustion of natural gas in turbines at gas terminals onshore.

Emissions from **Manufacturing Industries and Construction** are collected through surveys carried out annually by Statistics Norway as described in Section 3.2.2.

In the case of **households** heavy fuel oil is taken from the sales statistics for petroleum products. As the consumption of each energy carrier shall balance against the total sales in the sales statistics, use of fuel oil, kerosene and heavy distillates in households is given as the residual after consumption in all other sectors has been assessed.

With regard to **agricultural activities**, data on energy use in hothouses are collected in surveys performed regularly. Sales figures are used to project the figures on oil products in the years between, while bio-fuels and LPG are kept constant. The Agricultural Budgeting Board has figures on use of petrol, auto diesel and fuel oil in agriculture outside hothouses.

3.3.4. Emission Factors

The CO_2 emission factors used for liquid fuels reflect the average carbon content of Norwegian fuels (SFT 1990 and OLF 1994). They are presented in Table 23.

Table 23. Emission factors for CO_2 from the combustion of liquid fuels. Unit: Tonnes CO_2/tonne liquid fuel combusted. Source: SN/SFT

Liquid fuel	Emission factors
Motor gasoline	3.13
Aviation gasoline	3.13
Kerosene (heating)	3.15
Jet kerosene	3.15
Auto diesel	3.17
Marine gas oil/diesel	3.17
Light fuel oils	3.17
Heavy distillate	3.17
Heavy fuel oil	3.2

3.3.5. Uncertainties

The uncertainty in both the activity data and the emission factors is estimated to be ± 3 %.

The method used for finding the use of fuel oil, kerosene and heavy distillates in households implies a great deal of uncertainty regarding the quality of these figures, particularly for fuel oil, which is the most important of these three energy carriers. Since the late 1990s it has been necessary to also adjust

figures for other sectors in order to get consumption figures for households that look reasonable. It is hoped that new surveys will improve the quality of these figures in the future.

3.3.6. QA/QC and verification

The key source is subjected to the QA/QC procedures described in Section 1.6.

3.3.7. Recalculations

Recalculations in this key source are a result of minor revisions in the energy accounts and, more importantly, the methodological changes described in section 3.2.5 concerning the following sources: Manufacture of Solid Fuels and Other Energy Industries (1A1c) and Chemicals (1A2c).

In the case of residential plants (1A4b), estimates for the amount of wood and oil products used in households in 2002 are now updated. Emissions of all components increased in 2002 based on the final energy accounts.

3.3.8. Planned improvements

There are no plans for further improvements in this sector at present.

3.4. Stationary Fuel Combustion: Solid Fuels, Biomass, Other fuels – CO_2 – 1A1, 1A2, 1A4 (Non-Key Source)

Solid fuels

Norway has a modest coal production which takes place on the island of Svalbard/ Spitsbergen. The only coal producing company reports annually some minor use of oil products.

Use of coal, coke and petrol coke in manufacturing industries is annually reported from the plants to Statistics Norway. The statistics cover all main consumers and is of high quality. Combustion takes place partly in direct-fired furnaces, partly in boilers. Figures on some minor quantities burned in small ovens in private households are based on sales figures. In addition, an insignificant figure on use of coal in the agricultural sector is collected from the farmers.

The CO_2 emission factors used for coal and coke reflect the average carbon content of Norwegian fuels and are presented in Table 24.

Table 24. Emission factors for CO2 from the combustion of solid fuels, biomass and waste. Unit: tonnes CO2/tonne fuel combusted. Source SN/SFT.

Fuel	**CO_2**
Coal	2,52
Coke	3,19
Petrol coke	3,59
Fuel wood	(1.8)*
Wood waste	(1.8)*
Black liquor	(1.8)*
Municipal waste	0,251
Special waste	3,2

* Non-fossil emissions, not included in the inventory

Wood, wood waste and black liquor
Use of wood waste and black liquor in manufacturing industries is taken from Statistics Norway's annual survey on energy use in these sectors. Use of wood in households is based on figures on the amount of wood burned from the annual survey on consumer expenditure. The statistics cover purchase in physical units and estimates for self-harvest. Figures on some minor use in agriculture and in construction are derived from earlier surveys for these sectors. Combustion takes place in boilers and in small ovens in private households. Consumption figures for wood pellets and wood briquettes are estimates, based on annual information from producers and distributors.

The emission factors used in the calculations are presented in Table 24. However, non-fossil emissions are not included in the inventory and are referred to as a memo item.

With regard to recalculations, an amount of wood waste has been removed form one district heating plant for 2001 in the sub-sector of Public Electricity and Heat Production (1A1a) in order to avoid double counting. Furthermore, estimates for the amount of wood and oil products used in households (1A4b) in 2002 are updated. Emissions of all components increased in 2002 based on the final energy accounts.

Waste
District heating plants and incineration plants annually report combusted amounts of waste (boilers) to Statistics Norway and the Norwegian Pollution Control Authority. There is also some combustion in manufacturing industries, reported to Statistics Norway. In addition there are also some other minor sources for combustion of waste. According to the Norwegian Pollution Act each incineration plant has to report emission data, and the amount of waste incinerated to the county governor. The county governor then reports this information to the Norwegian Pollution Control Authority. If emissions are not reported the general method to estimate emissions from waste incineration is to multiply the amount of waste used by an appropriate emission factor. The emission factors used in this source category for CO_2 are shown in Table 24.

3.5. Stationary Fuel Combustion: All Fuels – CH_4, N_2O – 1A1, 1A2, 1A4 (Non-Key Source)

Emissions of CH_4 and N_2O from stationary fuel combustion are negligible. The collation of activity data follows the procedures described in Sections 3.2-4.

In general, information on emission factors for CH_4 and N_2O is very limited, because, unlike those for CO_2, they depend on the source of the emissions and the sector where the emissions take place. The emission inventory mostly uses default factors from the IPCC (1997b). The emission factor for methane from fuel wood is taken from SINTEF (1995). Due to lack of data, some emission factors are used for sector/source combinations other than those they have been estimated for.

The standard CH_4 and N_2O emission factors used in the emission inventory for this source are listed in Tables 25 and 26, respectively. Tables 27 and 28 display respectively the cases where emission factors other than the general ones were used in the calculations.

Table 25. General emission factors for CH_4, stationary combustion. Unit: kg CH_4/tonne fuel

Source	Direct-fired furnaces	Gas turbines	Boilers	Small stoves	Flares
Marine gas oil/diesel	0.016	-	0.4	-	-
Coal	0.028	-	0.28	8.4	-
Coke	0	-	0.28	8.4	-
Petrol coke	0	-	0.28	-	-
Fuel wood	-	-	-	5.3	-
Kerosene (heating)	-	-	0.17	0.3	-
Light fuel oils	-	-	0.4	0.4	-
Heavy distillate	0.04	-	0.4	0.4	-
Heavy fuel oil	0.04	-	0.4	-	-
LPG	-	-	0.17	0.24	-
Natural gas (1000 Sm^3)	0.0459	0.91	0.2	-	0.24
Refinery gas	0.054	-	0.24	-	0.28
Blast furnace gas	0.054	-	0.24	-	-
Landfill gas	-	-	0.24	-	0.37
Wood waste, Black liquor	-	-	0.25	-	-
Municipal waste	-	-	0.25	-	-
Special waste	-	-	0.23	-	-
Charcoal	0.04	-	0.4	-	-

Table 26. Exceptions from the general factors for CH_4, stationary combustion
Unit: kg CH_4/tonne fuel.

Emission factor	Fuel	Source	Sectors
0	Natural gas (1000 Sm^3), fuel gas	Direct fired furnaces	Manufacture of other mineral products Manufacture of cement, lime and plaster
0.085	Natural gas (1000 Sm^3)	Direct fired furnaces	Manufacture of plastics
0.03	Coal	Boilers	Coal mining Production and distribution of electricity
0.1	Fuel oils incl. special waste	Boilers	Industry incl. power supply
0.0425	Natural gas (1000 Sm^3)	Boilers	Coal mining Extraction of oil and natural gas Oil refineries Gas terminals Production and distribution of electricity

Table 27. General emission factors for N2O, stationary combustion.
Unit: kg N2O/tonne fuel

Source	Direct-fired furnaces	Gas turbines	Boilers	Small stoves
Marine gas oil/diesel	0.03	0.024	0.03	-
Coal	0	-	0.04	0.04
Coke	0	-	0.04	0.04
Petrol coke	0	-	0.04	-
Fuel wood	-	-	-	0.032
Light fuel oils	-	-	0.03	0.03
Heavy distillate	0.03	-	0.03	0.03
Heavy fuel oil	0.03	-	0.03	-
Natural gas (1000 Sm^3)	0.02	0.019	0.004	-
Refinery gas	0.024	-	0.005	-
Blast furnace gas	0.024	-	0.005	-
Landfill gas	0.024	-	0.005	-
Wood waste, Black liquor	-	-	0.005	-
Municipal waste	-	-	0.07	-
Charcoal	-	-	0.07	-

Table 28. Table XX. Exceptions from the general factors for N_2O, stationary combustion
Unit: kg N_2O/1000 Sm^3 natural gas

Emission factor	Fuel	Source	Sectors
0,017	Natural gas	Direct-fired furnaces	Manufacture of plastics
0,06	Natural gas	Flares	Oil drilling

The recalculations performed concern emissions of N_2O in the sub-sector 1A1a Public Electricity and Heat Production. As emissions of NO_X are reported from each plant to SFT, an estimated amount of 2.5% of this NO_X is subtracted and reported to the UNFCCC as N_2O. This methodology has until recently been applied to all district heating plants except from three of them and for the years 2001 onwards. In these cases, N_2O emissions were calculated through consumption data and appropriate emission factors. Emissions of N_2O for these three district heating plants have now been estimated for the years after 2000 according to the methodology applied to all other plants.

3.6. Civil Aviation: Liquid Fuels – CO_2 – 1A3a (Key Source)

3.6.1. Description

Emissions of CO_2 from civil aviation accounted for about 2 per cent of the total Norwegian CO_2 emissions in 2003. National emissions from civil aviation have increased by 40 % from 1990 to 2003. Although reduction in the number of flights resulted in an emission decline of 14% from 2001 to 2002, an increase of 4.5 % is now detected between 2002 and 2003 due to activity growth.

Civil aviation is a key source with respect to both level and trend due to uncertainties in the activity data. The contribution of this key source to the total level and trend uncertainty in 2003 is found to be ± 0.97 per cent and ± 0.83 per cent, respectively (see Section 1.5).

3.6.2. Methodological issues

The calculation methodology applied is described in the report by Finstad et al. (SN 2002). According to the IPCC Good Practice Guidance the methodology used is Tier 2 based on the detailed methodology in EEA (2001). This methodology allows estimation of emissions and fuel consumption for different types of aircraft according to the average flying distance and numbers of landings and take-offs (LTO). All movements below 1000 m are included in the "Landing Take Off" (LTO) cycle. Movements over 1000 m are included in the cruise phase. All emissions from international aviation are excluded from national totals, and are reported separately (see Section 3.23).

3.6.3. Activity data

Statistics Norway collects data on use of fuel from the air traffic companies annually. These data include specifications on domestic use and amounts bought in Norway and abroad. The types of fuel used in aircraft are both jet fuel (kerosene) and aviation petrol. The latter is used in small aircraft only. Emissions from the consumption of jet kerosene in domestic air traffic are based directly on these reported figures. Domestic consumption of jet kerosene has been reported to Statistics Norway by the airlines since 1993. The survey is annual, but data from the surveys for 1993 and 1994 have not been used here, as one of the largest airlines in Norway was not included. Domestic consumption prior to 1995 is estimated by extrapolation on the basis of domestic kilometres flown and is more uncertain (Finstad et al. 2002b). Sales figures are used for minor use of aviation petrol.

3.6.4. Emission factors

The Norwegian Petroleum Industry Association provides emission factors for CO_2 from the combustion of jet fuel and gasoline (SN 2002). The CO_2 emission factor used for aviation gasoline is 3.13 kg CO_2/tonnes fuel and has been applied to all small aircraft. All other aircraft use jet fuel (kerosene) with an emission factor of 3.15 kg CO_2/tonnes fuel. These factors are also listed in Table 29.

3.6.5. Uncertainties

The uncertainty in the activity data for civil aviation is estimated to be ±20 per cent of the mean, primarily due to the difficulty in separating domestic emissions from emissions from fuel used in international transport (SN 2000). In a recent study on emissions from aircraft (SN 2002), fuel consumption was also estimated bottom-up and compared to the reported figures (see also Section

3.6.6). The estimated and reported data differed by about 10 per cent. However, the reported data are considered most accurate and were used in the calculation. As described above, data before 1995 are more uncertain than for later years.

The uncertainty in the CO_2 emission factors is ±3 per cent.

3.6.6. Source specific QA/QC and verification

In 2002 a methodology improvement was made in the emission calculations for civil aviation (SN 2002). According to the IPCC Good Practice Guidance the methodology used is Tier 2 based on the detailed methodology in EEA (2001). This methodology allows estimation of emissions and fuel consumption for different types of aircraft according to the average flying distance and numbers of landings and take-offs (LTO).

3.6.7. Recalculations

No recalculations have been performed in this source category.

3.6.8. Planned improvements

There are presently no plans for further improvements in this source category.

3.7. Civil Aviation – CH_4, N_2O – 1A3a (Non-Key Source)

Aviation is a minor emission source of methane and nitrous oxide in Norway (less than 0.01 per cent of their respective totals in 2003). The methodology used in the calculations and the collation of activity data are described in Section 3.4.

Emission factors for CH_4 and N_2O are listed in Table 29. A default emission factor for N_2O for all aircrafts is used (IPCC, 2001) and is valid for both LTO and cruise. EEA (2001) and IPCC (2001) suggest using an emission factor for CH_4, given in Olivier (1991), to be 10 per cent of total VOC. This is, however, only valid for LTO since studies indicate that only insignificant amounts of methane are emitted during cruise. No methane is therefore calculated for cruise and all emission is assumed to be VOC (HC).

Table 29. Emission factors for aviation. Unit: kg/tonnes fuel. Source: IPCC (2001) and Finstad et. al (2002)

	CO_2		CH_4		N_2O
Source	**Aviation gasoline**	**Jet kerosene**	**Aviation gasoline**	**Jet kerosene**	**Aviation gasoline/Jet kerosene**
Charter/scheduled flights					
Domestic					
LTO (0-100 m)		3.15	3.61	0,1854	0.1
LTO (100-1000 m)		3.15	1,55	0,0304	0.1
Cruise (Above 1000)		3.15	0	0	0.1
Foreign					
LTO (0-100 m)		3.15	0.39		0.1
LTO (100-1000 m)		3.15	0.07		0.1
Cruise (Above 1000)		3.15	0		0.1
Helicopters					
LTO (0-100 m)		3.15	3.61	3.2	0.1
LTO (100-1000 m)		3.15	1.55	3.2	0.1
Cruise (Above 1000)		3.15	0	0	0.1
Small aircraft					
LTO (0-100 m)	3.13		3.61	0.35	0.1
LTO (100-1000 m)	3.13		1.55	0.35	0.1
Cruise (Above 1000)	3.13		0	-	0.1

Recalculations based on the methodology by EEA (2001) and Finstad et al. (SN 2002) have led to a change in the emission factors of CH_4 from the combustion of jet kerosene for previous years. Emission factors for the period 1989-1992 are now based on aircraft data from 1989 while emission factors for 1993-1997 are based on aircraft data from 1995. The time series of such changes is illustrated in Table 30. Emission factors for small aircraft remain the same for the whole period.

Table 30. Time series of changing CH_4 emission factors from the combustion of jet kerosene.

		CH_4 Emission Factor (kg/tonne fuel)		
Sector	**Source**	**1989-1992**	**1993-1997**	**1998-to date**
General	0-100 m	0.1558	0.2014	0.1854
	100-1000 m	0.0255	0.033	0.0304
	cruise	0	0	0
Norwegian Aviation abroad	0-100 m	0.1567	0.3361	0.3927
	100-1000 m	0.0257	0.055	0.0672
	cruise	0	0	0
Foreign Aviation In Norway	0-100 m	0.1567	0.3361	0.3927
	100-1000 m	0.0257	0.055	0.0672
	cruise	0	0	0

The uncertainty introduced in the emission estimates by the activity data is ±20 per cent of the mean. The uncertainty in the emission factors for CH_4 and N_2O is respectively ±69 and ±110 per cent of the mean.

3.8. Road Transportation: Liquid Fuels – CO_2, N_2O – 1A3b (Key Source)

3.8.1. Description

Carbon dioxide
Emissions of CO_2 from road traffic dominate the total emission in the transport sector and are an important part of the national GHG total. In 2003 they contributed 70 % to the sectoral total and about 17% to the total national GHG emissions.

Emissions have increased by 22 % between between1990 and 2003 due to the increasing number of vehicles and annual mileage driven. In 2003 emissions of CO_2 were 2.7 % higher than those of 2002.

This source category is a key source in both level and trend and contributes with 9.75 % and 3.9 % to the total level and trend uncertainty, respectively.

Nitrous oxide
Emissions of N_2O from road traffic accounted for about 13 per cent of the N_2O total and about 1 per cent of the national GHG emissions in 2003. Since 1989 they have been increasing rapidly due to the introduction of catalytic converters. In 2003 N_2O emissions were more than seven times greater than the 1990 levels. From 2002 to 2003 an increase of 8.5 per cent is detected.

This source category is a key source with respect to total level and trend and contributes to the total respective uncertainty with 4.01 and 13.21 per cent.

3.8.2. Methodological issues
A model for estimating emissions from road traffic was developed in 1993 (SFT 1993) and revised in 1999 (SFT 1999c). The results (expressed as average aggregated emission factors) from this model have been used as input to the general emission inventory model.

Model structure
A fuel-based model has been chosen, where the total consumption of various fuels provides the framework for determining the emissions. The emission factors depend on the kind of vehicle (type, weight, technology, age), fuel type, and driving mode. The total number of vehicle-kilometres does not enter the calculations directly. However, fractions of the total mileage are estimated for each combination of vehicle category and driving mode. These fractions are used to allocate fuel consumption to the various combinations. Emission factors may be given as emissions per vehicle-kilometre or per unit fuel consumed.

Total emissions (Q) of a pollutant (*j)* from fuel type (*k),* while driving with a warm engine may be calculated from equations (1) and (2) below:

$$(1) \qquad Q_{jk} = M_k \sum_i \left(p_{ijk} \cdot \frac{l_{jk}}{\overline{l_k}} \cdot \left(\frac{T_{ik}}{T_k} \right) \right)$$

or

$$(2) \qquad Q_{jk} = M_k \sum_i \left(q_{ijk} \cdot \frac{1}{\overline{l_k}} \cdot \left(\frac{T_{ik}}{T_k} \right) \right)$$

$$q_{ijk} = p_{ijk} \cdot l_{ik}$$

where

Q: Total emissions
M: Total fuel consumption
p: Emission factor, g/kg
q: Emission factor, g/km
l: Fuel consumption, kg/km
T: Vehicle-kilometres
$_k$: Fuel type
$_i$: Combination of vehicle type, fuel type, and driving mode
$_j$: Pollutant

l_k is the average consumption, kg/km, of fuel (*k)* and is determined by equation (3).

$$(3) \qquad l_k = \sum_k l_{ik} \cdot \left(\frac{T_{ik}}{T_k} \right)$$

Emissions from evaporation and cold starts are added to the tailpipe emissions from warm motors.

The fuel-based model calculates changes in emissions between years from changes in M_k (total fuel consumption) and

- the number of vehicles in the various categories
- technologies in use
- annual average distance (km) driven per vehicle
- driving patterns.

Model parameters
Road traffic emissions are calculated for each combination of the following parameters:

- Pollutants: the same pollutants as in the general emission inventory model, excluding heavy metals and POPs.
- Vehicle categories: there are 10 classes, which are different combinations of vehicle type, weight, and fuel.

Table 31. Vehicle categories[1,2] in the emission model for road traffic

Fuel	Type	Total weight
Gasoline	Passenger car	..
"	Light duty	< 3.5 t
"	Heavy duty	> 3.5 t
"	Bus	> 3.5 t
Diesel	Passenger car	..
"	Light duty	< 3.5 t
"	Light heavy duty	3.5 - 7.5 t
"	Medium heavy duty	7.5 - 16 t
"	Heavy heavy duty	> 16 t
"	Bus	> 3.5 t

[1]Emissions from motorcycles and mopeds are calculated with a simplified method.

[2]The model may also be extended to include LPG and CNG vehicles.

- Vehicle age (0-29 and 30+ years, 31 age classes in all)
- Driving mode: Five modes are considered:

Urban	Speed limit	30 km/h or less
Urban	"	40 and 50 km/h
Rural	"	60 and 70 km/h
Rural	"	80 km/h
Highway	"	90 km/h

Note: The names of the driving modes do not indicate where driving actually takes place: for instance, driving is classified as urban driving if the speed limit is less than 50 km/h, even outside an urban area.

The modes apply only to driving with a warm engine. Emissions from cold start and evaporation are calculated separately as described in the following.

3.8.3. Activity data

All activity data are, as far as possible, updated for every year of the inventory. Data are taken primarily from official registers, public statistics and surveys. However, some of the data are based on assumptions. The sources of activity data are listed below:

- Total fuel consumption: the total amounts of fuels consumed are corrected for off-road use (in boats, snow scooters, motorised equipment, etc.). These corrections are estimated either from assumptions about the number of units, annual operation time, and specific fuel consumption, or from assumptions about and investigations of the fraction of consumption used off-road in each sector. The Norwegian Petroleum Industry Association supplies the data for total fuel consumption.
- Number of vehicles: the number of vehicles in the various categories and age groups is taken from the official register of the Norwegian Directorate of Public Roads.
- Average annual mileage: most figures are determined from surveys by Statistics Norway or the Institute of Transport Economics. In some instances assumptions are needed.
- Driving modes: the Directorate of Public Roads has data on the annual number of vehicle-kilometres driven on national and county roads. The data are allocated by speed limits and vehicle size (small/ large). Similar data exist for municipal roads in the ten largest cities. The same distribution is assumed to be valid for other municipal roads.

The fraction T_{ik}/T_k of the vehicle-kilometre total for each fuel is calculated using the following variables:

- Number of vehicles, by category and age.
- Average annual mileage, by category.

- Average annual mileage, by age and aggregate vehicle category.

These fractions are used to together with specific fuel consumption factors to allocate fuel used by road traffic to categories defined by the parameters vehicle type, vehicle age and driving mode.

3.8.4. Emission factors

The emission factors are based on several sources. Complete lists of sources with references are given in SFT (1999c). The most important references are listed below:

- Copert II (EEA 1997), a computer program to calculate emissions from road traffic. Both this and the following report have been used for several purposes, including warm engine emissions from light and heavy vehicles, cold start emissions and emissions from mopeds and motorcycles.
- Previous version of Copert (Eggleston et al. 1991).
- A detailed report for the German *Umweltbundesamt* (Hassel et al. 1994) based on measurements from TÜV (Technischer Überwachungs-Verein Rheinland), is used for emissions from light vehicles.
- Measurements performed by the National Institute of Technology in Norway (SFT 1993), used for emissions from light vehicles.
- Several reports from AB Svensk Bilprovning in Sweden (listed in SFT 1993), used for emissions from heavy vehicles.
- The Corinair Emission Inventory Guidebook (EEA 1996), used for evaporation.
- Results from the MEET programme (Methodologies for Estimating Air Pollution Emissions from Transport) (Sérié and Joumard 1996), are used for cold start emissions.

All factors are given by vehicle category and technology, and refer to new vehicles. Some factors also distinguish between driving modes. In addition, emission factors (hot and cold) and fuel consumption factors are corrected to take into account the change in values as the vehicles age.

For CO_2 the standard emission factors, based on carbon content, are used (see Table 23).

Emission factors for N_2O (as well as those for CH_4) vary from year to year due to changes in the vehicle population. The N_2O factors are listed in Table 32.

3.8.5. Emissions from evaporation and cold starts

Emissions and fuel consumption from evaporation and cold starts are calculated separately.

Evaporation of NMVOC from gasoline vehicles is calculated using the method given in the Corinair Emission Inventory Guidebook (EEA 1996). Emissions from running losses, hot soak emissions, and diurnal emissions are included. Average emission factors have been calculated, taking Norwegian climate conditions into account. Factors are given by vehicle category and technology.

In most cases, driving with a cold engine gives higher emissions than driving with a warm one, particularly for CO and NMVOC. The extra emissions are called cold start emissions. These are calculated as an additional emission contribution per start. Factors are given by vehicle category and technology. They are mainly taken from Copert (EEA 1997) and Sérié and Joumard (1996). Detailed driving patterns and regional temperature data are used. The driving patterns are taken from a travel survey (Haukeland et al. 1999) and include trip length and time between trips. Engine temperatures are corrected for the use of engine pre-heaters.

The extra fuel consumption caused by evaporation and cold starts is subtracted from the total consumption before emissions from warm engines are calculated.

Table 32. Average N_2O emission factors from road traffic including cold start emissions and evaporation. Unit: g/kg fuel. Source: SN

	Gasoline					***Autodiesel***		
Vehicle type	*Passenger cars*	*Other light duty*	*Heavy duty*	*Mopeds*	*Motor-cycles*	*Passenger cars*	*Other light duty*	*Heavy duty*
1973	0.068	0.063	0.031	0.059	0.061	0.138	0.166	0.146
1980	0.074	0.067	0.032	0.058	0.058	0.129	0.161	0.136
1986	0.085	0.074	0.034	0.059	0.054	0.132	0.185	0.127
1987	0.086	0.075	0.036	0.059	0.054	0.125	0.181	0.128
1989	0.094	0.075	0.039	0.059	0.053	0.112	0.168	0.128
1990	0.119	0.075	0.041	0.059	0.052	0.109	0.165	0.128
1991	0.151	0.075	0.042	0.059	0.052	0.109	0.164	0.128
1992	0.188	0.079	0.043	0.059	0.052	0.107	0.162	0.128
1993	0.243	0.096	0.044	0.059	0.052	0.119	0.163	0.130
1994	0.315	0.124	0.045	0.059	0.051	0.130	0.166	0.128
1995	0.404	0.164	0.045	0.059	0.051	0.139	0.174	0.131
1996	0.505	0.217	0.045	0.059	0.051	0.149	0.183	0.131
1997	0.622	0.281	0.045	0.059	0.051	0.159	0.190	0.133
1998	0.743	0.352	0.045	0.059	0.051	0.167	0.189	0.129
1999	0.880	0.429	0.045	0.059	0.051	0.176	0.182	0.126
2000	1.019	0.507	0.044	0.059	0.051	0.183	0.174	0.126
2001	1.163	0.584	0.044	0.059	0.051	0.192	0.167	0.126
2002	1.303	0.663	0.044	0.059	0.051	0.200	0.158	0.126
2003	1.431	0.740	0.044	0.59	0.051	0.207	0.152	0.126
2004	1.550	0.811	0.045	0.59	0.051	0.214	0.144	0.126

3.8.6. Uncertainties

With regard to CO_2 emissions from road transportation, the uncertainty in the activity data and emission factors is found to be ±20 per cent and ±3 per cent of the mean, respectively (SN 2000). In the case of N_2O the uncertainty in the activity data is ±20 per cent, but the uncertainty in the emission factors is as high as ±110 per cent.

3.8.7. QA/QC and verification

Top down and bottom up data on fuel consumption are compared for gasoline and diesel vehicles on an annual basis. The consumption of gasoline and auto diesel for road traffic is estimated as total sales minus consumption for other uses, i.e. a top down approach. The emission model for road traffic (SFT 1993; SFT1999c) also makes bottom-up estimates of consumption, which can be compared with the top-down data. For gasoline, the agreement is very good (difference < 5 per cent for most years). For auto diesel the agreement is poorer with the top-down estimate up to 40 per cent above the bottom-up estimate. The causes are on one hand uncertainties in the amount of non-road use and on the other hand uncertainties in mileage and specific consumption.

However, the total consumption of auto diesel, and hence the CO_2 emission from this fuel, is well known. The uncertainty concerns the allocation between road and non-road use. For N_2O (as well as CH_4) the total emission is sensitive to the allocation due to different emission factors.

3.8.8. Recalculations

New figures on average mileage and driven kilometres for passenger cars for the years 2000 to 2003 are now available from the Institute of Transport Economics (TØI) and are used in the calculations. These changes influence all emissions.

The decrease in emission of CO_2 from light and heavy duty vehicles in 2002 is due to changes in consumption of diesel according to the revisions in the energy accounts.

3.8.9. Planned improvements

As indicated by the various review teams so far, the N_2O emission factors in the national emission inventory are far too high compared to those of other European countries. In order to deal with this inadequacy in the national inventory, a project has been scheduled aiming at updating these emission factors. The project will be completed in time for next year's submission.

3.9. Road Transportation: Liquid Fuels – CH_4 – 1A3b (Non-Key Source)

The methodology used in the calculations and the collation of activity data are described in Section 3.8.

The emission factors for CH_4 are presented in Table 33. They vary from year to year due to changes in the vehicle population.

Table 33. Average CH_4 emission factors from road traffic including cold start emissions and evaporation. Unit: g/kg fuel. Source: SN

	Gasoline					***Autodiesel***		
Vehicle type	*Passenger cars*	*Other light duty*	*Heavy duty*	*Mopeds*	*Motorcycles*	*Passenger cars*	*Other light duty*	*Heavy duty*
1973	1.759	1.279	1.983	5.896	4.926	0.119	0.156	0.208
1980	1.684	1.259	1.964	5.843	4.940	0.119	0.155	0.208
1986	1.601	1.043	1.994	5.850	4.946	0.120	0.145	0.193
1987	1.601	1.032	2.014	5.850	4.944	0.122	0.147	0.194
1989	1.615	1.050	2.115	5.855	4.938	0.126	0.152	0.192
1990	1.589	1.052	2.168	5.855	4.939	0.128	0.154	0.190
1991	1.565	1.049	2.234	5.855	4.939	0.126	0.155	0.189
1992	1.610	1.079	2.303	5.855	4.939	0.125	0.151	0.188
1993	1.591	1.056	2.350	5.855	4.939	0.117	0.142	0.183
1994	1.565	1.027	2.395	5.855	4.939	0.108	0.130	0.174
1995	1.537	0.996	2.406	5.855	4.939	0.103	0.119	0.167
1996	1.498	0.951	2.404	5.855	4.939	0.098	0.111	0.158
1997	1.442	0.914	2.388	5.855	4.939	0.091	0.104	0.150
1998	1.382	0.877	2.362	5.855	4.939	0.085	0.098	0.142
1999	1.332	0.833	2.310	5.855	4.939	0.080	0.092	0.136
2000	1.312	0.795	2.154	5.855	4.939	0.074	0.085	0.132
2001	1.247	0.725	1.698	5.855	4.939	0.069	0.078	0.126
2002	1.208	0.681	1.314	5.855	4.939	0.063	0.072	0.120
2003	1.175	0.655	1.101	5.855	4.939	0.057	0.068	0.115
2004	1.120	0.619	0.961	5.855	4.939	0.051	0.063	0.109

The uncertainty in the activity data and the emission factors is ±20 and ±69 per cent of the mean, respectively.

Regarding recalculations, new figures on average mileage and driven kilometres for passenger cars for the years 2000 to 2003 are now available from the Institute of Transport Economics (TØI) and are used in the calculations. These changes influence on all emissions.

3.10. Railways: All Fuels – All Components – 1A3c (Non-Key Source)

Railway traffic in Norway uses mainly electricity. Auto diesel is used at a small number of lines, for shunting etc.

3.10.1. Methodological issues

Emissions from this source are estimated through the general methodology involving consumption figures and emission factors.

3.10.2. Activity data

Consumption figures for auto diesel used in locomotives are collected annually from the Norwegian State Railways.

3.10.3. Emission factors

The emission factors are the same as for diesel machinery in mining and quarrying (see section 3.20), with the exception of N_2O, where a value of 1.2 g/kg is used for machinery instead of 1.3 g/kg (IPCC Guidelines).

3.10.4. Uncertainties

The consumption data are of high quality. Their uncertainty is estimated to be ±10 per cent of the mean. The uncertainty in the emission factors for CO_2, CH_4 and N_2O is ±3, ±69 and ±110 per cent of the mean, respectively.

3.10.5. Source specific QA/QC and verification

Consumption data from the Norwegian State Railways are compared with sales to railways according to the Petroleum statistics. However, the latter includes some consumption by buses operated by the State Railways. Since 1998, the reported sales of "tax-free" autodiesel to railways have been around 20 per cent higher than the consumption data from the State Railways. Until 1997, the reported sales were around 5 per cent higher. The reason for this discrepancy has not been checked. "Tax-free" autodiesel is only for non-road use, so consumption by buses should not be the cause.

3.11. Navigation: Liquid Fuels – CO_2 –1A3d (Key Source)

3.11.1. Description

Emissions of CO_2 from navigation in Norway increased by about 29 per cent in the period 1990-2003 due to the general growth in economy activity, primarily in the oil and gas extraction sector. In 2003 such emissions were 14 per cent higher than those of 2002 and accounted for 4.5 per cent of the total GHG emissions in Norway.

Emissions of CO_2 from navigation constitute a key source in both level and trend uncertainty. The contribution of this source to the total level and trend uncertainty is 1.31 and 0.76 per cent, respectively (see Section 1.5).

3.11.2. Methodological issues

According to UNFCCC Norwegian national sea traffic is defined as ships moving between two Norwegian ports. In this connection installations at the Norwegian part of the continental shelf are defined as ports.

Emissions from navigation are estimated according to the Tier 2 IPCC methodology. The levels and the spatial distribution of emissions from national sea traffic are estimated by an updated and improved methodology presented in Tornsjø (SN 2001a). The improvement is due to the collection of new data on fuel use for the different vessel categories and the registration of changes in regular coastal trade (connections/distances). Mobile drilling rigs are also included in the calculations. Emissions from international marine bunkers are excluded from the national totals and are reported separately (Section 3.23), in accordance with the IPCC Good Practice Guidance.

Annual emissions are estimated from sales of fuel to domestic shipping and fishing using average emission factors in the calculations. For 1993 and 1998 emissions have also been estimated based on a bottom up approach (SN 2001a). Fuel consumption data were collected for all categories of ships (based on the full population of Norwegian ships in domestic transport); freight vessels (bulk and tank by size), oil loading vessels, supply/standby ships, tug boats, coastal ferries, military ships and other ships. Emissions were estimated from ship and size specific emission factors and the fuel use. From this information, average emission factors were estimated for application in the annual update based on fuel sales. This approach is unfortunately too resource demanding to perform annually. Sale of fuel to domestic shipping and fishing were about 15 per cent higher, in both 1993 and 1998, than the estimated numbers for the same years. Some explanations may be that the sales figures also include sales to foreign vessels bunkering in Norway. Norwegian vessels bunkered abroad are not included, other activities may be but as fishing and sale to fishing vessels may be included in other categories.

3.11.3. Activity data

The annual sales statistics for petroleum products gives figures on the use of marine gas oil, heavy distillates and heavy fuel oil in domestic navigation. For fuels used in fishing vessels, figures from sales statistics are used directly, according to the guidelines. Information on fuel used in freighters is gathered from surveys performed by Statistics Norway. In cases where information on oil related vessels is lacking, data are collected directly. Data on fuel consumed by public road ferries are available from the Directorate of Public Roads, whereas the consumption by other ferries and regular coastal trade vessels is obtained directly from the companies. The consumption figures for other types of ships and boats are mainly taken from Rypdal and Flugsrud (SN 1996).

For marine gas oil, the sales figures are adjusted up or down when problems in balancing the overall use against the total sale of this energy carrier arise, thus introducing an element of uncertainty regarding the quality of the figures actually used in the emission estimates. The total fuel use has been verified in Tornsjø (SN 2001a), showing a deviation of about 15 per cent. This can be explained by the fact that the bottom up method does not cover all ships, but it may also be that the domestic/international distinction is not precise enough in the sale statistics. The increase in bottom up consumption and sales between 1993 and 1998 is quite similar.

3.11.4. Emission factors

For CO_2 the following standard emission factors based on carbon content are used:

Marine gas oil/diesel and special distillate: 3.17 kg/kg fuel
Heavy fuel oil: 3.20 kg/kg fuel

3.11.5. Uncertainties

The estimated bottom-up emission figures are uncertain. The most important sources of error are assumed to be estimation of fuel used by fishing vessels, delimitation of national sea traffic and the emission factors. Generally there is also uncertainty connected to cases where calculations are

necessary because of the lack of data on fuel consumption. This applies particularly to large ships, as these usually use more fuel and accordingly have greater significance for the emissions. No analysis on levels of error has been made. National emission figures are generally more certain than the figures for the different vessel categories.

The uncertainty in the activity data and the CO_2 emission factors is assessed to be ±10 and ±3 per cent of the mean, respectively (SN 2000).

3.11.6. Source specific QA/QC and verification

In 2001 bottom-up (from surveys) and top down data (from sales) on fuel consumption were compared (SN 2001a). The outcome showed that data from sales were 15 per cent higher than data from reported consumption. This can be explained by the fact that the bottom up method does not cover all ships, but it may also be that the domestic/international distinction is not specified precisely enough in the sale statistics. A similar deviation has been found for the years 1993 and 1998. In the calculations, sales figures are used as they are assumed to be more complete and are annually available. As mentioned, emission estimates for ships have been made bottom up for 1993 and 1998 (SN 2001a). These results have been compared with the annual estimates. The agreement is reasonable given the uncertainty in the fuel data determined by both methods.

3.11.7. Recalculations

Emissions of CO_2 for 2002 are reduced in the final energy accounts, as sale figures were found to be lower than those assumed in the preliminary energy accounts.

The emission factor for CH_4 from LPG-driven ferries has been changed, leading to lower emissions for the years 2000-2002.

Furthermore, revisions in the energy accounts have resulted in small changes in other pertinent emission figures.

3.11.8. Planned improvements

There are presently no plans for further improvements in this sector.

3.12. Navigation: All Fuels – CH_4, N_2O –1A3d (Non-Key Source)

Emissions of CH_4 and N_2O from navigation (coastal traffic and fishing) are negligible. The methodology used in the calculations and the collation of activity data are described in Section 3.6.

For liquid fuels the general/standard emission factors for N_2O and CH_4 used in the emission inventory are taken from IPCC/OECD: 0.23 kg CH_4/tonne fuel and 0.08 kg N_2O/tonne fuel.
In the case of oil drilling, the employed factors are as follows:

- CH_4: 0.8 kg/tonne marine gas oil/diesel; 1.9 kg/tonne heavy fuel oil
- N_2O: 0.02 kg/tonne marine gas oil/diesel

Some natural gas is combusted in ferry transportation; the CH_4 emission factor used in this case is 56.04 kg/1000 Sm^3 fuel.

The uncertainty in the activity data is assessed to be ±10 per cent of the mean. For CH_4 the uncertainty ranges between -50 and +100 per cent of the mean. For N_2O it is between -66 and +200 per cent of the mean uncertainty (SN 2000).

3.13. Other Transportation: All Fuels – CO_2, CH_4, N_2O – 1A3e (Non-Key Source)

Emissions from transportation other than that discussed above comprise primarily emissions from motorised equipment and small releases from pipeline transport. These emissions are described in the following.

A. Pipeline transport

3.13.1. Methodological issues

Emissions are estimated through the general methodology described earlier involving consumption figures and appropriate emission factors.

3.13.2. Activity data

Figures on natural gas used in turbines for pipeline transport at two separate facilities are reported annually from the Norwegian Petroleum Directorate to Statistics Norway. Energy generation for pipeline transport take also place at the production facilities. These emissions are reported under IPCC 1A1.

3.13.3. Emission factors

The emission factors employed are the standard factors used for turbines fired with natural gas, namely: 2.34 kg CO_2/Sm^3, 0.91g CH_4/Sm^3 and 0.019 g N_2O/Sm^3 (see Tables 20, 25, 27).

B. Motorized equipment

3.13.4. Description

The category "motorized equipment" comprises all mobile combustion sources except road, sea, air, and railway transport. Farm and construction equipment are the most important categories. Other categories include mines and quarries, forestry, snow scooters, small boats and miscellaneous household equipment.

Emissions from motorized equipment are reported under several categories:

- Agriculture/Forestry/Fishing: IPCC 1A4c
- Households: IPCC 1A3e
- Military: IPCC 1A5b
- Other: IPCC 1A3e

Only consumption of petrol and auto diesel is considered.

3.13.5. Methodological issues

Emissions are estimated through the general methodology described earlier involving consumption figures and appropriate emission factors.

3.13.6. Activity data

Gasoline and auto diesel are handled differently. Consumption of *gasoline* is estimated bottom-up for each type of machinery based on data on the number of each type of equipment, usage and specific consumption.
Snow scooters: Number of equipment is obtained annually from the Norwegian Public Roads Administration. We assume a mileage of 850 km/year and a specific consumption of 0.15 l/km (TI 1991). A portion of 16 per cent of petrol consumption in agriculture is assigned to snow scooters. The remaining snow scooter fuel consumption is assigned to households.

Chainsaws and other two-stroke equipment: Only consumption in forestry considered, based on felling data. Felling statistics are gathered by Statistics Norway. 50 per cent is assumed to be felled with use of chain saws, with a consumption of 0.33 l/m^3. Note: Consumption has been kept fixed since 1994 based on a calculation by the Institute of Technology (Bang 1996).
Lawn mowers and other four-stroke equipment: Only consumption in households considered.

Consumption of *auto diesel* is based on data from the energy accounts. A certain fraction of the consumption in a number of industries is allocated to motorized equipment, based on surveys or expert judgment.

3.13.7. Emission factors

The CO_2 emission factors used are those listed in Table 23. For CH_4 and N_2O the employed emission factors are presented in Table 34 below.

Table 34. Emission factors of CH_4 and N_2O for boats, snowmobiles, motorised equipment and diesel locomotives. Source: SFT (1993) and IPCC (1997b)

	Unit (emission/fuel consumption)	Snow-mobiles	Boats, 2- stroke	Boats, 4- stroke	Motorised equipment, 2- stroke	Motorised equipment, 4-stroke	Diesel locomotives
Gasoline							
CH_4	kg/tonne	5.85	5.1	1.7	6-8.1[1]	2.2-5.5[2]	-
N_2O	kg/tonne	0.059	0.02	0.08	0.02	0.07/0.08	-
Diesel and light fuel oil							
CH_4	kg/tonne	-	-	0.18	-	0.17/0.18	0.18
N_2O	kg/tonne	-	-	0.03	-	1.3	1.2

[1] The emission factors covered are: 6, 6.2, 7.7 and 8.1 kg CH_4/tonne fuel.
[2] The emission factors covered are: 2.2, 3.7 and 5.5 kg CH_4/tonne fuel.

3.13.8. Uncertainties

The estimates of consumption are considered quite uncertain, particularly for gasoline. However, the total consumption of gasoline and auto diesel is well known.

3.14. Other Sectors: All Fuels – CO_2, CH_4, N_2O – 1A5 (Non-Key Source)

This source includes solely emissions from fuel use in military activities. A concise description is given in the following.

Military activities: Liquid Fuels – CO_2, CH_4, N_2O

Figures on fuel oil are annually collected directly from the military administration, while for other energy carriers figures from the sales statistics for petroleum products are used. Stationary and mobile emissions from the Norwegian military activities for the years 1990 and 1998-2003 are listed in Table 35.

Table 35. Stationary and mobile emissions from military activities
Unit: CO_2 in Mtonnes, CH_4 and N_2O in tonnes

	CO_2	CH_4	N_2O
1990			
1A5A Military - stationary	62.4	7.9	0.6
1A5B Military - mobile	393.7	15.1	12.5
1998			
1A5A Military - stationary	49.6	6.2	0.5
1A5B Military - mobile	309.9	10.9	11.3
1999			
1A5A Military - stationary	50.3	6.3	0.5
1A5B Military - mobile	341.3	10.6	12.0
2000			
1A5A Military - stationary	40.6	5.1	0.4
1A5B Military - mobile	137.5	7.5	5.3
2001			
1A5A Military - stationary	54.4	6.9	0.5
1A5B Military - mobile	240.6	12.8	8.3
2002			
1A5A Military - stationary	44.1	5.5	0.4
1A5B Military - mobile	409.2	9.8	13.3
2003			
1A5A Military - stationary	58.3	7.3	0.6
1A5B Military - mobile	114.2	6.7	3.9

3.15. Fugitive Emissions from Coal Mining and Handling – 1B1a – CH_4 (Key Source)

3.15.1. Description

There are today two coal mines at Spitsbergen (the largest island in the Svalbard archipelago) operated by a Norwegian company. They opened the second mine in 2001. Emissions from all activities at Svalbard should, according to official definitions, be included in the Norwegian GHG inventory. This means that also emissions from the Russian coal production in Barentsburg should be estimated. The production at Barentsburg is at present considerably smaller than the Norwegian production. Due to lack of data this has so far not been done, but, hopefully, figures will be included in the Norwegian emission inventory in 2006. From 1990 to 1998 there were two coal mines at Svalbard operated by the Russians and thereafter it is one.

At Svalbard there is a smouldering fire in an abandoned coalmine. This mine was operated by the Russians and was closed down in 1998. Due to lack of data, emissions from this fire are not estimated. However, Norwegian authorities assume that these emissions are limited.

From 2000 there has been a sharp increase in Norwegian coal production. In 2003, the production was 2.9 million tonnes, which is almost 10 times more than in 1990. The production and consequently the emissions increased by 38 per cent from 2002 to 2003.

CH_4 from coal mining is not defined as a key source in the Tier 2 key source analysis. However, we regard coal mining as a key source due to change in trend and due to the fact that the national emission factor we use is in an order of magnitude less than IPCC's default factors.

3.15.2. Methodological issues

CO_2
Indirect CO_2 emissions from methane oxidized in the atmosphere are calculated by multiplying the calculated CH_4 emission with the factor 2.74 tonne CO_2 per tonne CH_4. (Section 3.12.4 for more information on indirect CO_2)

CH_4
Emissions of methane from coal mining in Norway are calculated by multiplying the amount of coal extracted with a country specific emission factor (Tier 2). The calculations are performed by Statistics Norway.

3.15.3. Activity data
Production figures are reported by the plant to Statistics Norway.

3.15.4. Emission factor
CH_4
A country specific emission factor of CH_4 from extraction of coal was determined in 2000 in two separate studies performed by (IMC Technical Services Limited 2000) and (Bergfald & Co 2000).

The emissions of methane from coal mining were in the study measured in two steps. First, coal was sampled and the methane content in coal was analysed (IMC Technical Services Limited 2000). The sampling process started after a long period (a week) of continuous production. Small samples of coal were removed directly from the coalface as soon as possible after a cut was taken. This was to minimise degassing losses in the samples if the face or heading had been standing for a long time.

The samples yielded an estimate of seam gas content of 0.535-1.325 m^3 methane per tonne coal derived from an average content of 0.79 m^3 per tonne. This factor includes the total possible methane emissions from coal mining, loading and transport on shore and on sea. The factor also includes the possible emission from handling and crushing of coal at the coal power plant.

Secondly, the methane content in ventilation air from the underground coal mines at Spitsbergen was measured (Bergfald & Co 2000). From the Norwegian mines the methane content in the ventilation air was measured to 0.1-0.4 m^3 methane per tonne coal.

Considering the measurements it was therefore decided to use 0.54 kg methane per tonne coal as emission factor when calculating methane emissions from coal mining in Norway.

According to IPCC`s Good Practice Guidance, the Norwegian mines at Spitsbergen have characteristics that should define the mines as underground mines, whereas the emission factor we use is more characteristic for surface mines. The low content of methane is explained with the mine's location 300-400 metres *above* sea level. Furthermore, the rock at Spitsbergen is porous and therefore methane has been aired through many years.

3.15.5. Uncertainties
The uncertainty in the activity data is regarded as being low.
Today, a country specific factor based on measurements is used in the calculations, and we assume that the uncertainty in the EF is much lower than in Statistics Norway (2000), when an IPCC default emission factor was used. In (Statistics Norway 2000) the uncertainty in the EF was estimated by expert judgments to as much as -50 to +100 per cent.

The EF we use is an average of the measurement of methane in coal sampled in the study (IMC Technical Services Limited 2000). This average EF is two to eight times higher than the methane content measured in ventilation air by (Bergfald & Co 2000). This should indicate that the chosen emission factor is rather conservative.

Emissions from Russian coal extraction on Svalbard has so far not been included in the Norwegian emission calculations; hopefully, these will be included in the 2006 inventory. Other major missing emission sources are not likely.

3.15.6. Source specific QA/QC and verification

Independent methods to estimate the EF used in the calculations are described above in this chapter.

Statistics Norway and SFT carry out internal checks of the emission time-series and corrections are made when errors are detected. See Section 1.6 for general QA/QC procedures.

3.15.7. Recalculations

Final production figures for coal mining in 2002 were higher than the preliminary figures used in the calculation of the 2002 emissions reported in NIR 2004. Emissions of methane have therefore increased compared to those in the previous submission.

3.15.8. Planned Improvements

In the desk review report Norway is encouraged to assess the feasibility of applying a measurement-based tier 3 approach to this key source. Norway will consider this advice.

3.16. Fugitive Emissions from Oil and Natural Gas – 2B

3.16.1. Overview

Fugitive emissions from oil and natural gas contribute with about 6 per cent to the total GHG emission in Norway in 2003.

Due to increased amounts of crude oil loaded and a general growth in the production of oil and gas the emissions have increased by 11.9 per cent since 1990. There was a decrease in the emission of 1.6 per cent from 2002 to 2003 which was due to decreased indirect CO_2 emissions from loading and storage of crude oil. The reduction in the indirect CO_2 emisssions is due to emission permits issued by the Norwegian Pollution Control Authority that has lead to that NMVOC reducing technology has been implemented on loading and storage of crude oil offshore since 2001. The permits states 95 % of the oil must be loaded with NMVOC reducing technology by the end of 2007.

CO_2 from flaring off shore contributed in 2003 to 1.9per cent of the total GHG emissions in Norway. Despite increased production of oil and gas the CO_2 emissions from flaring is 19.3 per cent lower in 2003 than it was in 1990. From 2002 to 2003 the emission increased by 2.4 per cent. The amount of gas flared fluctuates from year to year due to variation of startups, maintenance and interruption in operation. To minimise emissions from venting and flaring technical measures have been implemented. The venting rate is low due to strict security regulations.

Table 36 gives an overview over the calculations of the fugitive emissions of CO_2, CH_4, N_2O and NMVOC.

Table 36. Fugitive emissions from oil and natural gas. Emission sources, compounds, methods, emission factors and activity data included in the Norwegian GHG Inventory.

B Fugitive emissions from fuels	CO_2	CH_4	N_2O	NMVOC	Method	Emission factor	Activity data

1.B.2.a Oil							
i. Exploration	IE	IE	NO	IE	Tier II	CS	PS
ii. Production	IE	IE	NO	IE	Tier II	CS	PS
iii. Transport	E	E	NO	E	Tier II	CS	PS
iv. Refining/Storage	E	E	NO	E	Tier I/II	CS	PS
v. Distribution of oil products	E	NE	NO	E	Tier I	Corinair/ CS	PS/CS
vi. Other	NO	NO	NO	NO			
1.B.2.b Natural gas							
Exploration	IE	IE	NO	IE	IE	IE	IE
i. Production/Processing	IE	IE	NO	IE	IE	IE	IE
ii. Transmission	IE	IE	NO	IE	IE	IE	IE
Distribution	IE	IE	NO	IE	Tier II	CS	PS
iii. Other leakage	E	E	NO	E	Tier II	CS	PS
at industrial plants and power stations	E	E	NO	E	Tier II	CS	PS
1.B.2.c							
Venting							
i. Oil	IE	IE	NO	IE	Tier II	CS	PS
ii. Gas	IE	IE	NO	IE	Tier II	CS	PS
iii. Combined	E	E	NO	E	Tier II	CS	PS
Flaring							
i. Oil (well testing)	E	NE	NE	E	Tier II	CS	PS
ii. Gas							
Gas and oil fields	E	E	E	E	Tier II	CS	PS
Gas terminals	E	E	E	E	Tier I	CS	CS
Refineries	E	E	E	E	Tier I	CS	CS
iii. Combined	IE	IE	IE	IE	Tier I	CS	CS

E = Emissions are calculated by SN or reported by plants, IE = Included elsewhere, NO = Not occurring, CS = Country specific, PS = Plant specific, Tier = the qualitative level of the methodology used.

3.16.2. Fugitive Emissions from Oil – CO_2, CH_4 - 1.B.2.a (Key Source)

3.16.2.1. Description

1.B2a covers emissions from loading and storage of crude oil, refining of oil and distribution of gasoline.

Loading, unloading and storage of crude oil on the oil fields offshore and at oil terminals on shore causes direct emissions of CH_4 and indirect emissions of CO_2 from oxidised NMVOC and CH_4. Non-combustion emissions from Norway's two oil refineries (a third was closed down in 2000) include CO_2, CH_4 and NMVOC. Gasoline distribution causes emissions of NMVOC, which lead to indirect CO_2 emissions.

CH_4 emissions and indirect emissions of CO_2 from oil loading etcetera are *key sources* both in level and trend due to uncertain emission factors. The contribution to total uncertainty in level and trend is shown in Table 1.5.

3.16.2.2. Method

Loading and storage of crude oil off shore and on shore

From 2003, emission of CH_4 and NMVOC from loading and storage of crude oil on shuttle tankers included in the GHG Inventory are based on reported emission figures from the oil companies.

For earlier years the reported emissions is calculated by SN. The calculation was based on the field specific amounts of crude oil loaded and stored multiplied with field specific emission factors. Field specific activity data and emission factors (only to SFT) used in the calculation are annually reported

to SN and SFT. Since year 2000 some shuttle tankers have had installed vapour recovery units (VRU), and emissions from loading of crude oil on shuttle tankers with and without VRU are calculated separately for each field. In addition emission figures were reported to SFT and used in the QC of the calculated SN emission figures.

Norway considers that the method for calculating the CH_4 and NMVOC emissions from loading and storage of crude oil is consistent for the period 1990-2003.

Only emissions from loading and storage of the Norwegian part of oil production is included in the inventory.

For the two Norwegian oil terminals on shore, the emissions from loading of crude oil are reported annually from the terminals to SFT. At one of the terminals VRU for recovering NMVOC was installed in 1996. The calculation of the emissions of CH_4 and NMVOC at both terminals is based upon the amount of crude oil loaded and oil specific emission factor dependent of the origin of the crude oil loaded.

The reported indirect CO_2 emissions from the oxidation of CH_4 and NMVOC in the atmosphere see Section 3.12.4, for this source category is calculated by SN.

Refining/Storage – 1.B.2.A.iv
The direct emissions of CO_2, CH_4 and NMVOC included in the inventory are reported by the refineries to SFT.

The *CO_2 emissions* is from the coke on the catalyst that is burned off and from the coke calcining kilns. The CO_2 emissions from catalytic cracker and calcining kilns from the formula

*(1) tonne CO_2 per year = ((Nm^3 RG per year * volume% CO_2) / 100 *(molar weight of CO_2 / 22.4)) / 1000*

- the amount of stack gas (RG) is measured continuosly
- the density of the stack gas is 1.31 kg/Nm^3
- volume percentage of CO_2 is based on continuosly measurements. However, if the refinery can document that the volume percentage of CO_2 is not fluctuating more than 2 per cent from last years report it is not mandatory to have continuos measurements.

Both CH_4 and NMVOC emissions are based on measurement carried out by Spectracyne latest in 2002.

The indirect CO_2 from oxidized CH_4 and NMVOC is calculated by SN.

Gasoline distribution – 1.B.2.a.v
NMVOC emissions from gasoline distribution are calculated from amount of gasoline sold and emission factors for, loading of tanker at gasoline depot, loading of tanks at gasoline stations and loading of cars.

3.16.2.3. Activity data
Loading and storage of crude oil off shore and on shore
The amount of oil buoy loaded and oil loaded from storage tankers that the oil companies emission calculations is based on is annually reported to SFT and NPD. The amount of oil loaded on shuttle tankers with or without VRU is separated in the report.

For the years before 2003, Statistics Norway gathered data on amounts of crude oil loaded at shuttle tankers and stored at storage vessels from the Norwegian Petroleum Directorate (NPD). The data from each field are reported monthly by the field operators to NPD on both a mass and a volume basis. The

allocation of the amount of crude oil loaded at shuttle tankers and stored at storage vessels with or without VRU is from the annually report the field operators are committed to deliver to SFT and NPD.

The amount of oil loaded at on shore oil terminals is also reported to SFT and NPD.

Gasoline distribution – 1.B.2.a.v
Gasoline sold is annually collected in SN's sale statistics for petroleum products.

3.16.2.4. Emission factors

Loading and storage of crude oil off shore and on shore
For the years before 2003, emission factors used in the calculation of CH_4 and NMVOC emissions offshore are field specific and were reported to SFT and NPD in an annual report. SFT forwarded the emission factors to Statistics Norway. From 2003 the emission figures reported by the field operators are used in the inventory.

The evaporation rate varies from field to field and over time, and the emission factors are dependent on the composition of the crude oil as indicated by density and Reid vapour pressure (RVP). The VOC evaporation emission factors are obtained from measurements, which include emissions from loading and washing of shuttle tankers. For some fields the emission factors are not measured, only estimated. The CH_4 content of the VOC evaporated is also measured so that total emissions of VOC are split between CH_4 and NMVOC.

The emission factors that the field operators use in their calculations is reported to SFT and NPD. They report emissions factor with and without VRU and the splitt beteen CH_4 and NMVOC.

Loading on shore: The emission factors are considerably lower at one of Norway's two oil terminals than at the other, because the oil is transported by ship and therefore the lightest fractions have already evaporated. At the other terminal the oil is delivered by pipeline. The latter terminal has installed VRU, which may reduce NMVOC emissions from loading of ships at the terminal by about 90 per cent. NMVOC emissions at this terminal is estimated to be more than 50 per cent lower than they would have been without VRU. However, VRU technology is not designed to reduce methane and ethane emissions.

Refining/Storage – 1.B.2.A.iv
See section 1.2.2.2 Method.

Gasoline distribution – 1.B.2.a.v
Emission factor for NMVOC from filling gasoline to cars used in the calculations are from (EEA 2001) and is 1.48 kg NMVOC/tonne gasoline.

3.16.2.5. Uncertainties

The uncertainty in the emission factors of methane from *oil loading* (Statistics Norway 2000) and NMVOC (Statistics Norway 2001c) is estimated to be ± 40 per cent and in the activity data ± 3 per cent.

3.16.2.6. Source-specific QA/QC

Statistics Norway gathers data for the amount of crude oil loaded off and on shore from the Norwegian Petroleum Directorate (NPD). This data is reported monthly by the fieled operators to NPD. The activity data are quality controlled by comparing them with the figures reported in the field operator's annual report to SFT and NPD.

SN's calculated emissions for 1990-02 are compared with the emission data that the field operators report to SFT and NPD. From 2003 SN estimate emission based on activity data that the filed operators monthly report to NPD and reported emission factors. When discrepancies are found

between the two sets of data they are investigated and corrections are made if appropriate. If errors are found, SFT contacts the plant to discuss the reported data and changes are made if necessary.

3.16.2.7. Recalculations

1 B 2 a i Exploration Production, Transport,
Process emission of CH_4 from oil loading on shore for one terminal has been revised for the whole time series. The emission figures for this terminal were based on calculations by Statistics Norway and SFT (emission factor * activity data) in the previous submission. Now reported figures are used. The percentage distribution between CH_4 and NMVOC for 2003 has been used as distribution formula for all years. This has led to an increase in emissions of CH_4. At the same time reported CH_4 process emissions from a refinery are included in the inventory. These figures replace formerly estimated figures for the years 1990 to 2003. Reported emissions from 1992 are used for 1990 and 1991 to missing figures.

3.16.2.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2006.

3.16.3. Fugitive Emissions from Natural Gas – 1.B.2.b (Non Key Source)

3.16.3.1. Description

Sector 1.B2b covers fugitive emissions of CH_4 and NMVOC and indirect emissions of CO_2 from the two gas terminals.

3.16.3.2. Method

Fugitive emissions of CH_4 and NMVOC from gas terminals are annually reported from the terminals to SFT.

The emissions are calculated based on the number of sealed and leaky equipment units that is recorded through the measuring and maintenance program for reducing the leakage. The number of sealed and leaky equipment units is collected two times a year and the average number of the countings is used in the calculation. It is assumed in the calculation that a leakage has a lasted the whole year if not the opposite is documented.

Measurement of the total emissions was carried out in 2002 and 2003.

3.16.3.3. Activity data

Activity data is sampled through the terminals measuring and maintenance program which aim is to reduce leakage.

3.16.3.4. Source-specific QA/QC

Reported emissions is compared with previous years emissions.

3.16.3.5. Recalculations

No recalculations since NIR 2004.

3.16.3.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2006.

3.16.4. Fugitive Emissions from Venting and Flaring – CO_2 , CH_4 - 1.B.2.c – (Key Source)

3.16.4.1. Description

Included in sector 1.B2c Flaring are emissions from flaring of gas off shore, at gas terminals and at refineries and the emissions is reported in sector 1.B.2.c.ii. Emission from flaring of oil by well testing is reported in sector 1.B.2.c.i.

Sector 1.B2c *Venting* includes emissions of CO_2, CH_4 and NMVOC from exploration and production drilling of gas and oil and reinjection of CO_2 at the Sleipner oil field. The major source is cold vent and leakage of CH_4 and NMVOC from production drilling.

The sector 1.B.2.c *Venting* includes emissions of CH_4 and NMVOC and hence indirect CO_2 emissions from cold venting and diffuse emissions from extraction and exploration of oil and gas. CO_2 emissions vented to the atmosphere when the injection of CO_2 has to stop for maintenance etc. is reported in this sector. See Section 3.9 **CO_2 capture and storage at the oil and gas production field Sleipner West** for further description of this source.

Most of the emissions in sector *1.B2c Flaring* come from flaring of natural gas offshore (during both well testing, extraction and pipeline transport) and at gas terminals and flaring of refinery gas at the refineries. There is some flaring of oil in connection with well testing - amounts flared and emissions are reported to Norwegian Petroleum Directorate (NPD) and SFT.

CO_2 and CH_4 from venting and flaring is *key source* with respect to the level and total trend due to change in trend. Their contribution to total uncertainty in level and trend is shown in Annex I.

3.16.4.2. Method

Venting

Emissions of CH_4 and NMVOC from cold venting and diffuse emissions for each field are reported annually to SFT from the field operator. The emissions are mostly calculated by multiplying the amount of gas produced with an emission factor for each emission source identified at the field. The indirect CO_2 emissions is calculated by SN.

The vented CO_2 at Sleipner West is measured.

Flaring

The CO_2, CH_4 and N_2O emissions from flaring of gas off shore is for the period 1990-2002 calculated by Statistics Norway on the basis of field specific gas consumption data and country specific average emission factor, see Table 37. From 2003, emissions of CO_2 and CH_4 from flaring offshore reported by the oil companies to NPD and SFT are used in the inventory. The same metod is used in the calculation of emission from flaring by well testing. We consider that the method is consistent for all year.

Emissions of CO_2 from flaring from one of the two gas terminals are reported from the plant. All other emissions from the gas terminals are based on activity data and emission factors.

The refineries reports annually CO_2 emissions from flaring to SFT. The emissions are calculated by multiplying the amount of gas flared with plant specific emission factors.

3.16.4.3. Activity data

Venting

Amounts of gas produced or handled at the platforms are reported from NPD and use in the QC of the reported emissions.

Flaring
Amounts of gas flared at offshore oil and gas installations are monthly reported by the operators to the Norwegian Petroleum Directorate (NPD). Amounts flared at the two gas terminals are reported to NPD and SFT. Amounts of refinery gas flared are found by distributing the total amounts between different combustion technologies by using an old distribution key, based on data collected from the refineries in the early 1990s. This distribution is confirmed in 2003.

3.16.4.4. Emission factors

Venting
The emission factors used are in Table 37. The reference is Aker Engineering (1992).

Table 37. Emission factors for cold vents and leakage at gas fields off shore

	NMVOC	CH_4	
	Emission factor	Emission factor	Calculation method
Emission source	[g/Sm3]	[g/Sm3]	
Glycol regeneration	0.065	0.27	
Gas dissolved in liquid from K.O. Drum	0.004	0.00	
Gas from produced water system	0.03	0.03	
Seal oil systems	0.015	0.01	
Leaks through dry compressor gaskets	0.0014	0.00	
Start gas for turbines [5]	0.4	0.36	Tonne per start up
Depressurisation of equipment	0.005	0.02	
Instrument flushing and sampling	0.00021	0.00	
Purge and blanket gas [1]	0.032	0.02	
Extinguished flare	0.014	0.02	
Leaks in process	0.007	0.02	
Depressurisation of annulus	0.0000005	0.00	
Drilling	0.55	0.25	Tonne per well

Flaring
From 2003, CO_2 emission figures reported by the oil companies to the SFT and NPD are used in the inventory. For earlier years 1990-02, average emission factors, based on field specific factors, are used, except for one field, for which a field specific factor is used for all years. In Table 39, the CO_2 emission factors for flaring off shore and at one gas terminals are shown. The other gas terminal used 2.72 tonne co2/tonne gas.

Emmission factors used in the calculations for well testing are shown in Table 39.

Table 38. Emission factors for flaring of natural gas at off shore oil fields and one gas terminal.

	Average content of CO_2 in gas flared at one gas terminal t CO_2 /t gas	**Average content of CO_2 in gas flared off shore kg CO_2 / Sm^3 gas**
2003	2.70/	2.41
2002	2.70	2.47

[5] The gas source is standard fuel gas.

2001	2.70	2.42
2000	2.70	2.52
1999	2.70	2.48
1998	2.70	2.34
1997	2.70	2.34
1996	2.70	2.34
1995	2.70	2.42
1994	2.70	2.34
1993	2.70	2.34
1992	2.70	2.34
1991	2.70	2.34
1990	2.70	2.34

Source: SFT/NPD

Table 39. Emission factors for flaring in connection with well testing.

Compounds (unit)	unit/tonnes flared oil	Source	unit/kS m^3 flared natural gas	Source
CO_2 (tonnes)	3.2	SFT (1990)	2.34	OLF (1990)
CH_4 (tonnes)	NE		0.00024	IPCC (1997b)
N_2O (tonnes)	NE		0.00006	
NMVOC (tonnes)	0.0033	OLF (1994)	0.00002	

[1]The Norwegian Oil Industry Association (OLF)

3.16.4.5. Uncertainties

The uncertainty in the amount of gas flared is in (SN 2000) regarded as being low, ±3 per cent, due to that there is a tax on gas flared and there is requirement by law that the gas volume flared is measured (NPD 2001). The uncertainty in the CO_2 emission factor for flaring is ±10 (SN 2000).

The uncertainty in CH_4 and NMVOC emissions from venting and, hence, in the indirect emissions of CO_2, is much higher than for flaring.

3.16.4.6. Source-specific QA/QC

SN collects the activity data used in the calculation from the Norwegian Petroleum Directorate (NPD). The figures are quality controlled by comparing them with the figures reported in the field operators annually report to SFT and NPD and time series are checked.

The calculated emissions are compared with the emission data the field operators report to SFT and NPD, before 2003. From 2003 reported emissions is checked by SFT and SN. SN calculate emissions from reported emission factors and activity data collected monthly by the office of statistics in NPD. When discrepancies are found between the two sets of data this is investigated and corrections are made if appropriate. If errors are found SFT contacts the plant to discuss the reported data and changes are made if necessary.

SN and SFT perform internal checks of the reported data for venting from the field operators. Some errors in the time-series are usually found and the field operators are contacted and changes are made. The same procedure is followed to check the amount of gas reported as flared. The quality of the activity data is considered to be high due to that there is a tax on gas flared off shore. NPD has a thorough control of the amount of gas reported as flared.

3.16.4.7. Recalculations

1 B 2 c Venting and flaring

For one gasterminal, CO_2,and NO_x figures for flaring for all years (1990-2003) reported to SFT replace estimates based on emission factors and activity data.

Emission of CH_4 from flaring of crude oil is deleted for the year 1980 to 1991. This is done after consultation with SFT.

In addition minor revisions (flaring at refineries) in the energy accounts have also given some minor recalculations in the emission figures.

3.16.4.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2006.

3.17. CO2 capture and storage at the oil and gas production field Sleipner West (Key Category)

3.17.1. Description

The natural gas in the Sleipner West offshore gas-condensate field contains about 9 per cent CO_2. The CO_2 content has to be reduced to about 3 per cent before transported to the consumers onshore. The CO_2 to be removed amounts about 1 million tonnes per year.

When this North Sea field was planned around 1990 the considerations were influenced by the discussions about strategies to reduce green house gas emissions and a possible national tax on CO_2-emissons (introduced in 1991 and extended in 1996). It was therefore decided that the removed CO_2 should be injected for permanent storage into a geological reservoir. The selection of an appropriate reservoir is essential for the success of geological storage of CO_2. In their search for a suitable reservoir the companies were looking for a saline aquifer with reasonable high porosity and a capture rock above to prevent leakage. Furthermore the CO_2 should be stored under high pressure - preferably more than 800 meters below the surface. Under these conditions CO_2 is buoyant and less likely to move upwards than CO_2 in gaseous form. The chosen reservoir is the Utsira formation which is a sandstone saline aquifer 1,000 metres beneath the seabed. The reservoir was characterised by reservoir information such as seismic surveys and information from core drillings. The field and the injection program have been in operation since 1996. Statoil monitor the injected CO_2 with respect to leakages.

Investigations carried out so far show that the injected CO_2 have been kept in place without leaking out. In case unexpected CO_2 movements take place beyond the capture rock in the future it can be registered by the monitoring technics.

The Table below give the amount of CO2 injected in the Utsira formation since the project stared in 1996.

Table 40. CO_2 from the Sleipner field injected in the Utsira-formation, 1000 tonnes. Source: SFT

	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2 (1000 tonnes)	70	665	842	971	933	1 009	955	914	750

When the injection has to stop for maintenance etc. the CO_2 is vented to the atmosphere. The amount vented to the atmosphere is included in the green house gas inventory reported under 1B2c - see 3.2.4. In 2003 this emission amounted to 23 909 tonnes CO_2. The figure for the other years is given in Table 41.

Table 41. Emissions of CO_2 from the Sleipner CO_2-injection plant due to inaccessibility of the injection facilities, tonnes. Source: SFT

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
CO_2 (tonnes)	..	29	4,195	9,150	8,318	3,050	7,567	23,909	21,377

3.17.2. Methodological issues

The reported data covers emissions to the atmosphere e.g. when the injection system is out of operation. These emissions are measured by continuous metering of the gas stream by VCONE-meter. The reported amounts of CO_2 which are injected in the Utsira formation are based on continuous metering of the gas stream by orifice meter.

The Sleipner CO_2-injection project is considered as the first industrial-scale, environmentally driven CO_2-injection project in the world. In order to document what happens with the CO_2 a European research project initially called SACS ("The saline aquifer carbon dioxide storage project") was organized around it. The SACS project ended in 2002 and was succeeded by the ongoing the EU-cofunded CO2STORE. The projects have run parallel to the development of Sleipner West and have special focus on monitoring and simulation. Research institutes and energy companies from several countries participate in the projects. The core of the projects has been to arrive at a reasoned view of whether carbon dioxide remains in the Utsira sand and whether developments in this formation can be monitored. The spread of carbon dioxide through the aquifer is recorded by seismic surveys. Base line 3D seismic data were acquired in 1994, prior to injection, and the first repeat survey was acquired in 1999, when some 2.28 mill ton of CO_2 had been injected into the reservoir. This was followed by seismic surveys in 1999, 2001, 2002 and 2004. Results from the projects are given in several reports and articles such as: "Final Tecnical Report of the SACS2 project – EU project NNE-1999-00521, issued 30. Aug. 2002", "Recent time-lapse seismic data show no indication of leakage at the Sleipner CO_2-injection site" published at 7th Greenhouse Gas Control Technologies Conference (GHGT7),Vancouver 2004 and "4D seismic imaging of an injected CO_2 plume at the Sleipner field, central North Sea" (under publishing in the Geological Society of London Memoir). The project has confirmed that sound waves reflect differently from carbon dioxide and salt water. Comparing seismic data collected before and after injection started has allowed researchers to show

how CO_2 deep inside the Utsira formation migrates. It is held under the layer of shale cap rock, 80 metres thick, which covers the whole formation. This extends for several hundred kilometres in length and about 150 kilometres in width.

The time-lapse seismic data clearly image the CO_2 within the reservoir, both as high amplitude reflections and as a pronounced velocity pushdown. The data also resolve a vertical CO_2 chimney, which is seen as the primary feeder of CO_2 in the upper part of the bubble. There are no seismic indications of faults within the upper part of the reservoir, and no indications of leakage into the capture rock.

The time-lapse seismic images clearly show the development of the CO_2 plume, and also have been used to calculate the amount of CO_2 in the reservoir. The volume calculated from the observed reflectivity and velocity pushdown is consistent with the injected volume.

3.17.3. Uncertainties

The reported data covers emissions to the atmosphere e.g. when the injection system is out of operation. The accuracy in these measurements made by VCONE-meter is $^{+}$/- 5 per cent. The orifice meter used to meter the amount of CO_2 injected in the Utsira formation have $^{+}$/- 3 per cent accuracy. So far there have not been detected any leakage from the storage. We expect to have more information from the SACS/CO2STORE-projects and the monitoring program as the Sleipner project develops – see QA/QC and verification below.

3.17.4. Source specific QA/QC and verification

The results are promising and so far it looks that the injected gas remains in place rather than leaking out. However, it remains to see how permanent the storage is. In Norway storage projects like Sleipner have to apply for a permit after the Pollution control Act. The storage of CO_2 is included in the emission licence for the Sleipner West field. According to the license Statoil is obliged to draw up a proposal for a monitoring program of the CO_2-storage. Furthermore Statoil reports the amount of CO_2 emitted and the amount injected every year to The Norwegian Pollution Control Authority The monitoring program will give a system for QA. So far the monitoring is included in the SACS/CO2STORE projects and when these detailed projects are finalized a decision will be taken about a further monitoring program for the Sleipner injection project. The injected CO_2 is believed to be removed from the atmosphere and hence it is not reported as in the emission inventory. When the injection have to stop for maintenance etc Statoil have to pay a CO_2-tax for the emissions. These emissions are reported to the Norwegian Petroleum directorate. In this national emissions inventory these fugitive emissions are reported under 1B2c.

3.18. International bunker fuels

Emissions from international aviation and marine bunker fuels are excluded from national totals as required according to the IPCC Guidelines. These emission figures are presented in Table 42.

In 2003, CO_2 emissions from ships and aircraft in international traffic bunkered in Norway amounted to a total of 2.5 million tonnes, which corresponds to about 6 per cent of the total Norwegian CO_2 emissions. CO_2 emissions from marine and aviation bunkers showed a growth of about 80 per cent during the period 1990 to 1997. This increasing trend was reversed in 1998, and from 1997 to 2003 emissions were reduced by 33 per cent. Compared to 1990, the emissions were 21 per cent higher in 2003.

Emissions of CO_2 from international air and ship traffic increased by 21 per cent from 1990 to 2003, primarily due to activity growth. Aircraft engines are more fuel-efficient now than they were some years ago. This means that the increase in international air traffic has been higher than that of the

emissions. During the last years, however, there has been a decrease in both sea and air traffic; in 2003 the CO_2 emissions from international sea traffic were more than 40 per cent lower than in 1997.

Table 42. Emissions of CO_2, CH_4, N_2O, NO_X, CO, NMVOC and SO_2 from ships and aircraft in international traffic bunkered in Norway, 1990-2003. Unit: 1000 tonnes, CO_2 in Mtonnes. Source: SN/SFT

Marine	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
CO_2	1.5	1.3	1.6	1.7	1.8	2.3	2.5	3.0	2.9	2.7	2.7	2.6	2.2	1.8
CH_4	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
N_2O	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
NOx	30.3	25.6	32.1	34.3	37.8	46.2	50.7	61.4	61.8	58.3	57.8	56.0	46.9	38.0
CO	1.4	1.2	1.5	1.6	1.8	2.2	2.4	2.9	2.6	2.5	2.5	2.4	2.0	1.6
NMVOC	1.1	0.9	1.2	1.3	1.4	1.7	1.9	2.3	2.2	2.1	2.0	2.0	1.7	1.3
SO_2	9.9	9.7	12.3	13.5	14.0	13.7	15.4	18.8	14.9	12.9	11.5	13.1	8.0	8.3

Aviation	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
CO_2	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.9	0.9	0.8	0.7	0.7
CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NOx	2.1	1.9	2.0	2.4	2.3	2.2	2.6	2.9	3.0	3.4	3.3	3.0	2.7	2.7
CO	0.8	0.7	0.7	0.9	0.8	0.8	0.9	1.0	0.8	1.0	0.9	0.8	0.8	0.8
NMVOC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
SO_2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

3.18.1. Methodological Issues

Greenhouse gas emissions from international bunkers (marine and aviation) have been estimated and reported separately from national estimates, in accordance with the IPCC Guidelines. The consumption of aviation bunker fuel in Norway is estimated as the difference between total purchases of jet kerosene in Norway for civil aviation and reported domestic consumption. Figures on total aviation fuel consumption are derived from sales data reported to Statistics Norway from the oil companies. These data do not distinguish between national and international use. Data on domestic fuel purchase and consumption are therefore collected by Statistics Norway from all airline companies operating domestic traffic in Norway. The bottom-up approach of Norway is the detailed Tier 2 CORINAIR methodology. The methodology is based on detailed information on types of aircraft and number of LTOs, as well as cruise distances.

The differences between the IEA data and the CRF in sectoral data for marine shipping and aviation are due to the fact that different definitions of domestic use are employed. In the Norwegian inventory, domestic consumption is based on a census in accordance with the IPCC good practice guidance. On the other hand, the IEA makes its own assessment with respect to the split between the domestic and the international market.

3.18.2. Precursors

Emissions of NO_x from international sea traffic in 2003 were 38 ktonnes, which equals 17 per cent of the national Norwegian NO_x emissions. During the period from 1990 to 2003, NO_x emissions from international shipping bunkered in Norway increased by 26 per cent. However, the 2003 emissions were nearly 40 per cent lower than in 1998, which had the highest emissions in the period. NO_x emissions resulting from international aviation amounted to 2.7 ktonnes in 2003. They increased by 31

cent from 1990 to 2003. As for the other gases in the table, emissions from international aviation and marine bunker fuels are small compared to the total national emissions of these gases.

3.19. Cross-cutting issues

3.19.1. Sectoral versus reference approach

As shown in CRF Table 1A(c), a comparison of CO_2 emissions from fuel combustion between the Reference Approach (RA) and the National Approach (NA) reveals large deviations in both the energy consumption data (5.7 per cent) and the CO_2 emissions (-10.8 per cent) in 2003. For earlier years the differences are even larger.

In the Reference Approach for 2003 the emission figure is very low compared to that of earlier years. Furthermore, some emission figures for 2002 used in the Reference Approach have been corrected. This resulted in a deviation for CO_2 emissions of 2.88 per cent, compared to -8.49 per cent in the 2004 submission. The deviation between the two approaches for CO_2 emissions in the years 1990 and 1998-2003 is displayed in Table 43.

Table 43. Comparison between the reference approach and the sectoral approach in 1990, 1998-2003 (in Gg). Change and deviation (in per cent). Source: Statistics SN/SFT.

	1990	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**90-98**	**90-99**	**90-00**	**90-01**	**90-02**	**90-03**
National Sectoral Approach (Gg)	25.7	30.8	31.2	30.2	32.5	32.5	34.5	20 %	21 %	17 %	26 %	26 %	**34 %**
National Reference Approach (Gg)	25.5	32.2	34.5	34.1	34.3	33.4	30.8	26 %	35 %	34 %	35 %	31 %	**21 %**
Deviation (%)	**-0.92**	**4.26**	**10.52**	**13.06**	**5.67**	**2.88**	**-10.78**	**-6 %**	**-14 %**	**-17 %**	**-9 %**	**-5 %**	**13 %**

Consumption figures used in the reference approach are based on annual (industry, households) and occasional (agriculture, services, construction, transport) surveys. There are systematic deviations between the Reference and Sectoral Approach. The main reason is probably inaccuracies in the oil and gas production or export statistics. Due to the large production and export, small errors can amount to large discrepancies in the national total emissions. Norway has a large non-energy use of coal, coke, natural gas and liquefied petroleum gas (LPG), large oil and gas production and exports (domestic supply is the difference between the two large numbers in each case), and relatively large statistical errors, which makes the use of the reference approach inappropriate. End-user statistics from sales by energy commodity, sector and source that are used in the sectoral approach are considered to be more reliable.

The energy balance data used in the CRF are the same data that Statistics Norway has reported to the IEA, but there are differences in the RA estimated by Statistics Norway and the one published by IEA. The main reason for this is that IEA distributes the statistical error between the RA and SA. The IEA estimate is furthermore based on default assumptions about carbon stored, which differs from the

actual situation in Norway. IEA and Statistics Norway use different definitions of domestic and international fuel use with respect to shipping, aviation and offshore gas combustion and flaring (offshore installations are included in the latter while excluded from the former).

Norway intends to examine more closely all figures involved in the compilation of this table. It is hoped that any discrepancies will be detected and resolved in time for the national submission in 2006.

3.19.2. Feedstocks and non-energy use of fuels

Emissions from the use of feedstocks are according to the Good Practice Guidance and are generally accounted for in the industrial processes sector in the Norwegian inventory. By-products from processes like CO gas that is sold and combusted are accounted for and reported under the energy sector.

Norway uses a carbon storage factor of 1 for the non-energy use in the Reference Approach (CRF Table 1A(d)). The respective default IPCC values are generally much lower. The factors proposed in IPCC (1997b) are quite general and may vary from year to year for some products. They give misleading results for Norway, because Norway uses large amounts of gas, coal and coke as feedstock for industrial processes. The values for "fractions stored" used for Norway are based on the actual national use of these products. It should be noted that fuels oxidized during industrial processes are assumed "stored". For natural gas and LPG the factors for the fraction stored are not applicable to the total amount used, but to the fractions used as feedstock.

3.19.3. Indirect CO_2 emissions from CH_4 and NMVOC

According to the reporting guidelines to the Climate Convention all emissions of carbon from fossil compounds are to be included in the national GHG inventory. When methane or NMVOC are oxidised in the atmosphere indirect CO_2 emissions are formed. The emissions of CH_4 and NMVOC from some sources will partly be of fossil origin and should therefore be included. Indirect CO_2 emissions originating from the fossil part of CH_4 and NMVOC during fuel combustion are automatically included in the emission inventory. The corresponding emissions from non-combustion sources are accounted for in the inventory under the following source categories:

- Coal Mining and Handling – 1B1a
- Gas terminals – 1B2b
- Oil terminals – 1B2a
- Refineries – 1B2a
- Oil gas extraction activity – especially from loading of crude oil – 1B2a and 2B2c
- Distribution of oil products – 1B2a
- Solvent and other product use - 5
- Solid waste disposal – 6A.

The indirect CO_2 emissions from oxidised CH_4 and NMVOC are calculated from the content of fossil carbon in the compounds. The average amount of carbon is estimated to be 75 per cent in methane and 82 per cent in NMVOC. This leads to the emission factors 2.75 kg CO_2/kg CH_4 and 3 kg CO_2/kg NMVOC.

4. Industrial Processes

4.1. Overview

This chapter provides descriptions of the methodologies employed to calculate emissions of greenhouse gases from industrial processes. Only non-combustion emissions are included in this chapter. Emissions from fuel combustion in the industry are reported in Chapter 3. Energy. Emission figures are either reported by plants to SFT or calculated based on emission factors and activity data by SN. The emission factors are collected from different sources, while the activity data is from official statistics collected by SN.

In 2003 The GHG emissions from Industrial processes contributed to 15.9 per cent of the GHG emissions in Norway. The emissions in 2003 from this source category decreased by 35.4 per cent from 1990 and 8.9 per cent from 2002. The decrease from 1990 to 2003 is mainly due to reduced PFC emissions from production of aluminiumin and SF_6 from production of magnesium. There was a reduction in the PFC emissions even if the production of aluminium increased by 36 per cent in the same period. The reduction in the SF_6 emissions is due to improvements in the GIS-sector and that the production of magnesium was closed down in 2002.

Metal production contributes to 60 per cent of the total GHG emissions from Industrial Processes, mainly from production of ferro alloys and aluminium. Chemical Industry and Mineral Product are the two other main contributing sectors with 23 and 10 per cent, respectively, of the total GHG emissions in this sector.

The Tier 2 key source analysis performed for 1990 and 2003 has revealed the key sources in terms of level and/or trend uncertainty in the sector Industrial Processes as shown in Table 44.

*Table 44. Key sources in the sector Industrial Prosesses***.**

IPCC	Source category	Gas	Method
2A1	Cement Production*	CO_2	Tier 2
2B1	Ammonia Production*	CO_2	Tier 2
2B2	Nitric Acid Production	N_2O	Tier 2
2C2	Ferroalloys Production	CO_2	Tier 2
2C3	Aluminum Production	CO_2	Tier 2
2C3	Aluminum Production	PFC	Tier 2
2C4	SF_6 Used in Aluminum and Magnesium Foundries	SF_6	Tier 2
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC	Tier 2

4.2. Mineral Products – 2A

The sector category Mineral products in the Norwegian GHG inventory includes CO_2 emissions from production of cement, lime and limestone and dolomite use (see Table 45). Table 45 shows if the CO_2 emission figures in the national inventory are based on figures reported to SFT by the plants (R) or estimated by SN (E), tier of method and if it key source or not.

Table 45. Mineral products. Components emitted and included in the Norwegian GHG inventory[1].

Mineral products	CO_2	Tier	Key source
-- Cement production	E	Tier II	Yes
-- Lime production	R	Tier I	No
-- Limestone and dolomite use	R	Tier I	No

[1] R means that emission figures in the national emission inventory are based on figures reported by the plants. E means that the figures are estimated by Statistics Norway (Activity data * emission factor). NA = Not Applicable.

4.2.1. Cement Production – CO_2 - 2A1 (Key Source)

4.2.1.1. Description

Two plants in Norway produce cement. Cement is produced from the raw material calcium carbonate ($CaCO_3$). During the calcinations of $CaCO_3$, calcium oxide (CaO) is produced which is heated to form clinker and then crushed to form cement. Production of cement gives rise to both non-combustion and combustion of CO_2. The emission from combustion is reported Chapter 3 Energy. The non-combustion emissions originate mainly from the calcination of the raw material calcium carbonate ($CaCO_3$). The resulting calcium oxide is heated to form clinker and then crushed to form cement.

(10) $CaCO_3 + heat \rightarrow CaO + CO_2$

The GHG emissions from cement production accounted for 1.6 per cent of the total GHG emissions in 2003 and 10 per cent of the emissions in sector Industrial processes.

From 1990-2003 the GHG emissions from cement production increased by 36 per cent due to increased production (46 per cent). The emission increased by 4 per cent from 2002 to 2003.

4.2.1.2. Methodological issues

SN calculates emissions of CO_2 on the bases of the annually clinker production data and country specific emission factors (SINTEF 1998a) and this is regarded as a Tier II metod.

4.2.1.3. Activity data

The activity data is clinker production based on annual data from the plants.

4.2.1.4. Emission factors

CO_2

The emission factors used are recommended by (SINTEF 1998a), and based on the actual composition of the raw materials used Table 46. These emission factors are calculated particularly for the two Norwegian factories and are 0.520 and 0.541 tonne CO_2 per tonne clinker respectively. The IPCC default emission factor is 0.5071 tonne CO_2/tonne clinker.

Table 46. Emission factors for CO_2 from production of clinker.

Emission factors (tonnes/tonne produced)
0.520/0.541

Source: SINTEF (1998a)

4.2.1.5. Uncertainties

Uncertainty estimates for greenhouse gases are given in Annex II.

4.2.1.6. Source specific QA/QC and verification

The emission figures calculated by SN are compared to emission figures reported by the plants to the SFT. The calculated emission figures agree quite well with emissions figures reported by the enterprises.

The emission data reported by the plants are controlled by SFT. If errors are found the plants are contacted and changes in the emissions are made when necessary.

4.2.1.7. Recalculations
No recalculations have been carried out since NIR 2004.

4.2.1.8. Planned improvements
Our intention is to include reported emissions from the plants for the whole time serie in next years submission.

4.2.2. Lime Production – 2A2 (Non Key Source)

4.2.2.1. Description
One plant produces lime in Norway. Emissions of CO_2 are from the production process.

4.2.2.2. Methodological issues
The plant calculates the emissions of CO_2 based on actual production volumes of lime and plant specific emissions factors of CO_2 for lime and dolomite respectively. The emissions are reported to SFT.

4.2.2.3. Uncertainties
No source specific uncertainty is known.

4.2.2.4. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.2.5. Recalculations
No recalculations have been carried out since NIR 2004.

4.2.2.6. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.2.3. Limestone and Dolomite Use 2A3 (Non Key Source)

4.2.3.1. Description
One plant in Norway neutralizes sulphuric acid waste with limestone and fly ash. This produces CO_2. The use of fly ash decrease the CO_2 emissions compared when limestone is used.

4.2.3.2. Methodological issues
The plant reports emission figures of CO_2 to SFT.

4.2.3.3. Emission factors
An emission factor of 0.45 tonnes CO_2 per tonne sulphuric acid is used by the plant, calculated from the reaction equation.

4.2.3.4. Uncertainties
No source specific uncertainty is known.

4.2.3.5. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.3.6. Recalculations
No recalculations have been carried out since NIR 2004.

4.2.3.7. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2006.

4.3. Chemical Industry – 2B

In the Norwegian inventory, there are 14 different activities included under chemical industry. Most of the emission figures are reported figures from the plant to the SFT. Only CO_2 emissions from ammonia production, and CO and CH_4 emissions from silicon carbide are estimated figures calculated by SN. Production of carbides causes emission of many components, but most of the activities only cause emissions of one or two components (Table 47).

Table 47. Chemical industry. Components emitted and included in the Norwegian inventory.

	CO_2	CH_4	N_2O	NMVOC	Tier	Key source
Ammonia	R	NA	NA	NA	Tier 2	Yes
Nitric acid	NA	NA	R	NA	Tier 2	Yes
Silicon carbide	R+E	E	NA	NA	Tier 2	No
Calcium carbide	R	NA	NA	R	Tier 1	No
Methanol	E	R	NA	R	Tier 2	No
Plastic	R+E	R	NA	R	Tier 2	No

E = Figures estimated by Statistics Norway
R = Figures reported by the plant to SFT
NA = Not Applicable
IE = Included Elsewhere

4.3.1. Ammonia Production – CO_2 - 2B1 (Non Key Source)

4.3.1.1. Description

In Norway ammonia is produced by catalytic steam reforming of wet fuel gas (containing ethane, propane and some buthane). This is one of the steps during fertilizer production. Hydrogen is needed to produce ammonia, and wet fuel gas is the basis for the production of hydrogen.

4.3.1.2. Methodological issues

The CO_2 emission figures in the Norwegian emission inventory model are based on emission reports from the plant. The plant calculates the emissions by multiplying the amount of each gas used with a gas specific emission factor.

The plant has reported consistent figures back to 1990. A part of the CO_2, which is generated during the production process, is captured and sold to other objectives etc. soft drinks, and therefore deducted from the emission figures for this source and reported in 2D2 Food and Drink. Some of the captured CO_2 is exported to other countries. These emissions are not included in the Norwegian GHG Inventory, but are the responsibility of the importer country.

A part of the CO_2 which is generated during the production process is captured and sold to other companies in Norway or exported. The amount of CO_2 sold/exported has been taken into account in this submission to the UNFCCC. In 2003, approximately 213 ktonnes CO_2 were captured and sold. 69.7 ktonnes of this were used in Norway, mainly as carbonic acid in carbonated beverages (now reported under Food and Drink 2D2).

4.3.1.3. Activity data

The total amount of gas consumed is annually reported by the plants to the SN. These figures are used for the QA/QC calculations by alternative method.

4.3.1.4. Emission factors

The plant bases reporting on annual reports on carbon content in the gases consumed.

4.3.1.5. Uncertainties
There are believed to be limited uncertainties in the figures reported by the plant. Uncertainty estimates are given in Annex II.

4.3.1.6. Source specific QA/QC and verification
The figures reported from the plant are compared to calculations done by SN based on total amount of gas consumed and an emission factor on 3 tonnes CO_2/tonne LPG recommended by IPCC (1997b). The calculated emission figures agree quite well with emissions figures reported by the enterprises.

4.3.1.7. Recalculations
For one plant, CO_2 figures for all years (1990-2003) reported to SFT replace figures calculated by SN based on emission factors and activity data. We consider that the change of method has improved the quality of the emission estimates

4.3.1.8. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.3.2. Production of Nitric Acid –N_2O - 2B2 (Key source)

4.3.2.1. Description
There are two plants where nitric acid is produced in Norway. Nitric acid is used as a raw material in the manufacture of nitrogenous-based fertilizer. The production of nitric acid (HNO_3) generates nitrous oxide (N_2O) and NO_X as by products of high temperature catalytic oxidation of ammonia (NH_3). The production of nitrogenous-based fertilizer also leads to emissions of particles.

The GHG emissions from production of nitric acid accounted for 3 per cent of the total GHG emissions in 2003 and 4 per cent of the emissions in sector Industrial processes.

4.3.2.2. Methodological issues
$NO_{2\ x}$
The two plants report the emissions of N_2O to the SFT. At one plant the emissions are measured continuously, whereas at the other the figures are calculated from monthly measurements.

4.3.2.3. Activity data
The plants report the production of HNO_3 to SFT.

4.3.2.4. Uncertainties
The uncertainty in the measurements is estimated by the plant to ±7 (SFT 2000).

There is uncertainty regarding the size of the particles emitted since there is no plant specific information available. The distribution recommended by TNO is used in lack of other data.

4.3.2.5. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.2.6. Recalculations
No recalculations have been carried out since NIR 2004.

4.3.2.7. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.3.3. Silicon Carbide – 2B4 (Non Key Source)

4.3.3.1. Description

Silicon carbide is produced at three plants.

Silicon carbide (SiC) is produced by reduction of quartz (SiO_2) with petrol coke as a reducing agent.

(11) $SiO_2 + 3C \rightarrow SiC + 2CO$

$CO \xrightarrow{O_2} CO_2$

In the production of silicon carbide, CO_2 and CO is released as a by-product from the reaction between quartz and carbon. Methane (CH_4) may be emitted from petrol coke during parts of the process and sulphur origin from the petrol coke.

4.3.3.2. Methodological issues

CO_2

Emission figures are reported to the SFT by the plants. The CO_2 emissions are estimated from the consumption of petrol coke in dry weight multiplied with an emission factor. Indirect emission of CO_2 are calculated based on the emission of CH_4.

CH_4

The IPCC default method is used for the calculations. Emissions are calculated by SN using a default emission factor recommended by IPCC (1997b) and consumption of petrol coke.

4.3.3.3. Activity data

The activity data used by the plants for the calculation of CO_2 is the consumption of petrol coke in dry weight. The activity data used by SN for the calculation of CH_4 and CO is the consumption of petrol coke as reported to SN.

4.3.3.4. Emission factors

CO_2

The emission factor 2.56 tonne CO_2 per tonne produced silicium carbide is used by to plants. The third plant uses 2.41 tonne CO_2 per tonn petrol coke in dry weight.

CH_4

For calculation of methane emissions the emission factor 10 kg/tonne petrol coke is used (IPCC 1997b) (Table 48).

Table 48. Emission factor for CO_2, CH_4 and CO used for silicon carbide production.

Component	Emission factor	Source
CO_2	2.51 tonnes CO_2/tonnes petrol coke	SINTEF (1998e)
CH_4	0.01 tonnes CH_4 /tonnes petrol coke	IPCC (1997b)
CO	0.4 tonnes CO/tonnes petrol coke	Rosland (1987)

4.3.3.5. Uncertainties

CO_2 and CH_4
The estimate of the total yearly emissions of particularly CO_2 is considered to be of high quality. There is however, uncertainty connected to both activity data and the emission factors used in the calculations. The consumption of petrol coke that the plants report to SN is not corrected for the water content.

4.3.3.6. Source spesific QA/QC and verification
The quality of the reported figures of CO_2 is controlled by SN and SFT. SN is calculating the emissions from the consumption of petrol coke reported by the plant to SN and the emission factor of 2.51 tonnes CO_2/tonne petrol coke (Table 48).

4.3.3.7. Recalculations
Emissions of CO_2 have decreased due to revision of the whole time series for all factories producing carbide. Now emissions reported to SFT are included in the inventory, previous calculation made by SN was based on emission factor and activity data.

4.3.3.8. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.3.4. Production of Calcium Carbide – 2B4 (Non Key Source)

4.3.4.1. Description
One plant in Norway was producing calcium carbide until 2003. The production of calcium carbide generates CO_2 emissions when limestone is heated and when petrol coke is used as a reducing agent.

The reaction
(12) $CaCO_3 \rightarrow CaO + CO_2$
which takes place when limestone (calcium carbonate) is heated.

The reactions
(13) $CaO + C\ (petrol\ coke) \rightarrow CaC_2 + CO$
(14) $CO \xrightarrow{O_2} CO_2$
where petrol coke is used as a reducing agent to reduce the CaO to calcium carbide.

4.3.4.2. Methodological issues
The CO_2 figures in the National GHG emission inventory are based on emission figures reported from the plant to SFT. The emission estimates are based on the amount of calcium carbide produced each year and an emission factor estimated by (SINTEF 1998e). Some of the carbon from petrol coke will be sequestered in the product, but not permanently. Thus, this carbon is included in the emission estimate.

4.3.4.3. Activity data
The amount of calcium carbide produced is reported by the plant to SFT.

4.3.4.4. Emission factors
The emission factor used by the plants in the calculation of CO_2 has been estimated by (SINTEF 1998e) to be 1.71 tonnes/ tonne. The default IPCC factor is 1.8 tonnes/tonne. (SINTEF 1998e) concludes that the one reason for the difference between the factors is that the IPCC assumes that all calcium carbonate is calcinated.

4.3.4.5. Uncertainties
Uncertainty estimates for greenhouse gases are given in Annex II.

4.3.4.6. Source specific QA/QC and verification
For CO_2 the data reported from the plant are compared to estimates done by SN. There is no other source specific QA/QC procedure for this production. See section 1.6 for the description of the general QA/QC procedure.

4.3.4.7. Recalculations
No recalculations have been carried out since NIR 2004.

4.3.4.8. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.3.5. Production of Methanol - 2B5 (Non Key Source)

4.3.5.1. Description
One plant in Norway produces methanol. CH_4 and NMVOC are emitted during the production process. Natural gas and oxygen are used in the production of methanol. The conversion from the raw materials to methanol is done in various steps and on different locations at the plant.

Indirect emission of CO_2 are calculated by SN based on the emission of CH_4 and NMVOC.

4.3.5.2. Methodological issues
The plant reports emission figures of CH_4 and NMVOC to SFT. The reported emissions are based on measurements.

4.3.5.3. Uncertainties
No source specific uncertainty is known other that there is uncertainties the measurements..

4.3.5.4. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.5.5. Recalculations
No recalculations have been carried out since NIR 2004.

4.3.5.6. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.3.6. Production of Plastic 2B5 (Non Key Source)

4.3.6.1. Description
Three plants report emission under this source category. Two of the plants were one plant up to 2001. One of the plants produces ethylene and propylene where the other has vinyl chloride production Various components are emitted during the production of plastic.

CH_4 and NMVOC emissions are from leakages in the process. Direct CO_2 emission is from combustion and is reported in Chapter 3 Energy.

During the production process of ethylene and vinyl chloride there is an oxide chloride step for production of ethylene chloride followed by cracking to vinyl chloride monomer and hydrochloric acid.

4.3.6.2. Methodological issues

CO_2 ,CH_4 and NMVOC

Emission figures are annually reported to SFT. CO_2 from combustion is based on gas specific emissions factors and activity data. CH_4 and NMVOC emissions reported are based on measurements.

Indirect emission of CO_2 calculated by SN are based on the emission of CH_4 and NMVOC.

4.3.6.3. Uncertainties

It is difficult to measure leakages of CH_4 and NMVOC and therefore the uncertainty is regarded as being large.

4.3.6.4. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.6.5. Recalculations

No recalculations have been carried out since NIR 2004.

4.3.6.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2006.

4.3.7. Production of Explosives - 2B5 (Non Key Source)

4.3.7.1. Description

There has been one plant in Norway producing explosives, but the plant was closed down in 2001. Nitric acid was used as a raw material in the manufacture of explosives and in the production of nitric acid NO_X was emitted.

4.4. Metal Production – 2C

Metal production in Norway includes plants producing iron and steel, ferroalloys, aluminium, magnesium, nickel and zink. Production of anodes is also included in this chapter. As shown in Table 49 most of the figures in the national inventory is from the plant's annually report to the SFT.

Table 49. Metal production. Components emitted and included in the Norwegian inventory.

	CO_2	CH_4	PFCs	SF_6	Tier	Key source
Iron and steel	R	NA	NA	NA	Tier 2	No
Ferroalloys	R	R	NA	NA	Tier 2	Yes
Primary aluminium	R	NA	R	R	Tier 2	Yes
Secondary aluminium	NA	NA	NA	R	Tier 1	No
Magnesium	E	NA	NA	R	Tier 2	Yes
Nickel	R	NA	NA	NA	Tier 2	No
Anodes	R	NA	NA	NA	Tier 2	No

E = Figures estimated by Statistics Norway
R = Figures reported by the plant to SFT
NA = Not Applicable

4.4.1. Production of Iron and Steel – 2C1 (Non Key Source)

4.4.1.1. Description

Three plants producing iron and steel are included in the Norwegian Inventory. In Norway, iron is produced from ilmenite and coal is used as a reducing agent. Various components are emitted during the production process. Process emissions of CO_2 from an iron/steel production are primary from coal used as a reducing agent.

4.4.1.2. Methodological issues

In the Norwegian GHG Inventory, emission figures of CO_2, annually reported to the SFT, are used. These emission figures are based on calculations.

4.4.1.3. Uncertainties

Uncertainty estimates for greenhouse gases are given in Annex IV.

4.4.1.4. Source specific QA/QC and verification

CO_2 emission figures reported to SFT are compared with calculations at SN using the amount of reducing agent and emission factors. This method is recommended by IPCC when data from measurements are not available.

Annually reported emission figures are first controlled by the SFT and then SN.

Adjustments and recalculations have been done for those years reported emission figures seem to be unreasonable high or low compared to previously years. This is applicable when the variations in the reported emission figures do not have a natural explanation.

4.4.1.5. Recalculations

No recalculations have been carried out since NIR 2004.

4.4.1.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2006.

4.4.2. Production of Ferroalloys - CO_2 - 2C2 (Key source)

4.4.2.1. Description

There were 14 plants producing ferroalloys in Norway in 2003. Ferrosilicon, silicon metal, ferromangan and siliconmangan are now produced in Norway. Ferrochromium was produced until the summer in 2001. Ferrosilicon with 65 to 96 percent Si and silicon metal with 98-99 percent Si is produced. The raw material for silicon is quarts (SiO_2). SiO_2 is reduced to Si and CO using reducing agents like coal, coke and charcoal.

(15) $SiO_2 \rightarrow SiO \rightarrow Si + CO$

The waste gas CO and some SiO burns to form CO_2 and SiO_2 (silica dust).

In ferroalloy production, raw ore, carbon materials and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The carbon materials used are coal, coke and some biocarbon (charcoal and wood). Electric submerged arc furnaces with graphite electrodes or consumable Søderberg electrodes are used. The heat is produced by the electric arcs and by the resistance in the charge materials. The furnaces used in Norway are open, semi-covered or covered.

Several components are emitted from production of ferroalloys. Emission of CO_2 is a result of the oxidation of the reducing agent used in the production of ferroalloys. NMVOC and CH_4 emissions originate from the use of coal and coke in the production processes.

The GHG emissions (CO_2 and CH_4) from ferroalloy production accounted for 5.2 per cent of the national total GHG emissions in 1990 and have decreased to 4 per cent in 2003. The total GHG emissions from production of ferroalloy have decreased by 14 per cent from 1990 to 2003. The reduction is due to reduced activity in the sector and that plants have been closed.

CO_2 emissions from production of ferroalloys are key source in level and trend due to uncertainty in emission factors and the large share of total emissions.

4.4.2.2. Methodological issues

CO_2
The method used in the calculation of CO_2 emissions form production of ferroalloy is in accordance with the method recommended by the IPCC (IPCC 1997b). This methodology is based on the consumption of reducing agents in dry weight and electrodes and national emission factors. Emission data is reported from each plant in an annual report to the SFT, based on calculations at each plant.

Indirect emission of CO_2 are calculated based on the emission of NMVOC.

CH_4
Most plants producing ferroalloys report emission figures to the SFT. For the remaining plants figures are not available but the emissions are regarded as being insignificant and are therefore not included in the inventory. Emission figures have been available since 1992. Emission figures for 1991 have been calculated by SN while the 1990 emission figures have been collected from SINTEF and Det Norske Veritas (2004).

NMVOC
The emissions are estimated by SN from the consumption of reducing agents and an emission factor.

4.4.2.3. Activity data
The amounts of reducing agents that are used for the calculation of NMVOC emissions are annually reported to SN from each plant.

Calculation of emissions is based on the consumption of reducing agents and electrodes in the production of ferroalloys.

4.4.2.4. Emission factors
The CO_2 emissions are calculated based on the IPCCs recommended Tier 1 method using the amount of coal, coke and petrol coke used for calculating the emissions of CO_2. The emission factors used are country specific based on the actual composition of the raw materials. They are listed in Table 50.

Table 50. Emission factors from production of ferroalloys. Tonnes CO_2/tonne reducing agent or electrode.

	Coal	**Coke**	**Electrodes**
Ferro silicon	3.1	3.36	3.36
Silicon metal	3.1	3.36	3.54
Ferro chromium	-	3.22	3.51
Silicon manganese	-	3.24	3.51
Ferro manganese	-	3.24	3.51

Source: SINTEF (1998b, 1998c, 1998d and 1998e).

NMVOC
SN uses an emission factor of 1.7 kg NMVOC/tonne coal or coke (EPA 1986) in the calculations.

4.4.2.5. Uncertainties
The uncertainty in activity data and emission factors have been calculated to ±5 per cent and ±7 per cent respectively, see **Annex II**.

4.4.2.6. Source specific QA/QC and verification
SN makes an annual quality control (QC) of the emission data on the bases of the consumption of reducing agents they collect in an annual survey and average emission factors.

4.4.2.7. Recalculations

Reported emissions of CO_2 from two ferroalloy plants are now used instead of using the values calculated by SN that were used before. So now the total CO_2 emission from ferro alloy production is based on emissions reported by the plants to SFT. This change has increased the emissions of CO_2 for the whole time series.
Emission figures of CO_2 from one plant are revised for 2002. Previously incorrect figure was reported.

4.4.2.8. Planned improvements

No specific plans to improve the CO_2 emission data from the production of ferroalloy are planned before NIR 2006.

4.4.3. Production of Primary Aluminium –CO_2 and PFC - 2C3 (Key source)

4.4.3.1. Description

There are seven plants in Norway producing aluminium. Both prebaked anode and the Soederberg production methods are used. In the Soederberg technology, the anodes are baked in the electrolysis oven, while in the prebaked technology, the anodes are baked in a separate plant. In general the emissions are larger from the Soederberg technology than from the prebaked technology.

Production of aluminium leads to emission of various components as CO_2, SO_2, NO_X, perfluorocarbons (PFCs), heavy metals and persistent organic pollutants. The emission of CO_2 is due to the electrolysis process during the production of aluminium, while the SO_2 emissions are from the sulphur in the reducing agents used. NO_X is primary produced by the high temperature oxidation of nitrogen in the air. All plants also report emissions of particles, heavy metals and PAH. Emissions of heavy metals are due to the metal content in the raw materials used and the reducing agents.

PFCs from aluminium production accounted for 1.3 per cent of the national total GHG emissions in 2003. This is a decrease from 6.6 per cent in 1990. The reduction has been achieved by improving the efficiency of the production process and by installing point feeders to reduce the numbers and duration of anode effects per cell day (AEF). For Søderberg cells, installation of point feeders has contributed significantly. This has caused a reduction of the PFC emissions per tonne aluminium produced in Norway from 3.79 kg CO_2-equivalent in 1990 to 0.59 kg CO_2-equivalent in 2003. The relative emissions of PFCs in CO_2 equivalents per tonne aluminium produced have decreased by 45 per cent from 2002 to 2003. The large reduction is mainly due to that one plant converted from Søderberg to Prebaked technology in 2003 and at at the same time the production increased

An increase in production capacity is also included in the modernisation. The consequence is that emissions of PFCs will go down, while emission of CO_2 will increase.

About 70 per cent of the aluminium was produced with Prebaked technology in 2003. Almost 15 per cent was produced by old Søderberg and about 15 per cent by new Søderberg technology.

PFCs and CO_2 emissions from aluminium production are both key source level, PFC also in trens.

4.4.3.2. Methodological issues

CO_2

The inventory uses the emission figures reported to SFT, calculated by each plant on the basis of consumption of reducing agents. This includes carbon electrodes, electrode mass and petroleum coke. The emissions factors are primarily calculated from the carbon content of the reducing agents.

Previously, SN estimated the CO_2-emissions from consumption data provided by the enterprises but now figures reported by the plants are used. Reported figures are available since 1992. For 1990 and 1991 there were no data, hence recalculation was made using production data and reported emissions data for 1992.

The aluminium industry calculates the CO_2 emissions separate for each technology. The following methods are used:

CO_2 from Prebake Cells

(16) $Q = A*C*3.67$

Where
Q is the total yearly emissions of CO_2
A is the yearly net consumption of anodes
C is per cent carbon in the anodes
3,67 is the mol-factor CO_2/C

CO_2 from Søderberg Cells

(17) $Q = S*3.67*(K*C1+P*C2)$

Where
Q is the total yearly emissions of CO_2
S is the yearly consumption of Søderberg paste
K is the share of coke in the Søderberg paste
P is the share of peatch in the Søderberg paste
K+P=1
C1 is the fraction of carbon in the coke. Fraction is per cent Carbon/100
C2 is the fraction of carbon in the peach. Fraction is per cent Carbon/100

Percflourocarbons (PFCs)
Perfluorinated hydrocarbons (PFCs), e.g. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), are produced during anode effects (AE) in the Prebake and Søderberg cells, when the voltage of the cells increases from the normal 4-5V to 25-40V. During normal operating condition, PFCs are not produced. Starting of new electrolytic cells generates additional PFC emissions. The fluorine in the PFCs produced during anode effects originates from cryolite. Molten cryolite is necessary as a solvent for alumina in the production process.

Emissions of PFCs from a pot line (or from smelters) are dependent on the number of anode effects and their intensity and duration. Anode effect characteristics will be different from plant to plant and also depend on the technology used (Prebake or Søderberg).

In 1992, 1996-1997 and 2000-2001, the Norwegian aluminium industry measured emissions of PFCs from the smelters. For Søderberg potrooms, the monitoring also comprised PFCs in ventilation air from the potrooms. The measurements in production cells were carried out using a photoacoustic gas monitor.

The formula currently used in Norway for calculating CF_4 and C_2F_6 emissions from aluminium production is as follows:

(18) $Q = 1.01 \cdot [A \cdot B \cdot C \cdot D \cdot E + (F \cdot G)]$,

where Q is the total yearly emissions of CF_4 and C_2F_6

Variables to be reported each year:

B number of anode effects per cell per day
D average annual amperage in kA
E number of cells in production multiplied by number of production days

G number of "newly started" cells

Constants:

A average measured emissions per anode effect minute per kA per cell
C duration of anode effect in minutes
F average emissions per new start of a cell
1.01 The measured amount of $CF_4 + C_2F_6$ is multiplied by 1.01 in order to compensate for incomplete monitoring of C_2F_6, see explanation below.

Measurements from 1992 showed that the content of C_2F_6 in anode gas was 1 to 10 per cent, and 3 per cent on average. The measured emissions of CF, that is $CF_4 + C_2F_6$, include all CF_4, but only about 70 per cent of the C_2F_6 emissions. This means that 1 per cent of the total emissions of $CF_4 + C_2F_6$ was not measured. The measured total figure for $CF_4 + C_2F_6$ is therefore multiplied by a factor of 1.01 to include non-measured C_2F_6. The total amount of C_2F_6 in the total estimated $CF_4 + C_2F_6$ emissions (Q) is then 4 per cent. These results were confirmed by the measurements made in 1996-97.

The variables of the calculation

Factor B related to the number of anode effects per cell per day, factor D related to the average annual amperage in kA, factor E related to the number of cells in production multiplied by number of production days, and factor G related to the number of newly started cells, are all based on measurements and registrations that are done more or less continuously as part of the regular monitoring of operating results and plant performance. The data are assumed to be of good quality, and uncertainties in the figures will probably have no significant effect on the calculated emissions.

The constants of the calculation

Factor A
The emissions of CF_4 and C_2F_6 are calculated in kg per year and kg per tonne aluminium produced. These emissions are specified for each plant. For the plants that have both Søderberg and Prebake technology, the emissions are specific for each technology.

Monitoring of emissions followed by calculation of the average emissions of CF_4 per anode effect minute per kA per cell, was carried out in 1992, 1996-97 and 1999-2000. For Prebake-lines, the monitoring campaigns gave some differences in the results for each individual plant, while the average figure for all plants was fairly stable. The same situation applied for the Søderberg-lines.

Estimated uncertainty for both technologies is ± 20 per cent.

The results from the Prebake-lines are reasonably in line with results from ALCOA and with the IPCC recommendation. Also the average results for Søderberg-lines are in line with the IPCC recommendation, but with smaller margin.

Monitoring of emissions of CF_4 from Søderberg-lines is more difficult than from Prebake-lines, mainly due to the difficulty of getting representative results from fugitive emissions in ventilation air from the potrooms.

The monitoring results of C_2F_6 have significantly bigger uncertainty than for CF_4, and the uncertainty is probably bigger for Søderberg-lines than for Prebake-lines.

Monitoring results from Prebake-lines in 1999/2000 have an estimated uncertainty of 40 per cent. The values are lower than the IPCC recommendation and lower than some other reported results. The main reason for the deviations is possibly problems to achieve representative monitoring results.

Factor C
The Norwegian calculations of emissions are based on constant duration of anode effects. These constants are specific for each plant and each technology. This is a simplification, which contributes to an uncertainty of the calculated result.

At all the plants there are major efforts to reduce the length of the anode effects, and the reported results will therefore be less accurate when the efforts pay off.

In The Aluminium Sector Greenhouse Gas Protocol, International Aluminium Institute, May 2003, the recommended calculation of PFC emissions in accordance with Tier 3 is based on real duration of anode effects. The Norwegian method of calculation will probably be in line with this recommendation when the method has been evaluated in 2004. (See the next section Completeness).

The factor 1,01
The accuracy will depend on the quality of the monitoring results of CF_4 and C_2F_6 and their ratio.

Sulphur hexafluoride (SF_6)
SF_6 used as cover gas in the aluminium industry is assumed to be inert, and SF_6 emissions are therefore assumed to be equal to consumption. At one plant SF_6 was used as cover gas in the production of a specific quality of aluminium from 1992 to 1996. The aluminium plant no longer produces this quality, which means that SF_6 emissions have stopped.

4.4.3.3. Activity data
Both production data and consumption of reducing agents and electrodes is reported annually to SFT.

4.4.3.4. Uncertainties
Uncertainty estimates for greenhouse gases and long-range air pollutants are given in Annex IV.

Percflourocarbons (PFCs)
The uncertainty in the emission estimates of PFCs from aluminium production is mostly determined by the uncertainty in the emission factors. PFCs from aluminium production are among the four source categories in the Norwegian GHG Inventory that is most important to the inventory's level and trend uncertainty (SN, 2000). This is in spite of the efforts that have been done to improve the quality of the emission data.

With the purpose of monitoring the reduction of emissions from 1990 to 2005, the current method for calculation of climate gases is considered to be acceptable, even if it has some weaknesses.

In the future, the absolute emission values will be more important, and all climate gasses will therefore have to be monitored or calculated more precisely. The method for monitoring of emissions will therefore be evaluated and improved. Discussions on this issue will start in 2004 in cooperation between the aluminium industry and the environmental authorities. The experience from other countries will be utilized.

4.4.3.5. Source specific QA/QC and verification
CO_2
The emission figures reported by the plants are controlled by SFT and SN. SN make own estimates based on the consumption of reducing agents and production data collected in an annual survey and average emission factors. If errors are found the plants are contacted and changes in the emissions are made when necessary.

Percflourocarbons (PFCs)
The emission figures from the aluminium plants are reported to SFT annually. As a quality control, it is checked that the reports are complete. Each figure is compared with similar reports from previous years and also related to technical changes and utilisation of production capacity during the year. If

errors are found the SFT contacts the plant to discuss the reported data and changes are made if necessary.

SFT has regular meetings with the aluminium industry where all plants are present. This forum is used for discussion of uncertainties and improvement possibilities.

SFT's auditing department are regularly auditing the aluminium plants. As part of the audits, their system for monitoring, calculation and reporting of emissions are controlled.

4.4.3.6. Recalculations
No recalculations have been carried out since NIR 2004.

4.4.3.7. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.4.4. Production of Secondary Aluminium – 2C4 (Non Key Source)

4.4.4.1. Description
One open mill in Norway is handling secondary aluminium production. For earlier (1998-2000) years there have been some emissions of SF_6.

4.4.5. Production of magnesium –SF_6 - 2C4 (Key source)

4.4.5.1. Description
There is one plant in Norway producing magnesium. The plant closed down the production of primary magnesium in 2002 but the production of cast magnesium is continuing. From the mid-1970s, both the magnesium chloride brine process and the chlorination process were used for magnesium production. Since 1991, only the chlorination process was in use.

Production of magnesium leads to non-combustion CO_2 and CO emissions. During the calcinations of Dolomite ($MgCa(CO_3)_2$) to magnesium oxide, CO_2 is emitted. During the next step, magnesium oxide is chlorinated to magnesium chloride and coke is added to bind the oxygen as CO and CO_2. SO_2 is emitted due to the sulphur in the reducing agent used.

In the foundry, producing cast magnesium, SF_6 is used as a cover gas to prevent oxidation of magnesium. The Norwegian producers of cast magnesium has assessed whether SF_6 used a cover gas reacts with other components in the furnace. The results indicate that it is relatively inert, and it is therefore assumed that all SF_6 used as cover gas is emitted to air.

SF_6 from magnesium foundries accounted in 2003 for 0.3 per cent of the total GHG emissions in Norway. In 1990 this sector contributed with 4.3per cent of the national total GHG emissions. The reduction is due to improvements in technology and in process management. The primary magnesium production stopped in 2002 and only secondary production is retained.

SF_6 emissions from magnesium foundries are key source in trend due to change in trend.

4.4.5.2. Methodological issues
CO_2
The IPCC (1997b) recommends using the consumption of reducing agent as the activity data for estimating emissions. (SINTEF 1998f), on the other hand, recommends using production volume in the calculations. The Norwegian emission inventory use production data as activity data. The CO_2 emissions are therefore calculated by using annually production volume and the emission factor recommended by (SINTEF 1998f)

SF_6
The consumption figures of the cover gas (SF_6) are used as the emission estimates in accordance with the IPCC Guidelines (IPCC 1997a, 1997b). The SF_6 emissions are annually reported to SFT.

Studies performed by the Norwegian producer have assessed that SF_6 used as cover gas is inert. Therefore the consumption of SF_6 is uses as the emission estimate in accordance with the IPCC Inventory Guidelines and Good Practice Guidance.

The plant reports the emissions each year to SFT

4.4.5.3. Activity data
The GHG emission inventory we use production volumes as activity data in the calculation of CO_2. This method is recommended by (SINTEF 1998f). The plant reports the consumption of SF_6 to SFT.

4.4.5.4. Emission factor
An emission factor of 4.07 tonnes CO_2/tonnes produced magnesium is used to calculated the annually emissions of CO_2 (SINTEF 1998f).

4.4.5.5. Uncertainties
The uncertainty in the emissions is assumed to be ± 5 per cent.

4.4.5.6. Source specific QA/QC and verification
The last years reported emission data from the plant is compared with previous reported data and the emissions are compared with the production.

4.4.5.7. Recalculations
No recalculations have been carried out since NIR 2004.

4.4.5.8. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.4.6. Production of Nickel - 2C5 (Non Key Source)

4.4.6.1. Description
One plant in Norway produces nickel. During the production of nickel CO_2 are emitted. CO_2 is emitted in the production of nickel due to the soda from the production of nickel carbonate and use of coke as a reducing agent.

4.4.6.2. Methodological issues
CO_2
Emission figures are annually reported from the plant to the SFT and based on calculation of material balance.

4.4.6.3. Uncertainties
Uncertainty estimates for greenhouse gases and long-range air pollutants are given in Annex II.

4.4.6.4. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.4.6.5. Recalculations
No recalculations have been carried out since NIR 2004.

4.4.6.6. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.4.7. Manufacture of Anodes - 2C5 (Non Key Source)

4.4.7.1. Description
Two plants in Norway produce anodes. One plant produces prebaked anodes and the other one produces anodes for ferroalloys production. Prebaked anodes and coal electrodes are an alternative to the use of coal and coke as reducing agents in the production process for aluminium and ferroalloys. The anodes and coal electrodes are produced from coal and coke. The production of anodes and coal electrodes leads to emissions of CO_2.

4.4.7.2. Methodological issues
CO_2, emission figures are based on measurements and reported to the SFT.

4.4.7.3. Uncertainties
Uncertainty estimates for greenhouse gases and long-range air pollutants are given in Annex II.

4.4.7.4. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.4.7.5. Recalculations
No recalculations have been carried out since NIR 2004.

4.4.7.6. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.5. Other Production – 2D

4.5.1. Food and drink - Production of Bread and Beer – 2D2 (Non Key Source)

4.5.1.1. Description
As mentioned under Section 4.3.1. Ammonia Production, some CO_2 from this production is used as carbonic acid in carbonated beverages. In 2003, about 69.3 ktonnes CO_2 were sold for national use, and as mentioned most of this for lemonade production. The whole tonnage is reported under this category, 2D2, although the largest part of the emissions takes place after the bottles are opened and not in the breweries.

4.5.1.2. Methodological issues
NMVOC
Production of bread and beer (and other similar yeast products) involves fermentation processes that lead to emission of NMVOC (ethanol). Emissions are calculated based on production volumes and emission factors.

4.5.1.3. Activity data
Production volumes of bread and beverage are annually reported to SN.

4.5.1.4. Emission factors
The emission factors are taken from (EEA 1996).

Table 51. NMVOC emission factors from production of bread and beverage.

	Emission factor	**Unit**
Production of bread	0.003	tonnes/tonnes produced
Production of beverage	0.2	kg/1000 liters

Source: EEA (1996)

4.5.1.5. Uncertainties
The emission factors used is recommended by EEA (1996) and not specific for Norwegian conditions.

4.5.1.6. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.5.1.7. Recalculations
No recalculations have been carried out since NIR 2004.

4.5.1.8. Planned improvements
There is no planned activity this year that will improve the data quality for NIR 2006.

4.5.2. Food and drink - Carbonic Acid to Breweries - 2D2
As mention under section 4.3.1, some CO_2 from ammonia production is used at carbonic acid in carbonated beverages. During the ammonia production, CO_2 is generated and then captured and sold to other companies in Norway or exported. Most of it is sold for lemonade production. All of the emissions are reported under this source, although the largest part of the emissions takes place after the bottles are opened and not in the breweries.

The figures are based on the sale statistics from the ammonia producing plant.

4.5.3. Production of Bio Protein (Non Key Source)
CO_2 emissions from production of bio protein from natural gas are included from the year 2001 when this production started. The bio protein is being used as animal fodder. Emission data reported from the plant to the SFT are used.

4.5.3.1. Recalculations
CO_2 emissions from production of bio protein from natural gas are included for the years 2001 to 2003. The bio protein is being used as animal fodder.

4.6. Consumption of Halocarbons and SF_6

4.6.1. HFCs and PFCs from Products and Processes – HFC - 2F (Key source)

4.6.1.1. Description
HFCs and PFCs are used as substitutes for ozone depleting substances (CFCs and HCFCs) that are being phased out under the Montreal Protocol. They are used in varied applications, mainly refrigeration and air conditioning equipment, as well as in foam blowing, fire extinguishers, aerosol propellants and analyses purposes. There are no production of HFCs and PFCs in Norway. The HFCs and PFCs registered for use in Norway are HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea and PFC-218.

In January 2003 a tax on import and production of HFC and PFC was introduced. In July 2004 this tax was supplemented with a refund for the destruction of used gas. In 2004 the tax and refund were both 183 NOK (appr. 22 Euro) pr. tonnes of CO_2-equivalents. This has lead to a considerable decrease in emissions in 2003 due to, among others, better maintenance. With regards to emission calculations 2003 must, however, be considered a transitional year, since we expect some time delay before the market adjusted to these new realities and that some increased purchases of gas took place just before the tax was introduced. Emissions for 2003 are estimated using a simplified methodology based on, among others, import statistics and information from users. Work has been established to completely review the methodology based on these new realities (se chapter 1). Unless otherwise stated, the

information in this chapter is based on the methodology used for the years prior to the introduction of the tax.

Sector 2F is key source due to trend.

4.6.1.2. Methodological issues

Actual emissions of HFCs and PFCs are calculated using the Tier 2 methodology. The emissions are calculated on a detailed level, based on yearly consumption figures from bulk importers and emission characteristics related to specific processes and equipment (SFT 1999). Maintenance routines and processes for recovery of chemicals are also taken into account. By accounting for the time lag in emissions from the compounds are introduced into the equipment and until they leak out it gives the actual emissions. Figures on import of products containing HFCs and PFCs in 1995-1997 were collected through a survey in 1999 (SFT 1999a), and the activity data for the following years were estimated by extrapolating these figures. Figures on imported bulk are collected each year.

We have also calculated the potential emissions employing the Tier 1b methodology, which only considers the import and export of chemicals in bulk and in products without time lag. It was found that the ratio between potential (Tier 1b) and actual emissions (Tier 2) was about 4:1 in 2002.

4.6.1.3. Activity data

Routines for the collection of information on imports of chemicals in bulk were established in 1990. The reporting system covers CFCs, HCFCs, HFCs and PFCs. Importers of bulk chemicals are contacted yearly by SFT, and are required to provide information on the types, amounts and application categories of the chemicals they import. A reporting system for imports and exports of equipment containing HFCs and PFCs has also been established. Since the introduction of the tax in 2003 information on import/export in bulk and products is also available from custom statistics. In future calculation this information will probably replace todays reporting system.

4.6.1.4. Emission factors

Emission characteristics for the different categories of equipment and products are defined by expert judgement (SFT 1999a) (Table 52).

Table 52. Emission factors for HFCs from products and lifetime of products

Application category	Lifetime of products (years)	Emissions during lifetime (per cent of initial charge)
Refrigeration and air conditioning		
Household refrigerators and freezers	15	1.5
Commercial and industrial applications	15	3.5
Refrigerated transport	15	15
Air conditioning aggregates and heat pumps	15	4
Water/liquid refrigerating aggregates, water-based heat pumps	15	5
Mobile air conditioners	12	10
Foam		
Polyurethane with diffusion barrier	40	1
Polyurethane without diffusion barrier	20	5
Extruded polystyrene	30	3
Fire extinguishers	15	5
Solvents	2	50
Aerosol propellants	2	50

Source: SFT (1999a).

4.6.1.5. Uncertainties

The uncertainties of the different components of the national greenhouse gas inventory were evaluated in detail in 1999 by SN (SFT 1999). The uncertainty both in relation to the Tier 1b (which only includes bulk chemicals) and the Tier 2 methods were assessed. Concerning the Tier 2 method, both the leakage rate (emission factor) and the stored amount of chemicals (activity data) were considered quite uncertain. The uncertainty of the leakage rate was calculated at ±50 per cent for HFC, while the uncertainty of the stored amount was found to be about ± 25 per cent. Furthermore, it was found that the uncertainty related to the Tier 2 method appeared to be higher than the uncertainty of Tier 1a. However, these figures are not directly comparable, and it is clear that the Tier 2 method predicts actual annual emissions much better.

Major missing emission sources are not likely. The emissions are probably underestimated, as some imported bulk is not included in current import statistics. New statistics based on taxation data are being prepared.

4.6.1.6. Source specific QA/QC and verification

There is no specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.6.1.7. Recalculations

There have not been any recalculations since NIR 2004.

4.6.1.8. Planned improvements

As a result of the introduction of taxation and refund schemes there is a need for an updating of the emission calculations from 2003 and onwards. In 2004 SN will lead a project that will prepare new methodologies for calculation of emissions of HFCs and PFC used in products and processes. Focus will be on new and improved import/export data from customs statistics and revision of emission factors based on feedback from users and scientists. This will probably lead to better estimates of 2003 emissions and a fully revised and improved methodology to be used for 2004 emissions and onwards.

4.6.2. Emissions of SF_6 from Products and Processes – 2F (Non Key Source)

4.6.2.1. Description

In mars 2002 a voluntary agreement was signed between the Ministry of Environment and the most important users and producers of GIS. According to this agreement emission from this sector should be reduced by 13% in 2005 and 30% in 2010 with 2000 as base year. For the following up of this agreement, the users (electricity plants and -distributors) and producers (one factory) report yearly to the government.

4.6.2.2. Methodological issues

The methodology for estimating SF_6 emissions was revised in 1999 (SFT 1999d). Today's method is largely in accordance with the Tier 2 methodology in the IPPC guidelines for emission inventories (IPCC 1997a,b). The emissions reported in the inventory take into account imports, exports, recycling, banking, technical lifetimes of products, and different rates of leakage from processes, products and production processes. For 2003 emission estimates reported directly from users and producers, according to the voluntary agreement, are important input.

Emissions from production of GIS (one factory) were included for the first time in 2003. The company has, as part of the voluntary agreement with the Ministry of the Environment, made detailed emission estimates for the years 2003 and 2000. For intermediate years emissions are estimated based on production data. These emissions constitute a significant part of national emissions of SF_6. In recent years emissions rates have been considerably reduced due to new investments and better routines. The company now performs detailed emission calculations based on accounting of the SF_6 use throughout the whole production chain.

4.6.2.3. Activity data

Data is collected from direct consultations with importers and exporters of bulk chemicals and products containing SF_6, and from companies that use SF_6 in various processes.

4.6.2.4. Emission factors

Leakage rates and product lifetimes used in the calculations are shown in Table 53 and Table 54.

Table 53. Yearly rate of leakage of SF_6 from different processes

Process emission source	Leakage rate (per cent of input of SF_6)
Secondary magnesium foundries	100
Tracer gas in the offshore sector	0
Tracer gas in scientific experiments	100
Production of semiconductors	50
Medical use	100
Production of sound-insulating windows	2
Other minor sources	100

Source: SFT (1999d).

Table 54. Product lifetimes and leakage rates from products containing SF_6

Product emission source	Yearly rate of leakage (per cent of remaining content)	Product lifetime (years)
Gas-insulated switchgear (GIS)	1	30
Electrical transformers for measurements	1	30
Sound-insulating windows	1	30
Footwear (trainers)	25	9
Other minor sources	..	..

Source: SFT (1999d).

4.6.2.5. Source specific QA/QC and verification

During the work on the new methodology for 2003 emissions, historical data were recalculated, emission factors from different sources were established and the bank of SF_6 in existing installations were estimated. New sources that have been included in this inventory were emissions from production of GIS, the use of SF_6 as a tracer gas, in medical surgery, in the production of semiconductors and in sound-insulating windows, and emissions of SF_6 from electrical transformers, footwear. Some other minor sources were also included. For GIS, information from the industry, attained through the voluntary agreement with the Ministry of Environment, was important input in this recalculation.

4.6.2.6. Recalculations

4.6.2.7. Emissions of SF_6 from production of medium voltage switches are included for the first time and a timeserie is established. Planned improvements

A preliminary assessment of the reporting according to the voluntary agreement from users (electricity plants and –distributors) and producer (one factory) of GIS indicates that this reporting is of high quality. However, a more thorough assessment of this reporting will be carried out in project on HFC.

5. Solvent and other product use

5.1. Overview

This chapter describes emissions from solvents and other products. Use of solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which is regarded as an indirect greenhouse gas. The NMVOC emissions will over a period of time in the atmosphere oxidise to CO_2.

Indirect CO_2 emissions from solvents and N_2O from anaesthesia and propellant represented approximately 0.3 per cent of the total GHG emissions in 2003 and 0.4 per cent in 1990

5.2. Solvent losses (NMVOC)

5.2.1. Description

The use of solvents leads to emissions of non-methane volatile organic compounds (NMVOC) which is regarded as an indirect greenhouse gas. The NMVOC emissions will over a period of time in the atmosphere oxidise to CO_2, which is included in the total greenhouse gas emissions reported to UNFCCC.

Solvents and other product use are non-key sources.

5.2.2. Method

The methodology used to estimate emissions from use of solvents and products containing solvents has been based on a solvent balance approach (Rypdal 1995). This method was used for 1990-1998 but has since then not been updated annually. The methodology described here is therefore the one used from 1990-1998. 1998 figures are used for the following years.

Solvents are both imported to and produced in Norway. Most of the solvents used will sooner or later evaporate to air. Solvents not emitted within the country are either exported, used as raw materials, incinerated or broken down in water. The solvent balance follows the flow of solvents from production, import and export, via transformation, to incineration or consumption. This methodology gives independent emission estimates for each year of inventory and in principle covers all fugitive sources.

The equation applied for the solvent balance is:

*(19) Emissions = [(Production + Import - Export - Destruction - Raw material use) *Solvent content *Fraction emitted] + Emissions from certain industrial processes*

The solvent balance is based on the commodities in the foreign trade and production statistics that are either pure solvents or contain solvents. The equation is applied to each commodity and total emissions are given by the sum of emissions from all commodities.

In the following, data of major importance for the solvent balance are described.

- *Imports and exports* of the various commodities are determined by Statistics Norway in collaboration with the customs authorities.

- *Production* of the commodities in Norway is based on the manufacturing statistics from Statistics Norway, which cover all main manufacturers annually.
- *Destruction* of solvent waste and paint is given by official statistics on waste delivered and incinerated (Norsas). In addition, the Norwegian Pollution Control Authority (SFT) has information about incineration in licensed plants.
- *Raw materials* used in industrial processes: data are gathered by Statistics Norway (Manufacturing Statistics). However, these data are not collected annually, but at roughly five-year intervals. Due to the infrequent collection these data make a large contribution to the uncertainty in the related emission figures.
- The *solvent content* is determined using several sources, the most important of which is the Norwegian Product Register. The average solvent content is determined from the average chemical composition of the product category. The solvent contents of the remaining commodities are, with few exceptions, taken from investigations in other countries.
- *Fraction emitted* to air: An amount is estimated for each commodity. Generally, the fraction is higher for products that are not water soluble than for those that are.
- In certain *industrial processes* where solvents are used as raw materials, fractions of the solvents may evaporate to air. Emissions from these plants have been added to the solvent balance where data are available. The emission estimates or emission factors are provided by the Norwegian Pollution Control Authority. However, figures have not been delivered every year and are not available for the most recent years for several plants.

NMVOC and CO_2
The use of solvents leads to emissions of non-methane volatile organic compounds (NMVOC) which is regarded as an indirect greenhouse gas. The NMVOC emissions will over a period of time in the atmosphere oxidise to CO_2, which is included in the total greenhouse gas emissions reported to UNFCCC.

5.2.3. Activity data
Activity data used in the solvent balance is collected by Statistics Norway in cooperation with authorities like SFT and the Norwegian Product Register.

5.2.4. Uncertainty
An uncertainty analysis was performed for long-range air pollutants by Statistics Norway (Statistics Norway 2001c). The analyses conclude that the source category Solvents are one of the highest ranked NMVOC sources with regard to uncertainty.

Of the data, used in the solvent balance, listed above, the amount of *raw materials* used in industrial processes and the *fraction emitted* to air will probably be the most uncertain figures and contribute most to the uncertainty in the figures for total emissions of solvents.

As mentioned earlier in this chapter, the calculations have not been updated since 1998, so the figures reported for instance for 2002, are actually the 1998 figures. The methodology needs to be reviewed and improved before calculating new data.

5.2.5. Source specific QA/QC
Internal checks of the time-series of calculated emissions data and input activity data have been conducted by Statistics Norway and corrections are made when errors are found.

5.3. Other product use -3D

5.3.1. Use of N_2O in anaesthesia – 3D

5.3.1.1. Methodological issues
N_2O is used in anaesthesia procedures and will lead to emissions of N_20. The figures are based on N_2O data from the two major producers and importers in 2000. In the inventory, sale is set to be equal to consumption in each year.

5.3.1.2. Activity data
For this source actual sale of N_2O is used for the year 2000.

5.3.1.3. Emission factors
As mentioned, no emission factors are used since the figures are based on sales of N_2O.

5.3.1.4. Uncertainty
The figures are uncertain. There may be small importers not included in Statistics Norway's telephone survey with 2000 data, but the emissions are small, so it is believed that the uncertainty is at an acceptable level.

5.3.1.5. Completeness
A minor consumption from small importers may be missing, but these will probably account for an insignificant fraction of the total N_2O emissions.

5.3.1.6. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6. for the description of the general QA/QC procedure.

5.3.2. Use of N_2O as propellant – 3D
N_2O is used as a propellant in spray boxes and this use will lead to emissions of N_2O. It is also used in research work, for instance in the food industry and at universities. Small amounts are used at engineering workshops among others for dragracing. There is no production of N_2O for these purposes in Norway.

5.3.2.1. Methodological issues
Information on sale volumes is given from the plants to Statistics Norway. Statistics Norway assumes that all propellant is released to air.

5.3.2.2. Uncertainty
The figures for 2000 are used for all years. It is believed that all figures from all major importers are included in the inventory.

5.3.2.3. Source specific QA/QC and verification
There is no source specific QA/QC procedure for this sector. See section 1.6. for the description of the general QA/QC procedure.

5.3.2.4. Recalculations
N_2O from propellant gas, drag racing and research is for the first time included in the inventory.

5.3.2.5. Planned improvements
There are not specific plans to improve the indirect CO_2 emission data before NIR 2006.

6. Agriculture

6.1. Overview

About 8 per cent of the total Norwegian emissions of greenhouse gases originated from agriculture, in 2003. This corresponds to 4.5 million tonnes CO_2-eqv. The emissions from agriculture are quite stable, with emissions in 2003, 2 percent lower than in 1990, but 2 percent higher than in 2002.

The sectors clearly biggest sources of GHG's are "enteric fermentation" (CH_4) from domestic animals, contributing with 37 per cent and "agricultural soils" (N_2O) contributing with almost 53 percent of the sectors emissions. These are also key sources. Manure management contributes with 10 percent.

Agriculture contributes particularly to CH_4, N_2O and NH_3 emissions. Domestic animals are the major source of CH_4 emissions from agriculture. Both enteric fermentation and manure management contribute to process emissions of methane. Manure management also generates emissions of N_2O.

Microbiological processes in soil lead to emissions of N_2O. Three sources of N_2O are distinguished in the IPCC methodology:
1. direct emissions from agricultural soils (from use of synthetic fertilisers, animal excreta nitrogen used as fertiliser, biological nitrogen fixation, crop residues, industrial and urban wastes and cultivation of soils with a high organic content)
2. direct soil emissions from animal production (emissions from droppings on pastures)
3. N_2O emissions indirectly induced by agricultural activities (N losses by volatilisation, leaching and runoff).

There are also some emissions of the greenhouse gases N_2O and CH_4 and of the precursor NO_X arising from the burning of crop residues on the fields.

Animal manure and the use of fertiliser also generate emissions of ammonia (NH_3). Another source of ammonia is treatment of straw using ammonia as a chemical.

As indicated in Table A1-4 in Annex 1 of this report, the key source analysis performed in 2005 for years 2000 and 2003 has revealed that in terms of total level and trend uncertainty the *key sources* in the Agricultural sector are the following:

- Cattle - CH_4 (4A1)
- Direct soil emissions - N_2O (4D1)
- Animal production - N_2O (4D2)
- Indirect emissions - N_2O (4D3)

In the documentation however these key sources are aggregated to two key sources; enteric fermentation - 4A (CH_4) and agricultural soils – 4D (N_2O). Of these, agricultural soils are the main contributor to uncertainty in both level (54.93%) and trend (25.16%) of the national GHG emissions.

6.2. Emissions from enteric fermentation in domestic livestock 4A– CH_4 (Key Source)

6.2.1. Description

CH_4 is the only important pollutant emitted from this source category. NH_3 can be emitted in small amounts, but no separate estimates have been made. The production of CH_4 by enteric fermentation in animals varies with digestive system and feed intake. Ruminants such as cattle and sheep produce most methane. However, enteric fermentation in pseudo-ruminants (e.g. horses) and monogastric animals (e.g. pigs) is also of significance. Norway has also tame reindeer emitting some CH_4.

.

Enteric fermentation is a key source because of uncertainty in level and trend. The use of a Tier 1 method explains some of this uncertainty which is associated with the number of animals (activity data) (10 %) and the use of standard emission factors for each kind of animal (25 %).)

Enteric fermentation contributed with 79.9 ktonnes of CH_4 emissions in 2003, corresponding to 1.68 Mtonnes CO_2 equivalents, which is 3 per cent of the national GHG emissions. Enteric fermentation constitutes 84 per cent of the overall CH_4 emissions from agriculture and 37 percent of this sectors GHG emissions. Emissions have been rather stable with minor fluctuations. Emissions decreased 2 percent in the period 1990-2003 and increased 1 percent in 2002-2003.

6.2.2. Methodological issues

The methodology for calculating CH_4 from enteric fermentation is in accordance with IPCC's Good Practice Guidance Tier 1 method (IPCC 1997a, 1997b). The numbers of animals of each kind and average emission factors for each kind of animals are used to calculate the emissions. An upgrade to Tier 2 methodology to estimate the CH_4 emissions from dairy and non-dairy cattle, as recommended by the UNFCCC review team, has not been achieved for this 2005 submission.

6.2.3. Activity data

Emissions are estimated from the animal population (IPCC Tier 1). The main source of the livestock statistics is the register of production subsidies. The register covers 90-100 per cent of the animal populations, except for horses and reindeer. The register is used in order to get consistent time series of data. Animals are counted twice a year and the register is updated with these counts. The average number of the two counts is used. In addition to the animals included in the register of production subsidies, an estimate of the number of horses that are not used in farming is obtained from the Norwegian Agricultural Economics Research Institute (NILF). The number of reindeer is obtained from the Norwegian Reindeer Husbandry Administration.

For some categories of animals not living a whole year, for instance lambs, lifetime is taken into account to get a yearly average for the number of animals. An expert judgment suggests an average lifetime of 143 days for lambs. The formula for calculating the average figure for lambs will then be:

$$(20) \qquad Lambs * \frac{143}{365}$$

There exist some differences between these numbers and the FAO statistics. The explanation is, that the figures to the FAO are supplied by the Norwegian Agricultural Economics Research Institute (NILF). NILF elaborates an overall calculation for the agricultural sector, which is the basis for the annual negotiations for the economic compensation to the sector. The overall calculation includes a grouping of all agricultural activities, comprising area, number of animals and production data. This method is a little different from the one used by Statistics Norway. Differences include

- Different emphasis on the dates for counting, 31.07 and 31.12
- NILF does not register pigs under 8 weeks, whilst Statistics Norway does.

6.2.4. Emission factors

The emissions depend on several factors and therefore vary between different individuals of one kind of animal. However, because of a lack of data to perform Tier 2 calculations, the Tier 1 default emission factors for each kind of animal (IPPC 1997a, 1997b) are used. The emissions from domestic reindeer, deer, ostrich and fur-bearing animals are included in the Norwegian calculations. Emission factors for these animals are developed by scaling emission factors for other animals that are assumed most similar with regard to digestive system and feeding. The scaling is done by comparing average weights for the actual animal groups. The emission factor used for reindeer is 11 kg/animal/yr, and has been estimated by scaling the emission factors for goats and sheep according to carcase weight. The emission factor for deer of 52.64 kg/animal/yr has been estimated by scaling the emission factor for dairy cattle, and the emission factor 4.97 kg/animal/yr for ostrich by scaling the emission factor for horses. The emission factor for fur-bearing animals is set to 0.10 kg/animal/yr, and has been estimated by scaling the emission factor for swine.

Table 55. Emission factors for CH_4 from enteric fermentation and different animal types

Animal	Emission factor (Tonnes/animal/year)
Dairy cattle	0.1
Non-dairy cattle	0.048
Horses	0.018
Sheep, incl. lambs	0.008
Goats	0.005
Pigs	0.0015
Hens	0.00002
Turkeys	0.00002
Reindeer	0.011
Deer	0.053
Ostrich	0.0050
Fur-bearing animals	0.0001

Source: IPCC (1997a, 1997b) and Agricultural Statistics from Statistics Norway.

6.2.5. Uncertainties

Activity data
The data are considered to be known within ±5-10 per cent. There is also an uncertainty connected to the fact that some animals are only alive part of the year, and a great uncertainty connected to the number of all types of poultry.

Emission factors
Although the emissions depend on several factors and therefore vary between different individuals of one kind of animal, average emission factors for each kind are used. The standard deviation of the emission factors is considered to be ±25 per cent. The use of IPCC Tier 1 emission factors leads to enhanced uncertainty compared with Tier 2.

6.2.6. Completeness
Major missing emission sources are not likely. There has been a tendency the last years for an increase in the body mass for dairy cattle. This constitutes an uncertainty factor that is not reflected in the simple Tier 1 methodology.

6.2.7. Source specific QA/QC
In 2001, a project was initiated to determine the exact number of animal populations. This was completed in 2002. The revised data on animal populations form the basis for the emission calculations for all years.

6.2.8. Recalculations
New revised figures for the population of different animals have been used for the whole time period 1990-2002. No recalculations are carried out since last year.

6.2.9. Planned improvements
Norway intends to update the methodology to Tier 2, however it is still uncertain exactly when this will be undertaken.

6.3. Emissions from manure management -4B- CH_4- , N_2O (Non Key Source)

6.3.1. Description

The relevant pollutants emitted from this source category are CH_4 (4B), N_2O (4B) and NH_3 (4B)
CH_4-emissions due to manure management amounted to 14.6 ktonnes in 2003, corresponding to 0.31 Mtonnes CO_2 equivalents.
N_2O-emissions due to manure management amounted to 0.35 ktonnes in 2003, corresponding to 0.14 Mtonnes CO_2 equivalents.

Manure management emitted in 2003 0.45 Mtonnes of CO_2 equivalents, which is 10 per cent of the GHG's from agriculture and 0.8 per cent of the Norwegian emissions of GHGs.

Emissions of GHGs from manure management decreased with 5 % in the period 1990-2003.

Organic material in manure is transformed to CH_4 in an anaerobic environment by microbiological processes. Emissions from cattle are most important in Norway. The emissions from manure depend on several factors; type of animal, feeding, manure management system and weather conditions (temperature and humidity).

During storage and handling of manure (i.e. before the manure is added to soils), some nitrogen is converted to N_2O. The amount released depends on the system and duration of manure management. Solid storage and dry lot of manure is the most important source.

In the IPCC default method a NH_3 volatilisation fraction of 20 per cent is used for the total N excretion by animals in the country. But in the Norwegian emission inventory, ammonia volatilisation values from Statistics Norway's ammonia model are used, which are expected to give more correct values for Norway. Emissions of NH_3 from manure depend on several factors, e.g. type of animal, nitrogen content in fodder, manure management, climate, time of spreading of manure, cultivation practices and characteristics of the soil.

6.3.2. Methodological issues

CH_4

Emissions of methane from manure are estimated using the following equation, in accordance with the IPCC Tier 2 method (IPCC 1997a, 1997b):

$$(21) \qquad E_i = \frac{N_i \cdot M_i \cdot VS_i \cdot B_{0_i} \cdot MCF_i}{1000}$$

E: Emissions of methane
N: Population of animals
M: Production of manure (kg/animal/year)
VS: Volatile solids (per cent)[6]
B_0: Maximum methane-producing capacity (m^3/kg-VS)
MCF: Methane conversion factor
$_i$: Species

Table 56. Norwegian factors used to estimate CH_4 from manure management in the IPCC Tier 2 method

	Manure production (kg/animal/day)	VS (per cent)	B_0 (m^3/kg-VS)	MCF (per cent)
Dairy cattle	45	9.2	0.18	8
Bulls > 1 year	35	9.2	0.21	8
Heifers > 1 year	30	9.2	0.21	8
Non-dairy cattle < 1 year	15	9.2	0.21	8
Horses	25.5	16.4	0.21	8
Sheep > 1 year	2	19.5	0.19	5
Sheep < 1 year	1	19.5	0.19	5
Diary goats	1.8	23	0.19	5
Other goats	1	23	0.19	5
Pigs for breeding	9	9.5	0.21	8
Pigs for slaughter	4.5	9.5	0.21	8
Hens	0.16	15.6	0.25	8
Chicks bred for laying hens	0.085	19.4	0.25	8
Chicks for slaughter	0.085	19.4	0.25	8
Ducks for breeding	0.17	16	0.25	8
Ducks for slaughter	0.057	16	0.25	8
Turkey and goose for breeding	0.7	16	0.25	8
Turkey and goose for slaughter	0.29	16	0.25	8
Mink, males	0.35	16	0.25	8
Mink, females	0.7	16	0.25	8
Fox, males	0.56	16	0.25	8
Fox, females	1.12	16	0.25	8
Reindeer	2	19.5	0.19	2
Deer	23.7	9.2	0.18	8
Ostrich	7.05	16.4	0.21	8

Source: Agricultural Statistics from Statistics Norway and Norwegian University of Life Sciences.

The factors M, VS, B_0 and MCF are average factors meant to represent the whole country. The factor B_0 represents the maximum potential production of methane under optimum conditions. MCF is a correction of B_0 according to how the manure is handled reflecting Norwegian manure handling practices for each type of animal waste. The factors are estimated jointly by Statistics Norway and the Norwegian University of Life Sciences (Institute of Chemistry and Biotechnology, Section for Microbiology).

[6] Volatile solids (VS) are the degradable organic material in livestock manure (IPCC 1997a,b).

N_2O

In Norway, all animal excreta that are not deposited during grazing are managed as manure. N_2O from manure is estimated in accordance with the IPCC default method (IPCC 1997b), but with Norwegian values for N in excreta from different animals according to Table 57. Norwegian values are also used for the fraction of total excretion per species for each management system (MS) and for pasture. The same fractions are used every year and are given in Table 58.

Table 57. N in excreta from different animals

	kg/animal/year[1]
Dairy cattle	82
Heifer < 1 year	29
Bull < 1 year	24
Heifer > 1 year	35
Bull > 1 year	35
Horses	50
Sheep < 1 year	7.7
Sheep > 1 year	11.6
Goats	15.5
Pigs for breeding	18.3
Pigs for slaughtering[2]	4.4
Hens	0.7
Chicks bred for laying hens[2]	0.147
Chicks for slaughtering[2]	0.053
Ducks, turkeys/ goose for breeding[2]	2
Ducks, turkeys/ goose for slaughtering[2]	0.34
Mink	4.27
Foxes	9
Reindeer	6
Deer	12
Ostrich	12

[1] Includes pasture.

[2] Per stalled animal. Stall we define as the room for one animal. An animal that lives one year needs one stall the whole year. But for example in a stall (or pen) for slaughter swine you breed more than one slaughter swine per year. This means that the N in excreta for dairy cattle is from one cattle per year, but for slaughter swine is "per stalled animal" equal to 2.5 slaughter swine per stall (or pen) per year.

Source: Sundstøl and Mroz (1988) and estimations by Statistics Norway.

Table 58. Fraction of total excretion per specie for each management system and for pasture

	Anaerobic Lagoon	Liquid system	Solid storage and drylot	Pasture range and paddock	Other manure management systems
Dairy cattle	0	0.68	0.05	0.27	0
Non-dairy cattle	0	0.64	0.05	0.31	0
Poultry	0	0.27	0.73	0	0
Sheep	0	0.17	0.38	0.44	0
Swine	0	0.88	0.12	0	0
Other animals	0	0.14	0.41	0.45	0

Source: Gundersen and Rognstad (2001) and data for pasture times from Tine BA (2003) (Dairy cattle, goat), Statistics Norway's Sample Survey 2001 (Statistics Norway 2002) (non-dairy cattle, sheep) and expert judgements.

The emissions of nitrous oxide from manure are estimated using the following equation, in accordance with the IPCC Tier 2 method (IPCC 1997a, 1997b):

$$(22) \qquad E = \sum_s \left\{ \left[\sum_i \left(N_i \cdot Nex_i \cdot MS_{i,s} \right) \right] \cdot EF_s \right\}$$

E: Emissions of N_2O-N (kg N_2O-N/year, N_2O-N is the nitrate amount in the nitrous oxide compound)
N: Population of animals
Nex: Annual average N excretion (kg N/animal/year)
MS: Fraction of total excretion per specie for each management system
EF: N_2O emission factor (kg N_2O-N/kg N)
$_S$: Manure management system
$_i$: Species

NH_3

Statistics Norway's NH_3 model is used for calculating the emissions of ammonia from manure management. The principle of the model is illustrated in Figure 26.

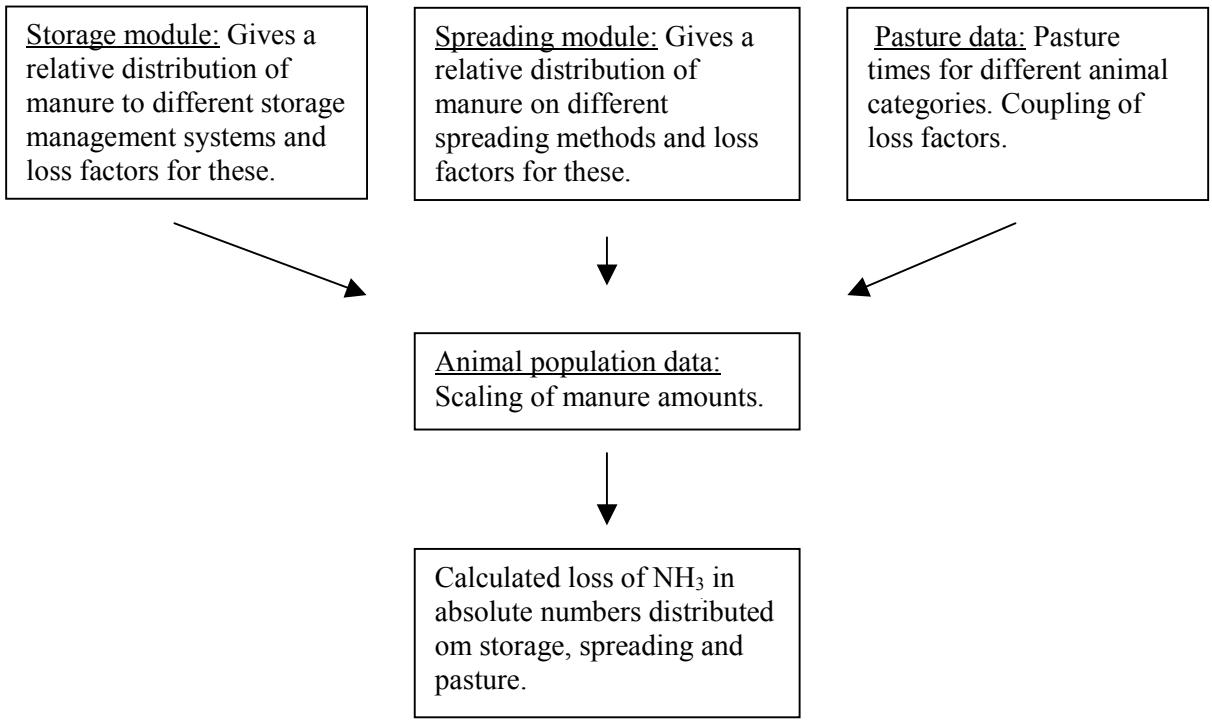


Figure 26. The principle of the NH_3 model

The storage module in the NH_3 model gives the relative distribution of manure to the different storage management systems. Total emissions from storage are estimated by multiplying the different emission factors for the storage systems by the amount of manure for each storage system and summarizing the results. The amount of manure is estimated by the number of animals and manure production factors for each type of animal (see Table 57).

6.3.3. Activity data

CH_4 and N_2O

Emissions are estimated from the animal population. How the animal population is estimated is described in Section 6.2.3.

NH_3

Activity data on storage systems are rare, and the only source practically available is the Statistics Norway survey of different storage systems in 2000 (Gundersen and Rognstad 2001). In addition, data on animal populations are used to estimate the amounts of manure. How the animal population is estimated is described in Section 6.2.3.

The manure is distributed to the following storage systems categories:

- Manure cellar for slurry
- Manure pit for slurry
- Indoor built up/deep litter
- Outdoor built up/enclosure
- Storage for solid dung and urine

Each of these categories are given for all combinations of the following productions and regions:
Regions:

- South-Eastern Norway
- Hedmark and Oppland
- Rogaland
- Western Norway
- Trøndelag
- Northern Norway

Production:

- Cattle
- Pork
- Sheep and goat
- Poultry
- Horse, farm raised fur-bearing animals and rabbit

Data for storage systems are unavailable for other years than 2000. Analyses and estimations of the effects on emissions of the assumed changes in storage systems since 1990, show that the assumed change is of little significance to the emissions.

6.3.4. Emission factors

CH_4
The calculated average emission factors for different animal types are shown in Table 59. They are country specific factors which may deviate from the IPCC default values.

Table 59. Average CH_4 emission factors for manure management in the Norwegian method. Tier 2

	Emission factor (kg/animal/day)
Dairy cattle	14.41
Bulls > 1 year	13.07
Heifers > 1 year	11.20
Non-dairy cattle < 1 year	5.60
Horses	16.98
Sheep > 1 year	0.90
Sheep < 1 year	0.45
Dairy goats	0.95
Other goats	0.53
Pigs for breeding	3.47
Pigs for slaughter	1.74
Hens	0.12
Chicks bred for laying hens	0.08
Chicks for slaughter	0.08
Ducks for breeding	0.13
Ducks for slaughter	0.04
Turkey and goose for breeding	0.54
Turkey and goose for slaughter	0.23
Mink, males	0.27
Mink, females	0.54
Fox, males	0.43
Fox, females	0.87
Reindeer	0.36
Deer	7.58
Ostrich	4.69

Source: Agricultural Statistics from Statistics Norway.

N_2O

The IPCC default values for N_2O emission factors from manure management are used. These are consistent with the good practice guidance (IPCC 2001).

Table 60. N_2O emission factors for manure management per manure management system

Manure management system	Emission factor, kg N_2O-N/kg N
Anaerobic lagoon	0.001
Liquid system	0.001
Daily spread	0
Solid storage and dry lot	0.02
Pasture range and paddock	0.02
Other system	0.005

Source: IPCC (1997b).

NH_3

Emission factors vary with production and storage system; in the model there is no variation between regions. The factors used are shown in Table 61:

Table 61. Emissions factors for various storage systems and productions. Per cent of total N

	Storage system						
	Manure cellar for slurry	Open manure pit for slurry	Manure pit for slurry with lid	Open flagstones	Indoor built up/deep litter	Outdoor built up/enclosure	Storage for solid dung and urine
	Gutter	Gutter		Drainage to gutter			
Cattle, milking cow:							
Loss from animal room	5	5	5	5	8	8	5
Loss from storage room	2	9	2	2	15	15	15
Total loss	7	14	7	7	23	23	20
Pigs:							
Loss from animal room	15	15	15	15	15	15	20
Loss from storage room	4	6	2	2	25	25	30
Total loss	19	21	17	17	40	40	50
Sheep and goats:							
Loss from animal room	15	15	15	15	15	15	15
Loss from storage room	2	6	2	2	10	10	10
Total loss	17	21	17	17	25	25	25
Poultry:							
Loss from animal room	12	10	12	12	25	25	25
Loss from storage room	15	15	15	15	25	25	25
Total loss	27	25	27	27	50	50	50
Other animals:							
Loss from animal room	5	0	0	0	15	15	15
Loss from storage room	10	0	0	0	15	15	15
Total loss	15	0	0	0	30	30	30

Source: Morken (2003).

The factors in Table 61 are based on data from Denmark, Germany and Netherlands, since measurements of NH_3-losses in storage rooms have so far not been carried out in Norway.

The factors are combined with the activity data in the survey (Gundersen and Rognstad 2001), and emission factors for NH_3 emissions from storage of manure and stalled animals are calculated for production and region (Table 62). To estimate losses, these emission factors are in turn multiplied with the amount of manure (based on number of animals and N-factors per animal). The number of animals is the only activity data that differs from year to year. New additional data on storage facilities will be available from the Sample survey of agriculture and forestry 2003.

Table 62. Average emission factors for the manure storage systems used, distributed on type of animal production and region. Per cent of total N

	South-Eastern Norway	Hedmark/Oppland	Rogaland	Western Norway	Trøndelag	Northern Norway
Cattle	9.6	8.2	8.8	8.1	7.7	7.7
Pigs	25.4	22.3	20.1	21.5	21.0	21.9
Sheep and goats	23.5	22.8	19.1	22.1	22.8	23.4
Poultry	47.0	46.4	38.7	37.3	41.7	44.5
Other animals	27.9	25.5	20.2	24.5	26.3	25.6

Source: Statistics Norway, NH_3-model estimations.

6.3.5. Uncertainties

6.3.5.1. Activity data

CH_4

The data for the number of animals are considered to be known within ±5-10 per cent(Rypdal and Zhang 2001). There is also an uncertainty connected to the fact that some animals are only alive part of the year and a great uncertainty connected to the number of all types of poultry. Other activity data are the different kinds of treatment of manure (which will determine the emission factor), which have been assessed by expert judgements. This will contribute to the uncertainty.

N_2O

Emissions are estimated from the animal population. The data for the number of animals are considered to be known within ±5-10 per cent(Rypdal and Zhang 2001). There is also an uncertainty connected to the fact that some animals are only alive part of the year and also a great uncertainty connected to the number of all types of poultry.

For the emissions of N_2O from manure management, Norwegian data for N in excreta are used. The nitrogen excretion factors are uncertain, but the range is considered to be within ±15 per cent. The uncertainty is connected to differences in excretion between farms in different parts of the country, that the survey farms may not have been representative, general measurement uncertainty and the fact that fodder and fodder practices have changed since the factors were determined.

There is also an uncertainty connected to the division between different storage systems for manure.

NH_3

Animal population data are considered to be known within ±5-10 per cent (Rypdal and Zhang 2001). There is also an uncertainty connected to the fact that some animals are only alive part of the year, and an uncertainty connected to the number of all types of poultry. The uncertainty for manure use is considered to be ±20 per cent (Rypdal and Zhang 2001). Uncertainty connected to the distribution between storage systems has not been estimated, but this uncertainty is assumed to be much larger than the uncertainty in the animal population data.

6.3.5.2. Emission factors

CH_4

Norway is using the IPCC default factors (Tier 2 methodology) for the emission of CH_4, but with some national data. The emission factors are considered to have the uncertainty range ±25 per cent (Rypdal and Zhang 2000).

N_2O

For the emission of N_2O from different storage systems, IPCC default emission factors are used. They have an uncertainty range of -50 to +100 per cent (IPCC 2001) except for the storage category "daily spread" where it is not applicable.

NH_3
Ammonia emissions from agriculture are estimated based on national conditions. There is not made any uncertainty analysis for the revised NH_3 model, which is in use since 2003. The revision of the model has reduced the uncertainty, but there are still uncertainties in several parameters (fraction of manure left on pastures, amount of manure, conditions of storage, conditions of spreading and climate conditions).

6.3.6. Completeness
Major missing emission sources are not likely.

6.3.7. Source specific QA/QC
In a Nordic project in 2002, the results for emissions of both CH_4 and N_2O from manure management in the national emission inventories have been compared with the results using the IPCC default methodology and the IPCC default factors (Petersen and Olesen 2002). This study contributed to discover differences and gaps in each of the Nordic national methodologies.

Statistics Norway has, in cooperation with the Norwegian University of Life Sciences (UMB), made improvements in the calculation model for ammonia emissions from the agricultural sector. Data sources used for the recalculations in the revised NH_3 model are coefficients from the Norwegian University of Life Sciences, and two surveys from Statistics Norway; a manure survey (Gundersen and Rognstad 2001) and the sample survey of agriculture and forestry (2001).

Statistics Norway's detailed manure survey gives more extended activity data which are better related to emission source categories, for manure management and spreading. New loss factors for different manure management categories are also used in the revised NH_3-model. These factors are closer connected to specific activities.

6.3.8. Recalculations
Emissions of N_2O from storage of manure are revised. The percentage distribution between different storage systems for manure and grazing is adjusted to Norwegian condition. The estimated emissions of N_2O from storage have been corrected for losses of N due to transformation of N_2O to volatile NH_3. The correction has been distributed on storage systems after how much the different storage systems are being used.

6.3.9. Planned improvements
No improvements are planned for 2005.

6.4. Direct and indirect emissions from agricultural soils - 4D - N_2O (Key Source)

:

6.4.1. Description

From agricultural soils in Norway are emitted the greenhouse gases N_2O and CO_2. The latter is treated in the next section.

The emissions of N_2O in Norway from agricultural soils amounted to 7.6 ktonnes in 2003, or 2.36 Mtonnes calculated in CO_2-equivalents. They accounted for about 44 per cent of the total Norwegian N_2O emissions in 2003 or about 4 per cent of the total Norwegian greenhouse gas emissions that year

Emissions from agricultural soils is a key source because of uncertainty, both in level and trend.

The emissions decreased by 2 % in the period 1990-2003 and increased by 2 % from 2002 to 2003

Three sources of N_2O from agricultural soils are distinguished in the IPCC methodology, namely:

- Direct emissions from agricultural soils (from use of synthetic fertilisers, animal excreta nitrogen used as fertiliser, biological nitrogen fixation, crop residues, industrial and urban wastes and cultivation of soils with a high organic content);
- Direct soil emissions from animal production (emissions from droppings on pastures);
- N_2O emissions indirectly induced by agricultural activities (N losses by volatilisation, leaching and runoff).

The use of synthetic fertilisers, animal excreta nitrogen as fertiliser, and droppings on pastures also give emissions of NH_3. For these sources, the calculated amount of nitrogen that is emitted directly as N_2O has been corrected for the nitrogen emitted as NH_3.

6.4.2. Methodological issues

6.4.2.1. Synthetic fertiliser

N_2O

The direct emissions of N_2O from use of synthetic fertiliser are calculated from data on annual consumption of fertiliser and its nitrogen content, multiplied with the IPCC default emission factor. The emissions are corrected for ammonia (NH_3) that volatilises during spreading.

NH_3

Statistics Norway's NH_3 model (described section 6.3.2) is used for calculating the emissions of ammonia from the use of synthetic fertiliser. The calculations of NH_3 emissions from the use of synthetic fertiliser are based on the amounts of nitrogen supplied and emission factors for the percentage of nitrogen emitted as NH_3 during spreading.

6.4.2.2. Manure applied to soils

N_2O

In Norway, all animal excreta that are not deposited during grazing are used as manure and applied to soils. Further, it is assumed that animals do not emit N_2O themselves, but emissions of N_2O and NH_3 from manure management before manure application on fields are taken into account (see section 6.3.2).

The emission of N_2O from manure used as fertiliser is calculated by multiplying the total amount of N in manure used as fertiliser with the IPCC default emission factor. The N_2O emissions are corrected for NH_3 that volatilises during spreading.

NH_3

Statistics Norway's NH_3 model is used for calculating emissions of ammonia from spreading of manure on cultivated fields and meadow. A spreading module in the NH_3 model gives the relative distribution of manure spread as fertiliser, distributed on different spreading methods. Total emissions from spreading are estimated by emission factors for the different spreading methods multiplied by the amount of manure. The amount of manure is estimated by the number of animals and manure production factors for each type of animal.

6.4.2.3. N_2O from biological nitrogen fixation

Another source of N_2O emissions is biological nitrogen fixation. The most important N-fixing crop in Norway is clover. The amount of nitrogen fixed by a crop is very uncertain, and it is difficult to assign a conversion factor for N_2O emissions derived from nitrogen fixation (IPCC 1997a, 1997b). The amount of nitrogen fixed is multiplied with the IPCC default emission factor.

6.4.2.4. N_2O from crop residues

Concerning re-utilisation of nitrogen from crop residues, there is only limited information. Nitrous oxide emissions associated with crop residue decomposition are calculated by estimating the amount of nitrogen entering soils as crop residue, as recommended by the IPCC (1997a, 1997b). The amount of nitrogen in crop residues returned to soils is assumed to be equal to that in the harvest (Aakra and Bleken 1997).This assumption differs from the default method and the review report for 2004 recommended explanations and eventually recalculations using the default method. Due to budgetary limitations this has not yet been possible. The amount of different harvested crops are multiplied with country specific N-factors, see Table 63. The amount harvested N has then been corrected for the amount burned on fields and for the water content that is set as 15 per cent (IPCC default for wheat and barley). The remaining amount has been multiplied with the IPCC default emission factor.

Table 63. N-factors used for the calculation of the nitrogen content in crop residues.

	per cent N
Grass	1.8
Cereals	1.7
Straw	0.6
Potatoes	0.35
Roots for feed	0.25
Green fodder	0.25
Fruits	0.06
Berries	0.11
Vegetables	0.25

Source: Aspmo (1986) and Statistics Norway.

6.4.2.5. N_2O from industrial and urban wastes

No data are available for the amount of N in industrial waste applied as fertiliser, but this source is assumed to be very limited in Norway. Data for the N_2O emission arising from sewage sludge applied on fields has been calculated by multiplying the amount of nitrate in the sewage sludge applied with the IPCC default emission factor. Statistics Norway (waste water statistics) annually gives values for the amount of sewage sludge, and the fraction of the sewage sludge that are applied on fields. The N-content in the sludge is given in Statistics Norway (2001), and the same value of 2.82 per cent is used for all years.

6.4.2.6. N_2O from cultivation of soils with a high organic content

Large N_2O emissions occur as a result of cultivation of organic soils (histosols) due to enhanced mineralization of old, N-rich organic matter (IPCC 1997a, 1997b). The emissions

are calculated using the IPCC default emission factor of 8 kg N_2O-N/ha per year, and an approximation of the area of cultivated organic soil in Norway. The same activity data are used for all years, due to lack of annual data. Jordforsk (the Norwegian Centre for Soil and Environmental Research) has estimated that there is 64 438 ha organic agriculture soils based on more than 500 000 soil samples. However, they expect organic soils to be underrepresented in their sampling. Jordforsk expect the real area to be between 70 000 and 100 000 ha (Jordforsk 2004). It is assumed to be 85 000 ha in the calculations. The estimate of organic soils is based on measurements of C in the soil. The estimate takes into account that the C in soil is gradually decreased and after some decades the soil is no longer classified as organic.

6.4.2.7. Direct soil emissions from animal production (emissions from droppings on pastures)

N_2O

The fraction of the total amount of animal manure produced that is droppings on pastures is given by national data for the distribution of manure to different storage systems (Gundersen and Rognstad 2001) and data for pasture times (Table 58). The amount of N deposited during grazing is multiplied with the IPCC default emission factor. The resulting emissions are corrected for the amount of ammonia volatilised.

NH_3

Statistics Norway's NH_3 model is used for calculating the emissions of ammonia from pastures. Animal population data, data for pasture times, and factors for the nitrogen amount in excreta for different animal categories give the nitrogen amounts for the animal categories on pastures. Specific emission factors by animal category are used.

6.4.2.8. N losses by volatilisation

Atmospheric deposition of nitrogen compounds fertilises soils and surface waters, and enhances biogenic N_2O formation. Climate and fertiliser type influence the ammonia volatilisation. Deposition of ammonia is assumed to correspond to the amount of NH_3 that volatilises during the spreading of synthetic fertiliser, storage and spreading of manure, and volatilisation from pastures. This amount is obtained from Statistics Norway's ammonia model. The N_2O emissions are calculated by multiplying the amount of N from deposition with the IPCC default emission factor.

6.4.2.9. N_2O from leaching and runoff

A considerable amount of fertiliser nitrogen is lost from agricultural soils through leaching and runoff. Fertiliser nitrogen in ground water and surface waters enhances biogenic production of N_2O as the nitrogen undergoes nitrification and denitrification. The fraction of the fertiliser and manure nitrogen lost to leaching and surface runoff may range from 10 to 80 per cent. The IPCC (1997a, 1997b) proposes a default value of 30 per cent, but in the Norwegian inventory a national factor of 18 per cent (Jordforsk 1998) is used. This country specific factor has been estimated from a runoff model by Jordforsk (Norwegian Centre for Soil and Environmental Research), and is believed to give better results under Norwegian conditions. The amount of nitrogen lost to leaching is multiplied with the IPCC default emission factor to calculate the emission of N_2O.

6.4.3. Activity data

N_2O

The activity data significant for the estimation of direct and indirect emissions of N_2O from agricultural soils and N_2O emissions from pastures, and the sources for the activity data are listed in Table 64.

Table 64. Activity data for process emissions of N_2O in the agriculture

	Sources
Consumption of synthetic fertilizer	Norwegian Food Safety Authority
Number of animals	Statistics Norway (applications for productions subsidies)
Distribution between manure storage systems	Gundersen and Rognstad (2001)
Pasture times for different animal categories	Tine BA (2003) (Dairy cattle, goat), Statistics Norway's Sample Survey 2001 (Statistics Norway 2002) (non-dairy cattle, sheep), expert judgements.
Biological N-fixation	Aakra and Bleken (1997)
Crop yield	Statistics Norway
Amount of sewage sludge	Statistics Norway, waste water statistics
Fraction sewage sludge applied on fields	Statistics Norway, waste water statistics
Area of cultivated organic soils	Jordforsk (2004)

NH_3

-Synthetic fertiliser

The Norwegian Food Safety Authority calculates a total value for annual consumption of synthetic fertilisers in Norway based on sale figures. For the calculation of the emission of NH_3 we need a specification of the use of different types of synthetic fertiliser. Due to the lack of newer data, we have to assume that the percentual distribution between the usage of different fertiliser types is the same as in 1994, see Table 66.

-Animal manure applied to soil and pasture

There are several sources of activity data on spreading of manure in the NH_3-model. The main sources are the manure survey in 2000 by Statistics Norway (Gundersen and Rognstad 2001), various sample surveys of agriculture and forestry 1990-2001 and the annual animal population. Animal population is updated annually. The animal population estimation methodology is described in Section 6.2.3. Data from the manure survey exists only for 2000, while the data from the sample surveys have been updated for several, but not all, years.

Data for time on pasture and share of animals on pasture are collected from the Sample Survey in Statistics Norway 2000 and from TINE BA (TINE BA is the sales and marketing organisation for Norway's dairy cooperative and covers most of the milk production). The data from TINE BA comprises pasture data for goats and milking cows and are updated annually. All other pasture data are from the Statistics Norway Sample survey 2000. The parameters used in the calculations and their sources are shown in Table 65.

Table 65. Parameters included in the estimation of NH_3 emissions from manure

Parameters (input)	**Sources**
Number of animals	Statistics Norway (applications for productions subsidies)
Nitrogen factors for manure	Various sources, compiled by Statistics Norway
Area where manure is spread, split on cultivated field and meadow.	Statistics Norway (Sample Surveys of Agriculture), Gundersen and Rognstad (2001)
Area where manure is spread, split on spring and autumn.	Statistics Norway (Sample Surveys of Agriculture), Gundersen and Rognstad (2001)
Cultivation practices concerning the addition of water to manure, spreading techniques, and usage and time of harrowing and ploughing.	Gundersen and Rognstad (2001), expert judgements
Pasture times for different animal categories	Tine BA (Dairy cattle, goats), Statistics Norway's Sample Survey 2001 (non-dairy cattle, sheep), expert judgements.

6.4.4. Emission factors

N_2O

The IPCC default emission factor of 0.0125 kg N_2O-N/kg N has been used for all sources of direct N_2O emissions from agricultural soils, with the following two exceptions: Emissions of N_2O from animals on pastures are calculated using the IPCC factor of 0.02 kg N_2O-N/kg N, and the emissions that occur as a result of cultivation of organic soils are calculated by using the IPCC default emission factor of 8 kg N_2O-N/ha per year (IPCC 2001).

The IPCC default emission factor of 0.01 kg N_2O-N/kg NH_3-N is used to calculate emissions of N_2O from ammonia volatilised. The IPCC default emission factor of 0.025 kg N_2O-N/kg N lost to leaching/runoff is used.

NH_3

-Synthetic fertiliser

Different types of synthetic fertilisers are being used, resulting in different emissions of NH_3. Their share, based on data from 1994, and their NH_3 emission factors are shown in Table 66.

Table 66. Emission factors for NH_3-N for different fertilisers and their share of the total use of fertiliser

Fertiliser	Emission factor (per cent of applied N)	Used (per cent)
Urea	15	0.3
Ammonium sulphate and Ammonium nitrate	5	0.02
Calcium nitrate	0	9.7
Calcium ammonium nitrate	1	10.7
NPK	1	77.6
Other	1	1.6

Source: ECETOC (1994) and Norsk Hydro.

-Animal manure applied to soil and pasture

Emission factors for spreading of stored manure vary with spreading method, water contents, type and time of treatment of soil, time of year of spreading, cultivation, and region. The basic factors used are shown in Table 67.

Table 67. Emissions factors for NH_3-N for various methods of spreading of manure. Per cent of total N

			Western and northern Norway			Southern and eastern Norway		
			Spring	Summer	Autumn	Spring	Summer	Autumn
Meadow								
Surface spreading			0.5	0.6	0.4	0.5	0.6	0.4
Injection			0.1	0.1	0.05	0.1	0.1	0.05
Water mixing			0.3	0.3	0.2	0.3	0.3	0.2
Dry manure			0.04	0.1	0.1	0.04	0.1	0.1
Open fields								
Method	Time before down-moulding	Type of down-moulding						
Surface spreading	0-4 hrs	plow	0.2		0.2	0.15		0.3
Surface spreading	+ 4 hrs	plow	0.5		0.35	0.4		0.4
Surface spreading	0-4 hrs	harrow	0.4		0.35	0.35		0.35
Surface spreading	+ 4 hrs	harrow	0.5		0.45	0.45		0.45
Water mixing	0-4 hrs	plow	0.1		0.1	0.1		0.15
Water mixing	+ 4 hrs	plow	0.25		0.2	0.2		0.25
Water mixing	0-4 hrs	harrow	0.2		0.2	0.2		0.2
Water mixing	+ 4 hrs	harrow	0.3		0.25	0.25		0.25
Dry manure			0.04		0.1	0.04		0.1

Source: Morken and Nesheim (2004):

The factors in Table 67 are combined with the activity data in the survey (Gundersen and Rognstad 2001) and a time series on mixture of water in manure, and emission factors for NH_3 emissions from spreading of manure distributed to meadow and cultivated fields, time of season and region are calculated (see Table 68). These factors are in turn connected to activity data that are updated in the years since 1990, i.e. number of animals (amount of manure), time of spreading and type of cultivation of the areas where the manure is spread.

Table 68. Average NH_3 emission factors for cultivated fields and meadows after time of spreading and region. Per cent. 2000

	South-Eastern Norway		Hedmark/ Oppland		Rogaland		Western Norway		Trøndelag		Northern Norway	
	Field	Meadow	Field	Meadow	Field	Meadow	Field	Meadow	Field	Meadow	Field	Meadow
Spring	32.9	43.1	35.3	43.0	23.2	49.1	4.0	40.4	28.7	46.8	5.1	49.5
Autumn	28.5	31.1	28.9	31.0	21.2	36.0	10.0	29.4	31.1	34.3	11.0	36.4

Source: Statistics Norway, NH_3-model estimations.

The emission factors used for the calculation of the NH_3 emissions from grazing animals are shown in Table 69. These are the same as the emission factors used in Germany (Dämmgen et al. 2002) and Denmark (Hutchings et al. 2001).

Table 69. Ammonia emission factors from droppings from grazing animals on pasture. Per cent

	N-loss/N applied
Cattle	7.5
Sheep and goats	4.1
Reindeer	4.1
Other animals	7.5

Source: Dämmgen et al. (2002), Hutchings et al. (2001).

6.4.5. Uncertainties

6.4.5.1. Activity data

There are several types of activity data entering the calculation scheme:

Sales of nitrogen fertiliser: The data are based on sales figures during one year (The Norwegian Food Safety Authority). The uncertainty in the sales figures is within ±5 per cent. Another possible error is that sale does not equal consumption in a particular year due to storage. The distribution between the use of the various types of nitrogen fertiliser is fixed to an investigation in 1994, and the error connected to this approach will probably increase over the years.

Ammonia losses from fertilizer containing ammonium are related to soil pH. This could probably also lead to uncertainness, but Norwegian soils are very dominated by soils with low pH, which leads to small losses of this type.

Amount of nitrogen in manure: The figures are generated for each animal type, by multiplying the number of animals with a nitrogen excretion factor. The nitrogen excretion factors are uncertain. However, due to research on nitrogen leakage problems in parts of Norway, the certainty has been improved over time (the range is considered to be within ±15 per cent). The uncertainty is connected to differences in excreted N between farms in different parts of the country, that the farms included in the same survey may not have been representative, general measurement uncertainty and the fact that fodder and feeding practices have changed since the factors were determined.

The uncertainty connected to the estimate of the amount of manure is higher than for the amount of synthetic fertiliser used.

Fate of manure: There is significant uncertainty connected to the allocation of manure between what is used as fertiliser and droppings on pastures.

Nitrogen in crop residues left after harvest: Norwegian factors have been used. These are 40 per cent lower than the IPCC default factors. The amount of nitrogen in the harvest is determined within ±10 per cent, but the expansion factor to account for nitrogen left after harvest is very uncertain. The assessed uncertainty range is about ±50 per cent.

Deposition of other agricultural emissions: The data are based on national NH_3 emission figures. These are within ±30 per cent.

Leakage of nitrogen: The upper limit for the leakage is the applied nitrogen. The uncertainty is roughly about ±70 per cent.

Cultivation of organic soils: Data are based on a one-year survey, and are uncertain by more than a factor of three.

6.4.5.2. Emission factors

N_2O

The uncertainties in the N_2O emission factors are high. In Rypdal and Zhang (2000), a factor of two was assumed, according to IPCC (1997b). In IPCC (2001), these uncertainty intervals have been narrowed somewhat. Aardenne et al. (1998) has estimated a 95 per cent confidence interval uncertainty (in emissions) of -40 to +70 per cent for this source, but this may not contain all systematic errors.

NH_3

The uncertainty in the estimate of emissions of NH_3 from use of fertiliser is assessed to be about ±20 per cent. This uncertainty could be lower if better data on fertiliser composition were obtained. The uncertainty is higher for animal manure (±30 per cent). This is due to uncertainties in several parameters (fraction of manure left on pastures, amount of manure, conditions of storage, conditions of spreading and climate conditions) (Rypdal and Zhang 2001). Other factors that could lead to uncertainness are variation in storage periods, variation in house types and climate, variation in manure properties.

6.4.6. Completeness

All sources described in the IPCC reporting guidelines are included in the estimates. However, the emission factors might not be reflecting national conditions.

6.4.7. Source specific QA/QC

In a Nordic project in 2002, the estimates for emissions of direct and indirect N_2O from agricultural soils in the national emission inventories have been compared with the results using the IPCC default methodology and the IPCC default factors. The results for the Nordic countries are presented in a report (Petersen and Olesen 2002). The report concludes that there are significant differences between the Nordic countries in the application of the IPCC methodology. It states that there is a clear need to improve this IPCC methodology and to make it more locally adapted, but based on common guidelines. The emission factors for nitrous oxide from both direct and indirect sources, should be differentiated more than what is currently the case. There is a need to re-evaluate the principles of the current IPCC methodology for some of the emissions from manure management.

In 2002, the calculation methodologies for the agricultural soil emission sources have been surveyed and one source has been added (industrial and urban waste). Some work is being done to find more updated activity data.

Statistics Norway has, in cooperation with the Norwegian University of Life Sciences (UMB), made improvements in the calculation model for ammonia emissions from the agricultural sector. Data sources used for the recalculations in the revised NH_3 model are coefficients from the Norwegian University of Life Sciences, and two surveys from Statistics Norway; a manure survey (Gundersen and Rognstad 2001) and the sample survey of agriculture and forestry (2001).

Statistics Norway's detailed manure survey gives more extended activity data which are better related to emission source categories, for manure management and spreading. New loss factors for different manure management categories are also used in the revised NH_3-model. These factors are closer connected to specific activities.

6.4.8. Recalculations

Emissions of N_2O from spreading of manure, grazing animals and leakage have been revised for all years due to new knowledge. Emissions have decreased for all years. The new calculations are adjusted to Norwegian condition.
A new figure for the area of cultivated histosols are now available from JORDFORSK, and are used for all years Emissions of N_2O from crop residue are recalculated for all years. These emissions have earlier been reported constant since 1998.

6.4.9. Planned improvements

No further improvements have been planned for 2005.

6.5. Emissions from agricultural residue burning (agricultural wastes)- 4F - CH_4 , N_2O (Non Key Source)

Burning of agricultural residues gives emissions of a large range of standard combustion products, ranging from GHGs to heavy metals and POPs.

6.5.1. Method

CH_4, N_2O and NO_X
The emissions from the burning of crop residues are being calculated according to the guidelines in the IPCC reference manual (IPCC 1997b).

(23) $CR = CRB * Fdm * Fo * Fc$

CR:	Amount of carbon released (tonnes C/yr)
CRB:	Amount of crop residue burned (tonnes/yr)
Fdm:	Dry matter fraction
Fo:	Fraction oxidised
Fc:	Carbon fraction

(24) $E_i = CR * ER * MW_i * (N/C)$

E:	Emissions (tonnes/yr)
CR:	Carbon released (tonnes C/yr)
ER:	Emission ratio
MW:	Molecular weight conversion factor
N/C:	Nitrogen/Carbon-ratio
$_i$:	Emission component

Table 70. Factors used for agricultural residue burning in Norway

Factor	Value			Source
Fdm	0.85			IPCC (1997b)
Fo	0.9			IPCC (1997b)
Fc	0.4643			IPCC (1997b), FAO (2002)
	CH_4	*N_2O*	*NO_X*	
ER	0.005	0.007	0.121	IPCC (1997b)
MW	16/12	44/28	46/14	IPCC (1997b9
N/C	-	0.012	0.012	IPCC (1997b)

The amount of carbon released is calculated according to equation (23). In the IPCC manual a default value of 0.9 for the fraction oxidised is given, and water content of 15 per cent for wheat and barley, which are the main cereals that gives straw in Norway. To find the C-fraction in Norwegian straw, the default values given for wheat and barley in the IPCC manual are being used, and scaled according to the per cent distribution between the two cereals in Norway in 1999 due to Food and Agriculture Organization of the United Nations (FAO 2002).

To calculate the emissions of CH_4, the amount of carbon released is multiplied with an emission ratio. The emission ratio gives the mass of the actual chemical substance emitted (in C-units) related to the mass of the total carbon emissions by residual burning. To get total amount of emissions of the actual emission component, a molecular weight conversion factor must also be multiplied.

For N_2O and NO_X, the emission ratio gives the ratio of emissions of N_2O relative to the N-content of the crop residuals. This factor also has to be multiplied with the ratio between nitrogen and carbon.

For the emission ratios, the IPCC default values are used. As N/C ratio a value of 0.012 is used, which is the IPCC default value for wheat.

6.5.2. Activity data

The annual amount of crop residue burned on the fields is calculated based on data from Statistics Norway and the Norwegian Crop Research Institute.

6.5.3. Emission factors

Table 71. Emission factors for agricultural residue burning. g emitted/tonnes crop residue burned

Components	Emission factors
Greenhouse gases	
CH_4	2 400
N_2O	46.9
Precursors	
NO_X	1 700

6.5.4. Uncertainties

6.5.4.1. Activity data

The uncertainty concerning the amount of crop residues and other agricultural waste is high. An exact estimate of the uncertainty has not been made, but the amount can be underestimated due to lack of adequate statistics in this area.

6.5.4.2. Emission factors

IPCC default factors are used for the fractions of dry matter, carbon and the fraction oxidised. For the N/C-ratio and the emission ratio, IPCC default factors are also used. The ranges for the emission ratios are ±40 per cent for CH_4, ±28.6 per cent for N_2O and ±22.3 per cent for NO_X. The uncertainty in the data applied can be larger than this for all pollutants.

6.5.5. Completeness

As mentioned, the estimations may not be entirely complete, since the statistics are not of particularly high quality or completeness.

6.5.6. Source specific QA/QC

In 2002, the emissions of CH_4, N_2O, NO_X and dioxin from agricultural residual burning were included in the Norwegian inventory, and in 2003, the emissions of As, Cr and Cu were added. The time series was included but it should be noted that the figures for the earlier years have a higher uncertainty than the more recent years.

6.5.7. Recalculations

The share of straw burnt has been changed, based on new estimates for the years 2001-2004, from 15% and gradually down to 7.5%. Emissions of CH_4 and N_2O have decreased.

6.5.8. Planned improvement

No further improvements have been planned for 2005.

6.6. Other agricultural emission sources – 4G – NH_3 (Non Key Source)

Straw treated with NH_3 to be utilised as fodder is a source for NH_3 emissions in Norway. Agricultural activities are also a source of process emissions of particles. There are also stationary emissions of particles as a result of combustion of different energy commodities in motorized equipment used in the agriculture. These emissions are included in Chapter 3 Energy.

6.6.1. NH_3 emissions from treatment of straw

6.6.1.1. Methodological issues

Emissions of NH_3 from treatment of straw depend only on the amount of NH_3 used. It is estimated that 65 per cent of the ammonia applied is not integrated with the straw, and is therefore emitted after the treatment.

6.6.1.2. Activity data

The amount of NH_3 used per year is obtained from Norsk Hydro and the Norwegian Agricultural Supply Cooperative. The area of cultivated fields is given from a sample survey of agriculture and forestry made by Statistics Norway 2003.

6.6.1.3. Emission factor

The emission factor is estimated by the Department of Animal Science at the Norwegian University of Life Sciences.

6.6.1.4. Uncertainty

Uncertainty in the estimate of emissions from ammonia treatment of straw is rather low (±5 per cent) (Rypdal and Zhang 2001).

6.6.1.5. Completeness

Major missing emission components are not likely.

6.6.1.6. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. See Chapter for the description of the general QA/QC procedure.

6.6.2. Particle emissions from the agricultural sector

Agriculture is responsible for various types of process emissions of particles. This is for example dust from crop that is harvested, soil dust from work with agricultural machines, wood particles from felling of trees etc.

6.6.2.1. Methodological issues

Due to the relatively few analyses of particle emissions from agriculture the calculations from this source are limited. Emission figures for three types of process emissions of particles from the agriculture are calculated; emissions from reaper, and from loading and transport on the fields. The total grain cultivation area in Norway is multiplied with emission factors, which gives emissions per area unit. For other actual activities in the agricultural fields, no emission factors have been found.

6.6.2.2. Activity data

The total grain cultivation area in Norway is used as activity data. Data source used are statistics over the area on holdings used for grain seeds from Statistics Norway.

6.6.2.3. Emission factor

The emission factors used are shown in Table 72. These factors refer to wheat cultivation, but they are used for all grain cultivation in Norway. The factors are based on measurements of particles with a diameter less than 7 μm. No measurements have been made for estimating the ratio between $PM_{2,5}$, PM_{10} and TSP. Therefore the estimation has been made that the calculated emission figures (in reality PM_7) is $PM_{10} = PM_{2,5} = TSP$.

Table 72. Emission factors for process emissions of particles from the agricultural sector

Emission source	g/km^2
Reaper	170
Loading	12
Transport	110

Source: EPA (1998)

6.6.2.4. Uncertainty

No uncertainty analysis has been made for this source. The few studies made in this field give a relatively high uncertainty for this source.

6.6.2.5. Completeness

The information about this emission source is poor, and it is likely that there are more particle sources from the agricultural sector than included here.

6.6.2.6. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. See Chapter 1 for the description of the general QA/QC procedure.

7. Land-Use, Land-Use Change and Forestry (LULUCF)

7.1. Overview

The IPCC-report "Good Practice Guidance for Estimating and Reporting of Emissions and Removals from Land-use, Land-use Change and Forestry" was finalised last year (IPCC (2004), here called GPG 2004), and the methodologies were accepted by the Conference of the Parties of the UNFCCC to be used for annual reporting. A study has been conducted in Norway with the aim to provide estimates of emissions and removals from the LULUCF-sector using the IPCC Good Practice Guidance, as well as to provide documentation of the implementation of the GPG for Norway. The work was carried out by the Norwegian Institute of Land Inventory (NIJOS), Center for International Climate and Environmental Research (Cicero) and Statistics Norway (SN). The report from the study will be published later this year (NIJOS 2005). All the information in this chapter is extracted from the LULUCF-study. The CRF-tables for LULUCF are contained in Annex X.

The average annual net sequestration from the land-use, land-use change and forestry sector was about 15 Mtonnes of CO_2 for the period 1990-1996, and about 22 Mtonnes per year from 1998 to 2003. More precisely, in 2003 the net sequestration was calculated at 22.5 Mtonnes of CO_2, which would offset 41 per cent of the total greenhouse gas emissions in Norway that year. The sequestration increased by approximately 47 per cent from 1990 to 2003, while the increase from 2002 to 2003 was 0.6 per cent. In 2003 the land-use category forest remaining forest was the single contributor to the total amount of sequestration with about 25 Mtonnes CO_2. All other land-use categories showed net emissions, which totalled 2.5 Mtonnes CO_2. Of these, the most important category was grassland remaining grassland with total emissions of 1.9 Mtonnes of CO_2; while land converted to settlements (deforestation) was the second most important emissions category with 342 ktonnes of CO_2.

Forest covers around one fourth of the mainland area of Norway (Figure 28) and is the most important land use category considered managed. Changes in soil carbon were calculated during the LULUCF study, and have not been estimated previously. The sequestration was found to be is 1/10 of the sequestration in living biomass, around 0.5 Mtonnes C annually. The carbon stock change in dead organic matter is 20 % of the change in living biomass; about 1 Mtonnes is sequestered annually. The annual stock change has increased for soils and living biomass, but has decreased for dead wood (Figure 27). The differences can be explained by reduced harvest since 1990. The increase in living biomass can be explained by changes in management (e.g. grazing and harvest), but also to some extent by natural factors.

Farmed organic soils (mostly for grass production) contribute with relatively large CO_2 emissions (1.9 Mtonnes). The uncertainties are, however, large (more than a factor of 2). The estimate has been kept constant because annual data are missing, but large annual changes are not likely given that very little new organic soils are farmed at present. CO_2 emissions from agricultural mineral soils are small due to small new areas cleared for agriculture. Erosion control (in particular spring-till only) has contributed to a small sequestration.

We find it interesting that the total net removal in forest living biomass for the period 1990-2003 calculated here deviates only by about 6 per cent from the sequestration reported previously to UNFCCC using a lower tier method based on annual increment, losses and biomass expansion factors.

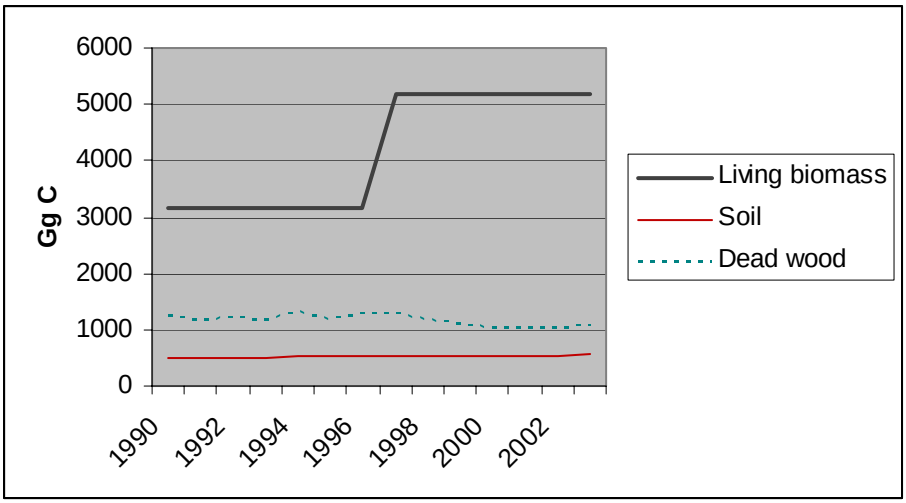


Figure 27. Carbon stock changes in forest living biomass, dead wood and soil organic carbon. 1990-2003.

Figure 27 shows the calculated carbon stock changes in forest land from 1990 to 2003.

The biomass has been assessed as an average for each inventory period and this value has been assigned to the reference year. Then an interpolation has been carried out in order to assess the annual change until next reference year. The reason for the increase in biomass is that annual fellings are much lower than the increment, thus causing an accumulation of wood and other tree components biomass.

Changes in soil carbon have not been reported or estimated earlier. From the study estimations of the sequestration in forest soil (forest remaining forest) were provided; they were calculated at around 0.5 Mtonnes carbon annually. On the other hand, calculations of carbon stock change in grassland soils showed a decrease in carbon of about the same amount; 0.5 Mtonnes C (corresponding to emissions of about 1.9 Mtonnes of CO_2). The uncertainties are, however, large (more than a factor of 2). The emissions factors will be reconsidered in light of a comprehensive Finnish research project which will be finalised in late 2005. CO_2 emissions from agricultural soils are minor due to small areas cleared for agriculture. Erosion control (in particular spring-till only) has contributed to a small sequestration.

The changes in land-use from 1990 to 2003 are quite small; the forest area is increasing and the agricultural area decreasing. Grassland and settlement areas have increased, while the deforested areas for settlements have been quite stable between 1990 and 2003. The changes in areas distributed on the six IPCC categories from 1990 to 2003 is illustrated in Figure 28.

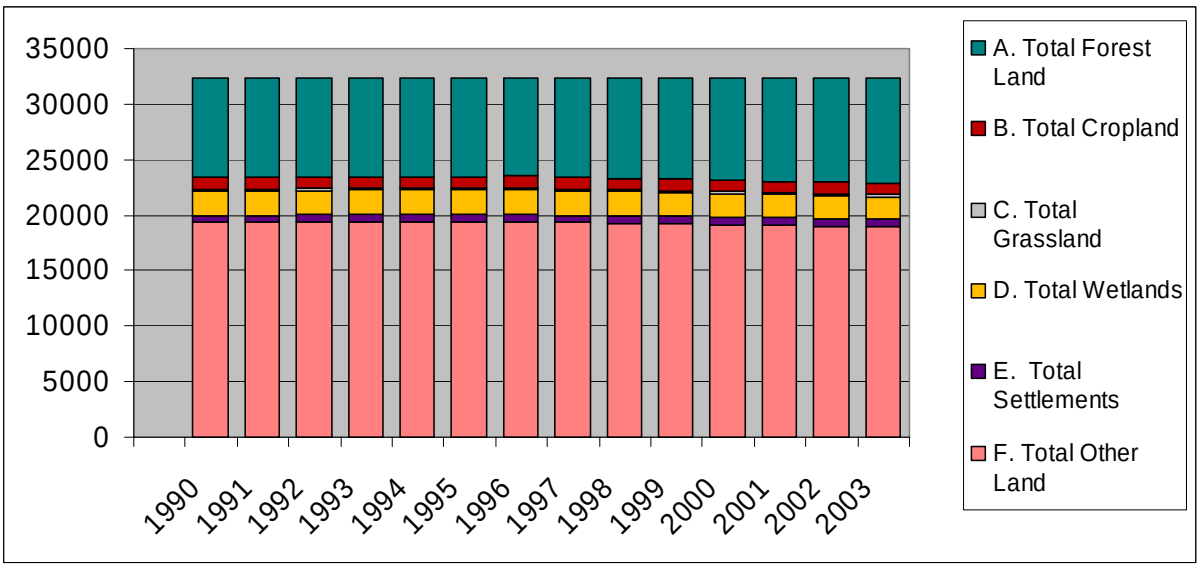


Figure 28. Area distribution on the IPCC land-use, land-use change and forestry categories 1990-2003 (k ha)

A key category analysis has been performed including non-LULUCF sources and the estimates for LULUCF provided in this report. LULUCF key categories identified using Tier 2 of GPG 2004 include the following:

- Living biomass in forest land remaining forest land (other) (5A1);
- Dead biomass in forest land remaining forest land (other) (5A1);
- Soil carbon in forest land remaining forest land (5A1);
- Soil carbon in forest land remaining forest land (drained organic soils) (5A1);
- Soil carbon in Grassland remaining grassland (histosols) (5C1).

In light of the importance of the forest sector and the lack of sources of statistical information that can be used to monitor all land-use transitions on an annual basis, data from the National Forest Inventory has been used as the most important source of information to establish total area of forest, cropland, wetlands, settlements and other land and land-use transitions between these. Annual data have been derived using extrapolations and interpolations. The data from the national forest inventory have been complemented with other statistical data, in particular for agriculture areas. These other data are less suited to derive exact land-use transitions.

In the following we provide information on how we have reported our emissions and removals of greenhouse gases from this sector in relation to the LULUCF-categories defined by the IPCC in GPG 2004 (Section 7.2), we present the inventory and statistical systems for LULUCF in Norway (Section 7.3), and the land area statistics and methods (Section 7.4). We further present the methodology used to calculate emissions and removals from the six different land-use categories respectively (Sections 7.5.-7.10). The methodology for liming of agricultural soils and liming of lakes is included in Section 7.6 on Cropland. Lastly, we have reported on calculations of emissions of non-CO_2 greenhouse gases (Section 7.11) and on uncertainties (Section 7.12), QA/QC and verification (Section 7.13), recalculations (Section 7.14) as well as planned improvements (Section 7.15).

The table below lists changes in carbon stocks for all categories within the LULUCF sector as defined by the IPCC (IPCC 2004).

Table 73. CO_2 emissions and removals from LULUCF. Gg C

	1990	1995	1997	1998	1999	2000	2001	2002	2003
Forest remaining forest	4906.6	4867.7	6888.9	6845.9	6780.7	6774.4	6786.3	6813.6	6888.9
- Living biomass	3158.0	3158.0	5196.3	5196.3	5196.3	5196.3	5196.3	5196.3	5196.3
- Dead organic matter	1244.3	1186.8	1283.1	1157.6	1110.9	1041.0	1032.4	1040.1	1064.6
- Soils	504.3	522.9	530.3	535.0	538.7	543.4	545.7	549.9	552.7
Land converted to forest	IE	IE	IE	IE	IE	IE	IE	IE	IE
Cropland remaining cropland	-52.90	-34.17	-32.39	-31.26	-28.28	-14.18	-13.78	-8.20	-13.27
- Living biomass	3.76	3.26	3.06	2.96	2.86	1.11	-1.27	4.31	-0.42
- Dead organic matter	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Soils	-56.67	-37.43	-35.46	-34.22	-31.14	-15.29	-12.51	-12.51	-12.84
Land converted to cropland	-22.8	-13.8	-11.9	-12.0	-12.1	-12.2	-12.3	-12.4	-12.4
- Living biomass	-22.8	-13.8	-11.9	-12.0	-12.1	-12.2	-12.3	-12.4	-12.4
- Dead organic matter	NE	NE	NE	NE	NE	NE	NE	NE	NE
- Soils	IE	IE	IE	IE	IE	IE	IE	IE	IE
Grassland remaining grassland	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0
- Living biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Dead organic matter	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Soils	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0
Land converted to grassland	0.0	-3.0	-3.0	-3.0	-3.0	-4.6	-6.8	-1.1	-5.7
- Living biomass	0.0	-3.0	-3.0	-3.0	-3.0	-4.6	-6.8	-1.1	-5.7
- Dead organic matter	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Soils	IE/NA	IE/NA	IE/NA	IE/NA	IE/NA	IE/NA	IE/NA	IE/NA	IE/NA
Wetlands remaing wetland	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92
- Living biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Dead organic matter	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Soils	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92
Land concverted to wetland	NO	NO	NO	NO	NO	NO	NO	NO	NO
Settlements remaining settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE
Land converted to settlements	-95.96	-90.12	-89.46	-90.12	-90.76	-91.40	-92.02	-92.63	-93.23
- Living biomass	-95.96	-90.12	-89.46	-90.12	-90.76	-91.40	-92.02	-92.63	-93.23
- Dead organic matter	NE?	NE?	NE?	NE?	NE?	NE?	NE?	NE?	NE?
- Soils	NE?	NE?	NE?	NE?	NE?	NE?	NE?	NE?	NE?
Other land remaining other land	NE	NE	NE	NE	NE	NE	NE	NE	NE
Land converted to other land	NE	NE	NE	NE	NE	NE	NE	NE	NE

IE – included elsewhere, NA – not applicable, NE – not estimated

7.2. IPCC Land-use, Land-Use change and forestry categories

Six broad categories of land are described in the GPG 2004; these are Forest land, Cropland, Grassland, Wetlands, Settlements and Other land. The categories are not defined in detail, giving each country the possibility to adapt their own land-use definitions to the broad categories. Further subdivision may be necessary in order to separate managed land from unmanaged land and to distinguish sub-categories of land-use. Carbon stock changes and greenhouse emissions are not reported for unmanaged lands, unless it is subject to land-use conversion to or from managed land. Reporting under the category "Other land" ensures that the total area identified equals the total area of the country. In this way all land-use transfers are included in the reporting. According to the GPG, reporting is not necessary for settlements and managed wetlands (for example reservoirs and drained peatlands), but emissions and removals should nevertheless be reported for transformations to and from these categories. See Figure 28 for area distribution on the six IPCC categories in Norway from 1990 to 2003.

7.2.1. Forest land

The definition of forest land is consistent with the FAO definition: *Land with tree crown cover of more than 10 per cent and area of more than 0.5 ha*. The trees should be able to reach a minimum height of 5 m at maturity in situ. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 per cent or tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention but which are expected to revert to forest.

Areas satisfying the tree cover requirements, and with land utilization either forestry, military training field, protected or recreational area, should be considered forest. E.g. areas designated for holiday cabins may meet the tree cover requirement, but will be considered settlements. Also forest patches smaller than 0.5 ha should be excluded from "forest", in order to make our definition consistent with the FAO definition. All areas meeting the forest definition will be considered managed, in that management does not only include management for wood supply, but also for protection, recreation, collection of non-wood forest products etc. Practically all forest in Norway will be used either for wood harvesting, or to a greater or smaller extent for hunting, picking berries, hiking etc.

7.2.2. Cropland

The GPG definition of cropland is: *All lands where the soil is regularly cultivated, and where annual or perennial crops are grown.* This category includes temporarily grazed lands that regularly are being cultivated. Unmanaged cropland is operationalised as cropland where economic subsidies are not applied for. Abandoned cropland may be used at a later stage for cropland or grassland, or undergo a transformation to vegetated "other land" or forest in the longer run. Unmanaged cropland is not spatially determined and it is not known whether abandonment is permanent or not. Cropland also includes areas for meadows and pastures close to the farm[7]. These are areas included in the agriculture statistics.

7.2.3. Grassland

Grassland is identified as areas utilized for grazing on an annual basis, but which are not mechanically harvested. More than 50% of the area should be covered with grasses. The soil is not cultivated, and may partly be covered with trees, bushes, stumps, rocks etc. Land with tree cover may be classified as grassland if grazing is considered more important than forestry. Meadows and pasture within the farm area are included under cropland, which is consistent with the agricultural statistics. All grassland is considered managed, because grassland left unmanaged will over time be converted to forest or vegetated "other land".

7.2.4. Wetlands

All areas regularly covered or saturated by water for at least some time of the year is defined as wetlands. The category includes swamps, mires, lakes and rivers. Possible tree cover of swamps and mires must not allow the area to be included as "forest". Lands used for peat extraction and reservoirs (dams) are considered managed wetlands.

7.2.5. Settlements

Settlements include all types of built-up land; houses, gardens, villages, towns and cities. This category also includes areas where infrastructure is predominant, industrial areas, gravel pits and mines. Included are also areas designated for sports or intensive recreational use (for example parks, golf courses and sport recreation areas. The area under power lines are also considered as settlements. All areas assigned to settlements are normally considered managed.

7.2.6. Other lands

Other lands comprise lands that are not covered under any of the other classes. The major part consists of low-productive areas with bare rocks, shallow soil or particularly unfavourable climatic conditions. This category would also include e.g. Calluna heath in western Norway (potential forest land but currently unused land without tree cover). Also the group "other wooded land" (land with sparse tree cover) on mineral soil is assigned to other lands.

7.3. Inventory and statistical systems for LULUCF in Norway

Different demands on accuracy with regard to delineation and demands to richness in details is a great and ongoing challenge with respect to official area statistics. The demand for higher accuracy increases with the number of classes in a classification system, and the demands for spatial data have been set by the reporting requirements of the UNFCCC. The main problem encountered in Norway is the low population density, which implies that mapping and maintenance of maps are relatively costly, especially in less inhabited areas. In the subsequent sections we will review existing sources of information. There are a number of existing sources of data on land-use. Most of them, however, do only show the current situation, and are not capable of presenting exact information on changes, e.g. area categories converted into other categories.

7.3.1. The National Forest Inventory

The National Forest Inventory (NFI) is a sample plot inventory with the aim of providing data on natural resources and environment for forest land in Norway. The NFI is the only system that can present area changes and current area distribution based on a georeferenced sample of field plots. The Norwegian Institute of Land Inventory (NIJOS) is responsible for the NFI. Inventory work was started in 1919 with regular inventory cycles. The last inventory cycle took place from 1999 to 2003. The inventory comprises all types of land below the coniferous forest limit, but a more comprehensive description is made only for forest land. Each inventory cycle covered the most important forest districts, while inventories in western and northern Norway were carried out less frequently and sometimes incompletely. During the three most recent periods (since 1986), all counties except Finnmark were surveyed.

The sampling design is based on a systematic grid of sample plots with 3 x 3 km spacing. Permanent sample plots were introduced for the 1986-1993 inventory cycle. A sub-sample of the established plots was marked, in order to be able to re-measure the exact same area in future inventories. This provides possibilities for detecting changes both in land-use and forest situation. When remeasuring the permanent plots, this has been done according to a specific pattern. All plots corresponding with the 3 x 3 km grid are surveyed every 5^{th} year, and provides national as well as regional statistics of forest resources. The remeasurement is carried out in such a way that 20% of the plots are surveyed every year, thus the cycle will be completed in 5 years. After 5 years, the procedure will start all over again. To obtain reliable data for individual counties, data from permanent plots are supplemented with data from temporary plots, which will not be described in further detail here.

Totally, approximately 16,500 permanent sample plots have been established, of which about 11,000 are located in productive forest and other woodlands below the coniferous forest limit. On average, the sampled area comprises about 3×10^{-5} of the surveyable area. One of the main tasks of the NFI has been an assessment of timber resources. Data are being collected so that the volume can be computed for different tree species and size classes. The number of trees and annual increment are also calculated.

The NFI has so far had certain limitations in providing a complete overview of all forests and all land-use types, due to the fact that areas above the coniferous forest limit and in Finnmark County have been excluded from the inventory, as mentioned. The boundary towards the coniferous forest limit has also been more or less subjectively assessed. To be able to obtain more consistent results, the

possibilities of introducing a simplified inventory procedure in mountain areas and in Finnmark will be explored later in 2005. Furthermore, the uncertainties in emission and removal figures are substantially higher for all other land-use classes compared to forest.

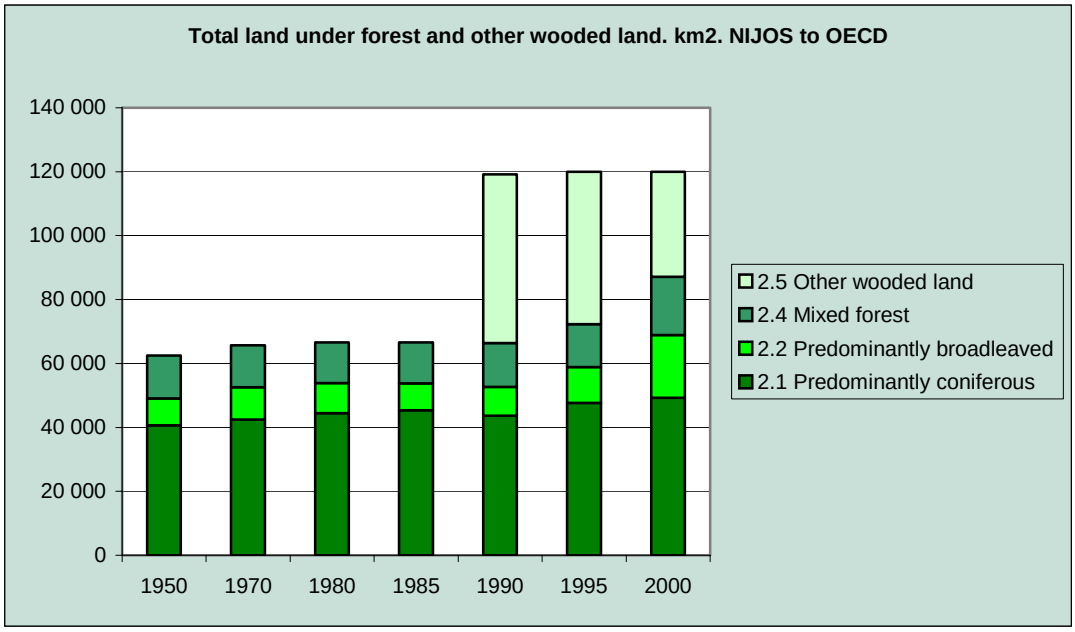


Figure 29. Land under forest and other wooded land in Norway. 1950-2000. km2 (Source: NIJOS)

Figure 29 shows the development of forest and other wooded land, as reported to OECD. The trend shown in the figure may, however, be somewhat misleading, due to the inconsistency in limitation of the forest area. Also, the area given for year 2000 applies to forest according to the FAO definition, while for the previous years the national definition has been used. The decrease of other wooded land is probably an artificial semblance, in that there is no update of the total area of woodlands. Therefore, an increase in forest implies a decrease in other wooded land.

7.3.2. Agricultural census

Censuses of agriculture have been held with intervals of approximately 10 years from 1907 to 1969. Combined censuses of agriculture and forestry were held in 1979 and 1989. A separate census of agriculture was carried out in 1999, which included all units with at least 0.5 hectares of agricultural area in use and comprised 70,700 respondents. In the periods between complete censuses, agricultural statistics are collected by annual sample surveys. The samples consist of about 11 500 - 13 000 units, which are drawn from the Farm register administered by the Norwegian Agricultural Authority. The samples are selected on the basis of agricultural areas in use and productive forest areas. The structural variation between different counties is also taken into consideration, and the relative size of the samples differs both by county and by size of holding.

The sample surveys of agriculture and forestry provide figures for number of holdings and the size of agricultural area in use. Data concerning soil preparation are collected regularly. The sample includes about 3,200 units registered with agricultural activity in the Farm register. Since 1984 the annual statistics concerning *utilization of agricultural area and number of livestock* are based on information given by holders applying for governmental grants. For previous years these figures were based on sample surveys in agriculture. Figures concerning *sales of concentrated feed, area subsidized for change of tillage, agricultural area transferred to non-agricultural use and producer prices* on certain agricultural products are given by the Norwegian Agricultural Authority. Statistics on *consumption of fertilizers* are based on data from the National Agricultural Inspection Service.

Area figures in Statistics Norway's agricultural statistics are more up to date than any other source, but do not have spatial coverage because of lacks in georeferencing (although most data are available at the municipality level). This means that the overall data for agricultural areas are of high quality, but they cannot be used to determine transitions between different land categories.

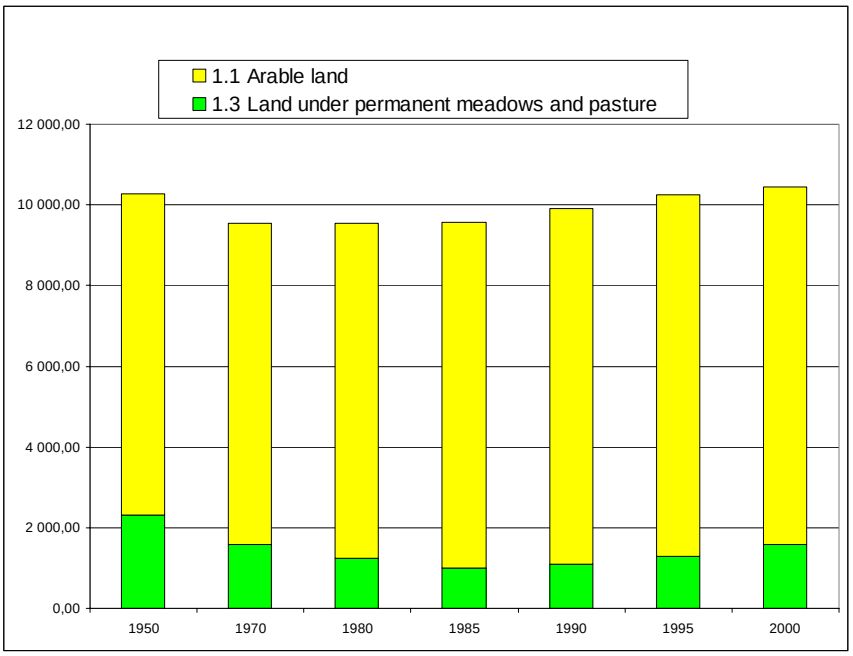


Figure 30. Agricultural land based upon the agricultural censuses. km²

7.3.3. Other sources of data

The main map series N50 (scale 1:50 000), covering the whole country, is another potential source of area statistics. The problem is, however, that the maintenance of the map series is quite variable. In some areas the data are about 20-30 years old, which means that determining reference year based upon N50 is difficult. Making land cover/use change statistics based upon this source would be a great challenge. The same is true for the land cover map N5 (Economic Map Series). A digital road map exists for all of Norway and covers all roads of more than 50 meters length. The road map is updated annually, and a data field for date of opening of road exists according to the Road Authorities (Statens vegvesen) for the last 12 years. There is, however, probably a time lag between the construction of roads and registering in the road map database.

Satellite images have often been pointed out as the solution to maintenance of maps and hence a potential source of area statistics. The resolution of satellite images is steadily increasing, but still costly, and has difficulties in covering the country with scenes free of clouds in one year, affecting the possibility of making a good area classification. The main problem with using satellite images is, however, the relatively low accuracy on land classification.

Orthophotos are increasingly being used and do have a high accuracy with respect to land classification. At the moment the coverage of orthophotos is quite low and non-random, resulting in being a biased source for area statistics. CORINE Land Cover is intended to provide consistent localized geographical information on the land cover in Europe. CORINE Land Cover is established with 44 item classes covering artificial surfaces, agriculture, forest, wetlands and water bodies. The minimum mapping unit size is 25 hectares. In Norway this dataset will be established by generalization of existing land cover datasets and by satellite interpretation. The work is planned to run from 2005 through 2007.

The Resource Account Grid is a point sampling grid dating from 1979, which Statistics Norway is in charge of. The point grid has not been used in later sampling surveys. Numerous variables (40-50) were interpreted from aerial photos and maps. The data could be interpreted as a picture of the situation at about 1970. The different sources of information may stem from a time span between 1960 and 1980.

There exists several administrative registers with relevance to area statistics. Most of them do, however, have drawbacks with regard to lack of systematizing, lack of time stamps, lack of delineation of physical features, incomplete coverage etc. Another problem for this application is that they normally are not able to track the initial land-use of a conversion. They may, however, to some extent still be useful for verification purposes. Only the most relevant registers are covered in the following. Data on reservoirs and dams are for example not available in a format that can be used for this project. Also information about parks and "green lungs" in urban settlements are lacking in a format that is relevant to the project.

Total land occupied by roads, railways, airports and buildings can be estimated by use of administrative registers (Table 74)

Table 74. Settlements by 1.1.2004

	Area (1000 ha)
Total	421.2
Roads	208.7
Railways	5.7
Buildings	41.6
Airports	1.4
Other urban settlements	163.8

There are, however, some limitations when it comes to estimating the previous land-use or land cover. The previous land cover often has no digital maps, or the historical information has not been archived. For buildings, time stamps are given from 1984 and onwards, but with variable quality. Roads managed by the road authority do have time stamps from 1988, but data are currently not readily accessible. Railways and airports lack time stamps, but play a minor role here. There are also some difficulties in concluding when a land-use change has taken place. This is either because of lack of time stamps in the registers, or that the registers are not properly systemized. With a new National Road Database and enhancing of building register with census data from 2001, it will be possible to give a better description of historical land-use change to settlements by the end of 2005.

Total Settlements in 2004 amounts to about 1.3 % of total land area according to the administrative registers and about 2.1 % according to NFI (see Table 75). This difference, 0.8 per cent or 259,000 ha, may be explained by differences in operationalisation. Urban settlements" are defined by Statistics Norway by a combination of criteria for density in built-up areas and a minimum number of 200 inhabitants within an area. "Other settlements" in Table 75 refers to areas within urban settlements which are not physically built-up. Settlement figures from NIJOS also include gardens and other surrounding areas of physically built-up areas, and areas in a zone below power lines.

The ground property register probably have information on land-use for all properties established after 1983. These properties are, however, not representative for the whole country, neither by land classification, region nor time. There are work going on by the National Mapping Authority (NMA) to have a one-to-one relationship between the ground property register and digital cadastre maps. This will, however, not be finished before the end of 2005 at the earliest.

7.4. Land Areas statistics and transitions

There is no system covering all of Norway that could be used for an at situ representation. The use of overall mapping seems not to be feasible, neither by technical nor economical terms. The approach for representing land areas will therefore be based on a combination of existing sources of data, with emphasis on data from the national forest inventory.

7.4.1. Choosing data according to IPCC Good Practice Guidance

The framework to estimate emissions and removals from LULUCF activities requires knowledge of areas of different land-use and the transition between them. The required main land-use types are forest, grassland, cropland, wetlands, settlements and other land and land-use changes refers to all transitions between these categories.

There are several reasons for primarily relying on the National Forest Inventory. First, forest covers 40 % of the mainland area of Norway and also is the most important area type with respect to carbon stock changes. Second, although the NFI is not equally accurate for non-forest land it is the only source of information that can track land-use changes from initial to final end use. The administrative data sources like road construction statistics and agriculture statistics normally only give information on final land-use, not the initial. The NFI gives information on initial and final land-use for the given categories.

Chapter 2 of GPG 2004 (Basis for consistent representation of land areas) introduces three approaches for representing land areas. Because the data from the National Forest Inventory does not have full spatial coverage, but gives transitions of land from one category to another use of these data corresponds to *Approach 2*. However, as discussed below, administrative data are used to complement, detail and/or verify the data from the NFI for use for reporting under the UNFCCC. In the next section we will discuss the application of the NFI data for estimating emissions and removals.

7.4.2. Area distribution and land-use transfers

The 6th National Forest inventory was carried out from 1986 to 1993. The NFI was progressed by regions of counties until 1993 and this makes it difficult to point out area estimates for a single year, e.g. for year 1990. Thus, the figures from the period 1986 to 1993 have to be used as the best estimate for the 1990 situation. From 1994 the NFI design was changed in such a way that a fraction of the field plots is measured in the entire country each year, and thus, single year estimates can be made. Data for 1991-1993 are based on linear interpolations of the 1990 data and 1994. For this project "annual" data were available until 2003 (only suited to give representative data for 2001) and extrapolations of the trends were used to obtain data for 2002 and 2003.

Even for the 7th NFI, from 1994 to 1999, and the 8th NFI, from 2000 to 2004, the areas in Finnmark County and above the coniferous forest limit in the mountains were not covered. These areas are now classified as "Other land" even if a smaller part in principle might be included in the other classes. In the reporting the forest areas in Finnmark have been reported under forest. The changes in the forest in Finnmark are discussed in Section 7.4.4.4.

The total land area of Norway has been divided into the six categories: forest land, cropland, grassland, wetlands, settlements, and other land. The classifications are shown in Table 75 to 77 (based on the NFI). The figures from the national land-use classification categories have been reclassified to meet the requirements of the GPG 2004. The figures of the category "Other land" ensure that the total land area identified equals the total area of the country (see discussion below concerning "other land").

The six land-use categories are consistent with the national definitions applied in 7th and 8th NFI. However, in the 6th NFI (which represents 1990) the crown cover percentage was not recorded, and

also the category "Grassland" had not been defined in the land-use classification. Crown cover is used for Forest land classification. Due to the missing assessments of the crown cover parameter and the area of "Grassland", the values from the 7th NFI were used as estimates of crown cover and grassland in the 6th NFI. Areas classified as grassland in the 7th inventory were assumed grassland also in the 6th NFI. Consequently, no land-use transfers from "Grassland" were assumed. In this way all land-use transfers are included in the reporting (Tables 75 to 77). The reason for not using extrapolations was that it is expected that parts of the changes observed from the 7th to the 8th inventory partly may be due to reclassifications. In this study, exclusive plots which are assigned to only one land-use class have been used. The plots with more than one land-use class (on the boundary between two classes) were not used in order to avoid problems with misclassification.

7.4.3. National data

The land area calculations were made by the Norwegian Mapping Authority and Statistics Norway. The total land area at county level is from (http://www.ssb.no/aarbok/tab/t-010101-021.html) and at municipality level is from (http://www.ssb.no/kommuner/region.cgi?nr=18). Below the land areas for the reference years are presented.

Table 75. Land-use classification in the 6th NFI (used to represent 1990).

	Land-use 6th inventory	
Classes	**Area (ha)**	**%**
Cropland	1 079 606	3.3
Forest	8 870 372	27.4
Grassland	154 629	0.5
Other	19 449 628	60.1
Settlements	629 154	1.9
Wetlands	2 196 811	6.8
Sum 6th	**32 380 200**	**100.0**

Table 76. Land-use classification in the 7th NFI (representing 1996)

	Land-use 7th inventory	
Classes	**Area (ha)**	**%**
Cropland	1 051 656	3.2
Forest	8 798 242	27.2
Grassland	154 629	0.5
Other	19 501 922	60.2
Settlements	643 580	2.0
Wetlands	2 230 171	6.9
Sum 7th	**32 380 200**	**100.0**

Table 77. Land-use classification at 8th National Forest Inventory (representing 2001)

	Land-use 8th inventory	
Classes	**Area (ha)**	**%**
Cropland	1 019 197	3.1
Forest	9 251 760	28.6
Grassland	170 858	0.5
Other	19 162 911	59.2
Settlements	667 023	2.1
Wetlands	2 108 451	6.5
Sum 8th	**32 380 200**	**100.0**

A key finding from these data is that change in land-use from 1990 to 2001 is quite small; the forest area is increasing and the agriculture area decreasing. Grassland and settlement areas have also increased.

Below we will discuss all land-use transitions in order to conclude which are real and which can only be explained as changes in classifications. In the cases where the changes cannot be considered real, we will also discuss how this is suggested treated in the calculations. It is important to bear in mind that not all the changes discussed in the end are important for the carbon stock changes calculated as described in the next chapter.

Conversions between cropland and forest land:
The (direct) conversions between these categories are small. Such a conversion is expected, however, due to abandonment of marginal agriculture land. An explanation may be that the transition occurs via other land or grassland.

Conversions between cropland and grassland:
Some conversion from cropland to grassland has been detected. The lack of transformations between the 6th and 7th inventory are an artefact because grassland was not recorded separately in the 6th inventory. In the data used in the calculations, the data in the 6th inventory have been corrected and assumed that the area is equal to the 7th inventory. A considerable amount of conversion from cropland to grassland has been detected between the 7th and 8th inventory. The data itself has been checked to be correct, however, it is rather unlikely that substantial transitions of this kind actually have taken place (some change may be real due to abandonment of marginal agriculture area). The most probable explanation is that there was an additional correction of the data that for some reason had not been reassigned between 6th and 7th inventory. Because this change does not affect the estimates of emissions and removals substantially, we propose using the data as they are reported in the calculations.

Conversions between cropland and settlements:
There is some conversion from cropland to settlements. These changes are considered to be real, given that the total cropland area has been decreasing and urban area increasing also according to administrative records.

Conversions between cropland and wetlands:
The conversions between these categories are negligible. There are, however, additional administrative data that can be used to conclude about drainage of wetlands for agriculture (also historically). These changes are small today and would nevertheless not be possible to identify through the NFI.

Conversions between cropland and other land:
The conversions between these categories are negligible.

Conversions between forest land and grassland:

In the 6th inventory, grassland was not a valid option; therefore all plots classified as grassland in the 7th inventory have been expected to belong to the same land-use class also in the previous cycle. The inventory data indicates some transition from forest to grassland between the 7th and the 8th inventory. It is likely that this can be explained in the same way as for cropland-grassland transitions. All sample plots may not be adequately reclassified in the 7th inventory; therefore the remaining plots on grassland were not reassigned until next time the plots were visited in the field. In these cases we assume that the change is not real, because forest clearing for grazing is not current practice. We assume these areas were grassland also in previous years.

The data shows no conversion from grassland to forest. Such a transition would not have been unlikely, because there has been a reduction in animal grazing in many rural districts. However, the process of reforestation is slow, and the revision of sample plots on grassland may also have been incomplete, since inventory of non-forested plots traditionally have not been given very high priority by the NFI.

Conversions between forest land and settlements:
There has been a rather large conversion from forest land to settlements between the forest inventories. These changes are likely real and are interpreted in this project as deforestation.

Conversions between forest land and wetlands:
There has been recorded a conversion from forest land to wetlands as well as from wetlands to forest land. Some of these differences can be explained by difficulties in classifying areas with tree cover on wetlands. However, there may also be some actual changes from wetlands to forest land. The limit for classifying as mire is < 10 % crown cover. In this situation we will assume that the last inventory is the most correct, and we will use the last year's classification also for earlier years.

Conversions between forest land and other land:
There has been a conversion from other land to forest land (7th and 8th NFI). These conversions are most likely in areas close to the timberline. Changes from other land to forest land are real and are partly human induced (changes in grazing). Some changes can also be due to a warmer climate. The explanations for increases in forest around the timberline has been discussed by Hofgaard (1997,a,b), who claims that most of the expansion of the mountain birch forests in Scandinavia after the mid-20 Century, is due to change of land-use as a result of diminished grazing pressure. The change from forest land to other land is difficult to explain. In the calculations we assume that this other land is vegetated and the consequences for the biomass calculations are consequently small. Of the total biomass on forest areas converted from forest land to settlements 75% is considered removed

Conversions between grassland and settlements:
A case of change from settlements to grassland has been observed. This change is not significant (assessed in one plot only). This conversion does, however, not have any major practical consequences for the estimates of emissions and removals.

Conversions between grassland and wetlands:
There has been some conversion between wetlands and grassland. Parts of this can be due to new areas used for grazing, but parts may be reclassifications. The changes are, however, small.

Conversions between grassland and other land:
There is some conversion from other land to grassland land. The large increase between the 6th and 7th inventory can be explained by the lack of a grassland category in the 7th inventory so that the other land category has been used more frequently. However, the changes are small.

Conversions between settlements and wetlands:
Conversions between settlements and wetlands are small. These apparent conversions may have been caused by subjective differences in classification of lands. However, they do not have any major consequences for the calculations of emissions and removals, as the result would be rather negligible.

Conversions between settlements and other land:
There has been some conversion from other land to settlements. This can be explained for example by road constructions. We assume that in these situations the other land is vegetated.

Conversions between wetlands and other land:
There has been an apparent conversion from other land to wetlands. This conversion is hard to explain and is probably caused by differences in judgment of classification. However, these apparent conversions do not have any major consequences for the calculations of emissions and removals and we assume that other land is not vegetated in this situation.

7.4.4. Use of administrative data to detail the categories

As already mentioned, the NFI data are not sufficiently detailed to estimate carbon emissions and removals for some of the transitions where more detailed information is needed to estimate emissions and removals. For this reason a further split of the cropland category has been made for all years. We also discuss a split of the other land-category.

7.4.4.1. Cropland

Agriculture statistics gives annual data on area used for different agriculture activities. For this project we have made the following split:

- Grain and oil seeds
- Root crops
- Meadows
- Horticulture
- Grassland

Grassland as defined here differs from grassland in the NFI tables in that it only includes pasture and meadow (that sometimes will be harvested) close to the farm. This type of grassland is classified as “agriculture” in the NFI.

The data are shown in Annex III of the report from the study (NIJOS 2005). Figure 31 illustrates the changes in these categories since 1989. There has been a reduction in areas used for potatoes (roots), grains and horticulture since 1989. This has, however, been compensated by an increase in meadows (grass production). Also agricultural grassland has increased a lot.

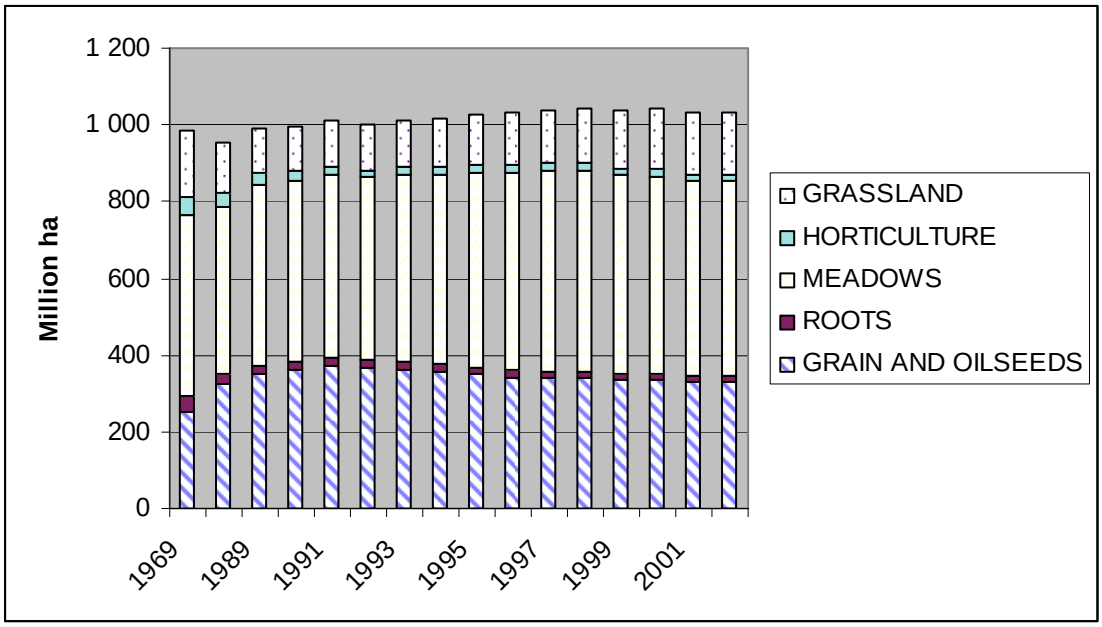


Figure 31. Agriculture practices. 1969-2002 (Statistics Norway)

One challenge in using these data is to combine them with the data from the National Forest Inventory (Table 78). The cropland + grassland area of the NFI is slightly higher than in the agriculture statistics (the difference was around 9 % in 1989, but only 2.5 % in 2002). One explanation is that the NIJOS data will record agricultural land as such also for some time after it has been abandoned. It also appears that some abandoned land will be in use again after a while. The data on the agriculture statistics are expected to be very accurate because agriculture production is highly controlled in Norway due to reliance of economic subsidies. Consequently, the agriculture statistics can be interpreted as figures for managed agriculture land (including certain pastures and meadows), and the difference unmanaged. The explanation of the apparent decrease in "unmanaged" agriculture land can be revegetation in certain areas.

Table 78. Agriculture area in the NFI

"1990" (NFI)	**Land-use 6th inventory**	
Classes	Area (ha)	%
Cropland	1 079 606	3.3
Grassland	137 498	0.4
"2000" (NFI)	**Land-use 8th inventory**	
Classes	Area (ha)	%
Cropland	1 019 197	3.1
Grassland	170 858	0.5

7.4.4.2. Other land

The "other land" category will under Norwegian conditions consist mainly of "other wooded land" (shrubland or land with some forest characteristics, but not meeting the forest definition) or barren land, especially in high altitude areas and far north. Thus, it is obvious that the biomass may vary

between the different sub-types. To be able to assess the importance of different nature conditions, estimates of the wooded part of "other" land have been derived and are presented in Table 79. The estimates have been obtained by subtracting the forest area assessed by the NFI from the total area of woodlands obtained from topographic maps. However, as the maps sometimes are 20-30 years old, these areas may be more or less underestimated. This land category plays a role in land-use changes, as other wooded land area is expected to increase due to reduced grazing. The carbon stock changes are nevertheless minor compared to the stock changes on land meeting the forest definition.

Table 79. Estimates of total wooded land area, forest, "other land" and "other land with tree cover" (ha). The regions are defined in Section 6.2.3.

Region	**Wooded land area** (forest + "other land" with tree cover)	**Forest**	**Other land** (total)	**"Other land with tree cover"**	**Percentage of "other land" with tree cover**
1	5 883 199	5 264 050	3 991 763	619 149	15.5
2	1 564 500	1 159 130	3 915 918	405 370	10.4
3	2 074 747	1 716 515	3 357 285	358 232	10.7
4	1 231 916	1 076 090	3 071 013	155 826	5.1
Total	**10 754 362**	**9 215 785**	**14 335 979**	**1 538 577**	**10.7**

7.4.4.3. Regional data

The land-use status and the transfer matrices have been described for four separate regions, in addition to the whole country. Criteria for stratification of the country could include statistical considerations for the sampling intensity or sampling approaches, considerations of the type and amount of land-use change activities and selected activities, as well as ecological or administrative considerations. In the report it is recommended to divide the country into four regions, which can easily be identified and reported on using the NFI data. At the same time, the ecological conditions and forestry activities have a high degree of similarity within each individual region. These regions are:

- **Østlandet + Sørlandet (Southeast and Southern Norway).** Comprises the counties Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold, Telemark, Aust-Agder and Vest-Agder.
- **Vestlandet (Western Norway).** Comprises Rogaland, Hordaland, Sogn og Fjordane and Møre and Romsdal.
- **Trøndelag og sørlige del av Nordland (Central Norway).** Comprises Sør-Trøndelag, Nord-Trøndelag and southern part of Nordland County.
- **Nord-Norge (Northern Norway).** Comprises northern part of Nordland County, in addition to Troms. Finnmark County is not included here due to lack of data, see Section 7.4.4.4.

The area data for these regions and the agriculture data are presented at the country level in an Annex of the report from the study (NIJOS 2005) and can be combined with these data as described for the country.

7.4.4.4. Finnmark County

Finnmark County (the northernmost county of Norway) has so far never been subject to any comprehensive forest inventory. A number of times the forests of commercial interest have been surveyed for management purposes. However, the inventories have not been set up in such a way that it is possible to detect changes in land-use over time. Data on "productive forest land" has repeatedly been reported by the forest owners to Statistics Norway's Census of Agriculture and Forestry. Some

information is also available from the Norwegian Mapping Authority, based on calculations from standard topographic maps. The data on settlements is taken from Statistics Norway 2004. Thus, an approximate land-use distribution has been established as shown in Table 80.

Table 80. Land-use in Finnmark County (ha)

Classes	Area (ha)	%
Cropland	9 980	0.2
Forest	83 100	1.8
Grassland	-	-
Other	4 177 230	91.8
Settlements	3 990	0.1
Wetlands	589 400	13.0
Sum	**4 550 400**	**100**

It is likely that the forest area shown in the table is underestimated, in that the total wooded area has been reported as high as 1,250,000 ha, and that the productive forest area usually is considerably lower than forest according to the international definition. Also, a larger forest area has previously been reported, according to older censuses of agriculture and forestry. Taking into account the figures listed in the table, 1,166,400 ha of the "other" category will have some kind of tree cover, comprising about 28% of this category. Most of this area will not meet the definition of forest applied in this project, but it is likely that a minor part could be assigned to this category. Taking into account the changes that have taken place in the adjacent county, the low population density and the fact that the human impact is generally very low (annual harvest is only around 14 000 m^3 annually according to Statistics Norway), it is highly probable that the forest area of Finnmark is increasing, or at least stable. The only aspect to consider would be the rather intensive reindeer grazing taking place in some areas. However, mostly lichens on low-productive soils are subject to browsing, and it is not very likely that the forest would be affected to any substantial degree.

7.4.4.5. Land-use changes prior to 1990

According to the Good Practice Guidance, it has been recommended that, when a piece of land changes use, then it is followed in that 'changed status' for 20 years, with each year 1/20 of the CO_2 and non- CO_2 effects reported. Tier 3 modelling approaches may utilize different assumptions, but still with a conversion category of 20 years. That means, land-use changes that have taken place after 1970 may still have an impact on soil organic matter in 1990. There was no forest inventory intended to assess land-use changes in 1970, and the forest inventory at that time was not covering the whole country. To be able to make a rough indication of the overall trend in forest area, the areas of "productive forest" according to national classification has been presented in Table 81. The data are taken from the Census of Agriculture and Forestry 1967, 1979 and 1989. These data may be used as a basis for extrapolating annual data for 1970-1988. Because no data from permanent sample plots exists before 1986 and relatively small changes has been detected in total forest land, we have chosen not to take into account changes that may have occurred prior to 1990.

Table 81. Estimates of productive forest land 1967-1989 (ha)

Region	1967	1979	1989
1	4 166 102	4 085 300	4 288 900
2	689 422	770 500	894 700
3	1 021 125	975 600*	1 255 200
4	522 110	744 000**	514 300
Total	**6 398 759**	**6 659 800**	**6 953 100**

* Trøndelag only
** Includes all of Nordland

7.4.4.6. Precision of estimates

About 17,000 permanent plots are available from the NFI. These plots will be revisited during each 5 year period. Estimates for the specific period are likely to be made based on data obtained as 5 year averages. With the number of plots, the precision of the estimates (in relative terms) will be high for the common land-use classes. Although the NFI is carried out as a systematic sampling of plot clusters, the formulas for simple random sampling can be used to provide approximate values for the precision of the area estimates. The report shows that the relative errors of the uncommon categories are rather high. On the other hand, once a certain category becomes more frequent, the relative precision of its assessment will be higher. Thus, by using the permanent plots of NFI as a basis for the area estimation, the uncommon classes will be assessed with low accuracy. The system is sensible to the number of permanent plots. For sparse categories the current number of plots may be considered being close to a minimum.

7.5. Forest land - 5A

7.5.1. Forest land remaining forest land – 5A1 (Key Category)

7.5.1.1. Description

Forest is the most important land cover type with respect to biomass sequestration in Norway. This category is found to be key category with respect to sequestration in living biomass, dead biomass, soils and drained organic soils from a Tier 2-analysis where the uncertainty in level and trend was assessed. The details of the biomass calculations is described in this section, but the same data will also be used to estimate losses of carbon when forest is converted to other land-use or removals when the forest area is increasing (Section 7.5.2).

The sequestration from forest land remaining forest land was about 25 Mtonnes of CO_2 in 2003, which would offset about 46 per cent of the total greenhouse gas emissions in Norway that year. Sequestration from this category represents the total sequestration from the LULUCF sector, since all the other categories provide net emissions. Emissions of CH_4 and N_2O from the category are negligible compared to the CO_2 sequestration; 0.7 and 0.05 ktonnes respectively (corresponding to about 15 and 16 ktonnes of CO_2-equivalents).

From 1990 to 2003 the sequestration increased by 39 per cent. The increase from 2002 to 2003 was 0.4 per cent.

In addition to changes between land categories and land management, the carbon stock changes are also influenced by changes in harvest. The harvest of all species have decreased since 1990, Figure 32.[8,9]

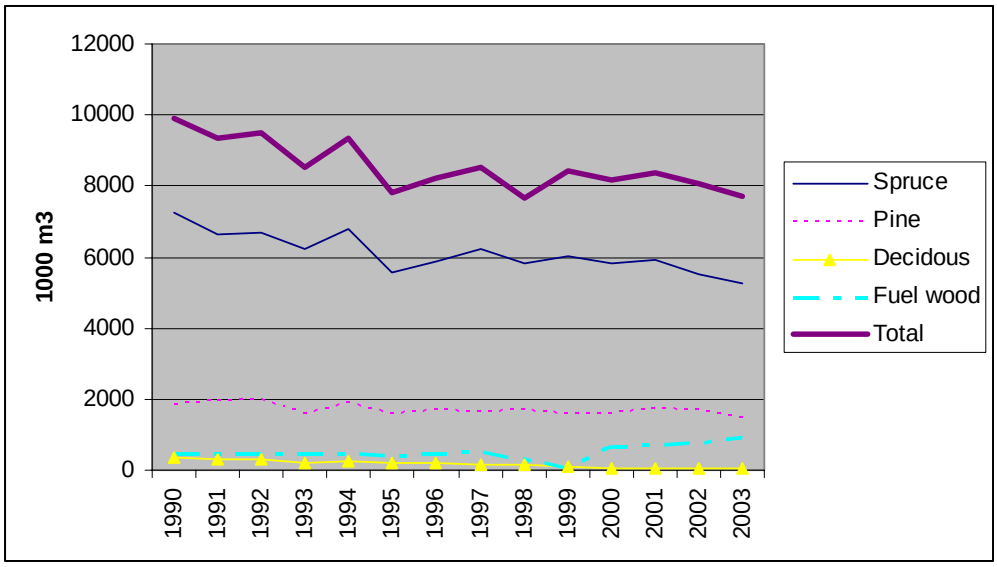


Figure 32. Forest harvest 1990-2003 (Statistics Norway, Forestry Statistics)

7.5.1.2. Methodological issues

Change in carbon stock in living biomass
The method implemented corresponds to Tier 3 of GPG 2004; a combination of national forest inventory data and models to estimate changes in biomass.

Materials and methods
The total biomass of forest trees was estimated using a set of equations developed in Sweden (Marklund, 1988) for single tree biomass of Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and birch (*Betula pubecens*). These equations provide biomass estimates for Norway spruce and Scots pine for the various tree biomass components; stem, stem bark, living branches, dead branches, needles, stump, roots larger than 5 cm in diameter and roots less than 5 cm in diameter. For birch, the biomass equations are available only for stem, stem bark, living branches and dead branches.

For the calculation, tree and stand attributes from the permanent NFI sample plots located throughout Norway were used, except from Finnmark County. Sample plots located on forest and other wooded land, were used in the calculations. The biomass of deciduous trees foliage was calculated by assuming it to be 2.2 % of the stem volume, with a dry weight of 0.520 Mg m^{-3} (Lethonen et al. 2004). Woody biomass for below ground components such as coarse roots larger than and less than 5 cm in diameter were calculated for deciduous trees by assuming the components' volume to be 8% of the stem volume, with a dry weight of 0.520 Mg m^{-3} (Lethonen et al. 2004). The stem volumes were calculated by using volume equations for Norway spruce, Scots pine and birch (Braastad 1966, Brantseg 1967, Vestjordet 1967). The biomass of fine roots, both for coniferous and deciduous trees, was assumed to be 20% of their respective foliage biomass (Vanninen et al. 1996).

[8] Figures for fuel wood production only include production for sale as registered
[9] The real harvest is higher, therefore the figures differ from those used to estimate emissions from fuel wood combustion.

The biomass for trees larger than 10 cm diameter at breast height was calculated from diameter and height for the basal area mean tree. For trees between 5 and 10 cm the biomass was calculated by means of biomass equations based only on diameter at breast height. The volume of coniferous and deciduous trees in young forest was calculated on the basis of observed mean height, estimated mean diameter and the number of coniferous and deciduous trees on the NFI plot.

Mean diameter was calculated by using a simple equation:

D (cm) = 1.4xH (m)–1.8
where H is the observed mean height.

This equation is based on the assumption that young trees have a linear growth ten years after reaching breast height (Tomter 1998, unpubl.). Trees with a height less then 1.3 m were excluded from the calculations because this is negligible. Stem volume under bark of coniferous and deciduous trees was calculated by using equations (Seip 1964). The biomass of these young trees was calculated by converting stem volume into biomass by using biomass expansion factors (BEF) for whole trees at a stand age of 10-19 years (Lethonen et al. 2004). The BEF used for Norway spruce, Scots pine and deciduous trees were, respectively, 0.862 Mg m^{-3}, 0.697 Mg m^{-3} and 0.544 Mg m^{-3}. The BEF for birch/deciduous trees accounts for aboveground biomass, only excluding foliage. Therefore, the same assumptions and calculations as described earlier were used for foliage and below ground woody biomass.

Table 82. Total biomass for deciduous trees, Norway spruce and Scots pine.

	8th inventory		**7th inventory**		**6th inventory**	
Species	**Total biomass** (Gg)	**Biomass** (Mg/ha)	**Total biomass** (Gg)	**Biomass** (Mg/ha)	**Total biomass** (Gg)	**Biomass** (Mg/ha)
Norway spruce	295631	31.95	273364	31.07	262949	29.63
Scots Pine	181936	19.67	167409	19.03	151304	17.05
Deciduous	151916	16.42	136749	15.54	125373	14.13
Total	**629483**	**68.04**	**577521**	**65.65**	**539626**	**60.81**
Area (ha)	9251760		8797521		8873347	

Another alternative to the calculations above is to apply only simple expansion factors for all components of the trees, based on total stem volume. Such a procedure has e.g. been described in the publication “The forest resources of the ECE region (1985). Overbark and underbark volume from the NFI were used as a starting point.

Total volume of tree biomass was calculated in the following way:

1. $V = V_1 + a + b$
2. $a = K_1 \times V_2$
3. $b = K_2 \times V_2$

where:
V = total volume of tree biomass
V_1= volume of wood overbark
V_2= volume of wood underbark
a = other above-ground biomass
b = volume of stumps and roots
K_1 , K_2 = constants

	coniferous	deciduous
K_1	0.25	0.25
K_2	0.25	0.2

and
$M = K \times V$

where
M = oven-dry tree biomass
K = constant, oven-dry density (g/m^3)
V = volume

Values of K:	Stemwood	Bark	Branches	Stumps and roots
Coniferous	0.40	0.31	0.48	0.42
Deciduous	0.52	0.50	0.55	0.53

Calculations based on these expansion factors are very easy and do not require detailed data at the tree or plot level. However, the accuracy must be expected to be somewhat lower than those obtained from individual tree biomass functions. In some cases it is, however, unavoidable that some simplified methods will have to be used. That is for trees outside the forest where no actual inventory data is available, but where there may exist a rough estimate of standing volume. The method can also be suited for QA/QC purposes. The total biomass for deciduous trees, Norway spruce and Scots pine calculated by means of biomass expansion factors shown in Table 83 below is based on the same data as Table 82 above. This method gives lower estimates of biomass than the method described above.

Table 83. Total biomass for deciduous trees, Norway spruce and Scots pine calculated by means of biomass expansion factors.

	8th inventory		**7th inventory**		**6th inventory**	
Species	**Total biomass** (Gg)	**Biomass** (Mg/ha)	**Total biomass** (Gg)	**Biomass** (Mg/ha)	**Total biomass** (Gg)	**Biomass** (Mg/ha)
Norway spruce	213199	23.04	196680	22.36	190170	21.43
Scots Pine	156488	16.91	141809	16.12	128999	14.54
Deciduous	104024	11.24	94446	10.74	87146	9.82
Total	**473710**	**51.20**	**432934**	**49.21**	**406315**	**45.79**
Area (ha)	9251760		8797521		8873347	

These data illustrates a substantial sequestration of carbon compared to total annual CO_2.

The changes in forest in Finnmark have been estimated using the Tier 1 method of GPG 2004.

Table 84. Total biomass in Finnmark county land of coniferous and deciduous trees calculated by means of biomass expansion factors.

	Finnmark county	
Species	**Total biomass** (Gg)	**Biomass** (Mg/ha)
Conferous	1213.40	14.60
Deciduous	443.64	5.34
Total	**1657.04**	**19.94**
Area (kha)	83	

Change in carbon stock in dead organic matter

Change in carbon stock in dead organic matter due to harvest residues and stumps and roots from harvested trees and natural mortality have been calculated from annual harvest volume using the YASSO-model (Liski et al. 2004), according to a Tier 3 method. Fractions of harvested trees are calculated by means of the biomass expansion factors ("The forest resources of the ECE region" (1985) and (Lethonen et al. 2004)). The decrease in harvest from 1990 influences the amount of harvest waste and therefore also the estimate of "dead organic matter".

Table 85. Total remaining biomass in harvest residues and stumps and roots from harvested coniferous and deciduous trees.

	Annual harvest (m^3)			Biomass (Mg)		
Year	**Conifers**	**Deciduous**	**Sum**	**Conifers**	**Deciduous**	**Sum**
1990	10080618	1269693	11350311	21513993	3829605	25343598
1991	9554399	1204219	10758618	21615841	3865241	25481082
1992	9725168	1210702	10935870	21718208	3895448	25613656
1993	8811162	1078636	9889798	21596153	3882062	25478215
1994	9648118	1116357	10764475	21649526	3886170	25535696
1995	8073829	1054197	9128026	21352330	3846401	25198731
1996	8447156	1113575	9560731	21140397	3825909	24966306
1997	8837010	1082437	9919447	21037547	3812657	24850204
1998	8444524	1080867	9525391	20869521	3792789	24662310
1999	8628946	1166997	9795943	20762283	3799838	24562121
2000	8416910	1091750	9508660	20626334	3788314	24414648
2001	8416910	1091750	9508660	20506594	3778138	24284732
2002	8416910	1091750	9508660	20403034	3769705	24172739
2003	8416910	1091750	9508660	20314475	3763023	24077498

Table 86. Total remaining biomass in dead wood from natural mortality for coniferous and deciduous trees.

	Dead wood (natural mortality. m^3)			Biomass (Mg)		
Year	**Conifers**	**Deciduous**	**Sum**	**Conifers**	**Deciduous**	**Sum**
1990	1120000	799000	1919000	9129536	8073624	17203160
1991	1142000	815000	1957000	9209203	8142929	17352132
1992	1166000	831000	1997000	9299152	8220568	17519720
1993	1190000	847000	2037000	9398651	8305875	17704526
1994	1214000	863000	2077000	9506989	8398245	17905234
1995	1245000	885000	2130000	9627859	8501663	18129522
1996	1288000	912000	2200000	9768128	8619363	18387491
1997	1288000	912000	2200000	9900164	8730417	18630581
1998	1288000	912000	2200000	10022894	8834022	18856916
1999	1288000	912000	2200000	10136109	8930025	19066134
2000	1288000	912000	2200000	10240082	9018616	19258698
2001	1288000	912000	2200000	10335331	9100170	19435501
2002	1288000	912000	2200000	10422491	9175140	19597631
2003	1288000	912000	2200000	10502222	9244019	19746241

In addition biomass from annual litter fall from living trees is calculated and added to carbon stock in dead organic matter.

Change in carbon stocks in soils

Data and calculation method for soil C in forest soils

Forest soil C estimates presented here are based on a reanalysis of data reported in De Wit and Kvindesland (1999) by Strand and De Wit (in prep) and by De Wit (pers.comm). A Tier 3 method was employed, where carbon stocks were estimated for a total number of 1033 soil profiles in productive and non-productive forest including wooded mire, and on organic and mineral soil types. The location of the profiles was a grid of 9x9 km, i.e. the grid of the national forest health monitoring (ICP forests, level 1 plots). Sampling was carried out from 1988-1992. Roughly 75% of the soil profiles were in productive forest and less than 10% were under wooded mire. 15% of all soil profiles were on organic soils and 85% on mineral soil types (classified according to the Canadian System of Soil Classification).

Soil C stocks per profile (Mg C ha^{-1}) were calculated for soil layers of 10 cm thickness and then summed to gain a C stock per profile. More details and equations are given below. Carbon stocks per profile for a given depth were calculated by summing the C stock per horizon, and where the given depth cut a horizon in two, it was assumed that the C stock for this horizon was evenly distributed, so that only the relevant part of the horizon was taken. In addition, sums were calculated for the forest floor where this was present and for mineral soils down to ≥ 30cm, ≥ 50 cm, ≥ 100 cm. The C densities were calculated according to the following equation:

Horizon/Soil layer:

$$C_{density} = BD * C_{content.} * T * CF_{coarse}$$

Profile:

$$C_{density}\,profile = (C_{density,\ horizon\ 1} + C_{density,\ horizon\ 2} + \ldots + C_{density,\ horizon\ n})$$

Where:

BD = bulk density (kg/m^3)

C_{cont} = organic carbon (kg/kg)

T = thickness of horizon (m)

CF_{coarse} = correction factor for stone and gravel content = 1- (gravel% + stone%)/100

Distribution of forest area between mineral and organic soil types

There are no direct estimates for area of forest on mineral and organic soil types, and the estimate must be therefore be derived from other available data. Here, we use the share of organic soil types and mineral soil types in the soil database and assume that it is representative for Norway. In this way, it can be assumed that 15% of all forested area is on organic soil types, whereas 85% is on mineral soil types.

Soil C stocks in forest

Soil type - mineral soil or organic soil - is a better explanation factor for the size of the C stock than the productivity class of the forest. Additionally, soil C stocks are not normally distributed around a mean value (Strand and se Wit (in prep.)). By contrast, the distribution is skewed and median values lower than mean values. Therefore, median soil C stocks for mineral soils are used as 'typical' values for forest. In agreement with GPG 2004, C stocks down to a depth of 30 cm are given (counted from the division between humus layer and top of the mineral soil, for mineral soil types; from the top of the soil for organic soil types). For comparison, C stocks for 1 m depth are also given. Similarly, median values were used to characterise organic soils.

Wooded mire is a separate category which is attributed to the land category 'wetlands' or forest in the land categorisation. The soil C stocks estimated here cannot be taken as typical for wetlands, because wetlands in general are too moist for tree growth, and moisture is a controlling factor for accumulation of organic matter. Most likely, C stored in wetlands is higher than the stocks that were found in wooded mire. The soil profiles under wooded mire were included in the sampling because forest monitoring plots were located here. Ideally, other data regarding wetlands should be included in order to produce a default value for C stocks in wetlands. The distinction between mineral soils and organic soils is based on the thickness of the humus layer. However, mineral soils under wooded mire had generally a very thick humus layer which lead to relatively similar values of C stocks in mineral soils and organic soils down to 30 cm soil depth. For wooded mire, no distinction was made for organic soils and mineral soils in Table 87.

Table 87. Mean and median soil C densities under forest. Standard deviation and nr of profiles given.

Depth	Soil type	mean	median	stdev	n
30 cm	Mineral	132	116	71	851
100 cm	Mineral	162	141	95	851
30 cm	Organic	132	107	59	108
100 cm	Organic	287	214	197	108

Table 88. Soil C stocks (until 30 cm and 100 cm depth) in forest and wooded mire in kg C/m2 for mineral and organic soil types. Number of profiles (n), mean and median values, standard deviation and standard error are given.

	Soil type	N	Cstock30 mean	Cstock30 median	Cstock30 st.dev	Cstock30 st.error	Cstock100 Mean	Cstock100 median
Productive forest	Mineral	681	13.1	11.4	7.2	0.3	16.2	14.2
Non-productive forest	Mineral	169	12.6	10.8	7.8	0.6	14.7	12.5
Productive forest	Organic	112	11.2	9.6	6.3	0.6	22.9	17.3
Non-productive forest (wooded mire)	Org/mineral	65	17.3	17.9	7.7	1.0	32.6	31.3

Table 89. Total soil C stocks in forest in Norway

Soil type	Area 1000 ha	Soil carbon Mg C/ha	Total soil C Tg C
Mineral	10 618[2]	116[1]	1 228
Organic	1 399[2]	107[1]	198

[1]Strand and de Wit (in prep), pers. comm. De Wit. See Table above. For soil depth down to 30 cm (from top of mineral soil for mineral soil types; from top of soil for organic soil types)
2 Based on contribution of organic soil types and mineral soil types in NIJOS forest soil database, i.e. 12% and 88% respectively. Assuming that this division is representative for forest in Norway

Methodology to estimate emissions and removals in forest remaining forest

Soil C stocks in forest are the result of soil forming processes like geology, climate, vegetation, topography and disturbances. The soil C stocks in Table 89 are not necessarily in a constant state with regard to these factors. Most likely, the C stocks are at present affected by changes in the vegetation, such as the ongoing accumulation of biomass in Norwegian, by forest management, and possibly by climate change. So, also for 'forest remaining forest' the soil may act as a source or a sink for atmospheric carbon.

De Wit et al. (submitted) calculated a mean annual removal value of *0.10 Mg C ha^{-1} $year^{-1}$* for mineral soils in productive forest in southeast Norway from 1971-2000. This calculation was based on forest inventory data from 1971-2000, which were converted to biomass using biomass expansion factors (Lehtonen et al., 2004) from which annual litter production was calculated using biomass turnover rates. Additionally, litter production from harvest residues and natural losses from 1960 was calculated. Litter production pr ha increased during the period of 1971-2000, and this is the main driving force behind the accumulation of carbon in the soil. The rate is likely less in *non-productive forest* because there is negligible or no harvest. De Wit et al. (submitted) estimated the contribution of harvest-related litter to total litter production in productive forest in southeast Norway to 28-34%. If it is assumed that no harvesting is done in non-productive forest, one might expect maximum 34% lower litter production than in productive forest, given that litter from standing biomass does not change. Litter from standing biomass is related to biomass, and it is reasonable to assume that biomass in non-productive forests is lower than in productive forest. As a rough estimate, one might assume that litter production in non-productive forest is 50% of the litter production in productive forest. Additionally, if it is assumed that the soil sink is linearly related to litter production, it follows that soil C accumulation in non-productive forest is about 50% of soil C accumulation in productive forest. Thus, a mean annual sink value for non-productive forest is 50 % of the estimated annual sink value of 0.10 Mg C/ha/year for productive forest: 0.05 Mg C/ha/year. The ratio of productive to non-productive forest was 3.0 in 1990 and 3.2 in 2000, and this gives a weighted average for mineral soil of 0.09 Mg C/ha/year. Productive and non-productive forest does not totally correspond to "forest" according to FAO/ECE, but we can assume that all productive forest and a substantial part of non-productive forest can be assigned to "forest".

Accumulation of C in organic soils is most likely dominated by litter contribution from other vegetation than trees, for example mosses. Consequently, we can assume that there is not net loss or uptake of carbon from this type of soil under forest remaining forest. However, because the YASSO model does not distinguish between mineral and organic soil it is assumed that all soil is mineral.

Table 90. Carbon pools in different components

	Natural mortality		Harvest		Litter from living forest		Sum		Net carbon stock change in dead organic matter	Net carbon stock change in soils
	Biomass	Soil	Biomass	Soil	Biomass	Soil	Biomass	Soil		
Year	C (Gg)	C (Gg)	C (Gg)	C (Gg)	C (Gg)	C (Gg)	C (Gg)	C (Gg)	C (Gg)	C (Gg)
1990	11117	1504	17905	1877	65452	9720	94473	13100	1244	541
1991	11209	1539	18073	1965	66359	10142	95641	13645	1168	546
1992	11314	1573	18195	2055	67345	10566	96854	14194	1213	549
1993	11429	1608	18163	2145	68429	10993	98021	14747	1167	552
1994	11556	1643	18184	2236	69579	11424	99319	15304	1298	557
1995	11697	1679	18014	2326	70795	11860	100505	15865	1187	561
1996	11857	1714	17848	2416	72081	12300	101786	16430	1280	565
1997	12014	1749	17732	2505	73322	12745	103069	16999	1283	569
1998	12164	1785	17593	2592	74469	13196	104226	17572	1158	574
1999	12304	1822	17495	2677	75538	13652	105337	18150	1111	578
2000	12434	1858	17384	2761	76561	14114	106378	18733	1041	582
2001	12554	1895	17280	2843	77577	14579	107411	19317	1032	585
2002	12664	1932	17188	2924	78599	15050	108451	19906	1040	589
2003	12765	1970	17108	3003	79642	15525	109516	20498	1065	592

Drained organic soils used for forest will lead to a substantial loss of C, and abandoning this measure will after some time lead to a slow accumulation of soil C. Due to the general increase in forest we assume no such abandonment. There is no direct data on the CO_2 loss from drainage. The loss is expected to be less than for agriculture because of the contribution from forest waste. The IPCC default factor for drained organic soils in managed forest is (boreal) is 0.16 Mg C/ha/year. This factor is used due to lack of national data (Tier 1).

The area of drained organic soils (accumulated) was 243.8 kha in 2000. This gives an annual estimate of 39 Gg C/year emitted from this source.

7.5.2. Land converted to forest land – 5A2

7.5.2.1. Description

The possible conversion under this category are the following: cropland converted to forest land, grassland converted to forest land, wetlands converted to forest lands, settlements converted to forest lands and other land converted to forest land.

The emissions and removals from ”land converted to forest land” have been reported as ”forest remaining forest”, since it takes time before an area change has any influence on estimates of carbon stock changes in Norway under the climatic conditions. We understand that GPG 2004 suggests considering land-use transitions over a period of 20 years.

After 20 years the forest will be considered as “forest remaining forest”. In this project we have classified areas by field work in 1990 (1986-1993), 1996 (1994-1998) and 2001 (1999-2003). Linear interpolation is used between these years. Field measurements before 1986 were not based on

permanent field plots and cannot be used for reporting of land conversions. Later, when the permanent field plots have been followed up over a longer time period, the concept may be adjusted.

7.5.2.2. Methodological Issues

As mentioned above, only area estimates are given in relation to the different conversions.

Change in carbon stock in living biomass
When a stand of trees in measurable size has been established, the estimate of living biomass will be based on these measurements. If the area in question previously was assigned to "other wooded land", the change in living biomass could be calculated from the growing stock before and after the conversion.

Change in carbon stock in dead organic matter
Change in carbon stock in dead organic matter due to harvest residues and stumps and roots from harvested trees and natural mortality have been calculated. An average value for forest will automatically be assigned to the area when converted into "forest".

Change in carbon stocks in soils
The methodologies used correspond to IPCC (GPG 2004) Tier 1 where emissions and removals are estimates considering the carbon stock before and after conversion and the duration of the transition. However, national data are used to the extent available.

From cropland
Cropland converted to forest. This conversion rarely goes directly (according to the LU matrix), most often it goes via "other land". The conversion is expected to lead to uptake of carbon, because there has likely been a carbon loss on agriculture land due to management and because forest will accumulate carbon. The data provided by JORDFORSK on SOC (see Section 7.2.1) does not give any smaller values than cropland for a given soil type (the value also includes pasture and meadows). This may be due to uncertainties in the data, but it can also be explained by the fact that C losses are low in Norway due to a cold climate and because the most carbon rich soil is used for agriculture. We propose to not estimate any instant change in SOC, but to account for the C uptake by using the C accumulation data provided for forest soils (see Section 7.1.1)

From grassland
Grassland may be converted to forest. In this situation the carbon in soil is expected to increase. However, it is not possible to conclude that the SOC in forest soil on average is higher than in grassland soils. The reason for this may be the low rate of loss from grassland soils due to a cold climate. As the accumulation of carbon in forest soil is well documented (GPG 2004), we propose to apply the same factors for soil accumulation as for forest remaining forest and assume no direct change in SOC due to the conversion.

From wetlands
Forestry in Norway has dramatically decreased its drainage of wetlands areas for tree planting over the last decades (Statistics Norway, 1998), see Figure 32. This is due to economic conditions and the increased focus on preserving mires. The number of ditches maintained – cleaned out or added to- have halved since 1989 (Statistics Norway, 1998). Bruun and Frank (1994) concluded for Norwegian conditions that drainage of mires can be an effective method of binding carbon in trees for a specified time span, if certain conditions are met. These conditions include fertilising to establish a productive forest. If the forest owner does not follow up the drainage and planting of a bog, a poor stand of trees is the result, and drainage will result in a net loss of CO_2 (De Wit and Kvindesland, 1999).

Conversion of wetlands to forest is expected to lead to a considerable loss of soil C at a relatively high rate, due to sudden aeration of the soils and a quick increase in decomposition rates. Initial rates of

peat oxidation may range from below 1 to over 3 Mg C/ha/yr according to a British study (Cannell et al., 1993). Laine and Minkkinen (1996) found that undrained mire accumulated on average 0.3 Mg/ha/yr more C than drained mire, and that there still was a large difference 30 years after drainage. In line with GPG 2004 we propose using the same emission factors as for drained organic soils also in the year of conversion (see forest remaining forest) (0.16 Mg C/ha/year). The area drained was 3.5 kha in 1990, which decreased to 0.04 in 2000.

From settlements
Conversions from settlements to forest are unlikely or small. For simplicity it assumed that there is no change in carbon stock in soils (this is rationalised because any such conversion is expected to be in an area which is already dominated by forest, for example abandoned small farms).

From other land
This conversion will be on vegetated "other land" (see Section 7.10). When this land is converted to forest, it is proposed to apply the carbon accumulation rates defined for forest remaining forest, assuming no change in SOC at the year of transition.

7.6. Cropland – 5B

7.6.1. Cropland remaining cropland – 5B1

7.6.1.1. Description

Cropland is defined in Section 7.2.2. Contrary to forest, most of the area for agriculture in Norway is used for annual crops which imply that the carbon is not stored over a very long time in aboveground biomass. An exception is horticulture. Carbon stocks in soils can be significant (GPG 2004). The soil carbon is, however, also affected by management practices (for example plowing and fertilization) (Singh and Lal, 2004). In addition, Norwegian soils are limed to stabilize the pH. Liming contributes to improving the biomass production and the potential for carbon sequestration.

The emissions from cropland remaining cropland were about 49 ktonnes CO_2 in 2003, which is an increase of 62 per cent from 2002. However, from 1990 the emissions of CO_2 decreased by 75 per cent. The emissions from this category in 2003 represented about 2 per cent of the total emissions from the LULUCF sector.

7.6.1.2. Methodological Issues

Change in carbon stock in living biomass
The annual changes in carbon stocks of cropland remaining cropland can be estimated as the sum of changes in living biomass and soil. GPG 2004 has proposed three tiers for living biomass and soils, respectively. Tier 1 is based on simple equations and default emission factors, Tier 2 allows for use of national specific emission factors and Tier 3 is based on disaggregated data and/or modelling. We have employed the Tier 1 method. Changes in living biomass have only been considered for perennial crops in line with GPG 2004. For annual crops, the increase of biomass in crops will equal loss from harvest and mortality the same year, and there is no net accumulation or loss.

Perennial crops
Change in living biomass is only estimated for perennial woody crops. Perennial crops are used in horticulture. Statistics Norway collects data on the area of fruit trees (apple, pears, plum, cherry and sweet cherry). The area has been decreasing since 1990. There are no national data on their volume

and carbon content. IPCC (2004) suggest default parameters for aboveground biomass carbon stock at harvest, biomass accumulation rate and biomass loss for temperate regions (it does not distinguish between vegetation types).

Changes in biomass in existing areas:
The IPCC default value for biomass accumulation rate (GPG 2004) is 2.1 Mg C/ha/year. This gives an annual uptake corresponding to only 19 Gg CO_2 per year. The average age at harvest is somewhat lover than the IPCC default assumption (20-25 years). The average height is around 2 m and one tree occupies about 10 m^2 according to the Norwegian University of Life Sciences. The "harvest" can then be estimated at around 6.3 Gg C/ha. Because the existing areas are at balance, we propose to assume that there is no net uptake or loss from these areas.

Conversion from perennial crops:
Because the area of fruit trees has decreased, there will be a net loss of CO_2 to the atmosphere which will be reported under the respective land conversions. There is no statistics indicating directly to what type of land it has been converted. It is likely that on the west coast the conversion is to grassland, in the eastern parts of the country the conversion may also be for grain production. In accordance with IPCC Tier 1 we assume that all carbon is lost at the year of harvest of the tree. The IPCC default value for carbon stock at harvest (temperate region) is 63 Mg C/ha. The resulting emissions are very small.

Table 91. CO2 emissions due to reductions in fruit trees for agriculture production

	Area (ha)	**Annual uptake** (Mg)	**Annual C-loss** (Mg)	**CO_2 emissions** (Gg)	**Net emissions** (Gg CO_2)
1989	3 267				
1990	3 220	6761.4	2998.8	11.0	13.2
1991	3 172	6661.4	2998.8	11.0	13.2
1992	3 124	6561.5	2998.8	11.0	13.2
1993	3 077	6461.5	2998.8	11.0	13.1
1994	3 029	6361.5	2998.8	11.0	13.1
1995	2 982	6261.6	2998.8	11.0	13.1
1996	2 934	6161.6	2998.8	11.0	13.0
1997	2 886	6061.7	2998.8	11.0	13.0
1998	2 839	5961.7	2998.8	11.0	13.0
1999	2 791	5861.7	2998.8	11.0	12.9
2000	2 718	5708.4	4599.0	11.0	18.8
2001	2 611	5483.3	6753.6	11.0	26.6
2002	2 593	5445.5	1134.0	11.0	6.0
2003*	2 503	5256.3	5676.3	11.0	22.6

*Preliminary figures Data for 1990 -1998 have been interpolated

Change in carbon stock in dead organic matter
This pool is considered insignificant (both the pool and changes in it) and no estimates are provided.

Change in carbon stocks in soils
A country specific methodology has been employed for these calculations (based on Tier 2), which will be explained in the following. The soil organic carbon (SOC) has been estimated by the Centre for Soil and Environmental Research (JORDFORSK). Data (in Mg SOC/ha) shows a large geographical variation, being highest in the south-western/western regions. SOC is also sampled by NIJOS. Data on SOC from JORDFORSK and NIJOS are shown in Table 92 and 93. The NIJOS data and their uncertainties are explained in (NIJOS 2005).

The data needs to be adjusted for sand and gravel (around 10 %). This gives an average SOC in mineral soils (the dominant soil type) of 135 Mg/ha. The reference value for spodic soils of GPG 2004

is 117 Mg C/ha, the value for leptosols is 68 (high activity clay soils). Consequently, the value from JORDFORSK is higher. Comparing these two independent sources of information from JORDFORSK and NIJOS for top soils (upper 23 cm layer), they are remarkably consistent. The main uncertainties are related to the stone and gravel content of sandy soils, the thickness of organic layer soils, which is assumed to be 25 cm in mixed mineral-organic soils and 50 cm in organic soils. The carbon content of organic matter in organic soils is assumed to be 0.537, the same as for mineral soils. The soil sample depth in mineral soils is assumed to be representative for the top soil (23 cm). The carbon content may be overestimated if the sample depth in old grassland is less than 23 cm, and the organic matter is highest in the upper part of the top soil (e.g. 0-10 cm).

Table 92. Reference values for carbon in soil (based on Grønlund & Njøs, 2002). C concentration=0.53

	Area 1000 ha	**Mg per ha**			**Total stocks** Tg
		Topsoil*	**Subsoil**	**Sum**	
Sum all soils	1046	105	36	141	147
Sum mineral soils	975	86	39	135	122
Sand**	617	97	40	137	84
Silt	72	69	46	115	8
Clay	286	66	35	101	29
Mixed mineral-organic soil	55	287	0	287	16
Organic soil	16	607	0	607	10

*0-23 cm in mineral soils, 0-25 cm in organic soils
** Sandy soils are assumed to content 10 volume percent gravel and stones.

Table 93. Soil C in plow layer in cultivated soils in Norway. Data from NIJOS. Depth is 23 cm; C content of organic matter is assumed to be 53.7%. Content of gravel and stones assumed to be 10%.

County	**area (ha)**	**Mg C/ha**	**Tg C**
Østfold	74 172	69.1	5.1
Vestfold	60 358	82.7	5.0
Akershus	86 600	75.9[1]	6.6
Rest of Norway	824 870	82.7[2]	68.3
Total Norway	1 046 000	81.3	84.9

1 Average C density of Østfold and Vestfold
2 C density of Vestfold

The IPCC default method takes into account a reference SOC and changes in management practices (tillage and input). IPCC (2004) has proposed default factors for correcting changes caused by management practices and input of organic matter over a 20 year period. Singh and Lal (2004) have considered the effect of plowing and other management on SOC content in soils. They conclude that the sequestration rate due to reduced tillage or increased N-application is higher in Norway compared to other countries, possibly due to lower temperatures and consequently lower rates of decomposition.

We have used a method corresponding to IPCC Tier 2 (GPG 2004) considering how management practices affect the SOC, but using national data. The measurements of carbon in soils by JORDFORSK and NIJOS are average data per soil types which cannot be directly linked to management practices and agriculture type.

Carbon in Norwegian cropland soils has been studied by Singh and Lal (2001;2004). Singh and Lal (2001) have estimated C loss by *accelerated erosion* of agriculture and pasture land. Erosion leads to

less productivity and consequently less biomass returned to soil, and it removes C from the site to somewhere else. On the whole, soil erosion leads to C emissions. In Norway, soil erosion is mainly a problem in south-eastern regions of the country. Based on assumptions on plowing practices and erosion rates from these, Singh and Lal (2001) have estimated a net erosion rate of 2.2 Mg/ha/years under autumn plowing. The rate in other areas is 0.44 Mg/ha/years. Singh and Lal (2001) assumed 70 % autumn plowing and 30 % spring stubble, arriving at an average of 1.67 Mg/ha/year for 1999. The grass and pasture erosion rate is 67 kg/ha year.

In line with Singh and Lal (2001) the following equation has been used to estimate the erosion:

SOC loss = Area * soil loss * sediment delivery ratio * SOC * Enrichment ratio

- Sediment delivery ratio is assumed to be 10 %.
- Enrichment ratio is assumed to be 1.35
- The mean carbon content of soils varies between regions, 27.3-58.7 g/kg, a value of 40 % has been used in the calculations.
(all these assumptions were taken from Singh and Lal (2001))

Finally, it is assumed that 20 % of the C transported by erosion is released to the atmosphere. We then consider other factors that may contribute to acceleration or retardation in erosion:

Singh and Lal (2001) lists:

- Tillage methods
- Residue management
- Fertilizer and organic manure
- Crop rotations
- Cover crops
- Grassroads and other types of physical erosion control

They have concluded that the largest potential for carbon sequestration lies in erosion control.

Crop residues contain about 40 % C, and enhance SOC and sequester carbon if returned to soil. There is, however, no statistics to monitor changes in crop residue management. Singh and Lal (2001) have estimated the potential top at 1.74 Tg/year (based on a sequestration factor of around 100 Mg/ha/year), given that 30 % of the area is brought under this practice. The level of this practice is not known. On-site burning of agriculture residues is regulated in some areas, there has been more focus on air quality problems, and the practice has decreased. Today around 5-10 % is annually being burned (expert estimate). However, some straw is collected and used for animal fodder. On areas without animal production it is more common to leave the residues. Around 5-10 % can be assumed used for fodder today. Because there are less combined farms and due to the regulation of onsite burning, it is likely that that more residues are left now than previously and around 80-85 % is left today. Due to lack of data we nevertheless propose to assume that there has not been any change in management and we do not estimate any carbon sequestration. Any changes would nevertheless be small – in the order of 10 Gg C per year.

In Norway it is rather common to rotate crops. There is, however, no statistics that can be used to conclude about the level of rotation practice and changes in this practice over time. However, due to the tendency of more specialized farming (previously a combination of grain and animal/grass production was normal) it is likely that crop rotation has been reduced. Due to lack of data we do not estimate any carbon sequestration due to crop rotation. In the calculations below we have ignored the effect of crop rotation when calculating carbon losses, assuming that losses only occur on new agriculture land. This assumption is meant to compensate for not accounting for sequestration due to crop rotation.

Farmers can claim economic support for using cover crops to reduce erosion. All farmers can get support, but the compensation is largest in the most vulnerable areas. Due to support to farmers the average area with cover crops has been as high as between 5 and 10 % during the last years. It is expected that when cover crops is used in combination with reduced till, the effect on reductions on carbon losses will be enhanced. Singh (pers. Comm.) has estimated a 70 % reduction in emissions using cover crops. This effect, however, also includes the effect of reduced tillage.

Nitrogen fertilization rates in Norway have not changed substantially over the last 20 years. The N-input in agriculture area was 0.11 Mg/ha in 1990, decreasing to 0.10 in 2002 (Resultatkontroll i jordbruk, Annual report from Statistics Norway). This reduction is around 10 % over a period of 12 years. However, according to data reviewed by Singh and Lal (2004) this decrease is not sufficient to assume that a major C loss has taken place (the dependency of N-content on C sequestration does not appear to be linear). Adding N as manure has a larger impact on SOC than N added as commercial fertilizers. However, there are no major changes in the N-application since 1990. We consequently propose ignoring the effect of changes in N-input since 1990 on the SOC and on emissions/removals. This assumption, however, needs to be reconsidered for future reporting years as a small decreasing trend is observed.

Tillage practices have been changing over the last 10 years aiming at reducing N-leakages and runoff. Farmers are informed and rewarded for reducing the tillage rates in vulnerable areas (in particular autumn tillage) (Statistics Norway, resultatkontroll i jordbruk), Figure 33. The fraction of area under autumn tillage was 82 % in 1989/2000, which was reduced to 43 % in 2001/2002 (based on annual surveys). Singh and Lal (2001 and 2004) cite data on the effect of *reduced plowing* on SOC. By changing from traditional plowing to minimum till, there is a SOC gain (20 cm depth) of *33.8 Mg/ha* over 13 years (this value is based on limited data from a single site and it is higher than values reported from other sites in Norway or other countries). Singh (pers. Comm.) has recommended rather using a factor of 500 kg C/ha/year by moving to minimum tillage.

Moving to autumn plow to tining has a very similar effect to minimum till. We assume that changes in tillage practices only have affected grain and oil crops (no change for potatoes and vegetables for example). Annual changes in management are taken from Statistics Norway (Resultatkontroll i jordbruk). The classes here are autumn till, shallow till, spring till (only) and no till. We have classified spring plowing only as “minimum till”. Erosion emissions will only be on new (< 25 years) agriculture land, however, the effect of sequestration due to reduced tillage will be on all land where changed tillage is practiced, but the effect of this conversion will be negligible after around 25 years.

The basic erosion factor for agriculture land under traditional till (autumn plowing) is 2.2 Mg/ha/year (Singh and Lal, 2001). This gives the following calculation:

Erosion rate (2.2 Mg/ha/year) * C content (40 g/kg) * Delivery ratio (10 %) * Enrichment ratio (1.35) = C loss by erosion (*12 kg C/ha/year*).

This figure may be distributed by county based on region specific carbon content in soil (Table 12 of Singh and Lal (2001)). We propose to use this factor only for newly cultivated agriculture areas over the last 25 years, because after that period the erosion loss will be negligible. As mentioned before, emissions and removals due to crop rotation has been ignored due to lack of data.

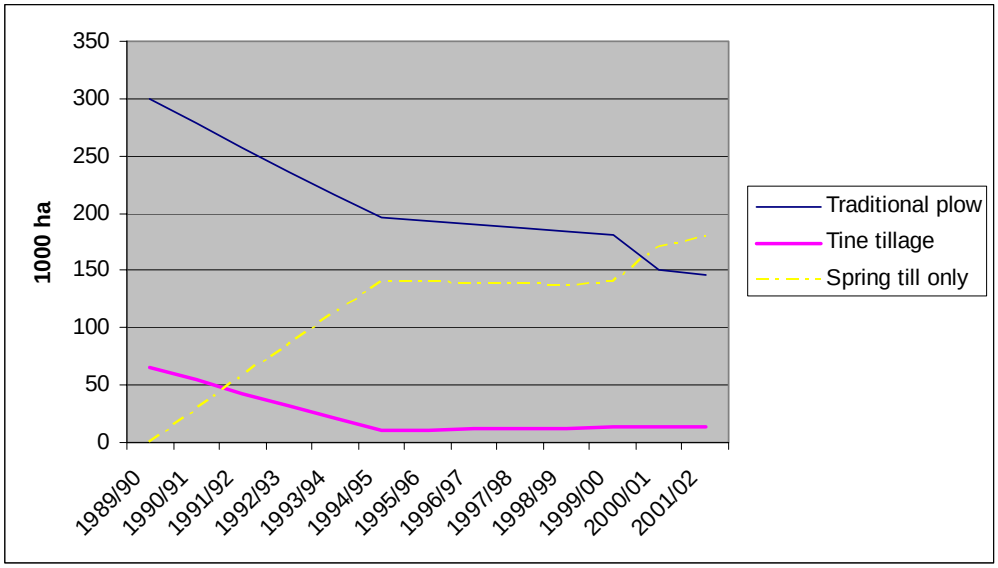


Figure 33. Tillage practices 1990-2002 (Statistics Norway)

To estimate the erosion emissions we use the statistics of new agriculture land from Statistics Norway. We assume all of this land is used for grain production (grain area has been rather stable, while other crop production has been reduced). We have assumed that half of the new land is under autumn plow. In fact, a small amount is also used for grass production (may subtract "surface cultivated" area, around 5 %). To estimate the uptake due to reduced tillage we consider all area under no till, reduced till or tine. Because tine was common previously and the difference between tine and minimum till is small, we subtract the 1979 tine area. After 25 years no more gain in SOC should be assumed. The results are shown in Table 94.

*Table 94. Erosion emissions due to plowing and uptake due to reduced plowing in Norway**

	25 year old agriculture area (ha)	Erosion emissions (Gg)	Area under traditional till, tine, no till or minimum till, subtracted 1979 tine area (ha)	Carbon uptake (Gg)
1990	151637	3.8	24700	12.3
1991	145794	3.6	34791	17.4
1992	139696	3.5	51729	25.9
1993	133219	3.3	68364	34.2
1994	128741	3.2	84693	42.3
1995	124262	3.1	84756	42.4
1996	118839	3.0	84793	42.4
1997	113099	2.8	84806	42.4
1998	106471	2.7	84795	42.4
1999	99122	2.5	88102	44.1
2000	92132	2.3	117983	59.0
2001	85429	2.1	140331	70.2
2002	78143	2.0	0	

*The effect of cover crops have not been included in the table to avoid double counting as this measure is combined will changes in tillage practices.

For vegetables and potatoes we can assume the same erosion rate as traditional till (12 kg/ha/year). The reason is that when harvested roots are taken from the soil, a subsequent carbon loss will occur. The area of vegetables is around 15118 ha. However, because the area of potatoes has been decreasing in the nineties, we assume that all area of vegetable and potatoes has been agriculture area for more than 25 years, and we assume no erosion loss of carbon. For grassland Singh and Lal (2001) propose a

basic erosion rate of 0.067 Mg/ha/year. Again this also applies to areas which are less than 25 years old.

This gives the following calculation:

Erosion rate (0.067 Mg/ha/year) * C content (40 g/kg) * Delivery ratio (10 %) * Enrichment ratio (1.35) = C loss by erosion (*0.36 kg/ha/year*). This figure may be distributed by county based on region specific carbon content in soil (Table 12 of Singh and Lal (2001)).

New area for pastures and meadows are according to Statistics Norway at present around 4166 ha annually. Assuming the same rate the last 25 years (was in fact higher previously) we get annual emissions that are very small (less than a Gg C). Some if this area may also be drained organic soils (see below).

There is also a CO_2 loss due to cropland on *organic soils* (histosols). Conversion of wetlands to cropland is at present less common than previously. According to GPG 2004, the accumulated area of organic soils should be multiplied with an emission factor. The default value for cold temperate region is 1.0 Mg C/ha/year. Jordforsk (the Norwegian Centre for Soil and Environmental Research) has calculated the area of farmed organic soil based on the frequency of organic soil among 500 000 soil samples.

Mixed organic-mineral soils (20-40% organic matter)	42,000 ha
Peat soils (>40 % organic matter)	21,000 ha
Sum organic soils	63,000 ha

However, they expect organic soils to be underrepresented in their sampling. The real area of farmed organic soils is therefore assessed to be between 70,000 and 100,000 ha. We have assumed 85,000 ha in the calculations. This number is smaller than previous estimates reported by Norway for estimating N_2O emissions. It is based on measurements of organic matter in soil and contrary to the previous estimate it takes into account that the C in soil is gradually decreased and after some decades the soil is no longer classified as organic. According to Jordforsk (Arne Gronlund, pers. Comm.) the soil database indicates the following distribution between crop types:

Grass: 86 %
Cereals: 9 %
Other crops (potatoes, vegetables, green fodder): 5 %

As soils samples are likely to be underrepresented on grass compared to cereals and more intensive productions, about 90 % of the farmed organic soils are used for grass. In this project we propose to assume that 10 % of the organic soil area is used for agriculture, the rest for grassland. For a discussion of emission factors, see “grassland remaining grassland”.

This gives an annual estimate of 208 Gg CO_2 from agriculture.

Liming of agricultural soils

Due mostly to low buffer capacity of soils, Norwegian soils may be limed using limestone (calcium carbonate - $CaCO_3$). This results in process emissions of CO_2, which traditionally have been included in the agriculture emission estimates. The estimate is based on the lime consumption as reported by "The Norwegian Agricultural Inspection Service" (for lakes "Directorate for Nature Management"). The emission factor is 0.44 tonne CO_2 per tonne calcium carbonate applied (SFT 1990). This emission factor is based on the stoichiometry of the lime applied and is consistent with IPCC (2004). The total emissions from this source amounted to 105 ktonnes CO_2 in 2003, which represent 0.2 per cent of Norway total GHG emissions. Thus this is regarded as a non-key source in the Norwegian emission inventory. National total emissions have been reported yearly from 1990 and onwards.

Liming of lakes

For several years many lakes in the southern parts of Norway has been limed to reduce the damages from acidification. The total emissions from this source amounted to 19 ktonnes CO_2 in 2003, which represent 0.03 per cent of Norway total GHG emissions. The amount of calcium carbonate used for liming of lakes was collected from Directorate for Nature Management. The emission factor used is 0.44 tonne CO_2 per tonne calcium carbonate applied (SFT 1990).

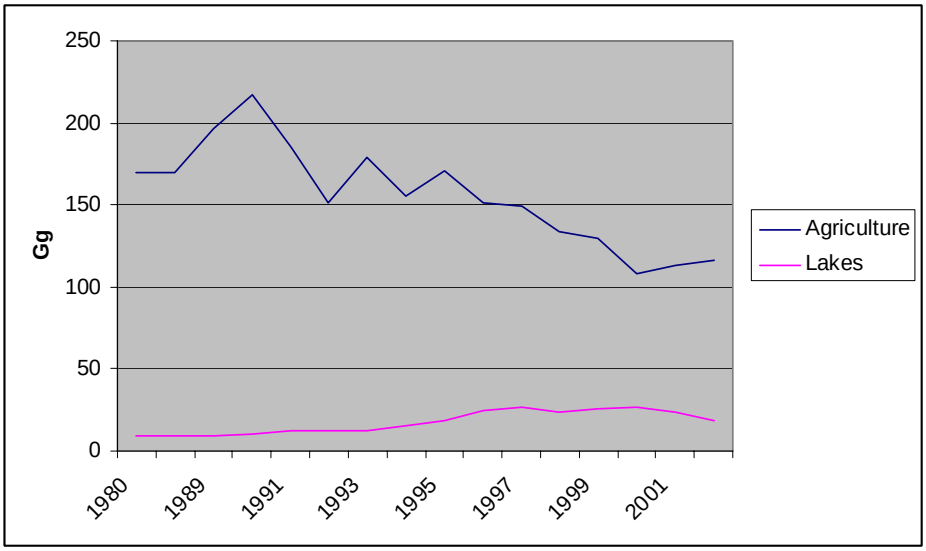


Figure 34. Liming of agriculture soils and lakes. 1989-2002.

Table 95. Amount of lime applied to agriculture area and lakes, and corresponding CO2 emissions. 1990-2003

Agriculture	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Amount of lime applied (Mg)	492407	388365	304041	294150	245884	257696	263499	237631
CO_2 emissions (Gg)	217	171	134	129	108	113	116	105
Lakes	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Amount of lime applied (Mg)	23000	42738	52802	59193	60076	54118	42089	41833
CO_2 emissions (Gg)	10	19	23	26	26	24	19	18

7.6.2. Land converted to cropland - 5B2

7.6.2.1. Description

Land conversion to cropland from forest, grassland or wetlands usually results in a net loss carbon from biomass and soils to the atmosphere (IPCC, 2004). With regard to changes in carbon stocks in living biomass, we have only calculated losses for conversion from forest.

Emissions from this category were estimated at approximately 46 ktonnes CO_2 in 2003. Between 1990 and 2003 the emissions decreased by 46 %.

7.6.2.2. Methodological Issues

Change in carbon stock in living biomass
As mentioned above, the losses are only calculated for conversion from forest. It is assumed that all living biomass is lost the year of conversion.

Change in carbon stock in dead organic matter
We assume that if land is converted to cropland all dead organic matter will be cleared.

Change in carbon stocks in soils

From forest
According to GPG 2004 SOC in cultivated soils is generally less than in forest and other land use, so a conversion results in a net carbon loss (emissions). After some decades there will be equilibrium. The time and level of equilibrium depend on soil, climate and management conditions. However, because Norwegian data indicates no major difference in SOC between forest and agriculture we assume no loss other than the losses which are depending on the management of the agriculture land after conversion (grassland, grain (tillage) or other use of the land).

NIJOS has estimated the mean carbon content in productive forest to 11.6 kg C/m^2. The corresponding mean value for all cultivated mineral soils (both grass and cropland) has been calculated at 14.1 kg C/m^2 by Jordforsk. The results indicate no difference in carbon content between forest and cultivated soils. The average value for agriculture land may, however, mask some differences between grassland and cropland.

JORDFORSK has collected data on organic matter content of 3920 farms in Norway (Table 96)

Table 96. Organic matter and C in farm soil. Weight % (source: JORDFORSK)

% grass area	Number of farms	Soil OM (%)	Organic C (%)
0	2009	4.2	2.3
0-80	1442	5.0	2.7
80-100	469	5.4	2.9

These data shows that the carbon content in general is lower in cropland compared to grassland (26 %). These differences are consistent with the proposed differences in erosion factors between cropland and meadows/pastures. The statistics do not allow for a more detailed analysis of differences and effect of crop rotations.

From all other land use
Administrative data show that since 1990, the annual conversion to agriculture land has been reduced from about 2000 ha to 1200 ha annually (Statistics Norway). Most of the area is used for grass production, but part of the area (about 10 %) is annually used for cropland in crop rotation systems. The original land-use is not known, but it can be forest and to a limited extent wetlands.

Conversion from grassland to cropland is not recorded. However, it is expected that the conversion rather is *from* cropland to grassland, due to the abandonment of farms and because the areas of meadows and pastures have been increasing during the nineties at the cost of grain and potatoes. Because the basic agriculture erosion factor (before accounting for management) is based on the one for grassland, we assume no immediate loss when land other than wetlands is converted to agricultural land. Losses are accounted for according to the changes in management (see agriculture remaining agriculture). The conversion of peatland (wetlands) to agriculture land was addressed above, under cropland remaining cropland. The emissions are not immediate, but occur over time.

7.7. Grassland – 5C

7.7.1. Grassland remaining grassland – 5C1 (Key Category)

7.7.1.1. Description

According to the area definitions, grassland also includes pasture. Grasslands are used for harvest and pasture. Parts of the pasture land are in the mountains. Pasture practices have been changing over the last decades, gradually leading to altered vegetation (including expansion of forests and other wooded land). As for agriculture, we consider changes in aboveground biomass and soil carbon. As described earlier, the statistics of NIJOS only cover grassland and pastures which are not part of the home fields (not for harvest), while the agriculture statistics cover only pasture and meadow close to the farm.

This category is identified as key category with respect to changes in carbon stocks in soils because of uncertainty in level. We assume no change in living biomass or dead organic matter for this category because the mass of aboveground biomass is small and is in a steady state (in accordance with IPCC (2004) Tier 1). Changes in management have, however, influenced the vegetation on pastures. Gradually, some of this area will fall under the forest definition.

The emissions from grassland remaining grassland in 2003 were estimated at 1.9 Mtonnes of CO_2, which represents 3.5 of the total emissions of greenhouse gases in Norway and 75 per cent of the total emissions from the LULUCF sector. Emissions of CH_4 and N_2O from the category are negligible. The emissions are considered to be constant from 1990 to 2003 since there have not been any major changes in management of grasslands in Norway during this period.

7.7.1.2. Methodological Issues

Change in carbon stocks in soils
Large amounts of carbon are stored in roots and soils. There have not been any major changes in management of grasslands (apart from pasture) in Norway. Consequently, that would justify ignoring carbon losses or uptake from mineral soils on existing grassland area. For grassland which is harvested (meadow) we have used the erosion factor of Singh and Lal (2001) of 0.78 kg C\ha\year. This factor should, however, only be applied to grassland which is younger than 20 years, see discussion under cropland remaining cropland. The calculations are based on a Tier 2 method.

There will be a loss of carbon from grasslands on *organic soils*. As discussed for cropland, it is assumed that 90 % of organic soil used for agriculture production is used for grass production (organic soils are not suited for example for producing grain). The IPCC default emission factor is 0.25 Mg C/ha/year for cold temperate regions. However, according to Norwegian measurements emission can be larger because the age of the organic soils is lower than in Southern Europe. The average subsidence has been estimated by Jordforsk at 2 cm/year[10] which is equivalent to 20 Mg C/ha.[11] Some of this reduction is due to compaction and can be attributed to a sink in the height of the soil layer[12]. The soil loss also includes leaching of organic components in the drainage water. Based on measurements the emission losses of CO_2 from farmed organic soils in Sweden and Finland have been reported to be between 200 and 1000 g CO_2-C/m^2/year (Final report from the EU Project Greenhouse Gas Emissions for Farmed Organic Soils (GEFOS). This corresponds to 2-10 Mg/ha/year. The assumptions on C-losses are also justified because a change in C/N ratio over time is observed. We

[10] Meadow. The decrease in layer is larger on field grassland. However, organic soils are rarely used for the purpose.
[11] Assuming a soil density of 0.2 kg/l, and 50 % C.
[12] Assuming a soil density of 0.2 kg/l, and 50 % C.

propose using a loss factor of 10 Mg C/ha/year for high organic matter soil. For mixed organic soils the factor will be lower, we propose using 5 Mg C/ha/year (expert judgement).

Of the total area of 85 000 ha, 90 % were assumed used for grass. Of these 76 500 ha, we assume one third is highly organic, the rest is mixed. This gives an annual emission rate of 510 Gg C/year or 1.9 Tg CO_2. Using the IPCC emission factor, we obtain an emission estimate of 21 Gg C/year (78 Gg CO_2). Further details are given in Table 97.

Table 97. Farmed organic soils by region. ha

	20-40 % OM	More than 40 % OM
Eastern counties	7 066	3 508
South counties	2 955	1 240
West counties	19 194	7 834
Mid counties (Trøndelag)	4 934	3 513
Northern Norway	7 752	4 956
Sum	41 902	21 051
Fraction	66 %	33 %

Given the importance of this estimate compared to other sources and the large difference from the IPCC default value, it is recommended to further improve the emission factor (measurements, modelling, literature). Other Nordic countries have similar agriculture practices. Sweden uses emission factors ranging from 1.6-7.9 Mg C/ha/year (largest for row crops). Finland has concluded on a range of emission factors for organic soils of 0-4- Mg C/ha/year (2-4 Mg C/ha/year for peatlands) (Riitta Pipatti Statistics Finland, pers. comm.). Finland has initiated a comprehensive research project on emissions from peatlands in Finland. Results are expected by the end of 2005. We will propose to reconsider the Norwegian emission factors in light of the results of the Finnish study.

Furthermore, the area is kept constant in the calculations. This is justified because new cultivation of organic soils is limited at present compared to the existing (existing areas is about 80 000 ha, new agriculture area is 1000 ha annually, but not all of this is organic soils). However, over time organic soils will be converted to mineral. Little is known about abandoned organic soils with respect to CO_2 uptake (and emissions of non CO_2 GHG). Because the drained soil is considered marginal it will be abandoned before other soil types. This uptake has been ignored in the calculations due to lack of activity data, but may potentially be important and should be considered in the future.

Grassland is not limed (any possible liming is reported under agriculture).

7.7.2. Land converted to grassland – 5C2

7.7.2.1. Description

According to IPCC (2004) the implications of converting other land to grassland is uncertain. In the case of conversion of forest to grassland, losses in living biomass will be accounted for according to the methodology of estimation described under forest. For other land-use change we assume no net change in carbon of living biomass. This is justified because the IPCC defaults for aboveground biomass are quite similar for grassland and cropland. (5 Mg carbon/ha for cropland, 8.5 Mg dry matter/ha for grassland (boreal zone) equal to 4.2 given a carbon content of 0.5).

Emissions from this category were estimated at about 21 ktonnes of CO_2 in 2003, corresponding to 1 % of the total emissions from the sector that year. In 1990 there were no emissions from this category, and the emissions in 2003 increased by a factor of five compared to emissions in 2002.

7.7.2.2. Methodological Issues

Change in carbon stock in living biomass
Losses in biomass are only calculated for conversion from forest. It is assumed that all living biomass is lost the year of conversion. The calculations are explained under "land converted to cropland".

Change in carbon stock in dead organic matter
We assume that if land is converted to grassland, all dead organic matter will be cleared.

Change in carbon stocks in soils
The SOC in grassland discussed under agriculture is probably more representative for grassland and meadows close to the farm. The SOC in grazing land and unmanaged grassland is not known. However, much of the grassland will be in mountain areas where the SOC can be low.

From forest
In line with the discussion of the area data we assume that transition from forest to grassland is rather unlikely but assume no change in SOC if recorded. Losses in living biomass would be calculated using the same assumptions as for cropland.

From cropland
When cropland is converted to grassland the SOC may change due to changes in management, for example plowing and N-fertilization. The result is expected to be a net uptake. According to Statistics Norway the managed grassland area have increased in the nineties. Data from Jordforsk confirms that farms with animals (and grass production) have a slightly higher SOC than those without (Table 92). There are no data for grassland outside home fields, but they likely have a lower SOC. We propose to assume that there is no change in SOC when cropland is transferred to grassland, because the changes are small and exact data are lacking.

IPCC default Tier 1 method accounts for differences in SOC in the land use conversion according to changes in management. Assuming that the grassland is nominally managed and the same level of fertilization, also the IPCC default method indicates no change.

From wetlands
See discussion on drained organic soils under grassland remaining grassland.

From all other land use
When other land use is converted to grassland we assume no emissions or removals due to changes in soil carbon.

7.8. Wetlands – 5D

7.8.1. Wetlands remaining wetlands – 5D1

7.8.1.1. Description

Most of the wetlands in Norway are unmanaged mires, bogs and fens, as well as lakes and rivers. Managed wetlands include peat extraction and reservoirs (dams). The emissions from this category were estimated at about 3 ktonnes of CO_2 in each year over the period 1990-2003.

7.8.1.2. Methodological Issues

Reservoirs
At present there exists no readily available water or land use change statistics related to dams or reservoirs. Wetlands remaining wetlands is only covered in appendix 3a.3 in the Good Practice Guidance (IPCC 2004). That means that reporting is not mandatory. Consequently, changes in carbon stocks in unmanaged wetlands and reservoirs have not been considered in this report. Reservoirs should be considered in the future due to the many hydroelectric power stations in Norway.

Peat extraction
Changes in carbon stocks for peat extraction are estimated with a tier 1 method based on Swedish emission factors. According to JORDFORSK, peat extraction in Norway is between 220,000 and 300,000 m^3/year (we assume no change in extraction). The extraction is around 5-10 cm/year. This corresponds to 13 m^2/m^3. The total area harvested is consequently around 338 ha.

The IPCC default method considers only change in soil carbon during peat extraction. Changes in biomass and changes in soil carbon due to other processes associated with extraction (drainage, stockpiling, etc) are assumed to be zero at tier 1. Extraction is assumed to enhance oxidation, leading to a continuing decrease in soil carbon. Although some of the extraction areas may belong to the temperate zone, we propose using the default emission factor for nutrient poor bogs in the boreal zone. The IPCC emission factor is 0.2 Mg C/(ha · yr).

We propose using emission factors for Sweden (Uppenberg et al. (2001)). Prior to drainage and extraction the peatland acts as a small carbon sink (62-96 g/m^2/year). During extraction emissions will be around 10 Mg/ha/year, somewhat lower after drainage and before extraction. Because the age of the harvested area is not known, we apply the same emission factor for every year.

This gives an annual estimate of 3.4 Gg CO_2, (using IPCC default data, 1.83 Gg CO_2.)

Wooded mire
Wooded mire according to Norway's national definition will be classified as forest, if the requirements of the international forest definition are met. The rest of wooded mire would be considered "other wooded land", and could form a subgroup under "wetlands". The living biomass would, however, be negligible compared to forest, and the usefulness of forming such a category would be questionable.

Liming
Lakes are limed in Norway to stabilize the pH. The methodology is explained in the section on agriculture, see Table 95. The corresponding emissions are about 25 Gg CO_2 annually.

Other wetlands
Other wetlands is considered unmanaged, and no emissions and removals are estimated (in line with GPG 2004).

7.8.2. Land converted to wetlands – 5D2

No data are available on land converted to managed wetlands. In practice, this is only relevant for reservoirs. Land taken into use for peat extraction would normally be unmanaged wetlands.

As discussed in Section 6.2.1 recorded conversions to wetland are considered as artefacts and are not used in the calculations. To the extent the transitions are real; it is assumed that changes in SOC are small because the native vegetation is assumed close to wetlands. Furthermore, conversion of forest to wetlands is expected to be a slow process, because this involves regrowth of ditches and a steady increase in water level. Additionally, a conversion to the land use category 'wetlands' requires a reduction in tree cover, otherwise the land would still be considered forest. Clearly, drained forest must have been abandoned for some time in order to return to the land use category of wetlands.

From other land use
Because we assume the features of these areas will approach those of wetlands or because some of the reported changes are considered reclassification, we assume no loss or uptake of carbon.

7.9. Settlements – 5E

7.9.1. Settlements remaining settlements – 5E1

7.9.1.1. Description

Reporting of emissions and removals from this category is not mandatory. There are, furthermore, no data available in Norway to estimate the tree biomass. Changes in carbon stocks for settlements remaining settlements have consequently not been estimated.

7.9.1.2. Methodological Issues

Two main trends in biomass in settlements can be outlined: 1) Growth in tree biomass on lands converted to settlements (after the initial clearing) probably extends well beyond the 20 year limit. 2) Trees are removed within settlements for new buildings, roads, etc. The balance between the two trends is not easily determined, but significant carbon sequestration in settlements is not expected.

7.9.2. Land converted to settlements – 5D2

7.9.2.1. Description

IPCC (2004) suggests a method in which only forest biomass is considered (deforestation). Thus, it is assumed that there are no carbon stock changes when land classes other than forest are converted to settlements. IPCC further suggests as a tier 1 method that all biomass is lost in the year of conversion. In the LULUCF study it was proposed also to estimates losses when other wooded land is converted to urban areas. However, this has not been done in this NIR.

The emission from this category was estimated at 342 ktonnes of CO_2 in 2003. Annual emissions from this category have been quite stable between 1990 and (between 326 and 352 ktonnes of CO_2).

7.9.2.2. Methodological Issues

Change in carbon stock in living biomass
We suggest that for forest land converted to settlements, only 75% of the biomass is considered to be lost. The remaining 25% refers to trees that are left standing in the built-up area. This figure is based on expert judgment.

The total biomass on forest land converted to settlements is calculated from the National Forest Inventory. Thus, the estimate takes into account the variation in forest types, and there is no need for general emission factors. The average biomass loss in 1996-2001 was 25 Mg C/ha.

Change in carbon stock in dead organic matter
We assume that all dead organic matter is cleared in this conversion.

Change in carbon stocks in soils

From forest

Forests may be converted to settlements. It is reasonable to assume that soils will be disturbed in order to make the surface suitable for building purposes, for instance by levelling the surface and by removing the top soil. As most C is in the top soil, it seems reasonable to assume that most soil C will be lost in a short time. If there is any default value for soils under settlements, it can be assumed that the default forest soil value decreases to the default settlement value in 1 yr. We propose assuming that settlements have the same SOC as grassland, and use the same methodology as for Section 7.2.1 and the erosion factor for grassland by Singh and Lal (2001). We assume that the losses occur over 25 years, so the 25 years accumulated value should be used (with an annual conversion of 300 000 ha and an annual loss rate of 0.78 kg/ha/year we get an annual loss of 6 Gg C/year).

From wetlands

If wetlands is converted to settlements it will likely be settlements which are "wetland like" or involve drainage. We propose applying the same factor for carbon loss as for forest, 0.16 Mg C/ha/year. This factor is applied over 25 years (in practice losses may occur over a longer period). This gives an annual loss of about 18 Gg/year.

From all other land

For all other land we assume no change in soil organic carbon.

7.10. Other land – 5E

7.10.1. Other land remaining other land – 5E1

7.10.1.1. Description

We assume no change in carbon stock in living biomass or soil in other land remaining other land. This is in accordance with GPG 2004 because this land is considered unmanaged. For Norway this assumption may underestimate carbon uptake because vegetation is increasing in many areas due to reduced grazing.

7.10.1.2. Methodological Issues

For reference we have estimated the sequestration in other wooded land based on an IPCC Tier 1 method, using expert judgment for annual increment. Biomass on other wooded land is calculated by means of biomass expansion factors (Table 98). The biomass has been considered unchanged from 1990 to 2003. An estimate of the growing stock has been used, thus the average value from a limited number of sample plots assessed on a similar land cover type.

Table 98. Total biomass on other wooded land of coniferous and deciduous trees calculated by means of biomass expansion factors.

	Other wooded land	
	Total biomass (Gg)	**Biomass** (Mg/ha)
Conferous	15599.25	5.61
Deciduous	6158.90	2.22
Total	21758.15	7.83
Area (kha)	2779	

7.10.2. Land converted to other land – 5E2

7.10.2.1. Description

In the case of conversion from forest, there will be a loss in biomass. In case the "other land" belongs to a category with some tree cover and has been assessed by the National Forest Inventory, the biomass can be estimated by repeated measurements.

7.10.2.2. Methodological Issues

Change in carbon stock in living biomass
As mentioned above, there will be a loss of biomass which may be calculated if the conversion is from forest or if there is some tree cover on the land which has been assessed by the NFI. If not, the biomass must be set at 0.

Change in carbon stock in dead organic matter
The same assumption as for living biomass, would also be valid for dead organic matter.

Change in carbon stocks in soils
We assume no change in soil carbon when land is converted to other land. This is because there exists no data, and as discussed before, SOC for grassland and forest in Norway are quite similar. "Other wooded land" will often be in marginal areas where the SOC is lower than in agriculture land. However, the same will be true for forest or grassland in these areas.

7.11. Reporting of emissions of non-CO_2 gases

7.11.1. Introduction

Changes in forest and other land use change will influence emissions of other greenhouse gases than CO_2. Emissions of methane (CH_4) are caused by fires. Changes in land-use may change also natural emissions, but according to the IPCC methodology these changes are not included in the accounting framework. Emissions of nitrous oxide (N_2O) are in addition to fires caused by soil organic matter mineralization, nitrogen input and cultivation of organic soils. Indirect emissions are not considered in this sector, but under agriculture. According to IPCC (2004) liming of forest and forest management may change N_2O emissions, but the effect is uncertain. Norwegian forest is, however, not subject to liming. The emissions of non-CO_2 gases are small (non-key) and default parameters and methods have been applied in most circumstances. Norwegian experts and to some extent Swedish have been contacted in search for improved information.

Emissions and removals in the Appendices of GPG 2004 have only partly been included. Methodologies have been presented in appendices of the report from the study (NIJOS 2005) for further methodology development, but the corresponding emissions can be reported if national information is available. For the non-CO_2 GHG reservoirs can be a source in Norway, but the corresponding emissions have not been estimated.

7.11.2. Forests

N_2O is produced in soils as a byproduct of nitrification and denitrification. Emissions increase due to input of N through fertilization and drainage of wet forest soil (IPCC, 2004). Forest management may also alter the natural methane sink in undisturbed forest soils (IPCC, 2004), but data does currently not

allow a quantification of this effect. According to IPCC (2004) fertilizer input is particularly important for this process, but fertilization of forest is of little importance in Norway.

N_2O from fertilization

Because national emission factors for fertilization of forest soil are unavailable the estimate is based on Tier 1 and default emission factors.

$N_2O\text{-direct}_{fertlizer} = (F_{SN} + F_{ON})*EF_1 * 44/28$

Where
F_{SN} = the amount of synthetic fertilizer applied to forest soil adjusted for volatilization as NH_3 and NO_x. Gg N.
F_{ON} = he amount of organic fertilizer applied to forest soil adjusted for volatilization as NH_3 and NO_x. Gg N.
EF_1 = Emission factor for emissions from N input, kg N_2O-N/kg N input.

There is national statistics on the area with fertilizer applied. This area is very small, only 15 km^2 in 2002 and 26 km^2 in 1990 (Statistics Norway, Forestry Statistics). The statistics does not specify whether this is synthetic or organic fertilizer. Furthermore, it does not say anything about the amount applied. Statistics Norway has supplied unpublished data on application on synthetic fertilizer for the period 1995-2002. The average ratio between the amount applied and the area fertilized was used to estimate the amount applied for 1990-1994. It is assumed that organic fertilizer is not applied to forest in Norway. To the extent that it is applied, the associated emissions will be reported under agriculture (this assumption is according to GPG2004). The amount of fertilizer applied is given as total weight. The nitrogen content is depending on the type used. According to Statistics Norway, 95 % NPK-fertilizer is used on wetlands. On dry land about half is NPK and the rest N-fertilizer. The N-content of these were taken from YARA (www.hydroagri.com).

The default emission factor is 1.25 % of applied N. There are no national data to improve this. 1 % of the N-applied is volatized as NH_3 (the ammonia model of Statistics Norway).
The resulting emissions are about 3-4 Mg N_2O per year, which is very small compared to the emissions from agriculture. The emission factor is highly uncertain. According to IPCC (2004), the range in emission factor can be from 0.25 % to 6%. The amount of fertilizer applied to forest should be subtracted from the input to the calculation of emissions from agriculture, because that figure is based on the total fertilizer sale.

Table 99. Estimated emissions 1990-2002 from fertilization of forest

	Estimate of input of N, Mg			**Estimate of net amount of N applied, Mg**		**Estimated emissions. Mg N_2O**
	Wetland	Dry land				
1990	51	177		225		4.4
1991	77	271		344		6.8
1992	119	210		326		6.4
1993	77	150		225		4.4
1994	77	140		216		4.2
1995	90	138		226		4.4
1996	45	179		222		4.4
1997	21	200		219		4.3
1998	31	216		244		4.8
1999	44	183		225		4.4
2000	23	124		145		2.8
2001	20	100		119		2.3
2002	8	155		162		3.2

Assumptions Nitrogen content	15%	22.5 %	Nitrogen volatilization	1 %	Emission factor	1.25 %

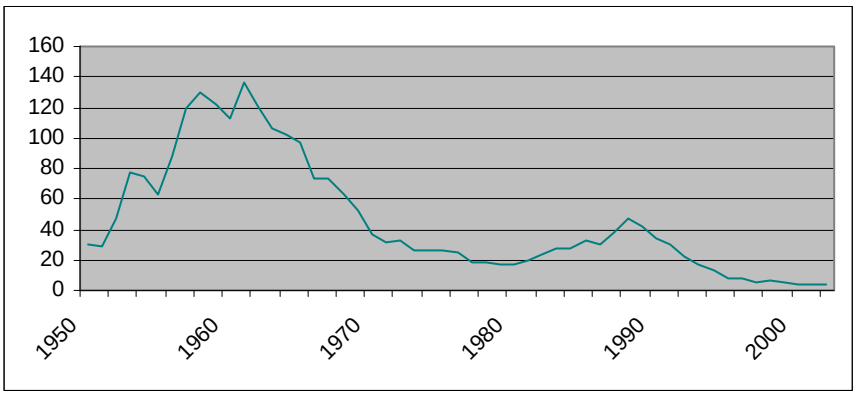
Source: Fertilizer consumption Statistics Norway, N-volatilization Statistics Norway, N-content YARA and emission factors IPCC

N_2O from drainage of forest soil

Drainage of organic soils generates emissions of N_2O in addition to CO_2. Drainage will also reduce methane emissions and even generate a sink (IPCC, 2004). However, data are unavailable to estimate this effect (IPCC, 2004) and there are no national data to estimate this. Given that the area drained in Norway currently is low, no estimate is given for methane. This methodology is given in an appendix in IPCC (2004) (for further methodology development). Because no national data are available, the estimation methodology for N_2O is based on IPCC (2004). It is assumed that all drainage is related to organic soils.

N_2O emissions = Area of drained forest soil * emission factor

The emission factor is taken from IPCC (2004). It is assumed that all soil is nutrient poor, the corresponding emission factor is 0.1 kg N_2O-N/ha/year (0.6 for nutrient rich). The range of emission factor is from 0.02 to 0.3 which is an indication of the large uncertainty of the estimate. The activity data is the area of drained forest soil. Draining back to 1950 has been taken into account (Figure 8.1). The graph shows that the area drained annually has been much reduced. 250 000 ha have been drained accumulated. It is assumed that there is no rewetting of drained forest soils.



Source: Statistics Norway

Figure 35. Drainage for forest. 1950-2002 (1000 Daa = 100 ha)

Table 100. Area drained and N_2O emissions from drainage of forest soil. 1990-2002.

	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Area drained (accumulated 1000 ha)	231.8	238.7	240.0	240.8	241.6	242.1	242.8	243.4	243.8	244.2	244.6
Emissions (Gg)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

N_2O and CH_4 from forest fires

No prescribed burning of forest takes place in Norway and all forest fires are due to accidents in dry periods (wildfires)[13]. According to IPCC (2004) the emissions of CO_2 from fires should be estimated, because the regrowth and subsequent sequestration are taken into account when it takes place. However, both the loss and uptake of CO_2 will be covered by the growing stock change based CO_2 calculations. The estimate provided here is for comparison only and to be able to estimate other

[13] There may be some trials of burning as part of forest management, but this is only performed in small scale and is ignored here.

pollutants, and will not be used in the CO_2 calculations. Data on area burned in forest fires are available from the Directorate for Civil Protection and Emergency Planning for 1993-2003. For 1990-1992 only data on the number of fires were available and these data were used to estimate the area burned based on the ratio for subsequent years. This method may be very inaccurate because the size of fires is very variable. Because the number of fires was higher in 1990-1992 than later, it is possible that the estimate for the base year is too high.

Table 101. Forest fires in Norway 1990-2002 (Source: Directorate for Civil Protection and Emergency Planning)

Activity data	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Number of fires	578	972	892	253	471	181	246	533	99	148	99	117	213
Unproductive forest (ha)	-	-	-	1355	1236	776	1697	6058	1647	734	1426		1247
Productive forest (ha)	2564*	4312*	3957*	883	1081	355	3438	2606	1103	127	293	52	958

* Estimated from the number of fires

In accordance with the principles of this report emissions in all forest is reported. The area burned varies considerably from year to year due to natural factors (for example variations in precipitation). Assuming that the carbon content of biomass is 50 %, half of the biomass burned will end up as CO_2. There are no exact data on the amount of biomass burned per area. Normally, only the needles/leaves, parts of the humus and smaller branches are burned. We have assumed that there are 20 m^3 biomass per ha and that the mass of trees burned constitute 25 % of this (this is consistent with IPCC (2004)). It is also likely that there is about 1 m^3 dead-wood per ha that will be affected by the fire due to its dryness. It is difficult to assess how much of the humus is burned, and this is much dependent on forest type. There is about 7500 kg humus per ha, we assume that 10 % of this is burned. This factor is, however, very dependent on the vegetation type. Most of the forest fires in Norway take place in pine forest with a very shallow humus layer.

Table 102. CO2 emissions from forest fires, 1990-2003. Gg

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Living biomass	17	29	26	4	4	2	9	16	5	2	3	0	4	14
Dead wood	0.9	1.4	1.3	0.2	0.2	0.1	0.5	0.8	0.3	0.1	0.2	0.0	0.2	0.7
Humus	1.3	2.2	2.0	0.3	0.3	0.2	0.7	1.2	0.4	0.1	0.2	0.0	0.3	1.0
Total	19.3	32.5	29.8	4.6	4.8	2.3	10.6	17.9	5.7	1.8	3.5	0.1	4.5	15.5

There are no national data on emission factors for non-CO_2 gases from forest fires. The guidance of IPCC (2004) is either to estimate emissions of non-CO_2 gases based on the C released (method 1) or to use emission factors on the amount burned (method 2).

Method 1
CH_4 emissions = C * Emission ratio * 16/12
CO emissions = C * Emission ratio * 28/12
N_2O emissions = C * N/C ratio * Emission ratio * 44/28
NOx emissions = C * N/C ratio * Emission ratio * 46/14

Where C is the carbon released.
IPCC (2004) suggests a default N/C ratio of 0.01. The methane emission ratio is 0.012 and for nitrous oxide 0.007.

Method 2
This method is using emission factors per kilo mass burned. The proposed emission factor is 7.1/9 g/kg for CH_4 (the average is applied here) and 0.11 g/kg for N_2O. N_2O emission factors have been derived from method 1 data. The emissions are small – in the size of less than 0.1 Gg CH_4 and 0.001

Gg N_2O. The ranges of the data given indicate that the uncertainty in emission ratios is about 25 % for methane and 30 % in nitrous oxide, but in addition comes the uncertainty of the C released. For N_2O the results differ between the two methods (appears to be due to some inconsistency in GPG 2004). We suggest using the emissions estimated using method 1 for CH_4 and N_2O.

Table 103. Estimates of CH4 and N2O emissions from forest fire. 1990-2003. Gg

	1990	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003*
CH_4 (method 1)	0.084	0.020	0.010	0.046	0.078	0.025	0.008	0.015	0.000	0.022	0.068
CH_4 (method 2)	0.084	0.020	0.010	0.046	0.078	0.025	0.008	0.015	0.000	0.022	0.068
N_2O (method 1)	0.0006	0.0001	0.0001	0.0003	0.0005	0.0002	0.00005	0.00011	0.00000	0.0001	0.0005
N_2O (method 2)	0.001	0.0003	0.0001	0.0006	0.0011	0.0003	0.0001	0.0002	0.0000	0.0003	0.0009

* Preliminary

Conversion to forest land from cropland, grassland and settlements does, according to IPCC (2004), not alter the emissions of non-CO_2 greenhouse gases. Exceptions are in cases of fertilization and drainage as addressed above.

7.11.3. Cropland

Emissions from on-site and off-site burning of agricultural waste are reported under the agriculture sector and are not addressed here. Emissions from application of fertilizer and cultivation of organic soils are also reported under the agriculture sector. Conversion of forest, grassland and other land to cropland is expected to increase N2O emissions. This is due to a mineralization of soil organic matter.

IPCC (2004) has proposed the following methodology:
N_2O-N = Area converted last 20 years * N released by mineralization * Emission factor
Data on the area converted last 20 year is available from Statistics Norway for 1970-1992 and for 1994-1998. Data are not available for later years. This area, however, also includes organic soils! The two data sets are inconsistent because the 1970-1992 data set is also covering area with government support for drainage, while the 1994-1998 data covers the total area.

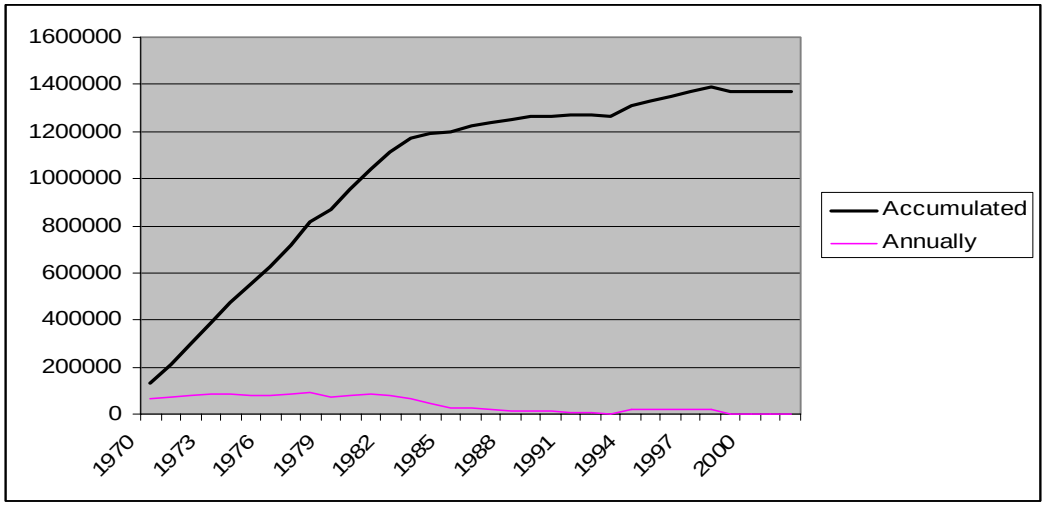


Figure 36. New agriculture area (ha). Annual values and accumulated. Source: Statistics Norway.

The N released by mineralization is estimated from the C released in mineral soils during conversion to cropland divided by the C:N ratio of soil organic matter (default is 15). According to JORDFORSK

the average C:N ratio in Norway is 13.4. The C-loss was based on the erosion loss estimated under "cropland remaining cropland" (section 7.2.2). The default emission factor from GPG 2004 is 1.25 %.

Table 104. Area converted to cropland and related N2O emissions. 1990-2003. Gg

	1990	1991	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003
Area converted last 25 years (1000 ha)	151.6	145.8	133.2	124.3	118.8	113.1	106.5	99.1	92.1	85.4	78.1	78.1
C emissions (Gg C)	3.8	3.6	3.3	3.1	3.0	2.8	2.7	2.5	2.3	2.1	2.0	2.0
Emissions (Gg N_2O)	0.006	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003

7.11.4. Grassland

Emissions from fertilization and drainage of wetlands are considered under agriculture. The effect of emissions from mineralization is very uncertain and is not accounted for. Fires in grasslands are ignored, the frequency of such fires is low in Norway. Fertilization of grassland may also alter the methane sink, but there are currently no data available to account for this.

7.11.5. Wetlands

Norway has many reservoirs due to hydroelectric power production. Flooding may generate emissions of CH_4 and N_2O. An emission methodology is given in an Appendix of IPCC (2004) for further methodology development. There is an ongoing national project (SINTEF and STATKRAFT) to estimate emissions from reservoirs. There will, however, not be any results from this project during the next year, and more measurements are needed to increase the representativity. N_2O emissions from organic soils managed for peat extraction can be estimated based on Uppenberg et al. (2001). Emission factors after drainage and before extraction range from 0.02-0.1 g/m^2. The first years after extraction has started (6-7 years) the range is 0.2-1 g/m^2, later on reduced to 0.01-0.05 g/m^2. Because the age of the land is not known we propose using a factor of 0.05 g/m^2 for all years.

The area was estimated in Section 7.4. This gives us an estimate of 0.2 Gg N_2O.
According to the same study peat extraction reduces CH_4 emissions (2-40 g/m^2 before drainage and 0.2-4 after). In line with GPG 2004 this reduction is not accounted for in the calculations.

7.12. Uncertainties

The study has identified several large uncertainties in the estimates. The uncertainties are particularly large for emissions of non-CO_2 gases and CO_2 from soil (except forest soil). For these categories of emissions and removals also often the activity data are uncertain. Changes in soil organic carbon are difficult to monitor due to upscaling problems, lack of time-series and lack of management data. Nevertheless, we are able to conclude that emissions of non-CO_2 gases are small. Also lack of knowledge of the history of a piece of land causes problems. More measurements and more use of models could contribute to reductions in these uncertainties. Uncertainties are also large for other wooded land (tree covered land that does not meet the forest definition) and for Finnmark County which is not included in the National Forest Inventory. These changes are expected to be small. Also reservoirs should be further investigated due to the importance of dams in Norway (hydroelectric power stations), estimates for these have not been included in the present study. Data are, however, quite certain for stock changes in forest remaining forest which constitute the largest removal of the inventory.

A formal uncertainty analysis has not been performed as a part of this project. The largest uncertainties are related to N_2O from fertilizer use and land disturbances, where the uncertainty will be larger than 100 %. Also the estimate of CO_2 from farmed organic soils is very uncertain, using the data

from Sweden and Finland as an indicator the uncertainty is more than 100 %. Also CO_2 from agriculture soils are quite uncertain, but more than 100%. CO_2 from liming is in the other hand well determined as the application is monitored and the emission factor is based on stoichiometry.

7.13. Source-specific QA/QC and verification

The Norwegian Institute of Land Inventory undertakes a control assessment each year to check data quality and ensure consistent methodology in the survey. Statistics Norway examines the various statistical data for consistency over time. Due to time constraints, we have no further information on the QA/QC procedures for the LULUCF sector now. However, we will provide more information on the specific QA/QC procedures in NIR 2006.

The Norwegian Institute of Land Inventory (NIJOS) will be in charge of archiving all data from the calculations of emissions and removals from LULUCF. Statistics Norway will be in charge of ensuring consistency between LULUCF and non-LULUCF categories and make sure there is no double-counting of emissions or removals between these.

7.14. Recalculations

Implementation of the new IPCC Good practice guidance has provided a different inventory for the land-use, land-use change and forestry sector; hence the whole time-series have been recalculated.

7.15. Planned improvements

The study on LULUCF that was carried out pointed out several needs for improvements, which we have to consider with the aim to improve the methodology and as a part of the total plan of improvement of the Norwegian GHG inventory described in Section 1.9. We will need to have a special focus on this sector in this work, since the calculation methodology recently has been developed according to the newly adopted GPG 2004, and since it is much more comprehensive than before.

8. Waste

8.1. Overview

This sector includes emissions from landfills (6.A), wastewater handling (6.B) and small scale waste incineration (6.C). Waste incineration with energy utilisation is accounted for under 1A (Energy combustion). Waste incineration included here are emissions from natural gas flared outside the energy sector, methane flared at landfills and combustion of hospital waste and cremations, see Documentation box in Table 6A in the CRF tables.

The emissions of greenhouse gases from the waste sector were relatively stable during the 1990s, with emission levels of around 2.6 million tonnes CO_2-equivalents (Section 2.3). Solid waste disposal on land (Landfills) is the main category within the waste sector, accounting for about 92.5 per cent of the sector's total emissions. Wastewater handling and waste incineration account for approximatley 5,9 and 1,6 per cent respectively. The waste sector accounted for 4.0 per cent of the total GHG emissions in Norway in 2003.

8.2. Managed Waste Disposal on Land – CH_4 – 6A1 (Key source)

8.2.1. Description

CH_4 and non-fossile CO_2 are emitted during biological decomposition of waste. This transformation of organic matter takes place in several steps. During the first weeks or months, decomposition is aerobic, and the main decomposition product is CO_2. When there is no more oxygen left, the decomposition becomes anaerobic, and methane emissions start to increase. After a year or so, CH_4 emissions reach a peak, after that the emissions will decrease over some decades (SFT 1999b).

The emissions of methane have decreased slightly since 1996 due to reduction of the amount of waste disposed at disposal sites (Chapter 2.2). This reduction is the result of several measures which were introduced in the waste sector particularly in the 1990s. With a few exceptions, it is prohibited to dispose easy degradable organic waste at landfills in Norway. In 1999 a tax was introduced on waste delivered to final disposal sites. This tax was equal to 320 NOK per tonne waste disposed at landfill sites in 2002, and increased to 327 NOK from 2003. In addition, landfills receiving biodegradable waste (waste containing degradable organic carbon (DOC)) are required to collect and treat landfill gas. In 2002 a total of 60 landfills had installed a landfill gas extraction system, and approximately 22 ktonnes of methane was recovered in 2002. In addition, the amounts of waste recycled have increased significantly since 1990.

Emissions of CH_4 from solid waste disposal is key source in level and trend due to uncertainty in AD and EF. The contributation of this source category to the total uncertainty in level and in trend is 3.72 per cent and 4.47 per cent, respectively.

8.2.2. Method CH_4

In 1999, the Norwegian Pollution Control Authority (SFT) developed a model for calculating methane emissions from landfills (SFT 1999b). The model was based on the IPCC theoretical first order kinetics methodologies (IPCC 1997b) and the method was consistent with the IPCC Good Practice Guidance. The effect of weather conditions had also been taken into account.

However, both the former Norwegian and the IPCC 1997 model contain a mathematical error. As the rate of reaction decreases over the year, the average rate of reaction over the year has to be found. This is done through integration and neither the former Norwegian model, nor the IPCC 1997 model, contained such integration. The result was that with a half-life time of 10 years the emissions were underestimated by 3.5 per cent. The models were also complicated and difficult to understand, and gave a poor view into the calculations. Therefore a new model taking account of these issues was developed in 2004. Methane emissions are in the new model calculated from the amount deposited every year, and the amounts added at the end

(SFT 2005).

This new model starts with the calculation of the amount of dissimilating $DDOC_m$ (mass of dissimilatable organic carbon = the part of DOC (degradable organic carbon) that will dissimilate (degrade) under anaeronic conditions) contained in the amount of material being landfilled. This is done in exactly the same way as in the former Norwegian model.

As this is a first order reaction, the amount of product formed will always be proportional to the amount of reactant. This means that it is of no concern to the process when the $DDOC_m$ came into the landfill. As far as we know the amount of $DDOC_m$ in the landfill at the start of the year, all years can be considered to be the first calculating year. This simplifies calculations. With reaction start set to be on January 1 the year after landfilling, the "motor" of the new calculating model has been made out of these two very simple equations:

$$(26) \quad DDOC_{mdiss} = (DDOC_{ma(ly)} + DDOC_{md}) * (1- e^{-k})$$
$$(27) \quad DDOC_{ma} = (DDOC_{ma(ly)} + DDOC_{md}) * e^{-k}.$$

Equation (26) calculates DDOCmass dissimilating ($DDOC_{mdiss}$), from the not dissimilated DDOC mass accumulated from last year ($DDOC_{ma(ly)}$), plus DDOC mass landfilled last year ($DDOC_{md}$). Equation (27) calculates the DDOCmass accumulated as not dissimilated ($DDOC_{ma}$), for next year's calculations from the same basis as equation (26).

After that the amount of dissimilated $DDOC_m$ has been found, CH_4 produced and CH_4 emitted is found by using the same set of procedures and factors as in the former model.

The full set of equations is found below. If the reaction is set to start in the year of landfilling, separate calculations have to be made for that year and two extra calculating equations will have to be added. They are included in the equations below.

To calculate $DDOC_{md}$ from the amount of material

$$(28) \quad DDOC_{md} = W * MCF * DOC * DOC_f$$

To calculate $DDOC_m$ accumulated in the SWDS

$$(29) \quad DDOC_{ml} = DDOC_{md} * e^{-k*((13-M)/12)}$$
$$(30) \quad DDOC_{ma} = DDOC_{ma(ly)} * e^{-k} + DDOC_{ml}$$

To calculate $DDOC_m$ dissimilated

$$(31) \quad DDOC_{mdi} = DDOC_{md} * (1-e^{-k*((13-M)/12))}$$
$$(32) \quad DDOC_{mdiss} = DDOC_{ma(ly)} * (1-e^{-k}) + DDOC_{mdi}$$

To calculate methane produced from DDOC dissimilated

$$(33) \quad CH_{4\ prod} = DDOC_{mdiss} * F * 16/12$$

To calculate methane emitted

*(34) CH_4 emitted in year T = ($\sum CH_{4\ prod}(T)$) - R(T)) * (1-OX)*

Where:

W	: amount landfilled
MCF	: Methane Correction Factor
M	: Month number for reaction start. (January 1, year after landfilling, M=13)
DOC	: Degradable Organic Carbon
DOC_f	: Fraction of DOC dissimilating, anaerobic conditions
DDOC	: Dissimilatable Organic Carbon, anaerobic conditions
$DDOC_{md}$	: DDOC mass landfilled
$DDOC_{ml}$	: DDOC mass left not dissimilated from DDOCm landfilled, year of landfilling
$DDOC_{ma}$	: DDOC mass left not dissimilated at end of year
$DDOC_{ma(ly)}$	: DDOC mass accumulated from last year
$DDOC_{mdi}$	: DDOC mass dissimilated from DDOCm landfilled, year of landfilling
$DDOC_{mdiss}$	: DDOC mass dissimilated in calculation year
$CH_{4\ prod}$	: CH_4 produced
F	: Fraction of CH_4 by volume in generated landfill gas
16/12	: Conversion factor from C to CH_4
R(T)	: Recovered CH_4 in year of calculation
OX	: Oxidation factor (fraction).

8.2.3. Activity data

The amount of different waste materials is compiled in annual surveys carried out by Statistics Norway. These data are used as input into the model used to calculate methane emissions. For the new model, historic data have been recalculated from the former waste category basis, to a material waste basis. The model is based on types of materials food waste, paper, wood and textiles.

Data from each landfill site with methane recovery units are compiled by the county governors and reported to SFT. These data are imported into the national model for calculating methane from landfills.

8.2.4. Emission factor

The emission factors used in the Norwegian model are a mixture of country-specific factors, estimated by a range of officials and Norwegian waste experts. IPCC defaults values are applied where country-specific information is not available. Table 105 shows some of the variables used in the calculations of methane emissions from solid waste disposals.

Table 105. Variables used in the calculations of methane from landfills.

Variables	Type of waste		
	Food waste	Paper	Wood and textiles
$t_{1/2}$ (half life time)	2.8 years	8.4 years	10.5 years
DOC	0.170 Mg/Mg	0.370 Mg/Mg	0.400 Mg/Mg
DOC_f (Part of DOC dissimilating)	0.5	0.5	0.5
Ox. Methane oxidized in top layer	0.1	0.1	0.1
F. Part of methane in generated landfill gas	0.5	0.5	0.5

Source: SFT (2079/2005)

8.2.5. Uncertainties

The importance of the uncertainties in calculations of methane from landfills will decrease with decreased source contribution and improved IPCC default parameter values, but most likely it will still remain among the main uncertainties in the Norwegian GHG inventory.

The methodology Statistics Norway/SFT use to calculate methane emissions from landfills is identical for the whole time series. The quality of the activity data used in the model has been improved in the last years. This is also the case regarding the data for recovered methane.

8.2.6. Source specific QA/QC

Internal checks of time series for all emission sources are made every year when an emission calculation for a new year is done.

Internal checks of time series of waste data, methane recovered at landfill sites and calculated methane emissions from the model are carried out and corrections are made if any kinds of errors are found. If there is a change in the trend of methane recovered from a landfill site, the site is contacted to identify a plausible explanation. Corrections are made if there is no plausible explanation of the change.

8.2.7. Recalculations

In 2004, Norway has gone through a full review of its 1999 calculating model, and not just the mathematical handling described above. The changes that have been carried out in the model and that have resulted in substantial reduction in the methane emissions:

The new model is based on materials to comply with the current SN statistics, and the review of parameters has given the following results:

a. In the new model plastics is omitted as degradable material under anaerobic conditions. This change lowers the 2002 calculated methane emission with 14 per cent compared to the former model.
b. The absorption of carbon dioxide in the seepage water had not been taken into account when setting the part of methane in developed landfill gas. In the new model, the IPCC default value of 50 per cent is being used. 50 per cent methane in developed landfill gas also is the theoretical methane content in generated gas from landfills with the main portion of dissimilating material being cellulose and hemicellulose. This lowers the calculated methane production in SWDS with 9 per cent compared to the former model.

c. The DOC_f value of 0.7 was in compliance with a 2000 IPCC default value. But at the same time IPCC set a default value for wood not including lignin to 0.77. With wood containing 20 per cent lignin, the default value for wood would be 0.62. In the same guidelines DOC_f values from 0.5 to 0.6 were also considered to be good practice. Today $DOC_f = 0.7$ seems to be considered as the upper theoretical value, and new research on wood and paper shows DOC_f values for wood and newspaper and magazine paper even well below 0.5. Based on this new knowledge, DOC_f has been lowered from the uppermost limit of IPCC recommendations from 2000 of 0.7, to the lowest recommended value of 0.5. This lowers the calculated amount of methane emitted with an additional 26 per cent.
d. The correction of the mathematics of the former model increases the calculated amount of methane emitted by 3.2 %

The total result of the review of the Norwegian model for calculating methane emissions from SWDS, is a 45.7 per cent drop for 2002

Table 106. The revision of the model has resulted in these recalculations for 1990 and 2002.

	NIR 2004	NIR 2005	Change in per cent
1990	181.701	117.295	35.4
2002	184.201	99.975	45.7

8.2.8. Planned improvements
No further improvements are planned before NIR 2006.

8.3. Unmanaged Waste Disposal Sites – 6A2 (Non Key Source)

In Norway landfilling of solid waste has been regulated and controlled for some decades, and unmanaged landfills are from before 1970. Futhermore, the methane emissions for all years have been calculated from the total amounts of landfilled materials. Therefore Norway does not separately report emissions from unauthorized/unmanaged SWDSs.

8.4. Wastewater handling - 6B (Non Key Sources)

8.4.1. Description
Emissions of CH_4 and N_2O from Wastewater handling has been relative stable during the 1990 to 2003, with a small increase for CH_4. The emission trend for this periode is described in Section 2.2.

8.4.2. Method
CH_4
Emissions of methane from domestic and commercial waste water has been calculated. Emissions from breweries, dairies and slaughterhouses are included. Emissions of methane from industries with their own waste water treatment plants are small, because the plants are

mainly aerobic or the methane gas is being recovered. CH_4 from domestic sludge is calculated together with the waste water emissions.

Emissions of methane from domestic waste water are calculated according to the IPCC default methodology:

$$(35) \quad E_i = N_i * D * B_0 * MCF$$

E: Emissions of methane
N: Population in Norway
D: Organic load in biochemical oxygen demand (kg BOD/1000 persons/year)
B_0: Maximum methane-producing capacity (kg CH_4/kg DC)
MCF: Methane conversion factor
$_i$: Year

N_2O
Emissions of nitrous oxide from domestic and commercial wastewater only has been calculated. The N_2O from sewage sludge applied on fields is included under Chapter 6, Agriculture. For N_2O, emissions are calculated from nitrification/denitrification that occurs in the pipelines and the N_2O emissions that occur as a by-product in biological nitrogen-removal plants. This is assumed to be a more precise method than the recommended IPCC method that is based on the annual per capita protein intake.

8.4.3. Activity data

CH_4
Data for the number of residents in Norway are given from Statistics Norway's population statistics. The IPCC default value of 18 250 kg BOD/1000 persons/year is used for D, the degradable organic component in the waste, for all years.

N_2O
A yearly estimate for the amount of nitrate supplied to the pipelines is obtained from the waste water statistics at Statistics Norway.

Data for the amount of nitrogen that is removed in the biological step in the actual wastewater plants are given by The Norwegian Pollution Control Authority (SFT).

8.4.4. Emission factor

CH_4
The IPCC emission factor for B_0 of 0.6 kg CH_4/kg DC is used. The methane conversion factor (MCF) is, according to good practice, given by the fraction of BOD that will ultimately degrade anaerobically. A country-specific factor of 0.02 is used for the fraction that is anaerobic treated. The factor is from Statistics Norway (waste water statistics), and corresponds to the fraction of the waste water plants that are categorized as "Sealed tank" and partly the category "Separate toilet system".

N_2O

For calculation of the emissions from the pipelines, we use the IPCC default emission factor of 0.01 kg N_2O-N/kg sewage-N produced.

It is assumed that 2 per cent of the nitrogen removed from plants will form N_2O. This country-specific emission factor is given in SFT (1992), and the assumption is based on measurements in plants and comparisons with factors used in Sweden.

8.4.5. Uncertainties

The uncertainty in AD is estimated to ±41, CH_4 EF to ±53 and N_2O EF to ±110 per cent (SN 2000), see Annex II.

8.4.6. Source Spesific QA/QC

There is no source specific QA/QC procedure for this sector. See Section 1.6 for the description of the general QA/QC procedure.

8.4.7. Recalculations

There are no recalculations done for this sector this year.

8.4.8. Planned improvements

No further improvements are planned before NIR 2006.

8.5. Waste incineration – CO_2 – 6C (Non Key Source)

8.5.1. Description

Emissions from waste incineration in district heating plants are reported under energy (IPCC 1A1a), as the energy is utilised, and therefore described in Chapter 3. In 2003, there were 10 waste incineration plants where household waste is incinerated. In addition, some incineration plants burn waste other than household waste, mainly wooden waste, paper, pasteboard and cardboard. These emissions are reported and described under energy (IPCC 1A2d). Waste, other than household waste, is also used as energy source in some manufacturing industries. In this chapter, the focus will be on waste reported in IPCC sector 6C. This includes emissions from flaring, except flaring from energy sectors, and emissions from cremation and hospital waste. The emission trend from 1990 to 2003 is described in Section 2.3.

8.5.2. Method

Emissions from flaring of landfill gas by landfills are estimated. The emissions are estimated by multiplying the amount of gas flared with the emission factors shown in Table 107. Emissions from flaring of natural gas by production of methanol are also estimated. The amount of gas used in flaring is multiplied by appropriate emission factors, found in Table 107. There is one exception, emissions of NO_x, which are reported from the plant directly to the Norwegian Pollution Control Authority.

Emissions from cremation and hospital waste are estimated by emission factors multiplied with activity data. For hospital waste, the emissions of heavy metals used in the model are reported to the Norwegian Pollution Control Authority.

8.5.3. Activity data

Landfill gas
The total amount of landfill gas extracted each year is reported by landfills to the Norwegian Pollution Control Authority. Statistics Norway subtracts the amount utilized for district heating and thermal power, which is given by the energy statistics in Statistics Norway. To find the amount flared of the remaining landfill gas, a fraction given from a survey of waste statistics from Statistics Norway is used. This survey is made every third year, but is planned to be annual in the coming years.

Natural gas
The amount of natural gas flared by the production of methanol is reported directly to Statistics Norway.

Hospital waste
The amount of hospital waste was reported to Statistics Norway for the years 1998 and 1999. For the period 1990-1997 the average for 1998 and 1999 has been used. After 1999 there has been no collection of hospital waste data. Due to the lack of better information, the waste amount for 1999 has been used to calculate the emissions for subsequent years.

Cremation
The number of cremated bodies is taken from the death statistics at Statistics Norway (Statistical Yearbook). It is assumed that the average weight of a body is 60 kilogram. Further is it assumed that 40 per cent is dry substance. The weight of a coffin is set to 25 kilogram.

8.5.4. Emission factors

Table 107. Emission factors for flare, cremation and hospital waste incineration

Component	Flare Landfill gas kg/tonnes	Flare Natural gas Tonnes/Sm^3	Cremation Tonnes/tonnes	Hospital waste Tonnes/tonnes
SO_2	0.02	0	0.00037	0.0014
CO_2	275	2340	0	0.3
CO	0.04	1.5	0.015	0.0028
NO_x	0.17	Reported to SFT	0.0009	0.0014
Particles	0.14	0.0018	0.0024	0.0005
NMVOC	0	0.06	0.0013	0.0007
CH_4	0.37	0.24	0.00024	0.00023
N_2O	0.0015	0.02	0.0003	
		mg/tonne	mg/tonne	mg/tonne
Pb	NA	0.3	0.37959	Plant-specific emission factors
Cd	NA	1.7	0.63408	Plant-specific emission factors
Hg	NA	1	102 040.8	Reported
Cu	NA	16	0.1573	2594.6
Cr	NA	21	0.1722	4705.6
As	NA	3.8	0.22387	1272.4
Dioxin	NA	0.00005	0.20408	0.29685
PAH	NA	1.44	700 000	2.5
PAH-4	NA	0	10 000	0.04
PAH-Ospar	NA	0.8	230 000	0.9

NA=Not Applicable

8.5.5. Uncertainties
Activity data-Amount of hospital waste
No new data has been reported since 1999. The amount of waste today may vary from the data reported in 1998 and 1999.

Emission factors
If the composition of the hospital waste is different to the waste the emission factors are based on, the calculated emissions will be incorrect. Combustion engineering and processes also influence the emissions. These uncertainties have not been calculated.

8.5.6. Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See Section 1.6 for the description of the general QA/QC procedure.

8.5.7. Recalculations
There was no recalculations done for this sector this year.

8.5.8. Planned improvements

No further improvements are planned before NIR 2006.

9. Recalculations

9.1. Overall description of recalculations

This chapter describes recalculations performed in the Norwegian emissions inventory since the NIR 2004 submission.

To account for new knowledge on activity data and emission factors and to correct for some errors in the calculations, the Norwegian emission inventory has been recalculated for the entire time series 1990-2002 for all components. The figures reported in this submission are therefore consistent through the whole time series.

Most of the recalculations have been performed for 2002 because the energy accounts for 2002 that was the basis for last year's submission were "preliminary". Now the "final" figures for the energy accounts are available. This is due to the fact that final energy consumption figures from the manufacturing statistics and some other final energy figures now are included in the energy accounts. These types of revisions caused by the energy balance will not be commented specifically under each IPCC code.

The most important recalculations are

1. Recalculation of land-based industry and offshore oil industry, caused by inclusion of emission figures reported to SFT and Norwegian Petroleum Directorate. Emissions were earlier estimated by emission factor and activity data.
2. A new calculation method in the methane emission model contributes to lower emissions from landfills than previous calculations suggest.

9.2. Specific description of the recalculations

9.2.1. IPCC category 1 Energy

As mentioned above, most of the recalculations for 2002 are caused by revisions in the energy accounts from “preliminary” in last submission to “final” in this submission.

FUEL COMBUSTION ACTIVITIES
1 A 1 a Public Electricity and Heat Production
An amount of wood waste is removed from one district heating plant for 2001 in order to avoid double counting.

Another recalculation performed concerns emissions of N_2O from district heating plants. As emissions of NO_X are reported from each plant to SFT, an estimated amount of 2.5% of this NO_X is subtracted and reported to the UNFCCC as N_2O. This methodology has until recently been applied to all district heating plants except from three of them and for the years 2001 onwards. In these cases, N_2O emissions were calculated through consumption data and appropriate emission factors. Emissions of N_2O for these three district heating plants have now been estimated for the years after 2000 according to the methodology applied to all other plants.

1 A 1 c Manufacture of Solid Fuels and Other Energy Industries
CO_2 emissions from extraction of oil and gas have been recalculated. For the year 2003 emission figures for each fields reported by all field operators are used in the emission model. For the years 1990-2002 emission estimates are based on field-specific emission factors which vary from year to

year. This is an important improvement in the national inventory, given that in all earlier submissions one universal emission factor was used for all fields and for all years.

1A2 Manufacturing Industries and Construction
1 A 2 a Iron and Steel
The emission figures for two plants consuming CO-gas have been recalculated. In this submission reported figures have been used for these two plants; for 1990 to 2003 for one of the plants and for 1997 to 2003 for the other plant. The CO_2 is now reported under non combustion emissions.

1 A 2 c Chemicals
For one plant, CO_2 figures for all years (1990-2003) reported to SFT replace figures based on emission factors and activity data.

There have been minor revisions in the energy accounts for some sectors.

1A3 Transport

Road Transportation
New figures on average mileage and driven kilometres for passenger cars for the years 2000 to 2003 are now available from the Institute of Transport Economics (TØI), and are used in the calculation. These changes influence on all emissions.

The decrease in emission of CO_2 from light and heavy duty vehicles in 2002 is due to changes in consumption of diesel according to the revisions in the energy accounts (final figures)

Navigation
Emissions of CO_2 for 2002 are reduced in the final energy accounts. The sale was lower than what was assumed in the preliminary energy accounts.

Emission factor for CH_4 from LPG- ferry has changed. Emissions for the years 2000-2002 have decreased due to this change.

Furthermore, revisions in the energy accounts give small revisions in other emission figures.

1A4 Other sectors
1 A 4 b i Residential plants
Estimates for the amount of wood and oil products used in households in 2002 are updated. Emissions of all components increased in 2002 based on the final energy accounts.

FUGITIVE EMISSIONS FROM FUELS
1 B 1 a Coal Mining and Handling
Final production figures for coal mining in 2002 were higher than the preliminary figures. Emissions of methane have therefore increased compared to previous submission.

1B2 Oil and Natural Gas

1 B 2 a i Exploration Production, Transport
Process emission of CH_4 from oil loading on shore for one terminal has been revised for the whole time series. The emission figures for this terminal were based on calculations by Statistics Norway and SFT (emission factor * activity data) in the previous submission. Now reported figures are used. The percentage distribution between CH_4 and NMVOC for 2003 has been used as distribution formula for all years. This has led to an increase in emissions of CH_4. At the same time reported CH_4 process emissions from a refinery are included in the inventory. These figures replace formerly estimated figures for the years 1990 to 2003. Reported emissions from 1992 are used for 1990 and 1991 to missing figures.

1 B 2 c Venting and flaring
For one gasterminal, CO_2, and NO_x figures for flaring for all years (1990-2003) reported to SFT replace estimates based on emission factors and activity data.

Emission of CH_4 from flaring of crude oil is deleted for the year 1980 to 1991. This is done after consultation with SFT.

I addition minor revisions (flaring at refineries) in the energy accounts have also given some minor recalculations in the emission figures.

9.2.2. IPCC category 2 Industrial processes

2A Mineral Products
2 B 1 Ammonia Production
For one plant, CO_2 figures for all years (1990-2003) reported to SFT replace figures based on emission factors and activity data.

2 B 4 Carbide Production
Emissions of CO_2 have decreased due to revision of the whole time series for all factories producing carbide. Now emissions reported to SFT are included in the inventory, previous calculation made by SN was based on emission factor and activity data.

2C Metal Production
Reported emissions of CO_2 from two ferroalloy plants are now used instead of using the values calculated by SN that were used before. So now the total CO_2 emission from ferro alloy production is based on emissions reported by the plants to SFT. This change has increased the emissions of CO_2 for the whole time series. Emission figures of CO_2 from one plant are revised for 2002. Previously wrong figure was reported.

2 D Food and Drink
CO_2 emissions from production of bio protein from natural gas are included for the years 2001 to 2003. This is a new source from 2001, and the bio protein is being used as animal fodder.

2F Consumption of Halocarbons and Sulphur Hexafluoride
Emissions of SF_6 from production of medium voltage switches are included for the first time and a timeserie is established.

3D Other
N_2O from propellant gas, drag racing and research is for the first time included in the inventory.

9.2.3. IPCC category 4 Agriculture
Statistics Norway has made improvements in the calculation model for N_2O emissions from the agricultural sector. This gives changes in the figures for all reported years for several emission sources for N_2O. National N-factors used for calculating ammonia are now also used for estimation of N_2O.

4B Manure Management
Emissions of N_2O from storage of manure are revised. The percentage distribution between different storage systems for manure and grazing is adjusted to Norwegian condition. The estimated emissions of N_2O from storage have been corrected for losses of N due to transformation of N_2O to volatile NH_3. The correction has been distributed on storage systems after how much the different storage systems are being used.

4D Agricultural Soils
Emissions of N_2O from spreading of manure, grazing animals and leakage have been revised for all years due to new knowledge. Emissions have decreased for all years. The new calculations are adjusted to Norwegian condition.
A new figure for the area of cultivated histosols are now available from JORDFORSK, and are used for all years Emissions of N_2O from crop residue are recalculated for all years. These emissions have earlier been reported constant since 1998.

4F Field burning of agricultural residue
The share of straw burnt has been changed, based on new estimates for the years 2001-2004, from 15% and gradually down to 7.5%. Emissions of CH_4 and N_2O have decreased.

9.2.4. IPCC category 7 Land-Use, Land-Use Change and Forestry (LULUCF)
Implementation of the new IPCC Good Practice guidelines has provided a different inventory for LULUCF sector, hence the whole time series have been recalculated. This is described in further detail in Chapter 7.

9.2.5. IPCC category 6 Waste
6A Solid Waste Disposal on Land
Corrections in the methane emission model gives lower calculated emissions from landfills than previous calculations. In this new model is it assumed that plastic is not degradable. In the old methane emission model was it assumed that plastic was degradable, and contributed to about 13 percent of total methane emissions from landfills. Some factors have also been changed in the new model.

Emission of CO_2 from solid waste disposal is removed. In the old methane emission model it was assumed that plastic and textiles were degradable, and generated emission of CH_4 during degradation. Indirect emissions of CO_2 were also estimated for the fossil part. Now plastics and textile is considered not degradable. Hence there is no fossil CO_2 emissions from this emission source. For further explanations see Chapter 8 Waste.

9.3. Implications of the recalculations

9.3.1. Implications for emissions levels
Table 108 and Table 109 show the effects of recalculations on the emission figures for the greenhouse gases 1990 – 2002.

Table 108. Recalculations in 2005 submission compared to the 2004 submission. CO_2, CH_4 and N_2O. Tonnes CO_2-equivalents

	CO_2			CH_4			N_2O		
	Previous submission	Latest submission	Difference (%)	Previous submission	Latest submission	Difference (%)	Previous submission	Latest submission	Difference (%)
1990	34690.2	34414.1	-0.8	6448.6	5159.2	-20.0	5517.1	5064.2	-8.2
1991	33559.1	33541.1	-0.1	6540.9	5194.3	-20.6	5362.3	4919.2	-8.3
1992	33930.6	33762.7	-0.5	6627.0	5258.3	-20.7	4684.0	4256.2	-9.1
1993	35565.0	35408.3	-0.4	6757.4	5303.4	-21.5	5046.9	4603.9	-8.8
1994	37296.1	37265.8	-0.1	6844.2	5381.4	-21.4	5144.3	4722.4	-8.2
1995	37389.9	37225.2	-0.4	6902.5	5389.8	-21.9	5225.8	4800.1	-8.1
1996	40606.8	40392.8	-0.5	6980.9	5421.6	-22.3	5225.0	4887.0	-6.5
1997	40569.5	40565.5	0.0	7033.0	5478.0	-22.1	5163.8	4821.8	-6.6
1998	40838.3	40774.4	-0.2	6951.9	5320.7	-23.5	5448.3	5102.9	-6.3
1999	41316.8	41625.6	0.7	6905.8	5226.8	-24.3	5666.6	5299.1	-6.5
2000	40856.8	41143.6	0.7	7007.3	5317.7	-24.1	5549.8	5222.9	-5.9
2001	42065.5	42664.3	1.4	7002.1	5293.4	-24.4	5554.2	5211.0	-6.2
2002	40945.2	41238.9	0.7	6875.1	5119.2	-25.5	5814.9	5419.2	-6.8

Table 109. Recalculations in 2005 submission compared to the 2004 submission. HFCs, PFCs and SF_6. Tonnes CO_2-equivalents

	HFCs			PFCs			SF_6		
	Previous submission	Latest submission	Difference (%)	Previous submission	Latest submission	Difference (%)	Previous submission	Latest submission	Difference (%)
1990	0.02	0.02	0.00	3294.40	3294.40	0.00	2185.96	2202.02	0.73
1991	0.11	0.11	0.00	2523.63	2523.63	0.00	2065.89	2084.73	0.91
1992	0.34	0.34	0.00	2016.46	2016.46	0.00	687.63	707.82	2.94
1993	2.43	2.43	0.00	1980.37	1980.37	0.00	718.87	744.65	3.59
1994	9.23	9.23	0.00	1710.38	1710.38	0.00	854.45	886.67	3.77
1995	25.88	25.88	0.00	1561.93	1561.93	0.00	577.97	617.41	6.82
1996	52.87	52.87	0.00	1439.84	1439.84	0.00	543.14	584.49	7.61
1997	88.43	88.43	0.00	1376.67	1376.67	0.00	548.01	591.15	7.87
1998	132.64	132.64	0.00	1267.18	1267.18	0.00	694.54	738.88	6.38
1999	179.45	179.45	0.00	1123.01	1123.01	0.00	840.75	886.71	5.47
2000	232.10	232.10	0.00	899.24	899.24	0.00	890.81	947.93	6.41
2001	291.68	291.68	0.00	1043.41	1043.41	0.00	764.99	805.50	5.30
2002	365.12	365.12	0.00	1119.95	1119.95	0.00	222.35	253.30	13.92

9.3.2. Implications for emission trends

As a result of the different recalculations for 1990-2002 there have been some changes in the trends. The differences are shown in Table 110.

Table 110. Trends in emissions 1990-2002. This submission vs. previous submission. GHG. Per cent change 1990-2002

	GHG	CO_2	CH_4	N_2O	PFC's	SF_6	HFC's
This submission	6.75	19.83	-0.78	7.01	-66.00	-88.50	1992097
Previous submission	6.15	18.03	6.61	5.40	-66.00	-89.83	1992097

REFERENCES

Aker Engineering 1992 — *Direct Hydrocarbon Gas Emissions from Production and Riser Platforms*

Bang, J. (1996) — *Utslipp av NMVOC fra fritidsbåter og bensindrevne motorredskaper* (Emissions of NMVOC from leisure craft and gasoline-powered equipment), Oslo: National Institute of Technology.

Bergfald & Co as 2000 — *Emissions of methane from coal mining at Svalbard*. (Only in Norwegian)

Bleken (1996) — Bleken (1996) is based on Bolstad (1994).

Bolstad, T. (1994) — *Utskilling av nitrogen og fosfor i gjødsel og urin frå husdyr i Norge* (Nitrogen and phosphorus in manure and urine from domestic animals in Norway), Department of animal science, Ås: Agricultural University of Norway.

Braastad, H. (1966)

- Volumtabeller for bjørk. Meddr norske SkogforsVes. 21:23-78.

Brantseg, A. (1967) — **Furu sønnafjells. Kubering av stående skog. Funksjoner og tabeller. Meddr norske SkogforsVes. 22:689-739.**

Brandtzæg, B.A. (1998) — System for Tilstandsovervåkning og resultatkontroll i jordbrukets kulturlandskap: Beskrivelse og vurdering av definerte indikatorer. Rapport: nr. 13/99, Telemarksforsking, Bø.

Brown et al. (1998) — *IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories, Evaluating Approaches for Estimating Net Emissions of Carbon Dioxide from Forest Harvesting and Wood Products*

Bruun, F. R. and J. Frank. (1994) — Effekter av ulike skogskjøtseltiltak på karbonstatus i jord - En litteraturstudie og beregninger." Aktuelt fra Skogforsk 11: 1-21 Statistics Norway, 1998.

Cannell, M. G. R., R. C. Dewar and D.G. Pyatt. (1993) — Conifer plantations on drained peatlands in Britain: a net gain or loss of carbon. Forestry 66(4): 353-369

Claesson, S. and S. Steinbeck (1991) — *Växtnäring, hushålling - miljø* (Plant nutrients, their management and the environment), Speciella skrifter 41, Agricultural University of Sweden.

Dämmgen, U. (2003) — Personal communication with Dämmgen, U., 2003

De Wit, H. A. and S. Kvindesland (1999) — Carbon in Norwegian forest soils and effects of forest management on carbon storage. Rapport fra Skogforskningen. Aas, Norwegian Forest Research Institute: 52.

De Wit, H.A., Liski, J., Palosuo, T. and Hylen, G. (Submitted) A carbon budget of forest in southeast Norway

ECETOC (1994) *Ammonia Emissions to Air in Western Europe,* ECETOC Technical report No. 62, Brussels, Belgium.

EEA (1996) *EMEP/Corinair. The Atmospheric Emission Inventory Guidebook*. First edition, Copenhagen: European Environmental Agency.

EEA (1997) *Copert II. Computer programme to calculate emissions from road transport*. *Methodology and emission factors.* European Environmental Agency, Topic report 1997.

EEA (2001) *Atmospheric Emission Inventory Guidebook.* EMEP. CORINAIR. 3rd Edition. November 2001

Eggleston et al. (1991) *CORINAIR Working Group on Emission Factors for Calculating 1990 Emissions from Road Traffic. Volume 1: Methodology and Emission Factors.* Eggleston, Gorißen, Joumard, Rijkeboer, Samaras and Zierock: Final report, December 1991.

EU project NNE-1999-00521 Final Technical Report of the SACS2 project, issued 30. Aug. 2002

FAO (2002) FAOSTAT database, http://apps.fao.org

Geological Society of London Memoir) 4D seismic imaging of an injected CO_2 plume at the Sleipner field, central North Sea (under publishing)

Gjertsen, Arnt Kristian. Stokland, Jogeir. Jansen, Ivar Johan. Schøning, Per and Strøm, Guro Dahle (2004). Nasjonalt system for arealdekkeklassifisering (NaSAK). NIJOS 2004/3.

Gjertsen, Arnt Kristian and Eriksen, Rune. (2004) Test av MSFI-metoden - Nøyaktighetsanalyse på datasett fra Østfold og Hobøl. NIJOS 2004/2.

Gjertsen, Arnt Kristian (2004) Sample grid for area frame statistical surveys in Norway. NIJOS 2004/5.

Grøn, O. Helliksen, W., Sollund, M-L, Stornes, J. M. (1999) Årsrapport 1998 - Kulturminner. Registrering og kontroll innenfor et system for tilstandsovervåking og resultatkontroll i jordbrukets kulturlandskap ved hjelp av utvalgskartlegging. NINA-NIKU, Oslo.

Hassel et al. (1994) *Abgas-Emissionsfaktoren von Pkw in der Bundesrepublik Deutschland* (Exhaust emission factors for passenger cars in Germany). Hassel, Jost, Weber, Dursbeck, Sonnborn and Plettau: Berichte 8/94, Umweltbundesamt (UBA) 1994.

Haukeland J.V., A. Skogli and I.Stangeby (1999) *Reisevaner i Norge 1998* (Travel habits in Norway 1998), Report 418/1999, Oslo: Institute of Transport Economics (TØI).

Hofgaard, A., (1997) The role of "natural" landscapes influenced by man in predicting responses to climate change. Ecological bulletins 47.

Hofgaard, A., (1997) Inter-relationships between treeline position, species diversity, land use and climate change in the central Scandes Mountains of Norway. Global Ecology and Biogeography Letters (1997) 6, 419-429.

Hutchings et al. (2001) *A detailed ammonia emission inventory for Denmark*. Hutchings, N.J., Sommer, S.G., Andersen, J.M. and Asman, W.A.H. 2001, Atmospheric Environment 35:1959-1968

IMC (2000) *Seam Gas Content Analysis.* Technical Services Limited.

IPCC (1996) *Intergovernmental Panel on Climate Change (IPCC) 1996: Revised Guidelines for National Greenhouse Gas Inventories.*

IPCC (1997a) *Greenhouse Gas Inventory.* Workbook. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, London: Intergovernmental Panel on Climate Change.

IPCC (1997b) *Greenhouse Gas Inventory.* Reference Manual. Revised 1996. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, London: Intergovernmental Panel on Climate Change.

IPCC (2001) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.* Intergovernmental Panel on Climate Change. http://www.ipcc.ch/pub/guide.htm

IPCC (2001a) Intergovernmental Panel on Climate Change (IPCC), Climate Change 2001. The Scientific Basis. EDS J.T. Houghton, Y.Ding, D.J. Griggs, M.Noguer, P.J. van der Linden, X.Dai, K. Maskell and C.A. Johnson, Cambridge University Press, New York. pp. 881, 2001.

IPCC (2004) Good Practice Guidance for Land Use, Land-Use Change and Forestry. (J. Penman et al., eds.). IPCC National Greenhouse Gas Inventories Programme. Institute for Global Environmental Strategies, Hayama, Kanagawa, Japan. ISBN 4-88788-003-0.

JORDFORSK (1998) *Report from the monitoring of nutrients in 1997.* Vagstad, N., M. Bechmann, P. Stålnacke, H.O. Eggestad and J. Deelstra. Centre for Soil and Environmental Research (JORDFORSK).

Kvande, H., Nes, H. and Vik, L. (2001) *Measurements of perfluorocarbon emissions from Norwegian aluminium smelters, Light Metals.*

Laine, J. and Minkkinen, K. (1996) Effects of forest drainage on the carbon balance of a mire: a case study. Scandinavian Journal of Forest Research, 11 (3):307-312.

Lehtonen, A., Makipaa, R., Heikkinen, J., Sievanen, R. and Liski, J., (2004) Biomass expansion factors (BEFs) for Scots pine, Norway spruce and birch according to stand age for boreal forests. Forest Ecology and Management 188(1-3): 211-224.

Lunnan et al. (1991) *Skog og skogproduksjon i Norge som virkemiddel mot CO_2-opphoping i atmosfæren*. Skogforsk 6 (1991)

Marklund, L.G., (1988) Biomassefunktioner för tall, gran och björk i Sverige. *Biomass functions for pine, spruce and birch in Sweden.* Institusjonen för skogtaxering. Sveriges Lantbruksuniversitet. Rapport 45, 1-73.

Morken, J. (1994). *Ammoniakktap fra husdyrrom og gjødsellager* (Losses of ammonia from livestock housing and manure storage facilities), ITF report no. 13/94, Department of Agricultural Engineering, Ås: Agricultural University of Norway.

NIJOS (2000) *Skog 2000: statistikk over skogforhold og -ressurser i Norge* (Statistics of forest conditions and resources in Norway). Ås: National Institute of Land Inventory.

NIJOS (2001) Markslagsklassifikasjon i Økonomisk Kartverk. NIJOS 2001/16. Schjalm, A. 1999: Sluttrapport om utvalg og estimering av kulturlandskapsovervåking. Notater 9/99. SSB, Oslo.

NIJOS (2005) Emissions and removals from land-use, land-use change and forestry in Norway. K. Rypdal, S. Tomter, K. Flugsrud, H. Aalde, T. Gobakken. NIJOS-report (in prep)

NPD (2001) *Forskrift om måling av petroleum for fiskale formål og for beregning av CO_2-avgift* (Regulation on measurements of petroleum for fiscal purposes and for the calculation of the CO_2 tax) - 1. november 2001 Oljedirektoratet (OD) http://www.npd.no/regelverk/r2002/frame_n.htm

OLF 1991 OLF Environmental Programme. Emissions to air. Report Phase I - Part A, Stavanger: Norwegian Oil Industry Association.

OLF (1993) *OLF Environmental Programme. Phase II. Summary Report.* March 1993, Stavanger: Norwegian Oil Industry Association.

OLF (1994) *Anbefalte retningslinjer for utslippsberegning. Identifisering, kvantifisering og rapportering av forbruks- og utslippsdata fra aktiviteter i norsk oljevirksomhet.* (Recommended guidelines for emission calculations. Identification, quantification and reporting of data on consumption and emissions from activities in the Norwegian oil and gas sector), Stavanger: Norwegian Oil Industry Association.

Olivier, J.G.J. (1991) *Inventory of aircraft Emissions: A review of Recent Literature*, Report no. 736 301 008, Bilthoven: National Institute of Public Health and Environmental Protection

Petersen, S.O. and Olesen J.E. (2002) *Greenhouse Gas Inventories for Agriculture in the Nordic Countries*, Proceedings from an international workshop, Helsingør, Denmark 24-25 January 2002, funded by the Nordic Council of Ministers, DIAS report Plant Production no. 81, Danish Institute of Agricultural Sciences)

Schøning, P. (1992) *Ressursregnskap for skog 1987-1991 : dokumentasjon av metode og resultater* (Resource accounts for forestry 1987-1991: Documentation of method and results). Internal notes 92/15, Oslo: Statistics Norway.

Seip, H.K. (1964) Tremåling. Ed. H.K. Seip, Skogøkonomi. Skogbruksboka. Vol. 3. Skogforlaget, Oslo. 251-292 pp.

Sérié E. and R. Joumard 1996 *Proposition of modelling of cold start emissions for road vehicles.* MEET Project. INRETS report LEN 9624, December 1996.

SFT (1990) *Klimagassregnskap for Norge. Beskrivelse av utslippsmengder, drivhusstyrke og utslippsfaktorer. Bidrag til den interdepartementale klimautredningen.* (Greenhouse gas inventory for Norway. Emissions figures, global warming potentials and emission factors. Contribution to the interministerial climate report). SFT-report.

SFT (1993) *Utslipp fra veitrafikk i Norge. Dokumentasjon av beregningsmetode, data og resultater* (Emissions from road traffic in Norway – Method for estimation, input data and emisson estimates).
J. Bang, E. Figenbaum, K. Flugsrud, S. Larssen, K. Rypdal and C. Torp. SFT-report 99:04.

SFT (1995) *Løsemiddelbalanse for Norge.* (Solvent balance for Norway). Kristin Rypdal. Statistics Norway. SFT-report 95:02.

SFT (1996) *A balance of use of wood products in Norway.*
Sónia F.T. Gjesdal, Ketil Flugsrud, Tone C. Mykkelbost and Kristin Rypdal. Statistics Norway. SFT-report 96:04.

SFT (1998) *Emissions of greenhouse gases in Norway - estimated by the default IPCC methodologies and the Norwegian national inventory model*. Tornsjø, B. The Norwegian Pollution Control Authority. Reports 98:06.

SFT (1999a) *Calculations of emissions of HFCs and PFCs in Norway.* Tier 2 method. Hans T. Haukås, Sigurd Holtskog (SN) and Marit Viktoria Pettersen (SFT). SFT-report 99:03.

SFT (1999b) *Beregningsmodell for utslipp av metangass fra norske deponier* (Model for estimation of CH_4 from landfills in Norway).
Jens Erling Frøiland Jensen, Torkil Williksen and Jørgen Bartnes. Norconsult. SFT-report 99:16.

SFT (1999c) *Utslipp fra vegtrafikk i Norge. Dokumentasjon av beregningsmetode, data og resultater* (Emissions from road traffic in Norway - Method for estimation, input data and emission estimates), Report 99:04 (Updated SFT report 93:12, Author: Bang, J., K. Flugsrud, G. Haakonsen, S. Holtskog, S. Larssen, K.O. Maldum, K. Rypdal and A. Skedsmo), Oslo: Norwegian Pollution Control Authority.

SFT (1999d) *Materialstrømsanalyse av SF_6. Beregning av potensielt og faktisk utslipp over tid* (Material flow analysis of SF_6. Calculation of potential and actual emissions over time), Report 99:14, Oslo: Norwegian Pollution Control Authority.

SFT (2001) *Estimating the net emission of CO_2 from harvested wood products: A comparison between different approaches.* Ketil Flugsrud, Britta Hoem and Kristin Rypdal. Statistics Norway. SFT-report 2001:1831.

SFT (2001a) *Greenhouse Gas Emissions in Norway 1990-1999.* SFT-report 2001:1801.

SFT (2001b) *Reduksjon i utslippene av HFK, PFK og SF6. Utredning av avgift som virkemiddel (*Reduction of HFC, PFC and SF6 emissions. Evaluation of tax as an instrument*).* Fredrik Weidemann. SFT-report 2001:1754

SFT (2005) *Methane emissions from solid waste disposal sites. TA- 2079. ISBN 82-7655-246-3.* http://www.sft.no/publikasjoner/luft/2079/ta2079.pdf

SFT/SN (1999a) *Evaluation of uncertainty in the Norwegian emission inventory.* Kristin Rypdal. Statistics Norway. SFT-report 99:01.

SFT/SN (1999b) *Utslipp fra veitrafikk i Norge. Dokumentasjon av beregningsmetode, data og resultater* (Emissions from road traffic in Norway - documentation of a calculation method, data and results). J. Bang, K. Flugsrud, S. Holtskog, G. Haakonsen, S. Larssen, K.O. Maldum, K. Rypdal and A. Skedsmo. SFT-report 99:04.

SFT/SN (2000) *Verification of the Norwegian Emission Inventory comparing emission intensity values with similar countries.* Elin Kvingedal, Bente Tornsjø, Sigurd Holtskog, Gisle Haakonsen and Kristin Rypdal. Statistics Norway. SFT-report 2000:1736.

Singh, B.R. and Lal, R, (2001) The potential of Norwegian soils to sequester carbon through land use conversion and improved management practices. Printed at the Ohio State University.

Singh, B.R. and Lal, R, (2004) The potential of soil carbon sequestration through improved management practices in Norway, Environment, Development and Sustainability. (in press)

SINTEF (1995) *Round robin test of wood stove-emissions.* SINTEF Report STF12 F95012. E. Karlsvik, Trondheim: Institute of Social Research in Industry (SINTEF).

SINTEF (1998a) *Emisjonsfaktorer for CO_2-utslipp fra sementproduksjon i Norge for 1990 og 1997* (Emission factors for CO_2 emissions from cement production in Norway for 1990 and 1997), SINTEF Report STF66 A98511 (Authors: Andersen, T. and K.H.Karstensen), Oslo: SINTEF (Institute of Social Research in Industry).

SINTEF (1998b) *Omregningsfaktorer for CO_2-utslipp fra metallurgisk industri og sementproduksjon. Delprosjekt 1. CO_2-utslipp fra forskjellige typer reduksjonsmaterialer* (Conversion factors for CO_2 emissions from metal manufacturing and cement production. Part 1. CO_2 emissions from various types of reducing agents), Revised edition, SINTEF Report STF24 A98550 (Author: Raaness, O.), Trondheim: SINTEF (Institute of Social Research in Industry).

SINTEF (1998c) *Omregningsfaktorer for CO_2-utslipp fra metallurgisk industri og sementproduksjon. Delprosjekt 2. Produksjon av ferrosilisium og silisiummetall i Norge* (Conversion factors for CO_2 emissions from metal manufacturing and cement production. Part 2. Production of ferro silicon and silicon metal in Norway), Revised edition, SINTEF Report STF24 A98537 (Author: Monsen, B.), Trondheim: SINTEF (Institute of Social Research in Industry).

SINTEF (1998d) *Omregningsfaktorer for CO_2-utslipp fra metallurgisk industri og sementproduksjon. Delprosjekt 3. Produksjon av ferromangan, silikomangan og ferrokrom i Norge* (Conversion factors for CO_2 emissions from metal manufacturing and cement production. Part 3. Production of ferro manganese, silicon manganese and ferro chromium in Norway), ST24 A98548 (Authors: Monsen, B. and S.E. Olsen), Trondheim: SINTEF (Institute of Social Research in Industry).

SINTEF (1998e) *Omregningsfaktorer for CO_2-utslipp fra metallurgisk industri og sementproduksjon. Delprosjekt 4. Utslipp av CO_2 ved produksjon av silisiumkarbid og kalsiumkarbid* (Conversion factors for CO_2 emissions from metal manufacturing and cement production. Part 4. CO_2 emissions from production of silicon carbide and calcium carbide), SINTEF Report STF24 A98549 (Authors: Raaness, O. and S. Olsen), Trondheim: SINTEF (Institute of Social Research in Industry).

SINTEF (1998f) *Omregningsfaktorer for CO_2-utslipp fra metallurgisk industri og sementproduksjon. Delprosjekt 5. Produksjon av magnesium* (Conversion factors for CO_2 emissions from metal manufacturing and cement production. Part 5. Magnesium production), SINTEF Report STF24 A98574 (Authors: Olsen, K., T. Støre and R. Tunold), Trondheim: SINTEF (Institute of Social Research in Industry).

SINTEF and Det Norske Veritas (2004) *Hvitbok om klimagassutslipp fra norsk landbasert prosessindustri* (White book about greenhouse gas emissions from Norwegian land based process industry), SINTEF Report STF24A03501, DNV Report 2002-1609, Revised February 2004.

SN (1991) *Utslipp til luft fra norsk luftfart* (Emissions to air from Norwegian air traffic). Kristin Rypdal and Bente Tornsjø. SN-report 97:20.

SN (1996) *Utslipp til luft fra innenriks sjøfart, fiske og annen sjøtrafikk mellom norske havner* (Emissions to air from domestic shipping, fisheries and other maritime traffic between Norwegian ports). Rypdal K. and Flugsrud K. SN-report 96:17.

SN (1998) *Utslipp til luft fra utenlandske skip i norske farvann 1996 and 1997.* (Emissions to air from foreign ships in Norwegian waters in 1996 and 1997). SN-report 98:22.

SN (1998a) *Mer avfall, men økt gjenvinning* (More waste, but more recycling). Weekly bulletin 25/98

SN (2000) *Uncertainties in the Norwegian greenhouse Gas Emission Inventory.* Kristin Rypdal and Li-Chung Zhang. SN-report 2000:13.

SN (2001a) *Utslipp til luft fra innenriks sjøfart, fiske og annen sjøtrafikk mellom norske havner.* (Emissions to Air from Fishing Fleet and Sea Traffic between Norwegian Harbours).
Bente Tornsjø. SN-report 2001:6.

SN (2001b) *Utslipp til luft fra vedfyring i Norge. Utslippsfaktorer, ildstedsbestnd og fyringsvaner*. (Emissions to air from combustion of wood in Norway). Gisle Haakonsen and Eli Kvingedal. SN-report 2001:36.

SN (2001c) *Uncertainties in Emissions of Long-Range Air Pollutants*. Kristin Rypdal and Li-Chun Zhang. SN-report 2001:37

SN (2001d) *CO_2 emission estimates for Norway.* Methodological difficulties. Kristin Rypdal. SN-document 2001:14.

SN (2001e) *Sensitivity Analysis as a Tool for Systematic Reductions in GHG Inventory Uncertainties.* Rypdal, K. and Flugsrud K. Statistics Norway.

SN (2001f) *Natural resources and the environment 2001. Norway*, Statistical Analyses 47, ISBN 82-537-4995-3.

SN (2001g) *Lagring og bruk av husdyrgjødsel* (Storage and use of manure). Gundersen, G. I. and O. Rognstad (2001). SN-report 2001:39.

SN (2002) *Utslipp til luft fra norsk luftfart 1989-2000* (Emissions to Air from Norwegian Air Traffic 1989-2000). Anne Finstad, Ketil Flugsrud og Kristin Rypdal. SN-report 2002:08.

SN/SFT (2000) *The Norwegian Emission Inventory. Documentation of methodology and data for estimating emissions of greenhouse gases and long-range transboundary air pollutants*. Ketil Flugsrud, Eilev Gjerald, Gisle Haakonsen, Sigurd Holtskog, Henning Høie, Kristin Rypdal, Bente Tornsjø and Fredrik Weidemann. Statistics Norway/ Norwegian Pollution Control Authority. SN-report 2000:1.

SN/SFT (2005) Documentation of the Norwegian system of emission inventories. Britta Hoem (ed). SFT/SN-report in prep.

Strand, L.T., and de Wit, H.A. (in prep) Factors determining the regional distribution of carbon stock in Norwegian forest soils

Sundstøl, F. and Z. Mroz (1988) *Utskillelse av nitrogen og fosfor i gjødsel og urin fra husdyr i Norge* (Nitrogen and phosphorus in manure and urine from domestic animals in Norway) (*se Bolstad 1994*), Report no. 4 from the project "Agricultural policy and environmental management", Ås: Agricultural University of Norway.

TI (1991) *Tiltak 11. Reduksjon av VOC-utslipp fra totaktsmotorer. Rapport utarbeidet av Teknologisk Institutt for Statens Forurensningstilsyn* (Reduction of VOC-emissions from two stroke engines), Oslo: National Institute of Technology.

Tomter, Stein (1997) Study on European Forestry Information and communication Systems. Reports on forestry inventory and survey systems. Volume 2. Country report from Norway. European Commission, Luxembourg.

UNFCCC (2000) *Methodological Issues Land-Use, Land-Use Change and Forestry*, 4 September. FCCC/SBSTA/2000/Misc.6/Add.1. http://unfccc.int/resource/docs/2000/sbsta/misc06a01.pdf

Uppenberg, S., Zetterberg, L., and Åhman, M. (2001) Climate change Impact from Peat utlisation in Sweden. IVL B 1423. http://www.ivl.se/rapporter/

Vanninen, P., Ylitalo, H., Sievänen, R. and Mäkelä, A. (1996) Effects of age and site quality on the distribution of biomass in Scots pine (*Pinus sylvestris* L.). Trees 10: 231-238

Vestjordet, E. (1967) Funksjoner og tabeller for kubering av stående gran. Meddr norske SkogforsVes. 22:539-574.

Aakra, Å. and M.A. Bleken (1997) *N_2O Emissions from Norwegian Agriculture as Estimated by the IPCC Methodology*. Departement of Biotechnological Sciences, Ås: Agricultural University of Norway.

7th Greenhouse Gas Control Technologies Conference (GHGT7) Vancouver 2004	Recent time-lapse seismic data show no indication of leakage at the Sleipner CO_2-injection site

Annex 1: Key Sources

This chapter outlines the Tier 2 methodology used to find which sources are key sources in the Norwegian Greenhouse gas emission inventory.

In previous Norwegian National Inventory Report (2003) the key source analysis was based on a work done by Rypdal and Zhang (SN 2000). This report used a tier 2 approach for uncertainty assessment and incorporated Monte Carlo analysis. The current analysis is simplified and uses a tier 1 uncertainty assessment as described in IPCC Good Practice Guidance (IPCC 2001), equations 7.3-7.4. According to the Good Practice Guidance the key source analysis is a Tier 2 method.

Key sources are identified as the emission sources that add up to 90 per cent of total uncertainty in level and/or trend. This definition of a key source is according to IPCC (2001) which is based on (SN 2001e).

The key source analysis is performed at the level of IPCC source categories and each GHG from each source category is considered separately with respect to total GWP weighted emissions. The advantage in using a Tier 2 rather than the Tier 1 methodology is that uncertainties are taken into account so the ranking shows where uncertainties can be reduced. In addition the Tier 1 method can identify sources that are not actually key sources according to Tier 2 (SN 2001e).

The steps taken to find key sources with respect to level and trend were the determination of uncertainties in input parameters (AD = activity data and EF = emission factors). Uncertainty data were obtained from SN (2000) with some modifications. The highest uncertainties from SN (2000) could not be used directly, as they would have totally dominated the analysis. These uncertainties were usually associated with emission factors with lognormal probability densities. They were "normalized" by the formula $U^* = ln\,(U + 1)$. The associated emission factors still dominate the analysis more strongly than in SN (2000), but the conclusions with respect to the key sources now seem more robust.

Uncertainties of activity data and emissions factors were combined to source uncertainty by the error propagation rule $U_{source} = \sqrt{U_{AD}^2 + U_{EF}^2}$ (IPCC 2001, equation 6.4).

The next step was the use of sensitivity analysis to identify which parameters in the inventory influence most the total GHG emissions in level and in trend. The current method does not take correlations into account. This has partly been handled by aggregating sources with the same emission factors in stationary combustion, categories 1A1, 1A2, and 1A4. However, correlations due to common activity data for several pollutants have not been taken into account. This may lead to an underestimation of the uncertainty importance for such sources.

Compilations of the uncertainty importance elasticity lead to the estimation of uncertainty importance of each input parameter with respect to total level and trend uncertainty. Out of this we get a ranked list of parameters which add up to 90 per cent of total uncertainty in level and trend.

The background data on emissions and uncertainties are shown in Table A1-1, which also gives the level of aggregation used in the analysis. Emission sources defined as key sources are shown in Tables A1-2 and A1-3, and a summary in Table A1-4.

The key sources identified correspond well with the previous analyses. The major difference is that 2C4 - *SF_6 Used in Aluminum and Magnesium Foundries* is identified as key by the trend analysis. This source has a low uncertainty. However, the major plant using SF_6 were closed in 2002. This leads to an even larger difference between total trend and source trend than in SN (2000).

N_2O from agriculture figure more prominently than in SN (2000). This is probably due to a different treatment of the very large uncertainty in this source. The source would be identified as key by all reasonable treatments. However, the choice of treatment influences which sources are included by the 90% threshold. The next sources in the trend analysis were both identified as key in the level analysis. The next sources in the level analysis were 2B2 *Nitric acid production* and 1A3e *Other motorized equipment*.

The other differences between the current analysis and SN (2000) have no bearings on the conclusions on key sources. There are some differences in ranking and in whether the sources are identified by the level, trend or both analyses.

CH_4 from coal mining - 1B1a - has been designated key in the previous National Inventory Reports. This source is not identified by the quantitative method. It is included because the national emission factor we use is in an order of magnitude less than IPCC's default factors (not shown in the tables).

No formal analysis of the separate effects of AD and EF uncertainty has been performed. SN(2000) concluded that the uncertainty importance of activity data is generally lower than the emission factors. Table A1-1 in Annex 1 shows that this conclusion is still valid. In fact, the only key sources for which activity data are more uncertain than emission factors are CO_2 from mobile combustion (1A3a, 1A3b, 1A3d).

The analyses have been performed for 1990 and 2003 GHG emission data. The main conclusion is that there are few differences in the result for 1990 compared with 2003.

Table A1-1 Background data for the key source analysis

IPCC	Source category	Emissions, 1000 t CO_2-eq.						Uncertainties			
								Acti-	Emission factors		
Part 1	CO_2, CH_4, and N_2O	CO_2		CH_4		N_2O		vity	CO_2	CH_4	N_2O
		1990	2003	1990	2003	1990	2003				
1A1, 1A2, 1A4	Stationary Fuel Combustion, Coal/coke	541	546	2	1	1	0	0.05	0.07	0.69	1.10
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	7 166	13 385	47	86	18	32	0.04	0.07	0.69	1.10
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	6 379	6 540	10	10	81	67	0.03	0.03	0.69	1.10
1A1, 1A2, 1A4	Stationary Fuel Combustion, Wood etc	.	.	119	163	40	48	0.30	.	0.69	1.10
1A1, 1A2, 1A4	Stationary Fuel Combustion, Waste	100	178	2	4	4	10	0.05	0.30	0.69	1.10
1A3a	Civil Aviation	679	954	0	1	7	9	0.20	0.03	0.69	1.10
1A3b	Road Transportation	7 850	9 576	59	43	92	714	0.20	0.03	0.69	1.10
1A3c	Railways	96	41	0	0	11	5	0.10	0.03	0.69	1.10
1A3d	Navigation	1 929	2 487	4	8	14	19	0.10	0.03	0.69	1.10
1A3e	Other (snow scooters, boats, motorized equipment)	544	646	6	7	40	52	0.20	0.03	0.69	1.10
1A5a	Military - Stationary	62	58	0	0	0	0	0.05	0.05	0.69	1.10
1A5b	Military - Mobile	394	114	0	0	4	1	0.05	0.05	0.69	1.10
1B1a	Coal Mining	0	4	3	33	.	.	0.03	0.69	0.69	.
1B2a	Oil (incl. oil refineries, gasoline distribution)	1 115	1 408	190	301	.	.	0.03	0.34	0.34	.
1B2b	Natural Gas	6	14	16	34	.	.	0.03	0.69	0.69	.
1B2c	Venting and Flaring	1 501	1 294	146	277	4	3	0.04	0.10	0.69	1.10
2A1	Cement Production	653	885	.	.	.	.	0.03	0.07	.	.
2A2	Lime Production	25	44	.	.	.	.	0.03	0.07	.	.
2A3	Limestone and Dolomite Use	20	22	.	.	.	.	0.03	0.07	.	.
2B1	Ammonia Production	500	180	.	.	.	.	0.03	0.07	.	.
2B2	Nitric Acid Production	.	.	.	.	2 062	1 711	0.00	.	.	0.07
2B4	Carbide Production	289	96	21	12	.	.	0.03	0.10	0.69	.
2B5	Other	3	2	1	3	.	.	0.10	0.10	0.69	.
2C1	Iron and Steel Production	201	328	.	.	.	.	0.03	0.07	.	.
2C2	Ferroalloys Production	2 574	2 214	16	12	.	.	0.03	0.07	0.69	.
2C3	Aluminum Production	1 431	1 891	.	.	.	.	0.03	0.07	.	.
2C5	Other	190	83	.	.	.	.	0.10	0.10	.	.
2D2	Food and Drink	20	70	.	.	.	.	0.10	0.10	.	.
3A	Paint Application	37	24	.	.	.	.	0.15	0.20	.	.
3B	Degreasing and Dry Cleaning	8	1	.	.	.	.	0.15	0.20	.	.
3C	Chemical Products, Manufacture and Processing	8	15	.	.	.	.	0.15	0.20	.	.
3D	Other	92	87	.	.	36	41	0.15	0.20	.	1.10
4A1	Cattle	.	.	1 360	1 285	.	.	0.10	.	0.25	.
4A3	Sheep	.	.	260	296	.	.	0.10	.	0.25	.
4A4	Goats	.	.	9	7	.	.	0.10	.	0.25	.
4A6	Horses	.	.	12	19	.	.	0.10	.	0.25	.
4A8	Swine	.	.	17	20	.	.	0.10	.	0.25	.
4A9	Poultry	.	.	1	1	.	.	0.10	.	0.25	.
4B1	Cattle	.	.	215	206	.	.	0.10	.	0.25	.
4B3	Sheep	.	.	24	27	.	.	0.10	.	0.25	.
4B4	Goats	.	.	2	1	.	.	0.10	.	0.25	.
4B6	Horses	.	.	11	18	.	.	0.10	.	0.25	.
4B8	Swine	.	.	23	27	.	.	0.10	.	0.25	.
4B9	Poultry	.	.	19	26	.	.	0.10	.	0.25	.
4B11	Liquid Systems	.	.	.	.	17	17	0.10	.	.	1.10
4B12	Solid Storage and Dry Lot	.	.	.	.	117	125	0.10	.	.	1.10
4B13	Other	.	.	4	4	.	.	0.10	.	0.25	.
4D1	Direct soil emissions	.	.	.	.	1 783	1 730	0.20	.	.	4.62
4D2	Animal production	.	.	.	.	219	222	0.20	.	.	4.62
4D3	Indirect emissions	.	.	.	.	417	410	0.41	.	.	4.62
4F1	Cereals	.	.	24	5	7	1	0.10	.	0.69	1.10
4A10	Other	.	.	54	50	.	.	0.10	.	0.25	.
6A	Solid Waste Disposal on Land	.	.	2 463	2 049	.	.	0.20	.	0.30	.

IPCC	Source category	Emissions, 1000 t CO_2-eq.						Uncertainties			
								Acti-	Emission factors		
Part 1	CO_2, CH_4, and N_2O	CO_2		CH_4		N_2O		vity	CO_2	CH_4	N_2O
		1990	2003	1990	2003	1990	2003				
6B	Wastewater Handling	.	.	20	21	91	110	0.41	.	0.53	1.10
6C	Waste Incineration	0	35	0	0	0	0	0.30	0.30	0.69	1.10
Part 2	HFCs, PFCs, and SF_6	HFC		PFC		SF_6			HFC	PFC	SF_6
		1990	2003	1990	2003	1990	2003				
2C3	Aluminum Production	.	.	3 294	703	.	.	0.03	.	0.41	.
2C4	SF6 Used in Aluminum and Magnesium Foundries	.	.	.	.	2 144	172	0	.	.	0.05
2F	Consumption of Halocarbons and Sulphur Hexafluoride	0	240	.	.	57	60	0	0.41	.	0.47

Table A1-2. Uncertainty importance of source categories with respect to total level uncertainty. 1990 and 2003. Sources with assessment in bold types are identified as key sources.

IPCC	Source category	Gas	Source category level assessment, with uncertainty (fraction of total)		Cumulative total
			1990	2003	2003
4D1	Direct soil emissions	N2O	**42.56 %**	**40.22 %**	40.22 %
1A3b	Road Transportation	CO2	**8.20 %**	**9.75 %**	49.97 %
4D3	Indirect emissions	N2O	**9.98 %**	**9.55 %**	59.52 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO2	**2.99 %**	**5.43 %**	64.96 %
4D2	Animal production	N2O	**5.23 %**	**5.16 %**	70.12 %
1A3b	Road Transportation	N2O	0.53 %	**4.01 %**	74.13 %
6A	Solid Waste Disposal on Land	CH4	**4.59 %**	**3.72 %**	77.85 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO2	**1.95 %**	**2.39 %**	80.24 %
4A1	Cattle	CH4	**1.89 %**	**1.74 %**	81.98 %
2C3	Aluminum Production	PFC	**6.92 %**	**1.44 %**	83.42 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO2	**1.40 %**	**1.40 %**	84.82 %
1A3d	Navigation	CO2	**1.04 %**	**1.31 %**	86.13 %
1A3a	Civil Aviation	CO2	**0.71 %**	**0.97 %**	87.10 %
1B2c	Venting and Flaring	CH4	0.52 %	**0.97 %**	88.06 %
2C2	Ferroalloys Production	CO2	**1.01 %**	**0.85 %**	88.91 %
2C3	Aluminum Production	CO2	0.56 %	**0.72 %**	89.64 %
1B2c	Venting and Flaring	CO2	**0.84 %**	**0.70 %**	90.34 %
2B2	Nitric Acid Production	N2O	**0.75 %**	0.60 %	90.94 %

Table A1-3. Uncertainty importance of source categories with respect to total trend uncertainty. 1990 - 2003. All sources in the table are identified as key sources.

IPCC	Source category	Gas	Source category trend assessment, with uncertainty (fraction of total) 1990-2003	Cumulative total 1990-2003
2C3	Aluminum Production	PFC	22.73 %	22.73 %
4D1	Direct soil emissions	N2O	19.50 %	42.23 %
1A3b	Road Transportation	N2O	13.21 %	55.44 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO2	8.64 %	64.08 %
6A	Solid Waste Disposal on Land	CH4	4.47 %	68.55 %
4D3	Indirect emissions	N2O	4.10 %	72.66 %
1A3b	Road Transportation	CO2	3.90 %	76.55 %
2C4	SF6 Used in Aluminum and Magnesium Foundries	SF6	2.09 %	78.65 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC	1.88 %	80.53 %
1B2c	Venting and Flaring	CH4	1.57 %	82.10 %
4D2	Animal production	N2O	1.56 %	83.66 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO2	1.24 %	84.89 %
4A1	Cattle	CH4	1.04 %	85.94 %
2C2	Ferroalloys Production	CO2	0.88 %	86.82 %
1A3a	Civil Aviation	CO2	0.83 %	87.64 %
1A3d	Navigation	CO2	0.76 %	88.41 %
2B2	Nitric Acid Production	N2O	0.73 %	89.14 %
1B2c	Venting and Flaring	CO2	0.72 %	89.86 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CH4	0.61 %	90.47 %

Table A1-4. Summary of identified key sources.

IPCC	Source category	Gas	Level assessment		Trend assessment	Method (Tier)
			1990	2003	2003	2003
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO2	2.99 %	5.43 %	8.64 %	Tier 2
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO2	1.40 %	1.40 %		Tier 2
1A3a	Civil Aviation	CO2	0.71 %	0.97 %	0.83 %	Tier 2
1A3b	Road Transportation	CO2	8.20 %	9.75 %	3.90 %	Tier 2
1A3b	Road Transportation	N2O		4.01 %	13.21 %	Tier 2
1A3d	Navigation	CO2	1.04 %	1.31 %	0.76 %	Tier 2
1B2a	Oil (incl. oil refineries, gasoline distribution)	CH4			0.61 %	Tier 2 / 3
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO2	1.95 %	2.39 %	1.24 %	Tier 2
1B2c	Venting and Flaring	CH4		0.97 %	1.57 %	Tier 2
1B2c	Venting and Flaring	CO2	0.84 %	0.70 %	0.72 %	Tier 2
2B2	Nitric Acid Production	N2O	0.75 %		0.73 %	Tier 2
2C2	Ferroalloys Production	CO2	1.01 %	0.85 %	0.88 %	Tier 2
2C3	Aluminum Production	CO2		0.72 %		Tier 2
2C3	Aluminum Production	PFC	6.92 %	1.44 %	22.73 %	Tier 2
2C4	SF6 Used in Aluminum and Magnesium Foundries	SF6			2.09 %	Tier 2
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC			1.88 %	Tier 2
4A1	Cattle	CH4	1.89 %	1.74 %	1.04 %	Tier 1
4D1	Direct soil emissions	N2O	42.56 %	40.22 %	19.50 %	Tier 1a
4D2	Animal production	N2O	5.23 %	5.16 %	1.56 %	Tier 1a
4D3	Indirect emissions	N2O	9.98 %	9.55 %	4.10 %	Tier 1a
6A	Solid Waste Disposal on Land	CH4	4.59 %	3.72 %	4.47 %	Tier 2
2A1	Cement Production*	CO2				Tier 2
2B1	Ammonia Production*	CO2				Tier 2

* Identified as key source because of large contribution to the total emissions (Tier 1)

In addition, we have identified the following key categories:

Table A1-5. Summary of identified key categories

IPCC Category		Gas	Level assessment		Trend assessment	Method (Tier)
			1990	2003	1990-2003	2003
5A1	Forest land remaining forest land, living biomass, other	CO_2	6.61 %	10.29%	19.97	Tier 3
5C1	Grassland remaining grassland, soils, histosols	CO_2	7.82	7.39	2.47	Tier 2*
5A3	Forest land remaining forest land, dead biomass, other	CO_2	7.04	5.70	2.04	Tier 3
5A4	Forest land remaining forest land, soils	CO_2	1.89	1.95	1.33	Tier 3
5A2	Forest land remaining forest land, soils, drained organic soils	CO_2	1.19	1.19	0.66	Tier 1
5B5	Cropland remaining cropland, histosols, soils	CO_2	0.87	0.83	-	Tier 2
**	CO_2 capture and storage	CO_2				CS (Tier 2)**

* Country specific emission factors
** No methodology or category is defined in IPCC Guidelines

Table A-6. Tier 1 level analysis 1990 and 2003 (including LULUCF). Sources with assessment in bold types are identified as key sources.

IPCC Source category		Gas	Source category level assessment, without uncertainty (fraction of total)		Cumulative total
			1990	2003	2003
5A1	Forest remaining Forest Living biomass, net change	CO_2	**16.26 %**	**22.98 %**	22.98 %
1A	Fuel Combustion Activities (Sectoral Approach) (gas)	CO_2	**10.06 %**	**16.15 %**	39.13 %
1A3b	Road Transportation	CO_2	**11.02 %**	**11.55 %**	50.68 %
1A	Fuel Combustion Activities (Sectoral Approach) (oil)	CO_2	**8.96 %**	**7.89 %**	58.57 %
5A3	Forest remaining Forest Dead biomass, net change	CO_2	**6.41 %**	**4.71 %**	63.28 %
1A3d	Navigation	CO_2	**2.71 %**	**3.00 %**	66.28 %
2C2	Ferroalloys Production	CO_2	**3.62 %**	**2.67 %**	68.95 %
5A4	Forest remaining Forest Soil, net change	CO_2	**2.79 %**	**2.62 %**	71.57 %
6A	Solid Waste Disposal on Land	CH_4	**3.46 %**	**2.47 %**	74.04 %
2C3	Aluminium Production	CO_2	**2.01 %**	**2.28 %**	76.32 %
5C1	Grassland remaining Grassland Histosols Soil, net	CO_2	**2.63 %**	**2.26 %**	78.58 %
4D1	Agricultural soils – direct soil	N_2O	**2.50 %**	**2.09 %**	80.67 %
2B2	Nitric Acid Production	N_2O	**2.89 %**	**2.06 %**	82.73 %
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	**1.57 %**	**1.70 %**	84.43 %
1B2c	Venting and Flaring	CO_2	**2.11 %**	**1.56 %**	85.99 %
4A1	Cattle	CH_4	**1.91 %**	**1.55 %**	87.54 %
1A3a	Civil Aviation	CO_2	**0.95 %**	**1.15 %**	88.69 %
2A1	Cement Production	CO_2	**0.92 %**	**1.07 %**	89.76 %
1A3b	Road Transportation	N_2O	0.13 %	**0.86 %**	90.62 %
2C3	Aluminium Production	PFCs	**4.63 %**	**0.85 %**	91.47 %
1A3e	Other (snow scooters, boats, motorized e	CO_2	**0.76 %**	**0.78 %**	92.25 %
1A	Fuel Combustion Activities (Sectoral Approach) (coal/coke)	CO_2	**0.76 %**	**0.66 %**	92.91 %
4D3	Indirect	N_2O	**0.59 %**	**0.49 %**	93.40 %
5E1	Forest converted to Settlementes Living biomass,	CO_2	**0.49 %**	**0.41 %**	93.81 %
2C1	Iron and Steel Production	CO_2	0.28 %	**0.40 %**	94.21 %
1B2a	Oil (incl. oil refineries, gasoline dist	CH_4	0.27 %	**0.36 %**	94.57 %
4A3	Sheep	CH_4	**0.37 %**	**0.36 %**	94.93 %
1B2c	Venting and Flaring	CH_4	0.21 %	**0.33 %**	95.26 %
2B1	Ammonia Production	CO_2	**0.70 %**	0.22 %	95.48 %
2C4	SF_6 Used in Aluminium and Magnesium Foundries	SF_6	**3.01 %**	0.21 %	95.69 %
1A5b	Military - Mobile	CO_2	**0.55 %**	0.14 %	95.82 %
2B4	Carbide Production	CO_2	**0.41 %**	0.12 %	95.94 %

Table A1-7. Tier 2 level analysis 1990 and 2003 (including LULUCF). All categories listed are identified as key

IPCC Source category		Gas	Source category level assessment, with uncertainty (fraction of total)		Cumulative total
			1990	2003	2003
4D1	Agricultural soils – direct soil	N_2O	31.36 %	28.76 %	28.76 %
5A1	Forest remaining Forest 0 Living biomass, net change	CO_2	6.61 %	10.29 %	39.05 %
5C1	Grassland remaining Grassland Histosols Soil, net	CO_2	7.82 %	7.39 %	46.44 %
1A3b	Road Transportation	CO_2	6.04 %	6.97 %	53.41 %
4D3	Indirect	N_2O	7.35 %	6.83 %	60.24 %
5A3	Forest remaining Forest Dead biomass, net change	CO_2	7.04 %	5.70 %	65.94 %
1A	Fuel Combustion Activities (Sectoral Approach) (gas)	CO_2	2.20 %	3.88 %	69.83 %
4D2	Animal production	N_2O	3.85 %	3.69 %	73.51 %
1A3b	Road Transportation	N_2O	0.39 %	2.87 %	76.38 %
5A4	Forest remaining Forest Soil, net change	CO_2	1.89 %	1.95 %	78.34 %
6A	Solid Waste Disposal on Land	CH_4	3.38 %	2.66 %	81.00 %
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	1.43 %	1.71 %	82.71 %
4A1	Cattle	CH_4	1.39 %	1.25 %	83.95 %
5A2	Forest remaining Forest Drained organic soils Soil	CO_2	1.19 %	1.19 %	85.14 %
2C3	Aluminium Production	PFCs	5.10 %	1.03 %	86.17 %
1A	Fuel Combustion Activities (Sectoral Approach) (Oil)	CO_2	1.03 %	1.00 %	87.17 %
1A3d	Navigation	CO_2	0.77 %	0.93 %	88.11 %
5B5	Cropland remaining Cropland Histosols Soil, net change	CO_2	0.87 %	0.83 %	88.93 %
1A3a	Civil Aviation	CO_2	*0.52 %*	0.69 %	89.63 %
1B2c	Venting and Flaring	CH_4	0.39 %	0.69 %	90.32 %
2C2	Ferroalloys Production	CO_2	0.75 %	*0.61 %*	90.93 %
2C3	Aluminium Production	CO_2	0.41 %	*0.52 %*	91.44 %
1B2c	Venting and Flaring	CO_2	*0.62 %*	*0.50 %*	91.95 %
2B2	Nitric Acid Production	N_2O	*0.55 %*	0.43 %	92.38 %

Table A1-8. Tier 1 trend analysis 1990-2003. (including LULUCF). All categories listed are key

IPCC Source category		Gas	Source category trend assessment, with uncertainty (fraction of total) 1990-2003	Cumulative total 1990-2003
5A1	Forest remaining Forest 0 Living biomass, net change	CO_2	28.49 %	28.49 %
1A	Fuel Combustion Activities (Sectoral Approach) (gas)	CO_2	23.07 %	51.57 %
2C3	Aluminium Production	PFCs	8.00 %	59.57 %
1A3b	Road Transportation	CO_2	7.91 %	67.48 %
2C4	SF_6 Used in Aluminium and Magnesium Foundries	SF_6	6.18 %	73.66 %
1A3d	Navigation	CO_2	2.40 %	76.06 %
1A	Fuel Combustion Activities (Sectoral Approach) (Oil)	CO_2	2.19 %	78.25 %
1A3b	Road Transportation	N_2O	2.15 %	80.40 %
2C3	Aluminium Production	CO_2	1.94 %	82.33 %
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	1.29 %	83.62 %
5A4	Forest remaining Forest Soil, net change	CO_2	1.14 %	84.76 %
1A3a	Civil Aviation	CO_2	1.11 %	85.88 %
5A3	Forest remaining Forest Dead biomass, net change	CO_2	1.08 %	86.95 %
2B1	Ammonia Production	CO_2	0.96 %	87.91 %
2A1	Cement Production	CO_2	0.96 %	88.87 %
1A5b	Military - Mobile	CO_2	0.85 %	89.73 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs	0.82 %	90.55 %
6A	Solid Waste Disposal on Land	CH_4	0.78 %	91.33 %
2B2	Nitric Acid Production	N_2O	0.67 %	91.99 %
2B4	Carbide Production	CO_2	0.59 %	92.58 %
2C2	Ferroalloys Production	CO_2	0.57 %	93.15 %
1A3e	Other (snow scooters, boats, motorized equipment)	CO_2	0.49 %	93.64 %
2C1	Iron and Steel Production	CO_2	0.49 %	94.12 %
1B2c	Venting and Flaring	CH_4	0.48 %	94.61 %
5C1	Grassland remaining Grassland Histosols Soil, net	CO_2	0.48 %	95.09 %

Table A1-9. Tier 2 trend analysis 1990-2003. (including LULUCF). All categories listed are key

IPCC Source category		Gas	Source category trend assessment, with uncertainty (fraction of total) 1990-2003	Cumulative total 1990-2003
5A1	Forest remaining Forest Living biomass, net change	CO_2	19.97 %	19.97 %
2C3	Aluminium Production	PFCs	15.19 %	35.16 %
1A3b	Road Transportation	N_2O	11.19 %	46.36 %
1A	Fuel Combustion Activities (Sectoral Approach) (gas)	CO_2	8.69 %	55.05 %
1A3b	Road Transportation	CO_2	7.47 %	62.52 %
4D1	Agricultural soils – direct	N_2O	5.95 %	68.48 %
5C1	Grassland remaining Grassland Histosols Soil, net	CO_2	2.47 %	70.94 %
5A3	Forest remaining Forest Dead biomass, net change	CO_2	2.04 %	72.98 %
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	2.03 %	75.01 %
4D3	Indirect	N_2O	1.78 %	76.80 %
1B2c	Venting and Flaring	CH_4	1.57 %	78.37 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs	1.55 %	79.92 %
2C4	SF_6 Used in Aluminium and Magnesium Foundries	SF_6	1.44 %	81.37 %
4D2	Animal production	N_2O	1.42 %	82.79 %
5A4	Forest remaining Forest Soil, net change	CO_2	1.33 %	84.12 %
6A	Solid Waste Disposal on Land	CH_4	1.31 %	85.44 %
1A3d	Navigation	CO_2	1.17 %	86.61 %
1A3a	Civil Aviation	CO_2	1.05 %	87.66 %
2C3	Aluminium Production	CO_2	0.69 %	88.35 %
1B2a	Oil (incl. oil refineries, gasoline dist	CH_4	0.68 %	89.03 %
5A2	Forest remaining Forest Drained organic soils Soil	CO_2	0.66 %	89.68 %
1A	Fuel Combustion Activities (Sectoral Approach) (fuel wood)	CH_4	0.65 %	90.33 %

10. Annex II: Uncertainty estimates for single sources

Greenhouse gases

Table A2-1. Summary of standard deviation and probability density of activity data.

IPCC source category	Pollutant source	Standard deviation (2σ). %	Density shape	Source/Comment
1A1, 1A2	Gas combustion	± 4	Normal	Directorate of oil and gas
1A1, 1A2, 1A3, 1A4	Oil combustion (total)	± 3	Normal	Spread in data.
1A1	Waste combustion - Energy industries	± 5	Normal	Expert judgement
1A2, 1A4	Waste combustion - Other sectors	± 30	Lognormal	Expert judgement
1A1, 1A2, 1A4	Wood combustion - All sectors	± 30	Lognormal	Expert judgement
1A2	Coal and coke combustion-Industry	± 5	Normal	Spread in data
1A3b, 1A3e	Oil, road/off-road/catalytic/non-catalytic	± 20	Normal	Comparisons of data
1A3a	Oil combustion - Aviation	± 20	Normal	Expert judgement
1A3d	Oil combustion - Shipping	± 10	Normal	Comparisons of data
1A4b	Coal and coke combustion - Residential	± 20	Normal	Expert judgement
1B1a	Mining of coal	± 3	Normal	Expert judgement
1B2a and b	Extraction of oil and gas	± 3	Normal	Expert judgement
1B2a	Loading of crude oil	± 3	Normal	Expert judgement
1B2c	Flaring of natural gas	± 4	Normal	As combustion of gas
2A1	Cement production	± 3	Normal	Expert judgement
2B1	Ammonia production	± 3	Normal	Expert judgement
2B2	Nitric acid production	-	-	Measured value
2B4	Carbide production	± 3	Normal	Expert judgement
2C1, 2C2, 2C3	Metal production	± 5	Normal	Expert judgement
2F	HFCs in products	-	-	See emission factor
2F	SF_6 in products	-	-	See emission factor
4A, 4B	Animal population	± 5-10	Normal	Expert judgement
4D	Agricultural soils - Fertiliser use	± 5	Normal	Agriculture authorities
4D	Agricultural soils - Manure use	± 20	Normal	Expert judgement
4D	Agricultural soils - Other activities	± 50	Lognormal	Expert judgement
6A	Solid waste disposal	± 20	Normal	Expert judgement
6B	Waste water treatment	± 25	Normal	Expert judgement

Table A2-2. Summary of standard deviation and probability density of emission factors.

IPCC source category	Pollutant source	Standard deviation (2σ). %	Density shape	Source/Comment
1A1, 1A2	CO_2 - Gas combustion	± 7	Normal	The Norwegian Petroleum Directorate
1A1, 1A2, 1A3, 1A4	CO_2 - Oil combustion	± 3	Normal	Spread in data
1A1, 1A2, 1A4	CO_2 - Coal combustion	± 7	Normal	Spread in data
1A1, 1A2, 1A4	CO_2 - Coke combustion	± 7	Normal	Spread in data
1A1, 1A2, 1A4	CO_2 - Waste combustion	± 30	Normal	Spread in data
1A1, 1A2, 1A4	CH_4 - Wood, coal, waste combustion	-50 - +100	Lognormal	Spread in data
1A3	CH_4 - Oil combustion. Road traffic	-50 - +100	Lognormal	Spread in data. Expert judgement
1A1, 1A2, 1A4	CH_4 - Oil combustion. Other	-50 - +100	Truncated N	Spread in data
1A3	N_2O - Oil combustion. Road traffic	-66 - +200	Beta	Spread in data. Expert judgement
1A1, 1A2, 1A4	N_2O - Oil combustion. Other	-66 - +200	Beta	Spread in data. Expert judgement. IPCC (1997)
1B2c	CO_2 - Flaring	± 10	Normal	As combustion of gas
1B1a	CH_4 - Coal mining	-50 - +100	Lognormal	Expert judgement. IPCC (1997)
1B2a, 1B2b	CH_4 - Oil & gas extraction, refineries	-50 - +100	Lognormal	Expert judgement
1B2a	CH_4 - Oil loading	± 40	Lognormal	Oil company
1B2c	CH_4 - Flaring	-50 - +100	Lognormal	As combustion of gas
1B2c	N_2O - Flaring	-66 - +200	Beta	As combustion of gas
2A1	CO_2 - Cement production	± 7	Normal	Spread in data. IPCC (1997)
2B1	CO_2 - Ammonia production	± 7	Normal	Expert judgement
2B2	N_2O - Nitric acid production	± 7	Normal	Plants' estimate. Continuos measurements
2B4	CO_2 - Carbide production	± 10	Normal	Spread in data
2C1, 2C2, 2C3	CO_2 - Metal production	± 7	Normal	Spread in data
2C4	SF_6 - Metal production	± 5	Normal	Expert judgement. Consumption of chemical
2C3	PFCs - Metal production	-30 - +50	Lognormal	Plants estimate
2F	HFCs from product use	± 50	Lognormal	Expert judgement
2F	SF_6 from product use	± 60	Lognormal	Expert judgement
4A	CH_4 - Enteric fermentation	± 25	Normal	IPCC (1997)
4B	CH_4 - Animal waste	± 25	Normal	IPCC (1997)
4D	N_2O - Agricultural soils	2 orders of magnitude	Lognormal	Expert judgement
6A	CH_4, CO_2 - Landfilled solid waste	± 30	Lognormal	SFT (1999a)
6B	CH_4 - Waste water treatment	± 70	Lognormal	Expert judgement

Table A2-3. Uncertainties in emission level. Each gas and total GWP weighted emissions.

1990	μ (mean)	Fraction of total emissions	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)
Total	52 mill. tonnes	1	0.103	21
CO_2	35 mill. tonnes	0.67	0.017	3
CH_4	317 ktonnes	0.12	0.111	22
N_2O	18 ktonnes	0.11	0.960	200
HFC	0.13 tonnes	0.00	0.251	50
PFC	390 tonnes	0.05	0.203	40
SF_6	95 tonnes	0.04	0.026	5

2010*	μ (mean)	Fraction of total emissions	Relative standard deviation	Uncertainty 2σ (% of mean)
Total	63 mill. tonnes	1	0.084	17
CO_2	48 mill. tonnes	0.76	0.018	4
CH_4	286 ktonnes	0.10	0.098	20
N_2O	19 ktonnes	0.09	0.852	170
HFC	580 tonnes	0.02	0.255	50
PFC	185 tonnes	0.02	0.202	40
SF_6	21 tonnes	0.01	0.043	9

* Projected data with uncertainties as if they were historical.

Table A2-4. Uncertainty of emission trend. 1990-2010*

	% change $((\mu_{2010}-\mu_{1990})*100/\mu_{1990})$	Relative standard deviation $(\sigma/(\mu_{2010}-\mu_{1990}))$	Uncertainty 2σ (%-point of change)
Total	21	0.107	4
CO_2	36	0.066	5
CH_4	-10	-0.785	16
N_2O	10	0.652	13
HFC	-	0.250	-
PFC	-51	-0.193	20
SF_6	-77	-0.024	4

* Projected values with uncertainties as if they were historical.

11. Annex III – Energy Balance

Energy balance sheet1).
1990
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	5 146	9	.	42	3 412	50	1 119	514
2	Imports	258	20	28	0	69	140	-	-
3	Exports	4 368	7	4	0	2 897	373	1 028	-
4	Bunker oil	19	-	-	-	-	19	-	-
5	Changes in stocks (+ net decrease, - net increase)	-64	-0	-1	..	-62	-1	.	
7	Net domestic supply (1.1+2-3-4+5)	952	21	23	42	521	-204	92	514
8	Energy converted	1 093	1	1	1	539	36	0	514
8.1	In blast furnaces	1	-	1	-	-	-	-	-
8.2	In crude petroleum refineries	575	-	-	-	539	36	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	1	1	-	1	-	-	-	-
8.5	In district heating plants	2	-	-	1	-	0	0	-
8.6	In hydropower plants	514	-	-	-	-	-	-	514
1.2	Production of derived energy bearers	1 036	.	6	.	.	542	45	
9	Consumption by energy sector	154	-	-	-	-	4	143	-
10	Consumption for non-energy purposes	47	.	.	.	.	47	-	-
11	Losses in transport and distribution	29	..	..	.	..	..	2	-
12	Statistical differences (7-8+1.2-9-10-11-13)	-43	-1	0	-0	-18	0	-24	-
13	Net domestic consumption	708	21	27	41	-	251	15	-
13.1	Manufacturing, mining and quarrying	277	21	27	21	-	29	15	-
13.2	Transport	161	-	-	-	-	159	-	-
13.3	Other sectors	269	0	0	20	-	62	0	-
14	Calculated energy consumption3)	540	17	22	27	-	109	14	-
14.1	Manufacturing, mining and quarrying	255	17	22	13	-	25	14	-
14.2	Transport	42	-			-	40		-
14.3	Other sectors	243	0	0	13	-	44	0	-
15	Energy losses in final consumption (13-14)	167	4	5	14	-	142	1	-
15.1	Manufacturing, mining and quarrying	22	4	5	7	-	4	1	-
15.2	Transport	119	-	-	-	-	119	-	-
15.3	Other sectors	26	0	0	7	-	19	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1991
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	5 607	9	.	40	3 899	49	1 142	468
2	Imports	251	17	26	0	69	128	-	-
3	Exports	4 861	8	3	0	3 459	333	1 036	-
4	Bunker oil	16	-	-	-	-	16	-	-
5	Changes in stocks (+ net decrease, - net increase)	14	1	-0	..	10	4	.	
7	Net domestic supply (1.1+2-3-4+5)	995	19	23	40	518	-168	106	468
8	Energy converted	1 019	1	2	1	510	35	0	468
8.1	In blast furnaces	2	-	2	-	-	-	-	-
8.2	In crude petroleum refineries	545	-	-	-	510	35	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	1	1	-	1	-	-	-	-
8.5	In district heating plants	2	-	-	1	-	0	0	-
8.6	In hydropower plants	468	-	-	-	-	-	-	468
1.2	Production of derived energy bearers	980	.	5	.	.	527	42	
9	Consumption by energy sector	151	-	-	-	-	4	139	-
10	Consumption for non-energy purposes	32	.	.	.	.	32	-	-
11	Losses in transport and distribution	28	..	..	.	..	..	2	-
12	Statistical differences (7-8+1.2-9-10-11-13)	47	0	0	-	8	48	-9	-
13	Net domestic consumption	697	18	26	38	-	240	15	-
13.1	Manufacturing, mining and quarrying	267	18	26	20	-	27	15	-
13.2	Transport	159	-	-	-	-	157	-	-
13.3	Other sectors	271	0	0	18	-	56	0	-
14	Calculated energy consumption3)	536	15	20	25	-	102	14	-
14.1	Manufacturing, mining and quarrying	247	14	20	13	-	23	14	-
14.2	Transport	42	-		-	-	39		-
14.3	Other sectors	247	0	0	12	-	39	0	-
15	Energy losses in final consumption (13-14)	161	4	5	13	-	138	1	-
15.1	Manufacturing, mining and quarrying	20	4	5	7	-	4	1	-
15.2	Transport	117	-	-	-	-	117	-	-
15.3	Other sectors	24	0	0	6	-	17	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1992
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	6 246	10	.	42	4 473	53	1 172	496
2	Imports	215	17	25	0	47	121	-	-
3	Exports	5 429	5	4	-	3 916	419	1 050	-
4	Bunker oil	20	-	-	-	-	20	-	-
5	Changes in stocks (+ net decrease, - net increase)	-29	-4	0	..	-25	-0	.	
7	Net domestic supply (1.1+2-3-4+5)	982	18	21	42	580	-265	122	496
8	Energy converted	1 118	1	1	4	572	43	0	496
8.1	In blast furnaces	1	-	1	-	-	-	-	-
8.2	In crude petroleum refineries	615	-	-	-	572	43	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-
8.5	In district heating plants	4	-	-	2	-	0	0	-
8.6	In hydropower plants	496	-	-	-	-	-	-	496
1.2	Production of derived energy bearers	1 069	.	6	.	.	584	51	
9	Consumption by energy sector	162	-	-	-	-	4	150	-
10	Consumption for non-energy purposes	31	.	.	.	.	31	-	-
11	Losses in transport and distribution	29	..	..	.	..	..	3	-
12	Statistical differences (7-8+1.2-9-10-11-13)	13	-1	0	-	8	0	6	-
13	Net domestic consumption	698	18	26	38	-	240	14	-
13.1	Manufacturing, mining and quarrying	264	18	25	20	-	26	14	-
13.2	Transport	164	-	-	-	-	162	-	-
13.3	Other sectors	270	0	0	18	-	53	0	-
14	Calculated energy consumption3)	535	15	20	25	-	100	14	-
14.1	Manufacturing, mining and quarrying	244	15	20	13	-	22	13	-
14.2	Transport	44	-	-	-	-	41	-	-
14.3	Other sectors	248	0	0	12	-	37	0	-
15	Energy losses in final consumption (13-14)	163	4	5	13	-	140	1	-
15.1	Manufacturing, mining and quarrying	20	4	5	7	-	4	1	-
15.2	Transport	120	-	-	-	-	120	-	-
15.3	Other sectors	22	0	0	6	-	16	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1993
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	6 533	8	.	45	4 747	87	1 140	507
2	Imports	229	20	25	0	56	125	-	
3	Exports	5 700	6	5	0	4 212	436	1 009	
4	Bunker oil	22	-	-	-	-	22	-	
5	Changes in stocks (+ net decrease, - net increase)	-33	2	-0	..	-31	-4	.	
7	Net domestic supply (1.1+2-3-4+5)	1 007	23	20	45	561	-251	131	507
8	Energy converted	1 127	1	1	5	570	43	0	507
8.1	In blast furnaces	1	-	1	-	-	-	-	
8.2	In crude petroleum refineries	613	-	-	-	570	43	-	
8.3	In thermal power plants	0	-	-	-	-	0	-	
8.4	In combined heat and power plants	3	1	-	2	-	-	-	
8.5	In district heating plants	4	-	-	2	-	0	0	
8.6	In hydropower plants	507	-	-	-	-	-	-	507
1.2	Production of derived energy bearers	1 083	.	7	.	.	585	53	
9	Consumption by energy sector	171	-	-	-	-	5	158	
10	Consumption for non-energy purposes	37	.	.	.	.	37	-	
11	Losses in transport and distribution	33	..	..	.	..	..	3	
12	Statistical differences (7-8+1.2-9-10-11-13)	4	2	-0	-	-9	2	6	
13	Net domestic consumption	717	21	26	40	-	248	16	
13.1	Manufacturing, mining and quarrying	273	21	26	20	-	26	15	
13.2	Transport	172	-	-	-	-	170	-	
13.3	Other sectors	272	0	0	21	-	51	0	
14	Calculated energy consumption3)	548	17	21	26	-	102	15	
14.1	Manufacturing, mining and quarrying	252	16	21	13	-	22	15	
14.2	Transport	46	-	-	-	-	44	-	
14.3	Other sectors	250	0	0	13	-	36	0	
15	Energy losses in final consumption (13-14)	170	4	5	14	-	145	1	
15.1	Manufacturing, mining and quarrying	21	4	5	7	-	4	1	
15.2	Transport	126	-	-	-	-	126	-	
15.3	Other sectors	23	0	0	7	-	16	0	

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1994
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	7 234	8	.	48	5 251	194	1 255	477
2	Imports	249	22	27	0	45	138	-	-
3	Exports	6 400	5	4	0	4 709	530	1 133	-
4	Bunker oil	24	-	-	-	-	24	-	-
5	Changes in stocks (+ net decrease, - net increase)	-19	-0	-0	..	-11	-8	.	
7	Net domestic supply (1.1+2-3-4+5)	1 040	26	23	48	575	-230	122	477
8	Energy converted	1 119	1	2	5	593	40	0	477
8.1	In blast furnaces	2	-	2	-	-	-	-	-
8.2	In crude petroleum refineries	633	-	-	-	593	40	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-
8.5	In district heating plants	4	-	-	2	-	0	0	-
8.6	In hydropower plants	477	-	-	-	-	-	-	477
1.2	Production of derived energy bearers	1 082	.	7	.	.	611	50	
9	Consumption by energy sector	186	-	-	-	-	6	169	-
10	Consumption for non-energy purposes	37	.	.	.	.	37	-	-
11	Losses in transport and distribution	33	..	..	.	..	..	3	-
12	Statistical differences (7-8+1.2-9-10-11-13)	10	1	-0	-	-18	41	-13	-
13	Net domestic consumption	737	24	29	44	-	257	14	-
13.1	Manufacturing, mining and quarrying	287	24	29	22	-	34	14	-
13.2	Transport	171	-	-	-	-	169	-	-
13.3	Other sectors	278	0	0	22	-	54	0	-
14	Calculated energy consumption3)	565	19	23	28	-	111	13	-
14.1	Manufacturing, mining and quarrying	264	19	23	14	-	29	13	-
14.2	Transport	46	-	-	-	-	44	-	-
14.3	Other sectors	255	0	0	14	-	38	0	-
15	Energy losses in final consumption (13-14)	173	5	6	15	-	146	1	-
15.1	Manufacturing, mining and quarrying	23	5	6	8	-	5	1	-
15.2	Transport	125	-	-	-	-	125	-	-
15.3	Other sectors	24	0	0	8	-	16	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1995
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	7 753	8	.	49	5 636	239	1 303	519
2	Imports	260	26	29	0	59	137	-	
3	Exports	6 883	5	4	0	5 155	533	1 154	
4	Bunker oil	30	-	-	-	-	30	-	
5	Changes in stocks (+ net decrease, - net increase)	-3	-1	0	..	-10	7	.	
7	Net domestic supply (1.1+2-3-4+5)	1 098	29	25	49	531	-179	149	519
8	Energy converted	1 111	1	2	5	542	41	0	519
8.1	In blast furnaces	2	-	2	-	-	-	-	
8.2	In crude petroleum refineries	583	-	0	-	542	41	-	
8.3	In thermal power plants	0	-	-	-	-	0	-	
8.4	In combined heat and power plants	3	1	-	2	-	-	-	
8.5	In district heating plants	4	-	-	3	-	0	0	
8.6	In hydropower plants	519	-	-	-	-	-	-	519
1.2	Production of derived energy bearers	1 056	.	6	.	.	559	43	
9	Consumption by energy sector	183	-	-	-	-	6	168	
10	Consumption for non-energy purposes	38	.	.	.	.	38	-	
11	Losses in transport and distribution	30	..	..	.	..	..	3	
12	Statistical differences (7-8+1.2-9-10-11-13)	43	1	-1	-	-11	37	9	
13	Net domestic consumption	747	27	30	44	-	257	12	
13.1	Manufacturing, mining and quarrying	292	26	30	22	-	31	12	
13.2	Transport	175	-	-	-	-	173	-	
13.3	Other sectors	280	0	0	22	-	54	0	
14	Calculated energy consumption3)	572	21	24	28	-	109	11	
14.1	Manufacturing, mining and quarrying	268	21	24	14	-	26	11	
14.2	Transport	47	-	-	-	-	45	-	
14.3	Other sectors	256	0	0	14	-	38	0	
15	Energy losses in final consumption (13-14)	175	5	6	15	-	148	1	
15.1	Manufacturing, mining and quarrying	24	5	6	8	-	4	1	
15.2	Transport	128	-	-	-	-	128	-	
15.3	Other sectors	24	0	0	8	-	16	0	

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1996
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	8 793	6	.	50	6 323	271	1 702	441
2	Imports	291	23	30	0	56	133	-	-
3	Exports	7 971	4	5	0	5 787	590	1 570	-
4	Bunker oil	32	-	-	-	-	32	-	-
5	Changes in stocks (+ net decrease, - net increase)	-36	1	-2	..	-27	-8	.	
7	Net domestic supply (1.1+2-3-4+5)	1 044	26	23	50	565	-226	132	441
8	Energy converted	1 099	1	1	5	601	48	0	441
8.1	In blast furnaces	1	-	1	-	-	-	-	-
8.2	In crude petroleum refineries	648	-	-	-	601	47	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	2	0	-
8.6	In hydropower plants	441	-	-	-	-	-	-	441
1.2	Production of derived energy bearers	1 065	.	7	.	.	626	49	
9	Consumption by energy sector	195	-	-	-	-	6	182	-
10	Consumption for non-energy purposes	39	.	.	.	.	39	-	-
11	Losses in transport and distribution	32	..	..	.	..	..	3	-
12	Statistical differences (7-8+1.2-9-10-11-13)	-28	-1	-1	-	-36	24	-18	-
13	Net domestic consumption	773	26	30	45	-	282	13	-
13.1	Manufacturing, mining and quarrying	287	26	30	22	-	37	13	-
13.2	Transport	183	-	-	-	-	181	0	-
13.3	Other sectors	302	0	0	23	-	64	0	-
14	Calculated energy consumption3)	587	21	24	29	-	124	12	-
14.1	Manufacturing, mining and quarrying	262	21	24	14	-	32	12	-
14.2	Transport	50	-	-	-	-	47	0	-
14.3	Other sectors	275	0	0	15	-	45	0	-
15	Energy losses in final consumption (13-14)	186	5	6	16	-	158	1	-
15.1	Manufacturing, mining and quarrying	25	5	6	8	-	5	1	-
15.2	Transport	134	-	-	-	-	134	0	-
15.3	Other sectors	27	0	0	8	-	19	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1997
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	9 093	11	.	52	6 329	325	1 906	470
2	Imports	299	24	27	0	66	150	-	-
3	Exports	8 232	5	3	0	5 818	662	1 725	-
4	Bunker oil	39	-	-	-	-	39	-	-
5	Changes in stocks (+ net decrease, - net increase)	1	-2	1	..	14	-12	.	
7	Net domestic supply (1.1+2-3-4+5)	1 122	28	24	52	591	-238	181	470
8	Energy converted	1 134	1	2	5	597	59	0	470
8.1	In blast furnaces	2	-	2	-	-	-	-	-
8.2	In crude petroleum refineries	655	-	-	-	597	58	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-
8.6	In hydropower plants	470	-	-	-	-	-	-	470
1.2	Production of derived energy bearers	1 092	.	7	.	.	626	52	
9	Consumption by energy sector	204	-	-	-	-	7	186	-
10	Consumption for non-energy purposes	49	.	.	.	.	40	9	-
11	Losses in transport and distribution	34	..	..	.	..	..	4	-
12	Statistical differences (7-8+1.2-9-10-11-13)	14	1	-1	-	-6	5	15	-
13	Net domestic consumption	777	26	30	47	-	277	19	-
13.1	Manufacturing, mining and quarrying	294	26	30	23	-	33	19	-
13.2	Transport	187	-	-	-	-	185	0	-
13.3	Other sectors	296	0	0	24	-	59	0	-
14	Calculated energy consumption3)	590	21	24	31	-	118	18	-
14.1	Manufacturing, mining and quarrying	269	21	24	15	-	28	18	-
14.2	Transport	51	-	-	-	-	49	-	-
14.3	Other sectors	270	0	0	16	-	41	0	-
15	Energy losses in final consumption (13-14)	187	5	6	17	-	158	1	-
15.1	Manufacturing, mining and quarrying	25	5	6	8	-	4	1	-
15.2	Transport	136	-	-	-	-	136	0	-
15.3	Other sectors	26	0	0	8	-	18	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1998
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	8 854	9	.	52	6 053	311	1 937	492
2	Imports	282	27	29	0	81	115	-	-
3	Exports	7 915	8	3	0	5 553	607	1 728	-
4	Bunker oil	38	-	-	-	-	38	-	-
5	Changes in stocks (+ net decrease, - net increase)	26	1	-0	..	23	3	.	
7	Net domestic supply (1.1+2-3-4+5)	1 209	29	26	53	605	-217	209	492
8	Energy converted	1 144	1	2	5	598	44	0	492
8.1	In blast furnaces	2	-	2	-	-	-	-	-
8.2	In crude petroleum refineries	641	-	-	-	598	43	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-
8.6	In hydropower plants	492	-	-	-	-	-	-	492
1.2	Production of derived energy bearers	1 083	.	7	.	.	599	50	
9	Consumption by energy sector	194	-	-	-	-	8	178	-
10	Consumption for non-energy purposes	54	.	.	.	.	37	17	-
11	Losses in transport and distribution	37	..	..	.	..	..	5	-
12	Statistical differences (7-8+1.2-9-10-11-13)	57	-1	1	-	6	11	40	-
13	Net domestic consumption	808	29	29	47	-	283	20	-
13.1	Manufacturing, mining and quarrying	312	28	29	25	-	35	19	-
13.2	Transport	192	-	-	-	-	190	0	-
13.3	Other sectors	303	0	0	23	-	59	0	-
14	Calculated energy consumption3)	617	23	23	31	-	121	19	-
14.1	Manufacturing, mining and quarrying	287	23	23	16	-	30	18	-
14.2	Transport	53	-	-	-	-	50	-	-
14.3	Other sectors	277	0	0	15	-	41	0	-
15	Energy losses in final consumption (13-14)	191	6	6	17	-	162	1	-
15.1	Manufacturing, mining and quarrying	26	6	6	9	-	5	1	-
15.2	Transport	140	-	-	-	-	140	0	-
15.3	Other sectors	26	0	0	8	-	17	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
1999
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	9 014	11	.	55	6 025	317	2 090	516
2	Imports	284	26	29	0	89	115	-	-
3	Exports	7 981	8	2	0	5 436	621	1 883	-
4	Bunker oil	35	-	-	-	-	35	-	-
5	Changes in stocks (+ net decrease, - net increase)	-0	1	0	..	1	-2	.	
7	Net domestic supply (1.1+2-3-4+5)	1 281	29	27	55	678	-226	207	516
8	Energy converted	1 184	1	2	5	607	53	0	516
8.1	In blast furnaces	2	-	2	-	-	-	-	-
8.2	In crude petroleum refineries	658	-	-	-	607	52	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-
8.5	In district heating plants	5	-	-	3	-	2	0	-
8.6	In hydropower plants	516	-	-	-	-	-	-	516
1.2	Production of derived energy bearers	1 135	.	7	.	.	628	51	
9	Consumption by energy sector	195	-	-	-	-	8	178	-
10	Consumption for non-energy purposes	51	.	.	.	.	32	19	-
11	Losses in transport and distribution	37	..	..	.	..	..	5	-
12	Statistical differences (7-8+1.2-9-10-11-13)	130	1	4	-	72	16	37	-
13	Net domestic consumption	820	27	29	50	-	293	20	-
13.1	Manufacturing, mining and quarrying	312	27	28	26	-	33	20	-
13.2	Transport	203	-	-	-	-	201	0	-
13.3	Other sectors	305	0	0	23	-	60	0	-
14	Calculated energy consumption3)	621	22	23	32	-	124	19	-
14.1	Manufacturing, mining and quarrying	286	22	23	17	-	29	19	-
14.2	Transport	56	-	-	-	-	53	-	-
14.3	Other sectors	279	0	0	15	-	42	0	-
15	Energy losses in final consumption (13-14)	199	5	6	17	-	170	1	-
15.1	Manufacturing, mining and quarrying	26	5	6	9	-	4	1	-
15.2	Transport	147	-	-	-	-	147	0	-
15.3	Other sectors	26	0	0	8	-	18	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
2000
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	9 664	18	.	55	6 505	302	2 182	603
2	Imports	235	26	29	0	43	132	-	-
3	Exports	8 439	16	1	0	5 822	566	1 960	-
4	Bunker oil	34	-	-	-	-	34	-	-
5	Changes in stocks (+ net decrease, - net increase)	-28	1	1	..	-35	5	.	
7	Net domestic supply (1.1+2-3-4+5)	1 398	28	29	55	690	-161	222	603
8	Energy converted	1 269	1	2	5	580	76	0	603
8.1	In blast furnaces	2	-	2	-	-	-	-	-
8.2	In crude petroleum refineries	656	-	-	-	580	75	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-
8.6	In hydropower plants	603	-	-	-	-	-	-	603
1.2	Production of derived energy bearers	1 196	.	7	.	.	616	50	
9	Consumption by energy sector	215	-	-	-	-	9	199	-
10	Consumption for non-energy purposes	53	.	.	.	.	33	19	-
11	Losses in transport and distribution	48	..	..	.	..	..	5	-
12	Statistical differences (7-8+1.2-9-10-11-13)	215	0	6	-	110	70	28	-
13	Net domestic consumption	794	27	28	50	-	268	21	-
13.1	Manufacturing, mining and quarrying	317	27	28	26	-	31	20	-
13.2	Transport	188	-	-	-	-	186	0	-
13.3	Other sectors	289	0	0	24	-	51	0	-
14	Calculated energy consumption3)	609	22	23	33	-	112	20	-
14.1	Manufacturing, mining and quarrying	292	22	23	17	-	27	19	-
14.2	Transport	52	-	-	-	-	49	-	-
14.3	Other sectors	265	0	0	16	-	36	0	-
15	Energy losses in final consumption (13-14)	186	5	6	18	-	156	1	-
15.1	Manufacturing, mining and quarrying	25	5	6	9	-	4	1	-
15.2	Transport	137	-	-	-	-	137	0	-
15.3	Other sectors	24	0	0	8	-	15	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
2001
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	9 865	50	.	60	6 485	415	2 341	513
2	Imports	262	23	27	1	41	131	-	-
3	Exports	8 789	42	0	0	6 006	683	2 031	-
4	Bunker oil	34	-	-	-	-	34	-	-
5	Changes in stocks (+ net decrease, - net increase)	66	-6	1	..	60	11	.	
7	Net domestic supply (1.1+2-3-4+5)	1 370	26	28	61	581	-160	310	513
8	Energy converted	1 140	1	1	6	538	78	0	513
8.1	In blast furnaces	1	-	1	-	-	-	-	-
8.2	In crude petroleum refineries	616	-	-	-	538	77	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-
8.5	In district heating plants	7	-	-	4	-	1	0	-
8.6	In hydropower plants	513	-	-	-	-	-	-	513
1.2	Production of derived energy bearers	1 079	.	7	.	.	577	47	
9	Consumption by energy sector	220	-	-	-	-	8	203	-
10	Consumption for non-energy purposes	73	.	.	.	.	50	23	-
11	Losses in transport and distribution	44	..	..	.	..	..	4	-
12	Statistical differences (7-8+1.2-9-10-11-13)	159	1	8	-	43	3	105	-
13	Net domestic consumption	814	24	26	55	-	277	22	-
13.1	Manufacturing, mining and quarrying	309	24	26	30	-	33	21	-
13.2	Transport	192	-	-	-	-	189	0	-
13.3	Other sectors	313	0	0	25	-	56	1	-
14	Calculated energy consumption3)	623	19	21	36	-	117	20	-
14.1	Manufacturing, mining and quarrying	284	19	21	19	-	29	20	-
14.2	Transport	52	-	-	-	-	50	-	-
14.3	Other sectors	287	0	0	16	-	39	1	-
15	Energy losses in final consumption (13-14)	191	5	5	19	-	160	1	-
15.1	Manufacturing, mining and quarrying	26	5	5	10	-	4	1	-
15.2	Transport	139	-	-	-	-	139	0	-
15.3	Other sectors	26	0	0	9	-	17	0	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
2002
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	10 166	60	.	56	6 223	485	2 792	550
2	Imports	223	18	27	1	27	131	-	
3	Exports	9 120	58	2	0	5 733	697	2 576	
4	Bunker oil	27	-	-	-	-	27	-	
5	Changes in stocks (+ net decrease, - net increase)	-2	2	0	..	-5	-0	-	
7	Net domestic supply (1.1+2-3-4+5)	1 240	23	25	57	512	-108	216	550
8	Energy converted	1 140	1	1	6	502	79	0	550
8.1	In blast furnaces	1	-	1	-	-	-	-	
8.2	In crude petroleum refineries	579	-	-	-	502	77	-	
8.3	In thermal power plants	0	-	-	-	-	0	-	
8.4	In combined heat and power plants	3	1	-	2	-	-	-	
8.5	In district heating plants	7	-	-	4	-	1	0	
8.6	In hydropower plants	550	-	-	-	-	-	-	550
1.2	Production of derived energy bearers	1 085	.	7	.	.	551	48	
9	Consumption by energy sector	219	-	-	-	-	6	205	
10	Consumption for non-energy purposes	69	.	.	.	.	52	17	
11	Losses in transport and distribution	39	..	..	.	..	..	4	
12	Statistical differences (7-8+1.2-9-10-11-13)	65	1	6	-	10	28	19	
13	Net domestic consumption	792	21	25	51	-	276	19	
13.1	Manufacturing, mining and quarrying	287	21	25	22	-	31	19	
13.2	Transport	191	-	-	-	-	188	0	
13.3	Other sectors	314	0	0	29	-	57	1	
14	Calculated energy consumption3)	604	17	20	33	-	117	18	
14.1	Manufacturing, mining and quarrying	265	17	20	14	-	27	18	
14.2	Transport	52	-	-	-	-	49	-	
14.3	Other sectors	287	0	0	19	-	40	1	
15	Energy losses in final consumption (13-14)	188	4	5	18	-	160	1	
15.1	Manufacturing, mining and quarrying	22	4	5	8	-	4	1	
15.2	Transport	139	-	-	-	-	139	0	
15.3	Other sectors	27	0	0	10	-	17	0	

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficiency
Source: Statistics Norway.

Energy balance sheet1).
Preliminary data 2003
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)
1.1	Production of primary energy bearers	10 243	83	.	58	5 927	607	3 120	449
2	Imports	259	19	24	2	26	140	-	
3	Exports	9 183	76	3	0	5 372	858	2 853	
4	Bunker oil	23	-	-	-	-	23	-	
5	Changes in stocks (+ net decrease, - net increase)	-33	-3	-1	..	-22	-7	-	
7	Net domestic supply (1.1+2-3-4+5)	1 265	23	20	60	559	-141	267	449
8	Energy converted	1 108	1	1	8	560	88	0	449
8.1	In blast furnaces	1	-	1	-	-	-	-	
8.2	In crude petroleum refineries	645	-	-	-	560	85	-	
8.3	In thermal power plants	0	-	-	-	-	0	-	
8.4	In combined heat and power plants	4	1	-	4	-	-	-	
8.5	In district heating plants	8	-	-	5	-	2	0	
8.6	In hydropower plants	449	-	-	-	-	-	-	449
1.2	Production of derived energy bearers	1 070	.	8	.	.	616	50	
9	Consumption by energy sector	234	-	-	-	-	6	218	
10	Consumption for non-energy purposes	79	.	.	.	.	55	24	
11	Losses in transport and distribution	36	..	..	.	..	..	3	
12	Statistical differences (7-8+1.2-9-10-11-13)	92	2	3	-	-2	39	50	
13	Net domestic consumption	786	21	24	52	-	288	22	
13.1	Manufacturing, mining and quarrying	294	21	24	23	-	33	21	
13.2	Transport	196	-	-	-	-	193	0	
13.3	Other sectors	296	0	0	29	-	61	1	
14	Calculated energy consumption3)	595	16	19	34	-	125	21	
14.1	Manufacturing, mining and quarrying	272	16	19	15	-	29	20	
14.2	Transport	55	-	-	-	-	53	-	
14.3	Other sectors	268	0	0	19	-	43	1	
15	Energy losses in final consumption (13-14)	191	4	5	18	-	163	1	
15.1	Manufacturing, mining and quarrying	22	4	5	8	-	4	1	
15.2	Transport	140	-	-	-	-	140	0	
15.3	Other sectors	28	0	0	10	-	18	0	

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 p
3) Line 14, "calculated energy consumption" shows the amount of energy actually utilized. The figures are estimated by multiplying the values in line 13 by thermal efficienc
Source: Statistics Norway.

12. Annex IV: CRF Summary II Tables 1990 - 2003

This annex contains Summary II-tables for the whole period 1990-2003. The full CRF tables for 1990 and 1998-2003 are enclosed in a zip-file.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1990
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**24 875,73**	**5 159,17**	**5 064,15**	**0,02**	**3 294,40**	**2 202,02**	**40 595,49**
1. Energy	**28 364,11**	**604,39**	**315,76**				**29 284,26**
A. Fuel Combustion (Sectoral Approach)	25 741,61	249,71	311,98				26 303,30
1. Energy Industries	6 513,92	47,34	21,49				6 582,76
2. Manufacturing Industries and Construction	3 541,61	10,33	38,46				3 590,40
3. Transport	11 099,18	69,84	163,67				11 332,69
4. Other Sectors	4 130,70	121,72	84,30				4 336,72
5. Other	456,19	0,48	4,06				460,74
B. Fugitive Emissions from Fuels	2 622,50	354,67	3,78				2 980,96
1. Solid Fuels	0,44	3,41	0,00				3,85
2. Oil and Natural Gas	2 622,06	351,27	3,78				2 977,11
2. Industrial Processes	**5 905,06**	**37,54**	**2 061,50**	**0,02**	**3 294,40**	**2 202,02**	**13 500,54**
A. Mineral Products	697,29	0,00	0,00				697,29
B. Chemical Industry	791,60	22,04	2 061,50				2 875,14
C. Metal Production	4 396,17	15,50	0,00		3 294,40	2 143,83	9 849,90
D. Other Production	20,00						20,00
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				0,02		58,19	58,21
G. Other							0,00
3. Solvent and Other Product Use	**144,49**		**35,53**				**180,02**
4. Agriculture	**0,00**	**2 034,53**	**2 560,23**				**4 594,76**
A. Enteric Fermentation		1 712,60					1 712,60
B. Manure Management		298,09	134,29				432,38
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 419,06				2 419,06
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		23,85	6,88				30,72
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-9 538,39**	**0,00**	**0,00**				**-9 538,39**
6. Waste	**0,46**	**2 482,72**	**91,13**				2 574,31
A. Solid Waste Disposal on Land	0,00	2 463,20					2 463,20
B. Wastewater Handling		19,51	91,07				110,58
C. Waste Incineration	0,46	0,01	0,06				0,54
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 097,52**	**2,30**	**17,61**				**2 117,43**
Aviation	619,47	0,06	6,10				625,63
Marine	1 478,05	2,24	11,51				1 491,80
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 717,37**						**4 717,37**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	19 726,69	-29 491,86	-9 765,17			-9 765,17
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	216,66		216,66			216,66
E. Other	10,12		10,12			10,12
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	19 953,47	-29 491,86	-9 538,39	0,00	0,00	-9 538,39

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	50 133,88
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	40 595,49

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1991
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 789,67**	**5 194,30**	**4 919,15**	**0,11**	**2 523,63**	**2 084,73**	**36 511,59**
1. Energy	**27 897,90**	**637,19**	**322,80**				**28 857,89**
A. Fuel Combustion (Sectoral Approach)	25 324,56	237,18	320,28				25 882,02
1. Energy Industries	6 834,53	49,61	25,04				6 909,18
2. Manufacturing Industries and Construction	3 360,81	9,95	36,59				3 407,35
3. Transport	11 016,13	67,71	175,01				11 258,85
4. Other Sectors	3 707,34	109,47	79,97				3 896,79
5. Other	405,75	0,43	3,67				409,85
B. Fugitive Emissions from Fuels	2 573,34	400,01	2,52				2 975,87
1. Solid Fuels	0,48	3,71					4,20
2. Oil and Natural Gas	2 572,86	396,30	2,52				2 971,67
2. Industrial Processes	**5 516,86**	**29,84**	**1 891,00**	**0,11**	**2 523,63**	**2 084,73**	**12 046,17**
A. Mineral Products	640,13						640,13
B. Chemical Industry	806,11	17,13	1 891,00				2 714,24
C. Metal Production	4 040,24	12,71			2 523,63	2 019,55	8 596,13
D. Other Production	30,38						30,38
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				0,11		65,18	65,29
G. Other							0,00
3. Solvent and Other Product Use	**125,23**		**35,30**				**160,53**
4. Agriculture	**0,00**	**2 061,43**	**2 578,91**				**4 640,34**
A. Enteric Fermentation		1 736,57					1 736,57
B. Manure Management		306,11	141,21				447,32
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 432,30				2 432,30
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		18,74	5,41				24,15
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-11 751,43**	**0,00**	**0,00**				**-11 751,43**
6. Waste	**1,11**	**2 465,84**	**91,13**				2 558,08
A. Solid Waste Disposal on Land	0,00	2 446,21					2 446,21
B. Wastewater Handling		19,60	91,07				110,67
C. Waste Incineration	1,11	0,03	0,06				1,20
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**1 811,80**	**1,95**	**15,25**				**1 829,01**
Aviation	559,65	0,06	5,51				565,21
Marine	1 252,15	1,90	9,75				1 263,79
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 407,64**						**4 407,64**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	18 192,81	-30 141,43	-11 948,62			-11 948,62
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	185,31		185,31			185,31
E. Other	11,88		11,88			11,88
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	18 390,00	-30 141,43	-11 751,43	0,00	0,00	-11 751,43

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	48 263,02
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 511,59

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1992
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**20 537,21**	**5 258,28**	**4 256,17**	**0,34**	**2 016,46**	**707,82**	**32 776,28**
1. Energy	**28 133,74**	**746,95**	**338,55**				**29 219,24**
A. Fuel Combustion (Sectoral Approach)	25 758,51	238,39	336,28				26 333,18
1. Energy Industries	7 435,86	53,34	27,61				7 516,81
2. Manufacturing Industries and Construction	3 213,11	9,76	35,96				3 258,83
3. Transport	11 231,78	68,21	191,02				11 491,01
4. Other Sectors	3 390,84	106,56	77,19				3 574,59
5. Other	486,91	0,53	4,49				491,93
B. Fugitive Emissions from Fuels	2 375,23	508,56	2,27				2 886,06
1. Solid Fuels	0,53	4,04					4,57
2. Oil and Natural Gas	2 374,70	504,52	2,27				2 881,49
2. Industrial Processes	**5 497,26**	**30,96**	**1 291,15**	**0,34**	**2 016,46**	**707,82**	**9 543,99**
A. Mineral Products	698,61						698,61
B. Chemical Industry	742,37	18,02	1 291,15				2 051,54
C. Metal Production	4 026,17	12,94			2 016,46	638,25	6 693,83
D. Other Production	30,10						30,10
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				0,34		69,57	69,91
G. Other							0,00
3. Solvent and Other Product Use	**129,62**		**35,21**				**164,83**
4. Agriculture	**0,00**	**2 057,60**	**2 500,13**				**4 557,73**
A. Enteric Fermentation		1 740,10					1 740,10
B. Manure Management		307,25	141,06				448,31
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 356,11				2 356,11
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		10,26	2,96				13,22
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-13 225,46**	**0,00**	**0,00**				**-13 225,46**
6. Waste	**2,05**	**2 422,76**	**91,14**				2 515,95
A. Solid Waste Disposal on Land	0,00	2 402,99					2 402,99
B. Wastewater Handling		19,71	91,07				110,78
C. Waste Incineration	2,05	0,06	0,07				2,18
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 169,53**	**2,43**	**18,12**				**2 190,09**
Aviation	602,87	0,06	5,93				608,86
Marine	1 566,66	2,37	12,19				1 581,23
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 335,87**						**4 335,87**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	17 413,94	-30 802,04	-13 388,10			-13 388,10
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	150,76		150,76			150,76
E. Other	11,88		11,88			11,88
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	17 576,58	-30 802,04	-13 225,46	0,00	0,00	-13 225,46

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	46 001,74
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	32 776,28

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1993
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 938,17**	**5 303,36**	**4 603,93**	**2,43**	**1 980,37**	**744,65**	**34 572,91**
1. Energy	**29 233,02**	**798,78**	**370,21**				**30 402,00**
A. Fuel Combustion (Sectoral Approach)	26 746,04	254,72	367,35				27 368,11
1. Energy Industries	7 746,57	56,13	26,98				7 829,68
2. Manufacturing Industries and Construction	3 454,54	9,85	36,01				3 500,40
3. Transport	11 845,66	67,97	223,56				12 137,19
4. Other Sectors	3 332,48	120,36	77,54				3 530,38
5. Other	366,79	0,40	3,26				370,46
B. Fugitive Emissions from Fuels	2 486,98	544,05	2,86				3 033,90
1. Solid Fuels	0,39	3,01					3,41
2. Oil and Natural Gas	2 486,59	541,04	2,86				3 030,49
2. Industrial Processes	**6 043,80**	**33,62**	**1 560,54**	**2,43**	**1 980,37**	**744,65**	**10 365,42**
A. Mineral Products	885,31						885,31
B. Chemical Industry	794,19	19,54	1 560,54				2 374,27
C. Metal Production	4 331,99	14,09			1 980,37	663,23	6 989,67
D. Other Production	32,31						32,31
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				2,43		81,43	83,85
G. Other							0,00
3. Solvent and Other Product Use	**129,28**		**35,94**				**165,22**
4. Agriculture	**0,00**	**2 040,73**	**2 542,82**				**4 583,55**
A. Enteric Fermentation		1 721,12					1 721,12
B. Manure Management		305,51	137,97				443,48
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 400,78				2 400,78
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		14,10	4,07				18,16
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-13 470,12**	**0,00**	**0,00**				**-13 470,12**
6. Waste	**2,18**	**2 430,23**	**94,42**				2 526,83
A. Solid Waste Disposal on Land	0,00	2 410,34					2 410,34
B. Wastewater Handling		19,83	94,35				114,19
C. Waste Incineration	2,18	0,06	0,07				2,31
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 312,09**	**2,68**	**19,30**				**2 334,06**
Aviation	635,14	0,13	6,25				641,53
Marine	1 676,94	2,54	13,05				1 692,53
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 606,74**						**4 606,74**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	17 775,67	-31 436,36	-13 660,69			-13 660,69
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	178,70		178,70			178,70
E. Other	11,88		11,88			11,88
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	17 966,25	-31 436,36	-13 470,12	0,00	0,00	-13 470,12

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	48 043,02
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	34 572,91

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1994
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 666,85**	**5 381,43**	**4 722,44**	**9,23**	**1 710,38**	**886,67**	**34 377,00**
1. Energy	**30 820,37**	**850,97**	**415,27**				**32 086,61**
A. Fuel Combustion (Sectoral Approach)	28 210,76	265,92	412,29				28 888,97
1. Energy Industries	8 450,88	59,96	28,75				8 539,59
2. Manufacturing Industries and Construction	4 102,86	10,99	40,48				4 154,32
3. Transport	11 675,08	66,34	264,94				12 006,36
4. Other Sectors	3 474,29	128,21	73,38				3 675,89
5. Other	507,65	0,43	4,74				512,81
B. Fugitive Emissions from Fuels	2 609,61	585,05	2,98				3 197,64
1. Solid Fuels	0,44	3,39					3,83
2. Oil and Natural Gas	2 609,17	581,66	2,98				3 193,81
2. Industrial Processes	**6 303,99**	**37,70**	**1 663,15**	**9,23**	**1 710,38**	**886,67**	**10 611,12**
A. Mineral Products	896,63						896,63
B. Chemical Industry	825,21	21,72	1 663,15				2 510,07
C. Metal Production	4 550,67	15,98			1 710,38	791,09	7 068,12
D. Other Production	31,48						31,48
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				9,23		95,58	104,81
G. Other							0,00
3. Solvent and Other Product Use	**138,88**		**38,50**				**177,38**
4. Agriculture	**0,00**	**2 059,65**	**2 505,41**				**4 565,06**
A. Enteric Fermentation		1 740,76					1 740,76
B. Manure Management		308,77	143,40				452,17
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 359,10				2 359,10
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		10,12	2,92				13,04
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-15 598,90**	**0,00**	**0,00**				**-15 598,90**
6. Waste	**2,51**	**2 433,11**	**100,11**				2 535,72
A. Solid Waste Disposal on Land	0,00	2 413,09					2 413,09
B. Wastewater Handling		19,94	100,05				119,99
C. Waste Incineration	2,51	0,07	0,07				2,65
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 462,27**	**2,93**	**20,43**				**2 485,62**
Aviation	616,57	0,13	6,07				622,77
Marine	1 845,70	2,80	14,36				1 862,86
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 973,04**						**4 973,04**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 267,19	-32 036,49	-15 769,30			-15 769,30
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	155,06		155,06			155,06
E. Other	15,34		15,34			15,34
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 437,60	-32 036,49	-15 598,90	0,00	0,00	-15 598,90

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	49 975,89
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	34 377,00

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1995
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 722,43**	**5 389,76**	**4 800,08**	**25,88**	**1 561,93**	**617,41**	**34 117,49**
1. Energy	**30 690,70**	**852,07**	**462,47**				**32 005,24**
A. Fuel Combustion (Sectoral Approach)	28 110,73	261,79	459,16				28 831,68
1. Energy Industries	8 302,49	60,21	28,68				8 391,37
2. Manufacturing Industries and Construction	3 811,67	10,88	40,89				3 863,44
3. Transport	12 074,72	65,20	314,11				12 454,03
4. Other Sectors	3 467,67	125,14	71,10				3 663,91
5. Other	454,19	0,37	4,38				458,93
B. Fugitive Emissions from Fuels	2 579,97	590,28	3,31				3 173,56
1. Solid Fuels	0,43	3,29					3,72
2. Oil and Natural Gas	2 579,54	586,99	3,31				3 169,84
2. Industrial Processes	**6 396,93**	**38,37**	**1 638,35**	**25,88**	**1 561,93**	**617,41**	**10 278,86**
A. Mineral Products	940,49						940,49
B. Chemical Industry	843,03	21,88	1 638,35				2 503,26
C. Metal Production	4 579,44	16,49			1 561,83	509,07	6 666,83
D. Other Production	33,97						33,97
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				25,88	0,09	108,34	134,31
G. Other							0,00
3. Solvent and Other Product Use	**135,22**		**38,94**				**174,16**
4. Agriculture	**0,00**	**2 087,61**	**2 556,73**				**4 644,34**
A. Enteric Fermentation		1 760,92					1 760,92
B. Manure Management		314,15	145,26				459,41
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 407,85				2 407,85
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		12,54	3,62				16,16
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-15 502,81**	**0,00**	**0,00**				**-15 502,81**
6. Waste	**2,40**	**2 411,70**	**103,59**				2 517,69
A. Solid Waste Disposal on Land	0,00	2 391,59					2 391,59
B. Wastewater Handling		20,05	103,52				123,57
C. Waste Incineration	2,40	0,07	0,07				2,54
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 841,18**	**3,54**	**23,32**				**2 868,05**
Aviation	585,57	0,12	5,76				591,45
Marine	2 255,62	3,42	17,56				2 276,59
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 021,54**						**5 021,54**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	17 628,85	-33 321,35	-15 692,50			-15 692,50
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	170,88		170,88			170,88
E. Other	18,80		18,80			18,80
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	17 818,54	-33 321,35	-15 502,81	0,00	0,00	-15 502,81

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	49 620,30
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	34 117,49

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1996
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**22 961,93**	**5 421,62**	**4 887,00**	**52,87**	**1 439,84**	**584,49**	**35 347,75**
1. Energy	**33 713,06**	**857,11**	**522,90**				**35 093,06**
A. Fuel Combustion (Sectoral Approach)	30 805,39	275,33	519,23				31 599,96
1. Energy Industries	9 149,61	64,41	30,75				9 244,77
2. Manufacturing Industries and Construction	4 339,92	11,03	41,65				4 392,60
3. Transport	12 716,81	65,27	370,04				13 152,12
4. Other Sectors	4 192,45	134,23	73,23				4 399,91
5. Other	406,60	0,39	3,56				410,55
B. Fugitive Emissions from Fuels	2 907,66	581,78	3,66				3 493,11
1. Solid Fuels	0,34	2,58					2,92
2. Oil and Natural Gas	2 907,33	579,20	3,66				3 490,18
2. Industrial Processes	**6 534,38**	**37,53**	**1 619,75**	**52,87**	**1 439,84**	**584,49**	**10 268,86**
A. Mineral Products	937,03						937,03
B. Chemical Industry	814,27	21,45	1 619,75				2 455,47
C. Metal Production	4 748,56	16,09			1 439,55	472,50	6 676,71
D. Other Production	34,52						34,52
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				52,87	0,29	111,99	165,14
G. Other							0,00
3. Solvent and Other Product Use	**142,70**		**39,51**				**182,20**
4. Agriculture	**0,00**	**2 108,87**	**2 594,60**				**4 703,47**
A. Enteric Fermentation		1 775,25					1 775,25
B. Manure Management		319,94	144,66				464,60
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 446,00				2 446,00
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		13,68	3,95				17,63
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-17 430,92**	**0,00**	**0,00**				**-17 430,92**
6. Waste	**2,71**	**2 418,11**	**110,25**				2 531,07
A. Solid Waste Disposal on Land	0,00	2 397,89					2 397,89
B. Wastewater Handling		20,15	110,18				130,33
C. Waste Incineration	2,71	0,08	0,07				2,86
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 171,59**	**3,91**	**26,11**				**3 201,61**
Aviation	691,44	0,15	6,80				698,39
Marine	2 480,16	3,76	19,30				2 503,22
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 122,07**						**5 122,07**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 378,33	-32 985,30	-17 606,98			-17 606,98
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	151,53		151,53			151,53
E. Other	24,53		24,53			24,53
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	15 554,39	-32 985,30	-17 430,92	0,00	0,00	-17 430,92

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	52 778,67
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	35 347,75

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1997
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**24 243,25**	**5 478,04**	**4 821,79**	**88,43**	**1 376,67**	**591,15**	**36 599,33**
1. Energy	**33 697,85**	**928,27**	**578,35**				**35 204,46**
A. Fuel Combustion (Sectoral Approach)	30 957,68	281,19	574,94				31 813,82
1. Energy Industries	9 505,25	67,66	31,13				9 604,05
2. Manufacturing Industries and Construction	4 314,21	11,66	43,25				4 369,12
3. Transport	12 962,84	63,24	425,39				13 451,46
4. Other Sectors	3 750,81	138,22	71,35				3 960,39
5. Other	424,57	0,41	3,82				428,80
B. Fugitive Emissions from Fuels	2 740,17	647,07	3,40				3 390,65
1. Solid Fuels	0,57	4,35					4,92
2. Oil and Natural Gas	2 739,60	642,72	3,40				3 385,73
2. Industrial Processes	**6 709,81**	**38,20**	**1 481,18**	**88,43**	**1 376,67**	**591,15**	**10 285,45**
A. Mineral Products	999,43						999,43
B. Chemical Industry	844,30	21,34	1 481,18				2 346,82
C. Metal Production	4 827,14	16,86			1 376,29	437,37	6 657,66
D. Other Production	38,94						38,94
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				88,43	0,39	153,78	242,59
G. Other							0,00
3. Solvent and Other Product Use	**137,17**		**39,44**				**176,61**
4. Agriculture	**0,00**	**2 109,76**	**2 603,92**				**4 713,68**
A. Enteric Fermentation		1 779,31					1 779,31
B. Manure Management		320,61	141,65				462,26
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 459,44				2 459,44
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,85	2,84				12,69
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-16 322,30**	**0,00**	**0,00**				**-16 322,30**
6. Waste	**20,71**	**2 401,81**	**118,90**				2 541,42
A. Solid Waste Disposal on Land	0,00	2 381,40					2 381,40
B. Wastewater Handling		20,26	118,78				139,04
C. Waste Incineration	20,71	0,15	0,11				20,98
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 771,31**	**4,71**	**30,95**				**3 806,98**
Aviation	770,89	0,16	7,59				778,64
Marine	3 000,43	4,55	23,36				3 028,34
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 368,06**						**5 368,06**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 403,78	-32 902,41	-16 498,63			-16 498,63
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	149,12		149,12			149,12
E. Other	27,22		27,22			27,22
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 580,11	-32 902,41	-16 322,30	0,00	0,00	-16 322,30

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	52 921,62
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 599,33

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1998
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 343,62**	**5 320,72**	**5 102,93**	**132,64**	**1 267,18**	**738,88**	**35 905,96**
1. Energy	**33 516,55**	**864,37**	**642,03**				**35 022,96**
A. Fuel Combustion (Sectoral Approach)	30 840,90	271,13	638,46				31 750,49
1. Energy Industries	9 167,94	64,80	29,99				9 262,72
2. Manufacturing Industries and Construction	4 279,58	12,22	45,03				4 336,84
3. Transport	13 305,42	61,82	487,24				13 854,47
4. Other Sectors	3 728,39	131,93	72,56				3 932,88
5. Other	359,57	0,36	3,64				363,57
B. Fugitive Emissions from Fuels	2 675,65	593,24	3,57				3 272,46
1. Solid Fuels	0,48	3,69					4,18
2. Oil and Natural Gas	2 675,17	589,55	3,57				3 268,29
2. Industrial Processes	**7 064,63**	**41,03**	**1 689,28**	**132,64**	**1 267,18**	**738,88**	**10 933,63**
A. Mineral Products	945,26						945,26
B. Chemical Industry	832,03	22,95	1 689,28				2 544,26
C. Metal Production	5 261,66	18,08			**1266,79**	581,97	7 128,49
D. Other Production	25,68						25,68
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				132,64	0,39	156,91	289,93
G. Other							0,00
3. Solvent and Other Product Use	**136,54**		**39,51**				**176,05**
4. Agriculture	**0,00**	**2 130,47**	**2 612,88**				**4 743,35**
A. Enteric Fermentation		1 795,42					1 795,42
B. Manure Management		324,71	141,58				466,29
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 468,32				2 468,32
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		10,34	2,98				13,32
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-17 430,80**	**0,00**	**0,00**				**-17 430,80**
6. Waste	**56,70**	**2 284,84**	**119,22**				2 460,77
A. Solid Waste Disposal on Land	0,00	2 264,22					2 264,22
B. Wastewater Handling		20,38	119,02				139,40
C. Waste Incineration	56,70	0,24	0,21				57,15
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 720,80**	**4,60**	**30,67**				**3 756,07**
Aviation	821,39	0,21	8,08				829,68
Marine	2 899,41	4,40	22,58				2 926,39
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 363,24**						**5 363,24**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 898,68	-33 486,49	-17 587,82			-17 587,82
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	133,78		133,78			133,78
E. Other	23,23		23,23			23,23
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 055,69	-33 486,49	-17 430,80	0,00	0,00	-17 430,80

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	53 336,76
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	35 905,96

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1999
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**24 013,71**	**5 226,85**	**5 299,13**	**179,45**	**1 123,01**	**886,71**	**36 728,86**
1. Energy	**34 639,34**	**824,08**	**712,96**				**36 176,39**
A. Fuel Combustion (Sectoral Approach)	31 184,71	268,90	708,20				32 161,82
1. Energy Industries	9 061,67	60,72	30,31				9 152,70
2. Manufacturing Industries and Construction	4 020,44	12,76	46,79				4 079,99
3. Transport	13 902,32	60,31	555,41				14 518,04
4. Other Sectors	3 808,72	134,76	71,82				4 015,30
5. Other	391,56	0,36	3,87				395,79
B. Fugitive Emissions from Fuels	3 454,62	555,18	4,76				4 014,57
1. Solid Fuels	0,59	4,55					5,14
2. Oil and Natural Gas	3 454,03	550,64	4,76				4 009,43
2. Industrial Processes	**6 804,19**	**36,91**	**1 878,60**	**179,45**	**1 123,01**	**886,71**	**10 908,87**
A. Mineral Products	933,42						933,42
B. Chemical Industry	456,36	18,92	1 878,60				2 353,87
C. Metal Production	5 395,09	18,00			1 122,62	725,37	7 261,07
D. Other Production	19,33						19,33
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				179,45	0,39	161,34	341,18
G. Other							0,00
3. Solvent and Other Product Use	**133,66**		**40,20**				**173,86**
4. Agriculture	**0,00**	**2 115,78**	**2 546,86**				**4 662,64**
A. Enteric Fermentation		1 784,72					1 784,72
B. Manure Management		321,69	142,23				463,93
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 401,93				2 401,93
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,37	2,70				12,07
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-17 611,86**	**0,00**	**0,00**				**-17 611,86**
6. Waste	**48,38**	**2 250,07**	**120,51**				2 418,96
A. Solid Waste Disposal on Land	0,00	2 229,32					2 229,32
B. Wastewater Handling		20,52	120,32				140,84
C. Waste Incineration	48,38	0,23	0,19				48,80
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 674,83**	**4,38**	**30,56**				**3 709,77**
Aviation	941,67	0,24	9,27				951,18
Marine	2 733,16	4,15	21,29				2 758,60
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 594,62**						**5 594,62**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 306,29	-34 073,62	-17 767,33			-17 767,33
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	129,43		129,43			129,43
E. Other	26,04		26,04			26,04
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 461,76	-34 073,62	-17 611,86	0,00	0,00	-17 611,86

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	54 340,72
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 728,86

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 2000
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**22 534,81**	**5 317,73**	**5 222,87**	**232,10**	**899,24**	**947,93**	**35 154,67**
1. Energy	**33 869,84**	**937,43**	**749,54**				**35 556,81**
A. Fuel Combustion (Sectoral Approach)	30 182,65	279,02	744,69				31 206,35
1. Energy Industries	9 889,99	70,43	33,41				9 993,82
2. Manufacturing Industries and Construction	3 880,84	12,62	46,11				3 939,57
3. Transport	13 027,83	58,76	594,89				13 681,48
4. Other Sectors	3 205,83	136,94	68,51				3 411,29
5. Other	178,16	0,27	1,77				180,19
B. Fugitive Emissions from Fuels	3 687,19	658,42	4,85				4 350,46
1. Solid Fuels	0,93	7,11					8,04
2. Oil and Natural Gas	3 686,26	651,31	4,85				4 342,42
2. Industrial Processes	**7 057,10**	**37,52**	**1 733,14**	**232,10**	**899,24**	**947,93**	**10 907,03**
A. Mineral Products	940,73						940,73
B. Chemical Industry	674,15	19,27	1 733,14				2 426,56
C. Metal Production	5 392,22	18,25			898,85	773,17	7 082,48
D. Other Production	50,00						50,00
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				232,10	0,39	174,77	407,25
G. Other							0,00
3. Solvent and Other Product Use	**126,82**		**40,04**				**166,86**
4. Agriculture	**0,00**	**2 082,66**	**2 591,97**				**4 674,63**
A. Enteric Fermentation		1 754,04					1 754,04
B. Manure Management		318,72	144,29				463,01
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 444,83				2 444,83
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,90	2,85				12,75
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-18 608,79**	**0,00**	**0,00**				**-18 608,79**
6. Waste	**89,85**	**2 260,11**	**108,17**				2 458,14
A. Solid Waste Disposal on Land	0,00	2 239,23					2 239,23
B. Wastewater Handling		20,60	107,88				128,47
C. Waste Incineration	89,85	0,29	0,30				90,43
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 624,42**	**4,34**	**30,11**				**3 658,87**
Aviation	912,88	0,23	8,98				922,09
Marine	2 711,55	4,11	21,12				2 736,78
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 635,28**						**5 635,28**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 952,55	-34 695,96	-18 743,41			-18 743,41
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	108,19		108,19			108,19
E. Other	26,43		26,43			26,43
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 087,17	-34 695,96	-18 608,79	0,00	0,00	-18 608,79

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	53 763,46
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	35 154,67

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 2001
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 833,50**	**5 293,40**	**5 210,98**	**291,68**	**1 043,41**	**805,50**	**36 478,47**
1. Energy	**35 695,23**	**1 063,01**	**852,89**				**37 611,13**
A. Fuel Combustion (Sectoral Approach)	32 463,54	293,29	848,58				33 605,41
1. Energy Industries	11 422,03	77,58	36,04				11 535,65
2. Manufacturing Industries and Construction	3 923,39	13,96	51,16				3 988,50
3. Transport	13 335,63	58,32	683,42				14 077,37
4. Other Sectors	3 487,57	143,02	75,23				3 705,82
5. Other	294,91	0,41	2,74				298,07
B. Fugitive Emissions from Fuels	3 231,70	769,72	4,31				4 005,73
1. Solid Fuels	2,63	20,13					22,75
2. Oil and Natural Gas	3 229,07	749,59	4,31				3 982,97
2. Industrial Processes	**6 806,16**	**34,08**	**1 693,84**	**291,68**	**1 043,41**	**805,50**	**10 674,67**
A. Mineral Products	898,10						898,10
B. Chemical Industry	656,12	18,96	1 693,84				2 368,92
C. Metal Production	5 195,41	15,12			1 043,03	645,30	6 898,86
D. Other Production	56,53						56,53
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				291,68	0,39	160,20	452,27
G. Other							0,00
3. Solvent and Other Product Use	**126,82**		**40,04**				**166,86**
4. Agriculture	**0,00**	**2 025,29**	**2 513,64**				**4 538,92**
A. Enteric Fermentation		1 706,95					1 706,95
B. Manure Management		310,55	142,57				453,12
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 368,82				2 368,82
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		7,79	2,25				10,04
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-18 830,76**	**0,00**	**0,00**				**-18 830,76**
6. Waste	**36,04**	**2 171,03**	**110,57**				2 317,64
A. Solid Waste Disposal on Land	0,00	2 150,15					2 150,15
B. Wastewater Handling		20,71	110,42				131,13
C. Waste Incineration	36,04	0,17	0,16				36,37
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 459,41**	**4,19**	**28,66**				**3 492,26**
Aviation	835,42	0,21	8,22				843,85
Marine	2 623,99	3,98	20,44				2 648,41
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**6 267,71**						**6 267,71**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 358,54	-35 326,50	-18 967,96			-18 967,96
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	113,39		113,39			113,39
E. Other	23,81		23,81			23,81
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 495,74	-35 326,50	-18 830,76	0,00	0,00	-18 830,76

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	55 309,225
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 478,47

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 2002
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 318,55**	**5 119,15**	**5 419,15**	**365,12**	**1 120**	**253,30**	**33 595,24**
1. Energy	**35 188,47**	**1 001,40**	**900,62**				**37 090,49**
A. Fuel Combustion (Sectoral Approach)	32 469,72	311,79	897,03				33 678,54
1. Energy Industries	11 639,14	80,86	37,72				11 757,71
2. Manufacturing Industries and Construction	3 613,34	11,22	39,45				3 664,01
3. Transport	13 123,97	56,65	741,21				13 921,83
4. Other Sectors	3 640,04	162,74	74,39				3 877,17
5. Other	453,23	0,32	4,26				457,81
B. Fugitive Emissions from Fuels	2 718,75	689,60	3,60				3 411,96
1. Solid Fuels	3,13	23,99					27,13
2. Oil and Natural Gas	2 715,62	665,61	3,60				3 384,83
2. Industrial Processes	**5 893,15**	**32,72**	**1 912,08**	**365,12**	**1 119,95**	**253,30**	**9 576,32**
A. Mineral Products	913,61						913,61
B. Chemical Industry	335,40	19,53	1 912,08				2 267,01
C. Metal Production	4 582,01	13,19			1 119,57	141,73	5 856,49
D. Other Production	62,13						62,13
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				365,12	0,39	111,58	477,09
G. Other							0,00
3. Solvent and Other Product Use	**126,82**		**40,10**				**166,92**
4. Agriculture	**0,00**	**1 964,58**	**2 463,70**				**4 428,28**
A. Enteric Fermentation		1 653,93					1 653,93
B. Manure Management		304,67	140,64				445,31
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 321,34				2 321,34
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		5,97	1,72				7,69
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-19 920,37**	**0,00**	**0,00**				**-19 920,37**
6. Waste	**30,50**	**2 120,46**	**102,64**				2 253,59
A. Solid Waste Disposal on Land	0,00	2 099,48					2 099,48
B. Wastewater Handling		20,81	102,50				123,31
C. Waste Incineration	30,50	0,17	0,14				30,81
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 933,28**	**3,51**	**24,38**				**2 961,17**
Aviation	739,74	0,18	7,28				747,20
Marine	2 193,54	3,33	17,10				2 213,97
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 778,01**						**5 778,01**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 941,29	-35 996,12	-20 054,83			-20 054,83
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	115,94		115,94			115,94
E. Other	18,52		18,52			18,52
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 075,75	-35 996,12	-19 920,37	0,00	0,00	-19 920,37

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	53 515,61
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	33 595,24

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 2003
Submission 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**22 107,47**	**5 056,84**	**5 326,42**	**240,26**	**703**	**232,63**	**33 667,08**
1. Energy	**37 244,36**	**968,14**	**960,17**				**39 172,67**
A. Fuel Combustion (Sectoral Approach)	34 524,35	322,35	957,03				35 803,74
1. Energy Industries	12 713,88	87,81	40,54				12 842,23
2. Manufacturing Industries and Construction	3 970,45	12,03	42,34				4 024,82
3. Transport	13 703,95	58,36	798,35				14 560,66
4. Other Sectors	3 963,59	163,87	74,43				4 201,88
5. Other	172,48	0,30	1,37				174,15
B. Fugitive Emissions from Fuels	2 720,01	645,79	3,14				3 368,93
1. Solid Fuels	4,32	33,13					37,46
2. Oil and Natural Gas	2 715,69	612,65	3,14				3 331,48
2. Industrial Processes	**5 812,99**	**27,19**	**1 711,08**	**240,26**	**703,45**	**232,63**	**8 727,60**
A. Mineral Products	950,04						950,04
B. Chemical Industry	278,04	14,92	1 711,08				2 004,04
C. Metal Production	4 515,19	12,26			703,45	172,08	5 402,98
D. Other Production	69,73						69,73
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				240,26		60,55	300,82
G. Other							0,00
3. Solvent and Other Product Use	**126,82**		**40,69**				**167,51**
4. Agriculture	**0,00**	**1 991,13**	**2 504,73**				**4 495,86**
A. Enteric Fermentation		1 677,85					1 677,85
B. Manure Management		308,45	142,20				450,65
C. Rice Cultivation							0,00
D. Agricultural Soils [2]			2 361,13				2 361,13
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		4,84	1,40				6,23
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-21 111,68**	**0,00**	**0,00**				**-21 111,68**
6. Waste	**34,98**	**2 070,38**	**109,76**				2 215,12
A. Solid Waste Disposal on Land	0,00	2 049,26					2 049,26
B. Wastewater Handling		20,94	109,61				130,54
C. Waste Incineration	34,98	0,18	0,15				35,31
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 528,79**	**2,89**	**21,23**				**2 552,91**
Aviation	747,48	0,19	7,36				755,02
Marine	1 781,32	2,70	13,87				1 797,90
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 945,11**						**5 945,11**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 470,46	-36 705,10	-21 234,64			-21 234,64
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	104,56		104,56			104,56
E. Other	18,41		18,41			18,41
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	15 593,42	-36 705,10	-21 111,68	0,00	0,00	-21 111,68

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	54 778,75
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	33 667,08

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.