National inventory report 2006 - Norway

Greenhouse gas emissions 1990-2004 reported
according to the UNFCCC reporting guidelines

TA-2181/2006
ISBN 82-7655-288-9

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 2006. 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 (SSB) has been the principle contributor to the preparation of the report, while the Norwegian Institute on Land Inventory (NIJOS) has contributed to the chapter regarding Land Use, Land Use Change and Forestry.

Oslo, 26. May 2006

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

National Inventory Report 2006

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E.S Executive Summary

E.S.1. Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) requires that the Parties to the Convention 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) 2006 for the period 1990-2004.

The report and the associated Common Reporting Format (CRF) tables have been 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* (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.

Emissions of the following greenhouse gases are covered in this report: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). In addition, the inventory includes calculations of emissions of the precursors NOx, NMVOC, and CO, as well as for SO_2. Indirect CO_2 emissions originating from the fossil part of CH_4 and NMVOC are calculated according to the reporting guidelines to the UNFCCC, and accounted for in the inventory. The Common Reporting Format (CRF) tables are included in Annex VI.

Norway will within 1. January 2007 submit the Initial Report according to Decision 13/CMP.1 on "Modalities for accounting of assigned amounts" under Article 7.4 of the Kyoto Protocol. The Initial Report will include a description of the "National system" for greenhouse gas inventory in Norway. In this 2006 issue of the NIR, a describing of the *existing* institutional arrangements, process of inventory preparations, methodologies etc. are given in chapter 1. The existing arrangement is expected to differ slightly from the forthcoming system to be described in the Initial Report.

The 2005 greenhouse gas inventory submission of Norway was subject to a centralized review by an expert review team (ERT) in October 2005. The main finding was that the Norwegian inventory was largely complete and transparent. However, both cross-cutting issues as well as specific source/sink categories of improvements were identified. In the 2005 issue of NIR, Norway also identified several areas for further improvements.
The present report has addressed all elements identified in the review and the 2005 issue of the NIR, and made improvements to the extent that has been possible. Among others is the formalization of a QA/QC plan about to be implemented as part of the National System, and will be further documented in the Initial Report. The uncertainty analysis is updated and improved, and is given in Annex II. The transparency of several parts of the documentation has been improved. Chapter 1 section 10 gives more details concerning implemented and planned improvements.

E.S.2 Summary of national emission and removal related trends

In 2004, the total emissions of greenhouse gases in Norway amount to 54.9 million tonnes CO_2–equivalents, disregarding emissions and removals from Land-Use, Land-Use Change and Forestry (LULUCF). From 1990 to 2004 the total emissions have increased by approximately 10 per cent. The increase was 1 per cent between 2003 and 2004. Norway experienced economic growth during the period since 1990, with only minor setbacks in the early nineties, which explains the general increase in emissions until 2004.

In 2004, CO_2 contributes with 80.1 per cent to the total emission figures, while methane and nitrous oxide contribute with 8.7 and 8.4 per cent respectively. PFCs, HFCs and SF_6 together account for approximately 2.8 per cent of the total emissions.

Removal by sinks amounts to 28.5 million tonnes for 2004. Forest land is the single contributor to this removal. All other land-use categories show net emissions, which totals 2.2 million tonnes CO_2. This gave a net CO_2 removal from the LULUCF Sector of 26.3 million tonnes.

The net greenhouse gas emissions including all sources and sinks are 28.6 million tonnes in 2004, a decrease of 19 per cent from 1990.

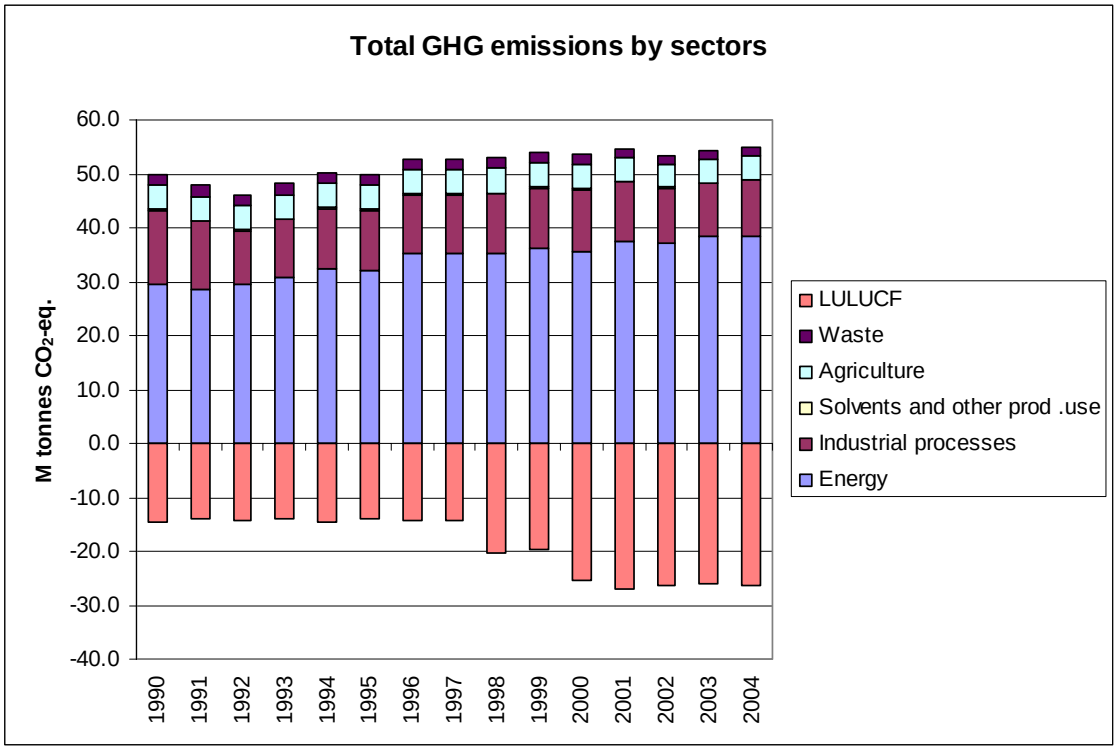


Figure 0.1 Total emissions of all GHG calculated as CO_2-equivalents from the different sectors. Source: Statistics Norway/SFT

E.S.3 Overview of source and sink category emission estimates and trends

Table 0.1 shows the overall trend in the total emissions by gas during the period 1990-2004.

Table 0.1 Emissions and removals of greenhouse gases 1990-2004. Source: Statistics Norway/SFT

Gas	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2	Mtonnes	34.8	33.2	34.2	35.9	37.8	37.8	40.8	41.0	41.1	41.9	41.5	42.9	42.0	43.5	44.0
CH_4	ktonnes	226.7	230.0	234.2	238.2	242.0	242.1	243.3	244.5	238.0	230.5	235.9	236.1	228.2	229.6	228.6
N_2O	ktonnes	15.2	15.2	12.7	13.6	14.1	14.2	14.3	13.9	14.6	15.1	14.6	14.3	14.9	14.3	14.8
CF_4	tonnes	467.4	378.5	321.6	286.8	286.9	283.3	229.6	229.9	209.8	196.2	186.4	187.5	201.3	125.6	122.1
C_2F_6	tonnes	36.2	28.0	21.4	17.4	18.3	18.1	13.9	15.1	13.3	12.3	11.6	11.9	14.0	10.1	9.4
PFK218	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	0.1	0.1
SF_6	tonnes	92.0	87.0	29.5	30.9	36.7	25.4	24.0	24.3	30.4	36.6	39.1	33.1	10.0	9.8	11.5
HFK 134a	tonnes	0.0	0.0	0.2	1.8	5.4	10.2	17.2	26.1	37.7	52.0	66.1	80.4	95.3	109.7	123.8
HFK 125	tonnes	0.0	0.0	0.0	0.0	0.5	2.4	5.5	9.7	14.8	20.0	26.2	33.4	37.9	38.4	38.8
HFK 143a	tonnes	0.0	0.0	0.0	0.0	0.2	1.5	3.9	6.9	10.5	14.9	20.5	27.1	31.6	32.0	32.3
HFK 32	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6	1.0	1.5	2.0	2.0	2.2
HFK 23	tonnes	0.0	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	0.2
HFK 152a	tonnes	0.1	0.4	0.7	0.8	0.8	1.0	1.5	2.4	5.6	8.9	12.3	16.2	19.0	23.3	29.4
HFK 227ea	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3
Total without LULUCF	**Mt CO2-eq.**	**49.8**	**47.5**	**46.0**	**47.9**	**50.2**	**49.9**	**52.6**	**52.7**	**52.9**	**53.9**	**53.5**	**54.7**	**53.5**	**54.3**	**54.9**
LULUCF	Mt CO2-eq.	-14.6	-14.0	-14.3	-13.9	-14.6	-13.8	-14.3	-14.3	-20.2	-19.8	-25.3	-27.1	-26.2	-26.0	-26.3
Total with LULUCF	**Mt CO2-eq.**	**35.2**	**33.5**	**31.7**	**33.9**	**35.6**	**36.1**	**38.3**	**38.4**	**32.7**	**34.1**	**28.2**	**27.6**	**27.2**	**28.3**	**28.6**

The contribution of CO_2 emissions to the national total greenhouse gas emissions has increased from 70 per cent in 1990 to 80 per cent in 2004. The increased proportion of CO_2 and the reduction of other gases are due to growth in the CO_2 emissions as well as a reduction in emissions of PFCs and SF_6 gases because of implemented environmental measures and/or technological improvements. This trend is illustrated in Table 0.2.

Table 0.2 Emissions in million tonnes CO_2-equivalents in 1990, 2003, 2004 and changes (per cent) between 1990-2004 and 2003-2004 (without LULUCF)

Emissions in Mtonnes CO_2 -eq.				Change	Change
	1990	2003	2004	1990-2004	2003-2004
CO_2	34.76	43.55	43.98	27 %	1 %
CH_4	4.76	4.82	4.82	1 %	0 %
N_2O	4.72	4.45	4.60	-2 %	3 %
PFCs	3.37	0.91	0.88	-74 %	-3 %
SF_6	2.20	0.23	0.28	-87 %	22 %
HFCs	0.00	0.38	0.40	NA	6 %
SUM	**49.81**	**54.35**	**54.94**	**10 %**	**1 %**

The growth in CO_2 emissions from 2002 to 2003 can mainly be explained by increased offshore oil and gas production, increased sales of fuels for road vehicles and aircrafts, and a small increase in process emissions from industry. The sales of mineral oil for heating went down to the 2002 level again, after a rise in 2003.

The emissions of PFCs continue to decrease. The decrease was 3 per cent from 2003 to 2004, and a total of 74 per cent from 1990. PFC emissions originate primarily from the production of aluminium, where technical measures have been undertaken to reduce these emissions. CO_2 emissions from aluminium production have been increasing since 1990, offsetting the total decrease of GHG emissions from this sector by about 25 per cent.

SF_6 emissions are reduced by 87 per cent from 1990 to 2004, mainly because of technological improvements and the closure of a production plant for primary magnesium in 2002. The existing emissions are now related to the magnesium recycling and product use. The emissions of SF_6 increased slightly from 2003 to 2004 because of a somewhat higher activity in the recycling plant.
HFC emissions have increased with 6 per cent since 2003. Last years reporting showed a reversed downward trend in the emissions of HFC. This year's calculations, which are based on interim results from an on-going project, indicate that the emission are still increasing, but at a slower rate.

In 2004, agriculture contributes with 46 per cent and nitric acid production with 40 per cent to the total emission of N_2O. The emissions of N_2O have decreased by a total of 2 per cent since 1990. This decrease has been enabled by the reduction of almost 11 per cent from the production of fertiliser due to technological improvements.

In 2005, the Land-Use, Land-Use Change and Forestry (LULUFC) was for the first time included in the Norwegian inventory based on the IPCC Good Practice Guidance for Land-Use, Land-Use Change and Forestry (GPG-LULUCF). For the 2006 issue, there have been updates of some methods and hence changes in results. The whole time-series is recalculated based on a revision of the method for calculation of total biomass of forest trees. In 2004, removals by sinks amount to 28.5 million tonnes of carbon dioxide, while carbon dioxide emissions from biomass and soils are approximately 2.2 million tonnes, which gives a net CO_2 sequestration from LULUCF of 26.3 million tonnes.
Since 1990 there has been an increase in carbon stored in biomass, dead organic matter and soils in Norway, increasing the net sequestration of CO_2 by 80 per cent since 1990. The increase in carbon stored is the result of an active forest management policy the last 50 years. The annual harvests are much lower than the annual increment, thus causing an accumulation of wood and other tree components biomass.

Figure 0.2 shows the various sectors' share of the total greenhouse gas emissions in Norway in 2004.

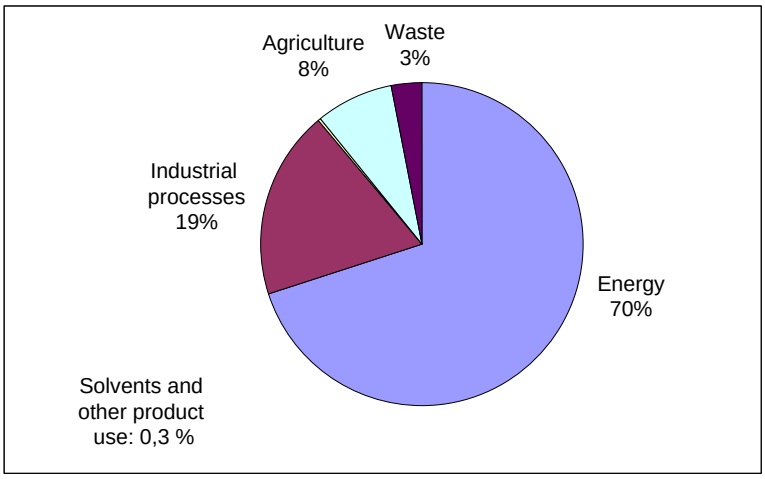


Figure 0.2 Emissions by UNFCCC sector in 2004. Source: Statistics Norway/SFT

The most important sector in Norway with regard to the emissions of greenhouse gases is the energy sector, accounting for 70 per cent of the total Norwegian emissions. The energy sector includes the energy industries (including oil and gas extraction), the transport sector, energy use in manufacturing and constructing, fugitive emissions from fuels and energy combustion in other sectors. 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.

Figure 0.3 shows the percentage change in emissions of greenhouse gases from 1990 to 2004 for the various UNFCCC sectors, compared to emissions in 1990. The development for each of the sectors since 1990 with regards to greenhouse gas emissions, and the most important sources, are described briefly in the following.

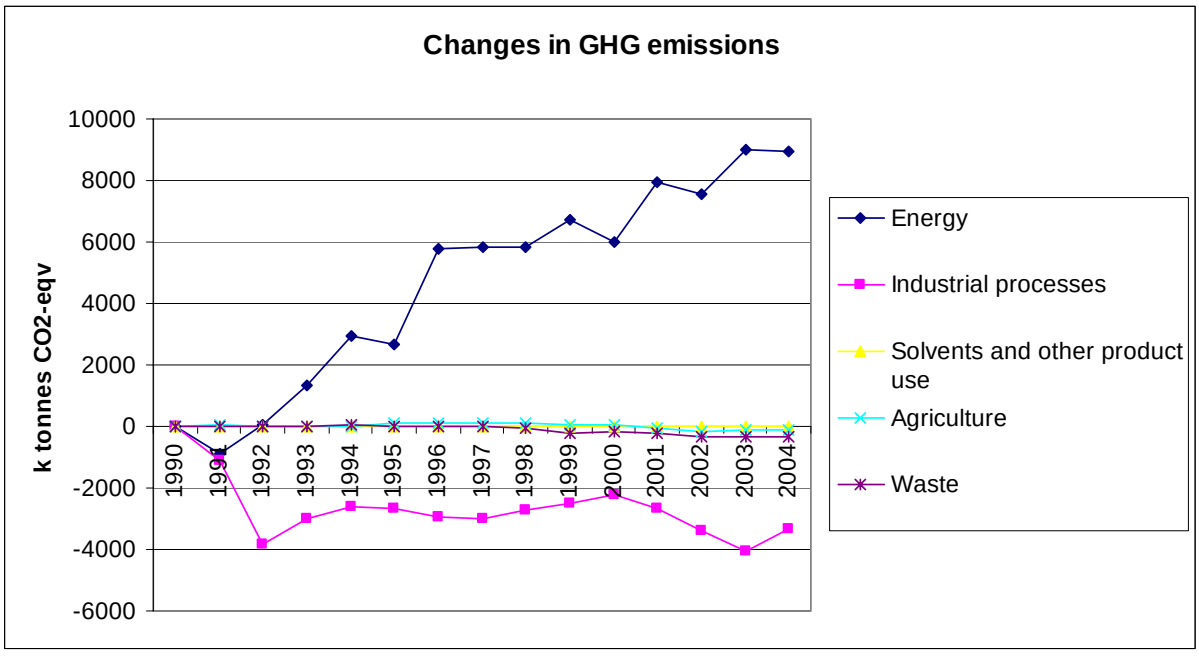


Figure 0.3 Changes in greenhouse gas emissions by UNFCCC sector 1990-2004 compared to 1990. Source: Statistics Norway/SFT

From 1990 to 2004 the increase in the emissions from the energy sector was 30 per cent, or almost 9 million tonnes. 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. In 2004, the emissions from the energy sector were on the same level as in 2003. However, emissions from oil and gas extraction as well as and transport still show an increasing trend, whereas fugitive emissions from offshore installations and manufacturing industries are reduced.

Industrial processes contribute with 19 per cent of the total national emissions of greenhouse gases. Production of metals and chemicals are 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 2004 the sector has experienced an overall decrease of 25 per cent. This is mainly due to reduced PFC emissions from the production of aluminium and SF_6 from the production of magnesium. Higher activity level in the process industry in 2004 increased emissions with almost 6 per cent compared to 2003. The increases are mainly from CO_2-gases (4.4 per cent).

The agricultural sector contributes to the total emissions of greenhouse gases with 8 per cent. This corresponds to 4.31 million tonnes CO_2-equivalents, which is 1 per cent lower than in 2003. This sector has experienced a small reduction in emissions over the period 1990-2004, which amounts to 2.5 per cent. The clearly biggest sources of GHG's are "enteric fermentation" (CH_4) from domestic animals and "agricultural soils" (N_2O). These are contributing with 44 and 45 per cent respectively.

The waste sector contributes with about 3 per cent of total Norwegian greenhouse gas emissions. The emissions of greenhouse gases from the waste sector were relatively stable during the 1990s, with emission levels of around 1.9-2.0 million tonnes CO_2-equivalents. From 1997 emissions declined and in 2004 emissions were 17 per cent lower than in 1990. Waste volumes have increased quite significantly over the period, but this has been counteracted by increased recycling and incineration of waste as well as 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.

In 2004, CO_2 emissions from ships and aircraft in international traffic bunkered in Norway amounted to a total of 2.7 million tonnes. This corresponds to about 6 per cent of the total Norwegian CO_2 emissions. The marine bunkers contribute with 1.9 million tonnes of CO_2, while air traffic contribute with 0.8 million tonnes. CO_2 emissions from this category showed a growth of about 80 per cent from 1990 to 1997, when the CO_2-emissions reached a 3.8 million tonnes. This increasing trend was reversed in 1998. From 1997 to 2004 emissions were reduced by 29 per cent. In 2004, the CO_2- emissions were 29 per cent higher than in 1990. These emissions are not included in the national totals, but reported separately as required by the UNFCCC reporting guidelines

Preliminary figures of the greenhouse gas emissions in 2005 indicate a decrease of approximately 1 per cent compared to 2004.

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) also has 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 extent included in the inventory.

The overall NO_x emissions have decreased with approximately 4 per cent from 1990 to 2004, primarily because of stricter emission regulations with regard to road traffic, which counteracted increased emissions from oil and gas production and from navigation. The total NO_x emissions were steady from 2003 to 2004.
The emissions of NMVOC experienced an increase in the period from 1990 to 2001, mainly because of the rise in oil production and the loading and storage of oil. However, the emissions have decreased by 32 per cent from 2001 to 2004, and are now 10 per cent lower than in 1990. This decrease has been achieved through the implementation of measures to increase the recycling of oil vapour at loading offshore and unloading at storage terminals.

Emissions of CO have decreased by 44 per cent over the period 1990-2004. This is explained primarily by the implementation of new emissions standards for motor vehicles.
With regard to emissions of SO_2, they were reduced by 52 per cent from 1990 to 2004. This can mainly be explained by a reduction in sulphur content of all oil products and lower process emissions from ferroalloy and aluminium production as well as refineries. However, the SO_2-emissions have increased slightly since 2002, and are now on the same level as in 2001. The reason for this is increasing emissions from ships and industrial activity over the last three years.

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 the greenhouse gases CO_2, CH4, N_2O as well as fluorinated greenhouse gases not controlled by the Montreal Protocol (HFCs, PFCs and SF_6), 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 2005.

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 five desk/centralized reviews, in 2000, 2001, 2003, 2004 and 2005. In addition, an in-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.

According to Decision 13/CMP.1 on "Modalities for accounting of assigned amounts under Article 7.4 of the Kyoto Protocol" Norway will within 1.January 2007 submit the Initial Report. This report will include a description of the national system for greenhouse gas inventory in Norway, in accordance with the guidelines for national systems as defined in the Annex to the COP/MOP decision under COP decision 20/CP.7 (FCCC/CP/2001/13/Add.3). The national system is about to be established. Hence, the report describing the national system might differ somehow slightly from this Chapter 1 Introduction in NIR 2006 describing the *existing* institutional arrangements, process of inventory preparations, methodologies etc.

The present report together with the associated Common Reporting Format (CRF) tables is Norway's contribution to the 2006 round of reporting under the Convention, and it covers emissions and removals for the period 1990-2004. 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 in 2004. The removals and emissions of greenhouse gases from this sector in Norway have been calculated during a project over a two year period, starting in 2004. 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 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).

Indirect CO_2 emissions originating from the fossil part of CH_4 and NMVOC are calculated according to the reporting guidelines to the UNFCCC, and accounted for in the inventory. This includes emissions from fuel combustion and non-combustion sources, such as fugitive emissions from loading of crude oil, oil refineries, distribution of oil products, and from solvents and other product use.

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 NO_x, NMVOC, CO and SO_2, which should be included according to the reporting guidelines. However, we have not in this submission included detailed descriptions of the calculation methodologies for these gases. This information is available in the report Statistics Norway/SFT (2005). 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 institutional arrangements are briefly described below. This might be altered due to the implementation of the National Greenhouse Gas Inventory System in Norway (National System). This will be described in more detail in the report on National System, which will be submitted together with the Initial Report in 2006.

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;
- Import and export data of HFCs, PFCs and SF_6.

- SF_6 emissions from large Gas-Insulated switchgears (GIS) based on data received as part of voluntary agreement.

Statistics Norway (SSB) is the other main actor in the reporting of national greenhouse gas emissions to the UNFCCC. Statistics Norway 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
- Emissions of CH_4 from landfills estimated by a model operated by SSB
- 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.

Figure 1.1 illustrates the flow of information and allocation of responsibilities between the institutions.

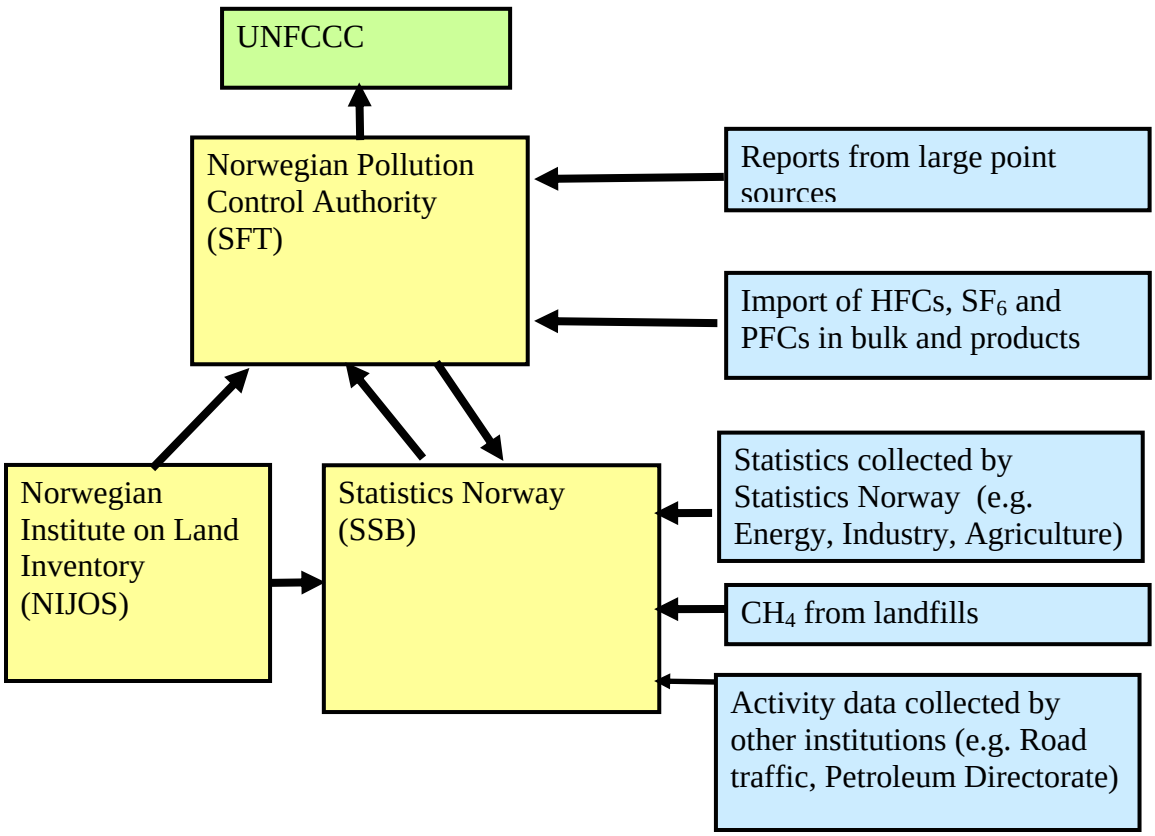


Figure 1.1 flow of information and allocation of responsibilities between the institutions.

Activity data are collected either internally at Statistics Norway (e.g. methane from landfills, data on energy use, industrial production, animals etc) or SFT (e.g. data on large point sources, HFCs, PFCs and SF_6 in bulk and 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, which are estimated by SFT. In the modelling activities Statistics Norway 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. Statistics Norway is the national institution responsible for the Norwegian energy balance and energy accounts, which are important data sources in the emission inventory.

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

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.

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 Statistics Norway with data from INKOSYS relevant for the preparation of the national emission inventory.

1.3.2. Data collection, processing and archiving

Statistics Norway 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.

The input data used in the model runs, the versions of the models used and the model output are all stored at Statistics Norway. 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, NMVOC and CO. Documentation of the calculation methodologies of these gases are contained in the report Statistics Norway (2005).

1.4.2. The Norwegian emission model

The general emission model is based on the equation:

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

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. Thus, 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:

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

A_{PS} and E_{PS} are the activity and the measured emissions at the point sources, respectively. Emissions from activities for which no point source estimate is available ($A\text{-}A_{PS}$) are still estimated with the regular emission factor.

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 (Erlandsen et al 2002) 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)[1] is responsible for calculating the emissions and removals of greenhouse gases from the LULUCF-sector, in cooperation with Statistics Norway. 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 calculations of greenhouse gas emissions measured as CO_2 equivalents are based on data on global warming potentials (GWP) for the different GHGs, 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. Statistics Norway and SFT have carried out several studies on specific emission sources. Usually, such projects are connected to an evaluation of emission reduction measures. An important element in Statistics Norway's work is to increase the environmental relevance of the statistical system.

[1] NIJOS will on 1. July 2006 merge with the Forest Research Institute, and will be called Norwegian Institute of Forest and Landscape.

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 Statistics Norway 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 categories

According to the IPCC definition, key categories are those that add up to 90 per cent of the total uncertainty in level and/or trend. In the Norwegian greenhouse gas emission inventory key categories are primarily identified by means of a Tier 2 method, as recommended by the IPCC Good Practice Guidance (IPCC 2001). A description of the methodology as well as background tables from the analyses is presented in Annex 1.

A Tier 2 key category analysis was performed in April 2006. The Table 1.1 below lists the 32 identified key categories arranged primarily according to contribution to the uncertainty in level (Tier 2). In addition we have also chosen to include CO_2 from cement and ammonia production as key categories in terms of the absolute level of emissions in 2004 (Tier 1).

Additionally, we have included fugitive emissions from coal mining and handling as a key category due e.g. to the fact that the national emission factors used is an order of magnitude less than IPCC's default factors. The last identified key category is CO_2 capture and storage. This removal category is considered key since there is presently no methodology as such defined in the IPCC guidelines and because these operations are unique internationally.

The Tier 2 analysis 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, except land-use, land-use change and forestry. 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 category analysis during the centralized review in 2005 on the basis of the NIR 2005 and identified two additional sources, Manure Management and Other Transportation. Both were found to be key in the current analysis.

Table 1.1. Summary of identified emission key categories. Excluding LULUCF.

	Source category	Gas	Level assessment Tier 2 1990	Level assessment Tier 2 2004	Trend assessment Tier 2 1990-2004	Method (Tier) 2004
4D1	Direct soil emissions	N_2O	**25.80**	**22.94**	**11.18**	Tier 1a
1A3 b	Road Transportation	CO_2	**8.34**	**9.82**	**4.35**	Tier 2
1A1	Energy Industries, Gas	CO_2	**4.53**	**7.98**	**11.14**	Tier 2
4D3	Indirect emissions	N_2O	**5.77**	**5.24**	**2.15**	Tier 1a
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	**4.58**	**4.98**	**1.03**	Tier 2
6A	Solid Waste Disposal on Land	CH_4	**6.70**	**4.94**	**6.26**	Tier 2
4A	Enteric Fermentation	CH_4	**5.05**	**4.54**	**1.99**	Tier 1/2***
1A4	Other Sectors, Oil	CO_2	**4.33**	**3.41**	**3.35**	Tier 2
1B2c	Venting and Flaring	CH_4	**1.58**	**3.20**	**5.25**	Tier 2
1A3 d	Navigation	CO_2	**2.05**	**2.35**	**0.88**	Tier 2
2C3	Aluminium Production	CO_2	**1.51**	**2.05**	**1.69**	Tier 2
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs	0.00	**1.89**	**6.25**	Tier 2
1A3a	Civil Aviation	CO_2	**1.40**	**1.80**	**1.23**	Tier 2
2C3	Aluminium Production	PFCs	**6.93**	**1.67**	**17.88**	Tier 2
1A3 b	Road Transportation	N_2O	0.50	**1.65**	**3.76**	Tier 2
4D2	Animal production	N_2O	**1.70**	**1.58**	0.52	Tier 1a
1A2	Manufacturing Industries and Construction, Gas	CO_2	**0.92**	**1.48**	**1.82**	Tier 2
1B2c	Venting and Flaring	CO_2	**1.64**	**1.32**	**1.17**	Tier 2
1B2a	Oil (incl. oil refineries, gasoline dist	CH_4	0.67	**1.32**	**2.12**	Tier 2
1A3e	Other (snow scooters, boats, motorized e	CO_2	**1.12**	**1.31**	0.57	Tier 2
2B2	Nitric Acid Production	N_2O	**1.47**	**1.21**	**0.94**	Tier 2
1A4	Other Sectors, Wood etc.	CH_4	**0.88**	**1.12**	**0.75**	Tier 2
4B	Manure Management	N_2O	**1.03**	**0.87**	0.59	Tier 1
6B	Wastewater Handling	N_2O	0.69	**0.77**	0.21	Tier 1
2C2	Ferroalloys Production	CO_2	**0.78**	**0.76**	0.09	Tier 2
4B	Manure Management	CH_4	**0.77**	0.74	0.15	Tier 2
1A2	Manufacturing Industries and Construction, Oil	CO_2	**0.89**	0.61	**0.97**	Tier 2
1A4	Other Sectors, Oil	N_2O	**0.76**	0.56	**0.69**	Tier 1
1A1	Energy Industries, Waste	CO_2	0.30	0.51	**0.69**	Tier 2
2D2	Food and Drink	CO_2	0.10	0.31	**0.70**	Tier 1/2
1B2b	Natural Gas	CH_4	0.02	0.24	**0.72**	Tier 2
2B4	Carbide Production	CO_2	0.42	0.10	**1.10**	Tier 2
2A1	Cement *	CO_2				Tier 2
2B1	Ammonia Production *	CO_2				Tier 2
1B1a	Coal Mining and Handling **	CH_4				Tier 2
	Capture and storage **	CO_2				CS (Tier 2)

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

** Defined as key category from qualitative criteria

*** Tier 2 used for the significant animal groups

The new uncertainty analysis has caused several changes in the key categories. Several different effects can be distinguished:

- Improved methodology and reduced uncertainty estimates for 4D - N_2O from agriculture - has reduced the dominance of this source. Thus, more sources need to be included in order to reach the 90 per cent threshold.
- The energy use sectors (1A) have been treated at a more disaggregated level. The result is that some of the major sources have a lower assessment value. They are still assigned as key, but the reduced dominance has the same effect as the previous point in increasing the total number of key categories.
- Some sources have reduced uncertainty estimates, and their ranks in the analyses are lowered.
- Some sources have increased emissions due to revised methods, and their ranks are higher.

Only one source that was identified as key in the 2005 NIR is absent from the new tier 2 analysis. The uncertainty estimate for 2C4 *SF_6 used in Aluminum and Magnesium Foundries* is significantly reduced. However, the source is still identified in the tier 1 analysis in 1990.

Table 1.2 shows LULUCF key categories identified in a Tier 2 analysis.

Table 1.2. Summary of identified LULUCF key categories Tier 2.

IPCC Category		**Gas**	**Level assessment**		**Trend assessment** 1990-2004	**Method (Tier)** 2004
			1990	2004		
5A1	Forest land remaining forest land, living biomass, other	CO_2	11.53	19.27	32.48	Tier 3
5C1	Grassland remaining grassland, soils, histosols	CO_2	13.51	11.66	6.26	Tier 2*
5A4	Forest land remaining forest land, soils	CO_2	6.34	5.09	1.81	Tier 3
5A3	Forest land remaining forest land, dead biomass, other	CO_2	2.52	2.28	1.46	Tier 3
5A2	Forest land remaining forest land, soils, drained organic soils	CO_2	2.38	2.17	1.44	Tier 1
5B5	Cropland remaining cropland, histosols, soils	CO_2	1.50	1.30	0.70	Tier 2
5E1	Forest converted to Settlements, Living biomass	CO_2	0.68	0.47	0.05	Tier 3
**	CO_2 capture and storage	CO_2				CS (Tier 2)**

Table 1.3. Summary of identified key categories Tier 1. Excluding LULUCF.

	Source category	Gas	Level assessment tier 1 1990	Level assessment tier 1 2004	Cumulative assessment 2004	Key cat. tier 1 any year	Key cat. tier 1 1990	Key cat. tier 1 2004
1A1	Energy Industries, Gas	CO_2	12.28	21.22	21.22	1	1	1
1A3b	Road Transportation	CO_2	15.77	18.21	39.43	1	1	1
1A4	Other Sectors, Oil	CO_2	8.20	6.32	45.75	1	1	1
2C2	Ferroalloys Production	CO_2	5.12	4.94	50.69	1	1	1
1A3d	Navigation	CO_2	3.87	4.37	55.05	1	1	1
2C3	Aluminium Production	CO_2	2.85	3.79	58.85	1	1	1
1A2	Manufacturing Industries and Construction, Gas	CO_2	2.24	3.56	62.41	1	1	1
4A	Enteric Fermentation	CH_4	3.91	3.45	65.86	1	1	1
2B2	Nitric Acid Production	N_2O	4.14	3.36	69.22	1	1	1
1A2	Manufacturing Industries and Construction, Oil	CO_2	4.14	2.80	72.02	1	1	1
6A	Solid Waste Disposal on Land	CH_4	3.67	2.65	74.67	1	1	1
4D1	Direct soil emissions	N_2O	2.80	2.44	77.12	1	1	1
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	2.25	2.40	79.52	1	1	1
1B2c	Venting and Flaring	CO_2	3.01	2.38	81.90	1	1	1
1A3a	Civil Aviation	CO_2	1.36	1.72	83.62	1	1	1
2C3	Aluminium Production	PFCs	6.77	1.60	85.22	1	1	1
2A1	Cement Production	CO_2	1.30	1.32	86.54	1	1	1
1A3e	Other (snow scooters, boats, motorized e	CO_2	1.09	1.26	87.80	1	1	1
2B1	Ammonia Production	CO_2	1.00	0.90	88.70	1	1	1
1A1	Energy Industries, Oil	CO_2	0.47	0.81	89.51	1	1	1
4D3	Indirect emissions	N_2O	0.84	0.75	90.26	1	1	1
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs	0.00	0.73	90.99	1	.	1
1A2	Manufacturing Industries and Construction, Coal/coke	CO_2	0.93	0.70	91.69	1	1	1
1B2a	Oil (incl. oil refineries, gasoline dist	CH_4	0.33	0.64	92.32	1	.	1
2C1	Iron and Steel Production	CO_2	0.40	0.62	92.95	1	.	1
1B2c	Venting and Flaring	CH_4	0.31	0.61	93.56	1	.	1
4B	Manure Management	CH_4	0.60	0.56	94.12	1	1	1
1A5b	Military - Mobile	CO_2	0.79	0.52	94.64	1	1	1
2D2	Food and Drink	CO_2	0.13	0.42	95.06	1	.	1
4D2	Animal production	N_2O	0.45	0.41	95.47	1	1	.
2C4	SF_6 Used in Aluminium and Magnesium Foundries	SF_6	4.31	0.37	95.84	1	1	.
		CO_2	0.41	0.23	97.22	1	1	.
		CO_2	0.80	0.18	97.83	1	1	.

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 is about to implement a formal quality assurance/quality control or verification plan. A detailed description of this will be in the report in National Greenhouse Gas Inventory System in Norway (National System) and be submitted as part of the Initial Report in 2006 (see section 1.1). This section will describe the existing, general QA/QC procedures.

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;
- Statistics Norway 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 categories and some non-key categories; 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 also to perform more extensive external peer reviews and/or audits (Tier 2) are being discussed as a part of the elaboration of steps and procedures to be included in the National System.

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 Statistics Norway, 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 over the last years since we have incorporated information on methodologies used in the inventory report. However, a joint, formalised procedure with regard to archiving will be implemented as part of the the National System.

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.

Check that assumptions and criteria for the selection of activity data and emissions factors are documented

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 Statistics Norway. This information is then thoroughly checked by two members of the inventory team at Statistics Norway. All changes in methodologies or data are documented and kept up to date.

Check for transcription errors in data input and references

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.

Check that emissions are calculated correctly

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 Statistics Norway 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, Statistics Norway makes, where possible, comparable emission calculations based on activity data sampled in official statistics and

deviations are explained through contact with the plants. Regarding more detailed information about the QC of data reported by industrial enterprises, see Section 1.6.4.

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. Statistics Norway 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 Statistics Norway/SFT calculated emission data for 2002 for the first time. These data were compared with the 2001 figures for detection of any considerable deviations. There may be large deviations that are 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
Statistics Norway 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
A new uncertainty analysis has been undertaken in 2006, see further information in Section 1.7 on Uncertainty and Annex II.

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 Statistics Norway staff must be documented. This should enable duplication of emissions and uncertainty estimates. The new model at Statistics Norway 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 Statistics Norway.

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 Statistics Norway/SFT calculated emission data for 2002 for the first time. These data were compared with the 2001 figures for detection of any considerable deviations. There may be large deviations that are 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

Statistics Norway 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 categories 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. The QC procedures will be further described in the report on the National System to be submitted by 1. January 2007.

The ERT requested in 2005 further information regarding the verification of quality of data reported by companies. The general checks performed are described under Section 1.6.3. In the following, please find a more detailed description of QC of emission data reported from plants:

Plant emission data that are used in the emission trading system will undergo annual QC checks. The source-specific QC checks for other plants are performed less frequently (every 3 years) for emission estimates used in key categories, which account for 25-30 % of the total of that category. The frequency of checking of non-key plants which are not included in the emission trading scheme is every 5 years. Statistics Norway is responsible for reporting the results of the key category analysis to SFT, while SFT will perform the assessment of the "key plants" within a category.

The QC checks include:

- An assessment of the internal QC/QC of the plants reporting data to SFT
    - Their QA/QC system including archiving
    - Any changes to the QA/QC system
- An assessment and documentation of measurements and sampling
    - Measurement frequency
    - Sampling
    - Use of standards (e.g. ISO)
    - Documentation for archiving
- An assessment and explanation of changes in emissions over time (e.g. changes in technology, production level or fuels) (annual check)
- An assessment of time-series consistency back to 1990 in cooperation with Statistics Norway (if plant emission data are missing for some years and estimates are made using aggregate activity data and emission factors)
- A comparison of plant emissions to production ratios with those of other plants, including explanations of differences
- A comparison of the production level and/or fuel consumption with independent statistics (in collaboration with Statistics Norway)
- An assessment of reported uncertainties (including statistical and non-statistical errors) to the extent this has been included in the reporting

The QC checks are made in close cooperation with the emission reporting plants.

For more details of QA/QC of specific source categories, see "source specific QA/QC and verification" in relevant chapters.

1.6.5. Verification studies

In general, the final inventory data provided by Statistics Norway are checked and verified by SFT. A formal verification procedure is about to be established in Norway as part of the implementation of the National System.

In the following, some 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/Statistics Norway 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 Statistics Norway, SFT and NIJOS (LULUCF) 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 Statistics Norway. With regard to LULUCF, the Norwegian Institute of Land Inventory (NIJOS) is in charge of archiving all data from the calculations of emissions and removals from this sector. A joint, formalised procedure with regard to archiving is considered as part of the National System.

1.6.7. Confidentiality issues

In general, the data contained in the Norwegian emission inventory are publicly available, both activity data and emission factors. The emission model might contain some micro-data which are not publicly available. An example is activity data for certain specific production plants, where the publication might reveal company sensitive information. But all relevant emission data are available. All emission data and activity data necessary for the CRF are publicly available.

1.7. Uncertainty evaluation

The uncertainty in the Norwegian emission inventory has been investigated systematically again this year and the analysis and the results are described in Annex II. This analysis has been an update of the uncertainty analysis *Uncertainties in the Norwegian Greenhouse Gas Emission Inventory,* documented in (Rypdal and Zhang 2000), which also include more detailed documentation of the analysis method used, and result discussions. In this note we mainly focus on the changes since (Rypdal and Zhang 2000). This includes new methodology for several source categories as well as revised uncertainty estimates.

The national greenhouse gas (GHG) emission inventory is compiled from estimates based on emission factors and activity data and direct measurements by plants. All these data and parameters will contribute to the overall inventory uncertainty. The uncertainties and probability distributions of the inventory input parameters have been assessed based on available data and expert judgements. Finally, the level and trend uncertainties of the national GHG emission inventory have been estimated using Monte Carlo simulation. The methods used in the analysis correspond to an IPCC Tier 2 method, as described in (IPCC 2001). Analyses have been made both excluding and including the sector LULUCF (land use, land-use change and forestry).

Uncertainty in emission level

The estimated uncertainties of the level of total emissions and in each gas are shown in Table 1.4 and 1.5.

Table 1.4 Uncertainties in emission level. Each gas and total GWP weighted emissions. Excluding the LULUCF sector.

1990	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	50 mill. Tonnes	1	7
CO_2	35 mill. Tonnes	0.69	3
CH_4	4.8 mill. Tonnes	0.10	15
N_2O	5.0 mill. Tonnes	0.10	57
HFC	18 tonnes	0.00	49
PFC	3.4 mill. Tonnes	0.07	21
SF_6	2.2 mill. Tonnes	0.04	2
2004	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	55 mill. Tonnes	1	6
CO_2	44 mill. Tonnes	0.80	3
CH_4	4.8 mill. Tonnes	0.09	14
N_2O	4.9 mill. Tonnes	0.09	59
HFC	401 ktonnes	0.01	51
PFC	880 ktonnes	0.02	20
SF_6	274 ktonnes	0.00	15

Table1.5. Uncertainties in emission level. Each gas and total GWP weighted emissions. Including the LULUCF sector.

1990	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	35 mill. Tonnes	1	14
CO_2	20 mill. Tonnes	0.56	20
CH_4	4.9 mill. Tonnes	0.14	16
N_2O	5.0 mill. Tonnes	0.14	59
HFC	18 tonnes	0.00	51
PFC	3.4 mill. Tonnes	0.10	20
SF_6	2.2 mill. Tonnes	0.06	2
2004	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	34 mill. Tonnes	1	14
CO_2	23 mill. Tonnes	0.67	18
CH_4	4.8 mill. Tonnes	0.14	14
N_2O	4.9 mill. Tonnes	0.14	53
HFC	401 ktonnes	0.01	52
PFC	880 ktonnes	0.03	20
SF_6	274 ktonnes	0.01	15

The total national emissions of GHG in Norway in 1990 are estimated with an uncertainty of 7 per cent of the mean. The main emission component CO_2 is known with an uncertainty of 3 per cent of the mean. In 2004, the total uncertainty has decreased to 6 per cent of the mean.

By including the LULUCF sector the results from the analysis show a total uncertainty of 14 per cent of the mean both in 1990 and in 2004. The doubling of uncertainty is caused mainly by forest biomass and grassland histosoils.

In the uncertainty analysis carried out in the year 2000 (Rypdal and Zhang 2000), the uncertainty for the total national emissions of GHG (LULUCF sector excluded) in 1990 was estimated to be 21 per cent of the mean. In the new analysis the uncertainty estimate is reduced to one third. There are several reasons for the new lower estimate. One reason is that Statistics Norway and the Norwegian Pollution Control Authorities have increased the inventory quality by using higher tiers for some key categories and also improved methodologies for other sources. But the main reason for the reduced uncertainty is that Statistics Norway has collected new and lower uncertainty estimates for some activity data and emission factors that contributed substantially to the total uncertainty in the emission estimate. This means that the total uncertainty of the inventory have not been reduced as much as the estimates indicates, since it is partly the uncertainty estimates themselves that have been improved. The main reduction lies is in the estimate of the uncertainty for the N_2O emissions. In 2000 the uncertainty in this components estimate was estimated to 200 per cent of the mean. In this years' analysis the uncertainty estimate is reduced to 57 per cent of the mean, see explanation to this reduction in the paragraph below. For CO_2 the uncertainty estimate is unchanged between the two analyses (3 per cent), while all the other emission components show a decrease in the uncertainty estimates in the new analysis compared to the analysis from 2000.

The main reason for the high uncertainty estimate for the N_2O emissions in the 2000 analysis was the high uncertainty estimate used for the emission factor used for estimating N_2O from agricultural soils (2 orders of magnitude). This uncertainty is in the new analysis reduced to an uncertainty of factor 5 for direct soil emission, factor 2 for animal production and factor 3 for indirect soil emission. These new uncertainty estimates are collected from the guidelines IPCC (2001) and IPCC (1997b), where also the emission factor used is collected.

As mentioned above, another reason for the reduced uncertainty is that in the years between the two analyses important inventory improvement work has been carried through.

Uncertainty in emission trend

The estimated uncertainties of the trend of total emissions and each gas are shown in Table 1.6 and 1.7.

Table 1.6. Uncertainty of emission trend. 1990-2004. Excluding the LULUCF sector.

	per cent change $((\mu_{2004}-\mu_{1990})*100/\mu_{1990})$	Uncertainty $(2*\sigma*100/\mu_{1990})$
Total	10	4
CO_2	26	4
CH_4	-1	11
N_2O	-2	18
HFC	-	-
PFC	-74	15
SF_6	-88	0

Table 1.7. Uncertainty of emission trend. 1990-2004. Including the LULUCF sector.

	Per cent change $((\mu_{2004}-\mu_{1990})*100/\mu_{1990})$	Uncertainty $(2*\sigma*100/\mu_{1990})$
Total	-2.1	7
CO_2	18	11
CH_4	-1	12
N_2O	-2	20
HFC	-	-
PFC	-74	15
SF_6	-88	0

The result shows that the increase in the total GHG emissions from 1990 to 2004 is 10 ±4 per cent when the LULUCF sector is not included. Norway has by the ratification of the Kyoto Protocol obliged to limit the emissions of greenhouse gases in the period 2008-2012 to 1 per cent over the emissions in 1990 after trading with CO_2 quotas and the other Kyoto mechanisms is taken into account. It is important to keep in mind that the emission figures reported in connection to the Kyoto Protocol has an uncertainty connected to the reported values.

In (Rypdal and Zhang 2000) the increase from 1990 to 2010 (in a given projection scenario) was 21 ±4 per cent. It is reasonable that the emission increase was higher in the 2000 analysis, since it was estimated for a longer period.

With the sector LULUCF included in the calculations there has been a decrease in the total trend uncertainty with -2 ±7 per cent.

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 1.6.7.

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

A complete set of CRF tables is submitted for all years 1990-2004.

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.
- 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:

- 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.

Notation keys have been used even more extensively than in any earlier submissions and we assume that notation keys have been filled where it is most essential. However, there have been some problems with data transmission into CRF Reporter. As a result of this some notation keys that were included in the database for LULUCF delivered by NIJOS to Statistics Norway have been lost during the import. We submit the database for LULUCF. There have also been some problems with producing Excel CRF Tables from CRF Reporter. We assume that the submitted XML-file will be helpful to solve this problem.

Emissions from the use of feedstock are in accordance with Good Practice Guidance, and they 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.

1.9. Implemented and planned improvements

1.9.1. Issues addressed in reviews and implemented improvements since NIR 2005

The Norwegian NIRs have undergone five desk reviews/centralized reviews, in 2000, 2001, 2003, 2004 and 2005 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.

The expert review team concluded that the Norwegian inventory is largely complete, transparent and largely consistent with the UNFCCC reporting guidelines and IPCC guidelines. The table below lists the cross-cutting issues for improvement identified by the ERT in 2005 and the actions taken by Norway responding to these issues.

Issues identified by the ERT	Improvements made in NIR 2006
Improve the transparency of the description of the differences between the reference and the sectoral approach including with regard to the linkage to the national energy balance,	**Has been further examined. See Section 3.6.1.**
Improve the transparency for some source categories in the Industrial Processes sector (e.g. 2.F Consumption of Halocarbons and SF_6);	**Methodologies for both have been updated and transparency improved. See Section 4.6.**
Increase the transparency of its reporting of CO_2 capture and storage by integrating more detail from key reports into the NIR in a separate annex;	**Has been improved. See Section 3.5.**
Reconsider the reference approach estimation of feedstocks and non-energy use of fuels based on the recommendations provided in the Energy sector;	**Has been considered. See Section 3.6.2.**
Describe the QA/QC activities performed to verify the quality of emissions data reported by companies;	**Has been further described in section 1.6.5. QA/QC has also been performed for GHG emissions from the largest industrial plants for the period 1990-2004, see Annex III.**
Use a higher-tier method for the key category CH_4 from enteric fermentation from cattle as has been indicated in several reviews;	**Methodology has been updated to IPCC's Good Practice Guidance Tier II method. See Section 6.2.**
Provide more information on the sources of uncertainty estimates provided in the NIR.	**The uncertainty analysis has been updated for NIR 2006. See Section 1.7 and Annex II.**

The ERT also recommended several improvements relating to specific source/sink categories. These have been addressed, to the extent possible, in the relevant sector sections of this NIR 2006.

In NIR 2005 Norway also identified areas for further improvements. These, together with how these have been addressed in NIR 2006 are listed below.

Issues identified by Norway	Improvements in NIR 2006
The elaboration of an inventory improvement plan;	**Work is going on. National System is about to be implemented. Will be further described in the Initial Report that will be submitted before 1.1.2007.**
The formalization of the QA/QC system;	**Is about to be implemented as part of the National System. Will be further documented in Initial Report.**
Examination of the differences between the reference approach and the sectoral approach in the Energy sector;	**Has been further examined. See section 3.6.1.**
The updating of the N_2O EF for road transport;	**Has been updated. Se Section 3.2.5.**

The updating of calculations of emissions from consumption of halocarbons and SF_6;	**Has been updated. See Section 4.6.**
Improvements of the national forest inventory and the establishment of permanent sampling plots;	**Has been improved. See Chapter 7.**
The elimination of double counting of N_2O emissions reported both under Agriculture (fertilizer sold in Norway) and under LULUCF, as part of the fertilizer sold is used on forest land.	**The amount of inorganic fertilizers used in forestry has been subtracted from the earlier used value for amount of inorganic fertilizers used in agriculture to avoid double counting.**

The present report addresses all the above points to the extent that that has been possible.

1.9.2. Planned improvements

The national greenhouse gas inventory has undergone substantial improvements over the recent years, and the inventory is now considered to be largely complete and transparent.

However, some improvements have so far been planned for the coming years, these include:

The implementation of a National System, which will formalise all institutional, legal and procedural arrangements in Norway, as well as for reporting and archiving inventory information. This will be submitted to the UNFCCC before 1.1.2007 as part of the Initial Report.

Several improvements are planned for the LULUCF sector. These will include:

- confirmation of the of the area of forest and other wooded land at higher altitudes
- improved forest inventory in Finnmark
- improvements by use of national aerial photographs to supplement field survey, focusing on regions with high economic activities
- developing more reliable inventory methods targeted for use in areas with limited information

A tax on import and production of HFC and PFC was introduced in January 2003. We are still gaining experience regarding which effect this tax might have on the calculated emissions. Norway will further improve the calculations accordingly.

2. Trends in Greenhouse Gas Emissions

2.1. Emission trends for aggregated greenhouse gas emissions

Total greenhouse gas emissions in Norway, expressed in carbon dioxide equivalents, were 54.9 million tonnes in 2004, which is an increase of 0.6 million tonnes compared to 2003, and 1.5 million tonnes compared to 2002. Total greenhouse gas emissions have increased by 5.1 million tonnes between 1990 and 2004, or by 10 per cent.
Norway will have to reduce its national GHG emissions by 9 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.

Removals by sinks accounted to 28.5 million tonnes of CO_2 in 2004. Emissions from soils were approximately 2.2 million tonnes CO_2, which gives a net removal from Land Use, Land Use Change and Forestry (LULUCF) of 26.3 million tonnes CO_2.

In 2004, the net greenhouse gas emissions including all sources and sinks were 28.6 million tonnes, a decrease of 19 per cent from 1990.
The total contribution from different sources from 1990 to 2004 is illustrated in Figure 2.1 and in Table 2.1.

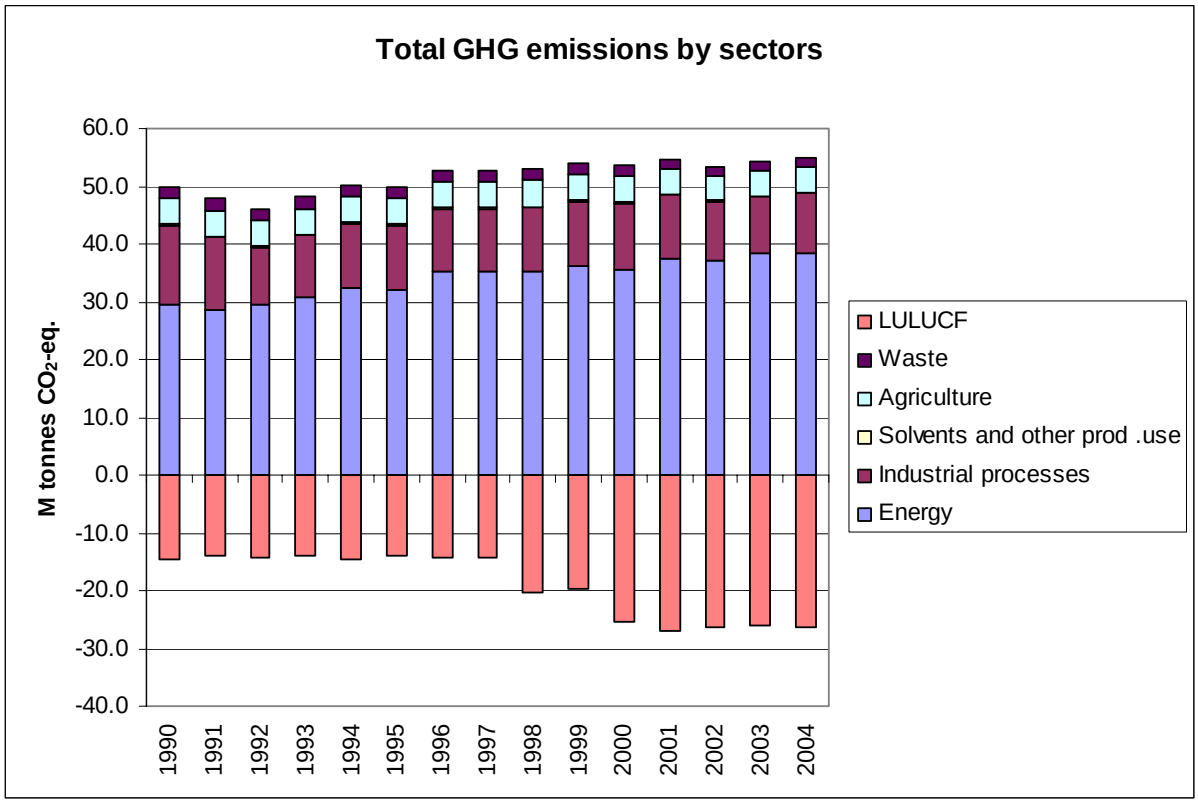


Figure 2.1 Total emissions of all GHG emissions calculated as CO2-equivalents from the different sectors. Source: SSB/SFT

Table 2.1 Total emissions of greenhouse gases by sources and removals from LULUCF in Norway 1990-2004. Million tonnes CO2-equivalents. Source: SSB/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy	29.5	28.6	29.5	30.8	32.5	32.2	35.3	35.3	35.3	36.2	35.5	37.4	37.1	38.5	38.4
Industrial processes	13.7	12.6	9.9	10.7	11.1	11.0	10.8	10.7	11.0	11.2	11.5	11.1	10.3	9.7	10.4
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	0.2
Agriculture	4.4	4.5	4.5	4.4	4.5	4.5	4.6	4.5	4.6	4.5	4.5	4.4	4.3	4.4	4.3
Waste	1.9	2.0	1.9	2.0	2.0	2.0	1.9	1.9	1.9	1.7	1.8	1.7	1.6	1.6	1.6
LULUCF	-14.6	-14.0	-14.3	-13.9	-14.6	-13.8	-14.3	-14.3	-20.2	-19.8	-25.3	-27.1	-26.2	-26.0	-26.3
Total – without LULUCF	**49.8**	**47.8**	**46.0**	**48.1**	**50.2**	**49.9**	**52.8**	**52.7**	**52.9**	**53.9**	**53.5**	**54.7**	**53.5**	**54.3**	**54.9**
Total – with LULUCF	**35.2**	**33.8**	**31.7**	**34.2**	**35.6**	**36.1**	**38.5**	**38.4**	**32.7**	**34.1**	**28.2**	**27.6**	**27.2**	**28.3**	**28.6**

Figure 2.2 illustrates the development of emissions of greenhouse gases from various sectors in changes in per cent.

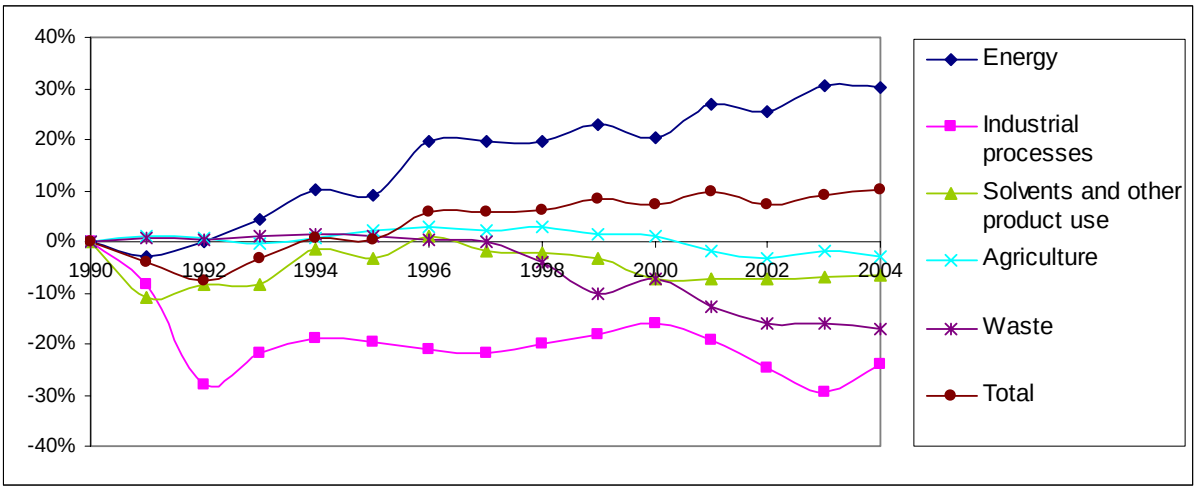


Figure 2.2 Changes in total greenhouse gas emissions by UNFCCC source categories during the period 1990-2004 compared to 1990. Source: SSB/SFT

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 the energy sector.

The total emissions (disregarding LULUCF) 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, it can be seen that the emissions increased by about 9 per cent. So far, 2004 has been the year with the highest emissions recorded.

The downward trend in the early 1990's was 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 total emissions decreased from 2001 to 2002 by about 2.3 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 1.6 per cent 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.

In 2004, the emissions are still on a rising trend, increasing with 1 per cent since 2003. The increase comes as a result of higher emissions in industrial processes, in particular from metal production and chemicals.

Preliminary calculations of the GHG emissions in 2005 indicate a decrease of 1 per cent since 2004. The development from 1990 to 2005 will then result in an increase in GHG emissions of approximately 10 per cent, which is 9 per cent above the Kyoto commitment.

2.2. Emission trends by gas

As shown in Figure 2.4, CO_2 is by far the largest contributor to the total GHG emissions, followed by N_2O and CH_4, and then the fluorinated gases PFCs, SF_6 and HFCs. In 2004 the relative contributions to the national totals from the different gases were: CO_2: 80 %, N_2O: 8 %, CH_4: 9 %, fluorcarbons (PFCs, SF_6 and HFCs) about 3 %.

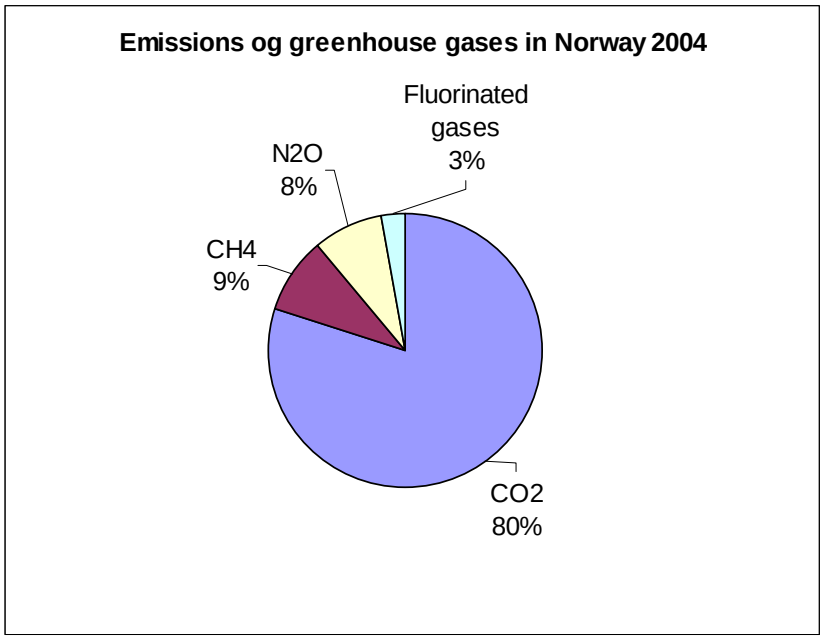


Figure 2.3 Distribution of emissions of greenhouse gases in Norway by gas, 2004. Source: SSB/SFT

Table 2.2 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 2.2 Emissions and removals of greenhouse gases in Norway during the period 1990-2004. Units: CO_2 and CO_2–eq. in Mtonnes, CH_4 and N_2O in ktonnes and other gases in tonnes. Source: SSB/SFT

		Year														
Gas	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
CO2	Mtonnes	34.8	33.2	34.2	35.9	37.8	37.8	40.8	41.0	41.1	41.9	41.5	42.9	42.0	43.5	44.0
CH4	ktonnes	226.7	230.0	234.2	238.2	242.0	242.1	243.3	244.5	238.0	230.5	235.9	236.1	228.2	229.6	228.6
N2O	ktonnes	15.2	15.2	12.7	13.6	14.1	14.2	14.3	13.9	14.6	15.1	14.6	14.3	14.9	14.3	14.8
CF4	tonnes	467.4	378.5	321.6	286.8	286.9	283.3	229.6	229.9	209.8	196.2	186.4	187.5	201.3	125.6	122.1
C2F6	tonnes	36.2	28.0	21.4	17.4	18.3	18.1	13.9	15.1	13.3	12.3	11.6	11.9	14.0	10.1	9.4
PFC 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	0.1	0.1
SF6	tonnes	92.0	87.0	29.5	30.9	36.7	25.4	24.0	24.3	30.4	36.6	39.1	33.1	10.0	9.8	11.5
HFC 134a	tonnes	0.0	0.0	0.2	1.8	5.4	10.2	17.2	26.1	37.7	52.0	66.1	80.4	95.3	109.7	123.8
HFC 125	tonnes	0.0	0.0	0.0	0.0	0.5	2.4	5.5	9.7	14.8	20.0	26.2	33.4	37.9	38.4	38.8
HFC 143a	tonnes	0.0	0.0	0.0	0.0	0.2	1.5	3.9	6.9	10.5	14.9	20.5	27.1	31.6	32.0	32.3
HFC 32	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6	1.0	1.5	2.0	2.0	2.2
HFC 23	tonnes	0.0	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	0.2
HFC 152a	tonnes	0.1	0.4	0.7	0.8	0.8	1.0	1.5	2.4	5.6	8.9	12.3	16.2	19.0	23.3	29.4
HFC 227ea	tonnes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3
Total without LULUCF	**Mt CO2-eq.**	**49.8**	**47.5**	**46.0**	**47.9**	**50.2**	**49.9**	**52.6**	**52.7**	**52.9**	**53.9**	**53.5**	**54.7**	**53.5**	**54.3**	**54.9**

Table 2.3 presents the changes in per cent for each greenhouse gas for the period 1990 – 2004, 2002- 2003, and 2003-2004.

Table 2.3 Changes in per cent for different time periods. Source: SSB/SFT

Emissions in Mtonnes CO_2 -eq.				**Change**	**Change**
	1990	**2003**	**2004**	**1990-2004**	**2003-2004**
CO_2	34.76	43.55	43.98	27 %	1 %
CH_4	4.76	4.82	4.80	1 %	0 %
N_2O	4.72	4.45	4.60	-2 %	3 %
PFCs	3.37	0.91	0.88	-74 %	-3 %
SF_6	2.20	0.23	0.28	-87 %	17 %
HFCs	0.00	0.38	0.40		6 %
SUM	**49.81**	**54.35**	**54.94**	**10 %**	**1 %**

As seen in table 2.2 and 2.3, there has been a significant increase in CO_2-emissions and a significant decrease in emissions of fluorocarbons in the period from 1990 to 2004.

The fluorocarbons constituted a larger fraction of the greenhouse gas emission total in the early 1990s than that in 2004 while CO_2 represented a smaller share in 1990 than in 2004. The emissions of CH_4 and N_2O have been relatively stable over the same period.

Figure 2.4 illustrate the changes in per cent for the different greenhouse gases for the period 1990 to 2004.

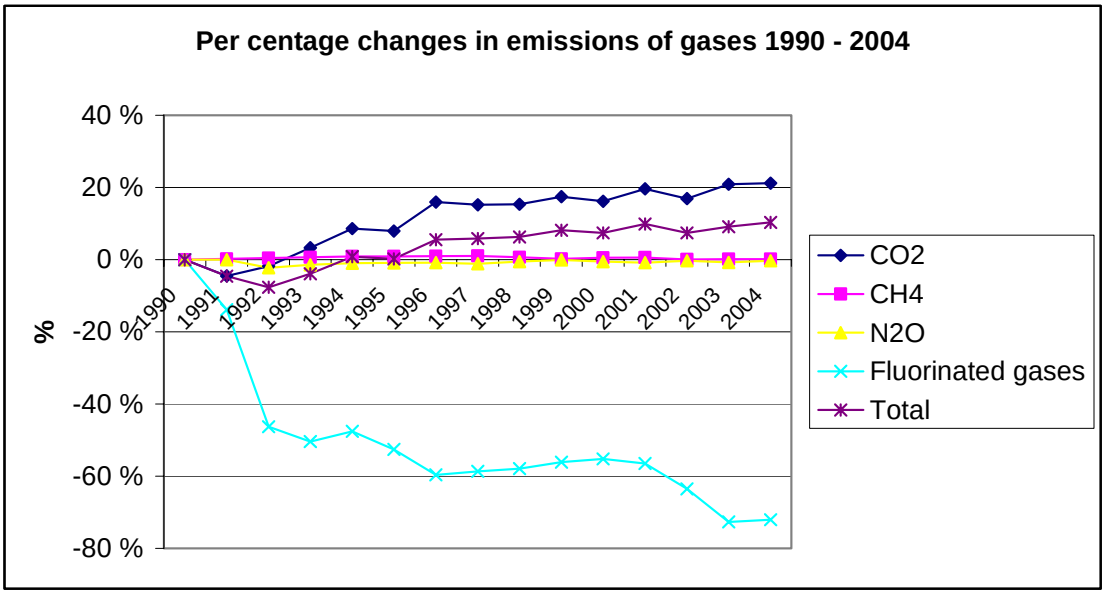


Figure 2.4 Changes in emissions of greenhouse gases by gas in Norway 1990-2004, compared to 1990. Source: SSB/SFT

Figure 2.4 shows that the overall increasing trend has been weakened by decreased emissions of fluorinated gases.
We will describe these trends further for each of the six greenhouse gases in the following. Note the fact that the source categories in this chapter are not completely consistent with the UNFCCC source categories.

2.2.1. Carbon dioxide (CO_2)

The Norwegian CO_2 emissions originate primarily from industrial sources related to oil and gas extraction, the production of metals, and 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 various categories is shown in Figure 2.5.

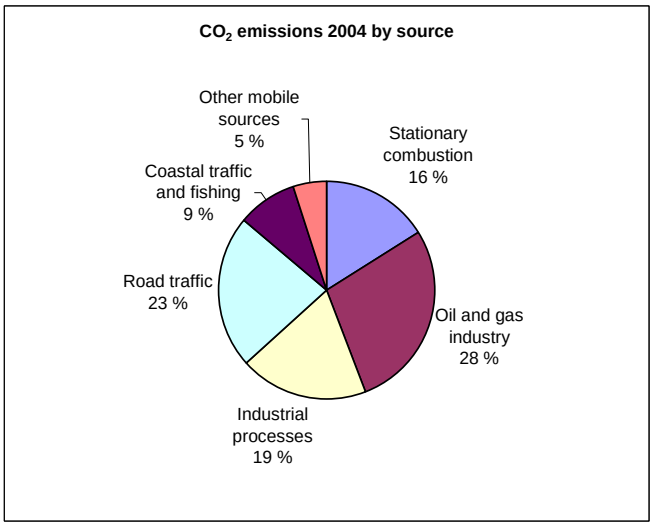


Figure 2.5: Distribution of CO2 emissions in Norway by source in 2004. Source SSB/SFT

Table 2.4 lists CO_2-emissions from each source category for the whole period 1990-2004. The change in emissions from 1990 to 2004 compared to 1990 is displayed in Figure 2.6.

Table 2.4 CO_2-emissions from different source categories for the period 1990-2003. Million tonnes. Source: SSB/SFT

Emissions Million tonn CO2-eq.	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Stationary combustion	7.4	6.9	6.8	7.1	7.9	7.3	8.7	8.0	8.1	7.8	6.9	7.2	7.1	7.9	7.1
Oil and gas industry	6.7	6.6	6.9	7.3	8.0	8.1	8.8	9.2	8.9	9.4	10.6	11.4	11.4	11.9	12.3
Industrial processes	7.4	6.7	7.2	7.8	8.2	8.3	8.5	8.6	8.7	8.6	9.1	8.9	8.1	8.1	8.5
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	10.0
Coastal traffic and fishing	3.4	3.3	3.3	3.4	3.3	3.4	3.7	3.9	4.1	4.3	4.0	3.8	3.8	3.9	3.9
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	2.2
Total	**34.8**	**33.2**	**34.2**	**35.9**	**37.8**	**37.8**	**40.8**	**41.0**	**41.1**	**41.9**	**41.5**	**42.9**	**42.0**	**43.5**	**44.0**

The total CO_2 emissions increased by 26 per cent or 9.2 million tonnes in the period from 1990 to 2004. 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 2004 the total Norwegian emissions of CO_2 were 44 million tonnes, which is an increase of about 1 per cent from the preceding year. The oil and gas industry, industrial processes, road traffic and other mobile sources all contributed to the total increase of 0.5 million tonne CO_2. from 2003.
Emissions from stationary combustion went down after an elevation in 2003, when high electricity prices and a cold winter increased the consumption of heating oil. A higher level of economic activity and a shift from oil- to gas exploitation, which is more energy demanding, increased emissions by 0.4 million tonnes.

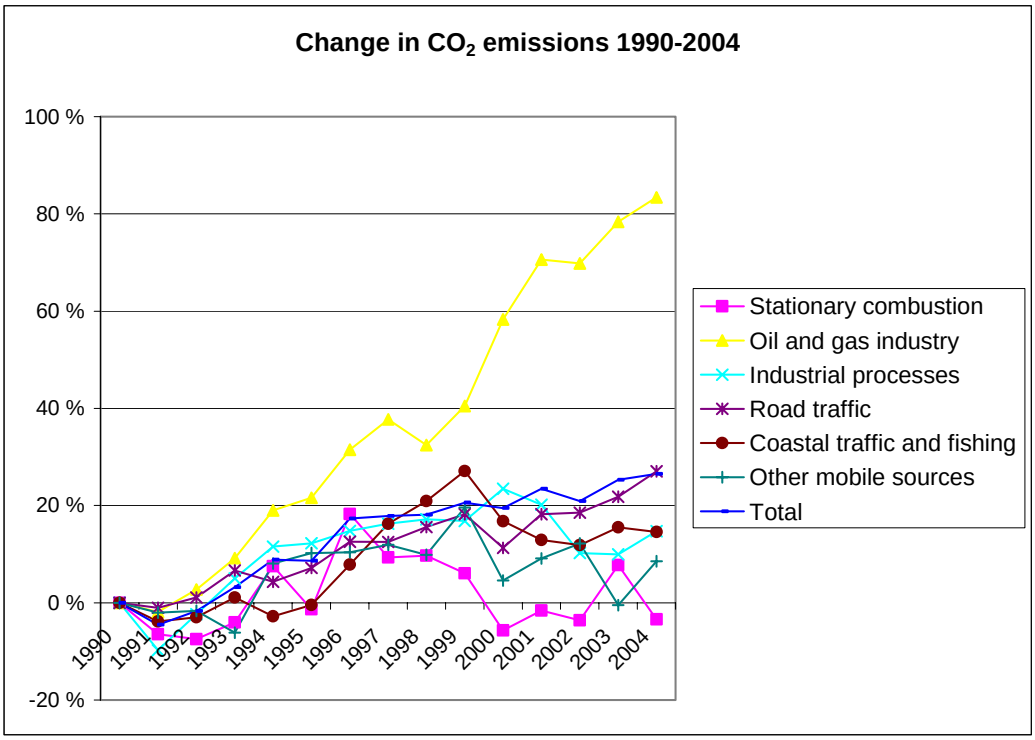


Figure 2.6 Changes in Norwegian CO_2 emissions 1990-2004 for major sources compared to 1990. Source: SSB/SFT

Emissions from the oil- and gas industry increased by about 83 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 established 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.

Road transportation has had an increase of 27 per cent CO_2 emission from 1990 to 2004. Although emissions from gasoline vehicles decreased by almost 10 per cent during this period, this fall was counteracted by the significant shift from gasoline to diesel vehicles.

Emissions of CO_2 from coastal traffic and fishing are 15% higher in 2004 than in 1990, mainly due to higher 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.

CO_2 emissions from industrial processes are about at the same level as in 1990, and contribute with about 19 per cent of total CO_2 emissions. 67 per cent of the CO_2 emissions from this sector are from metal production.

The CO_2 emissions from stationary combustion are 16 per cent of the total CO_2 emissions, a decrease of approximately 4 per cent compared to 1990. 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. A cold winter with high electricity prices in 2003, gave higher use of oil and higher CO2-emissions. However, the electricity prices went down in 2004, helping to reduce the emissions from this sector with 10 per cent in 2004 compared to 2003.

2.2.2. Methane (CH_4)

About 46 per cent of the methane emissions in 2004 originated from agriculture, and 30 per cent originated from waste treatment. Methane emissions from agriculture are dominated by releases from enteric fermentation. Combustion and evaporation/leakage in the oil- and gas industry accounted for 16 per cent of the total emissions in 2004, the largest fraction of which is releases of methane (venting) during the loading and unloading operations offshore. Other sources include emissions from among others petrol cars, domestic heating, coal mining and oil refineries.

Figure 2.7 illustrates the distribution of Norwegian CH_4-emissions in 2004.

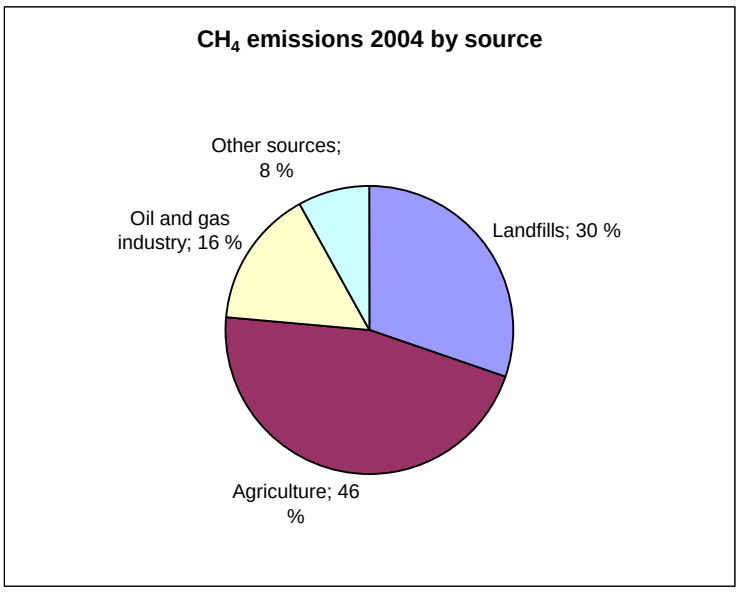


Figure 2.7 Distribution of Norwegian CH_4 emissions in 2004. Source: SSB/SFT

The methane figures from 1990 to 2004, distributed on the different categories are displayed in table 2.5:

Table 2.5 Emissions of CH_4 in Norway 1990-2004, ktonnes CH_4. Source: SSB/SFT

Emissions k tonnes CH4	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Landfills	87.0	87.7	87.4	87.8	87.9	87.3	86.2	84.8	79.5	73.9	75.2	72.6	70.0	69.7	69.4
Agriculture	106.9	108.6	108.8	107.4	109.2	110.4	111.0	110.3	111.3	110.8	109.3	107.1	104.9	107.3	105.1
Oil and gas industry	15.3	17.4	22.4	26.1	27.7	27.5	28.5	32.0	29.9	28.0	33.0	38.2	34.8	32.5	35.4
Other sources	17.6	16.3	15.6	17.0	17.2	16.8	17.6	17.5	17.3	17.9	18.4	18.2	18.5	20.1	18.7
Total	**226.7**	**230.0**	**234.2**	**238.2**	**242.0**	**242.1**	**243.3**	**244.5**	**238.0**	**230.5**	**235.9**	**236.1**	**228.2**	**229.6**	**228.6**

The total methane emissions decreased by about 0.4 per cent from 2003 to 2004. During the period 1990-2004 the total CH_4 emissions increased by almost 1 per cent. Table 2.5 and Figure 2.8 show that this decrease is primarily due to decreased emissions from waste treatment which more than compensated for the growth in emissions from the oil- and gas industry.

Small annual fluctuations in the emissions from the oil and gas industry can be explained by changes in production volumes. Measures for mitigating the emissions from combustion and evaporation/leakage in the oil- and gas industry have not been sufficient to compensate for the increase in activity level and change in extraction from oil to gas.
The waste volumes have grown during the period (1990-2004), but this effect has been more than offset by increased recycling and incineration of waste and increased burning of methane from landfills.

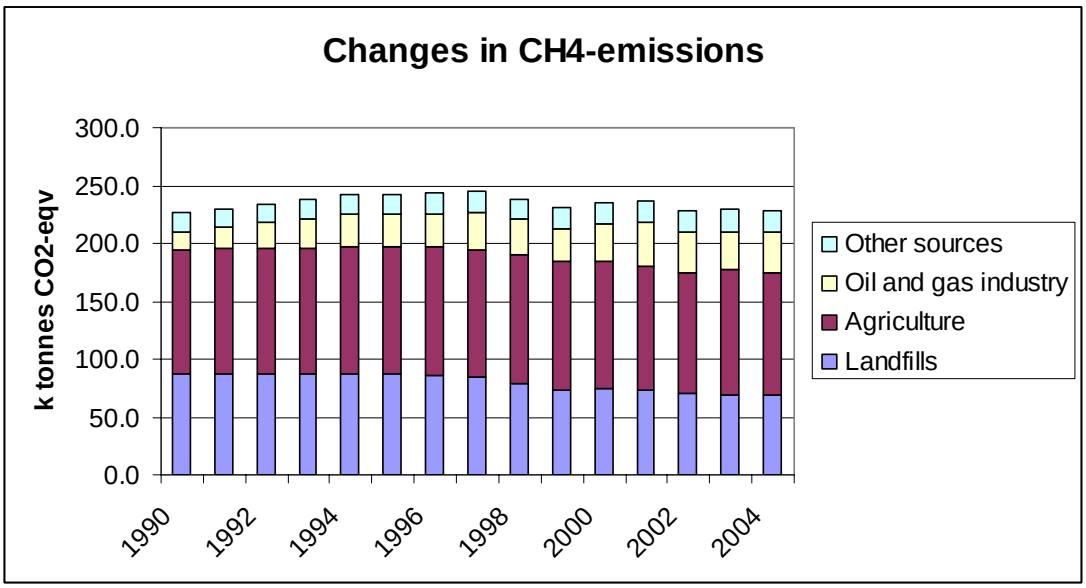


Figure 2.8: Changes in CH_4 emissions for major Norwegian sources between 1990 and 2004 compared to 1990. Source: SSB/SFT

2.2.3. Nitrous oxide (N_2O)

Figure 2.9 shows that almost half of the Norwegian emissions of N_2O are of agricultural origin (46 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 40 per cent of the total. The contribution from road traffic amounted to 4 per cent in 2004, 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.

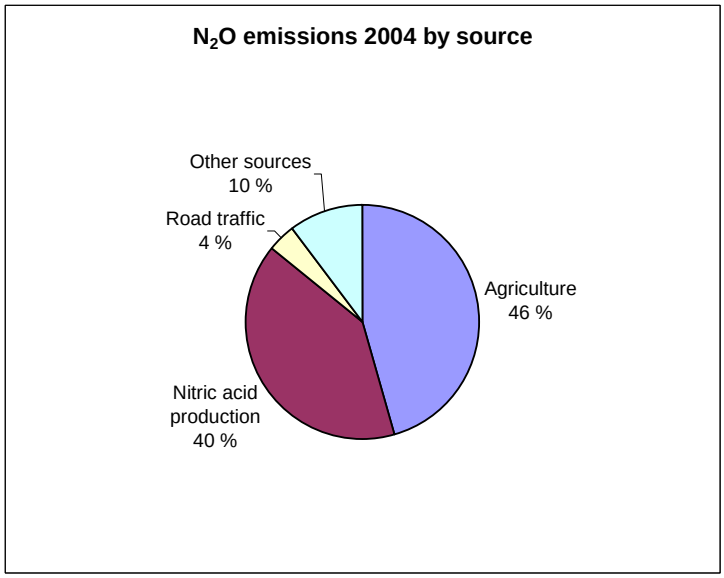


Figure 2.9: Distribution of Norwegian N_2O emissions by major sources in 2004. Source: SSB/SFT

The overall nitrous oxide emissions decreased by about 2.4 per cent from 1990 to 2004. Between 2002 and 2003 emissions increased by 3.5 per cent. This and other details are shown in Table 2.6 and Figure 2.10.

Table 2.6 Emissions of N2O in Norway by major sources 1990-2004. ktonnes. Source: SSB/SFT

k tonnes N2O	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Agriculture	7.00	7.05	7.01	6.98	6.98	7.10	7.16	7.16	7.16	6.98	7.04	6.79	6.72	6.77	6.77
Nitric acid production	6.65	6.67	4.17	5.03	5.37	5.29	5.23	4.78	5.45	6.06	5.59	5.46	6.17	5.52	5.95
Road traffic	0.16	0.18	0.20	0.24	0.26	0.30	0.36	0.40	0.43	0.46	0.47	0.51	0.53	0.54	0.56
Other sources	1.36	1.29	1.29	1.34	1.45	1.50	1.54	1.59	1.57	1.57	1.49	1.52	1.45	1.47	1.53
Total	15.17	15.18	12.66	13.59	14.06	14.18	14.29	13.92	14.62	15.07	14.59	14.28	14.87	14.31	14.81

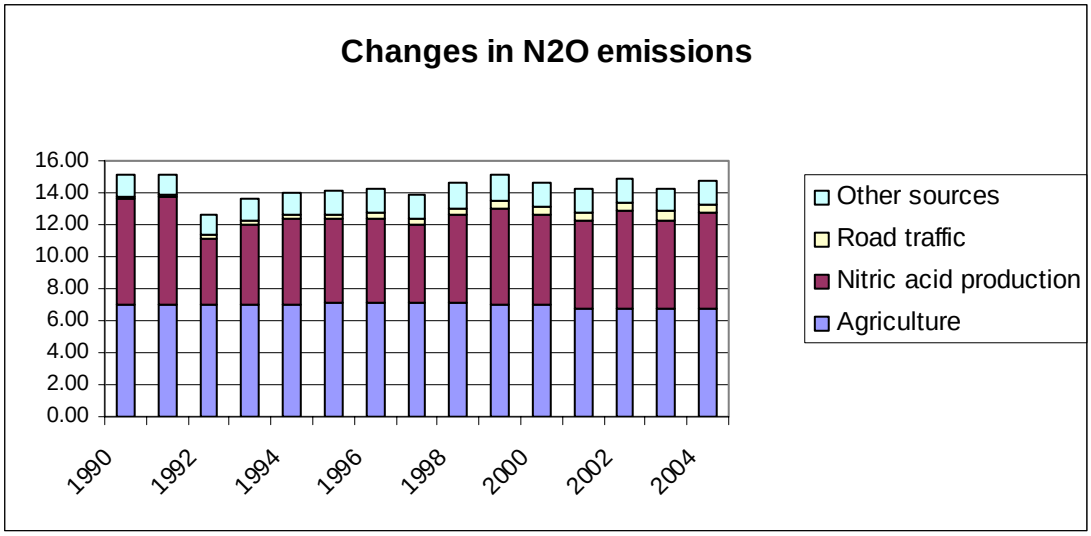


Figure 2.10 Changes in N_2O emissions for major Norwegian sources between 1990 and 2004. Source: SSB/SFT

Emissions of N_2O from agriculture have been rather stable through the 1990s and further on until 2003. Bearing in mind the very high level of uncertainty both in level and trend of the key category "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 further down again to a level 11 per cent lower than in 1990.

The increasing use of catalytic converters in light vehicles has increased the emissions of N_2O from road traffic with 0.4 kilo tonnes or 250 percent during the period 1990-2004.

2.2.4. Perfluorcarbons (PFCs)

The emissions of the perfluorcarbons tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from Norwegian aluminium plants in 2004 were reported at 122 and 9.4 tonnes respectively, corresponding to a total of 0.9 million tonnes of CO_2-equivalents.

The total emissions of PFCs decreased by 74 per cent in the period 1990-2004 following a steady downward trend as illustrated in Figure 2.11. 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 83 per cent decrease in the amount of PFCs emitted per tonne aluminium produced during the period 1990-2004. In 1990, the emissions of PFCs were 2.87 kg CO2-equivaltents per tonne of aluminium produced. In 2004, this is reduced to 0.66 kg per tonne of aluminium See Section 4.4 for further details.

PFCs may be used as substitutes for ozone-depleting substances. In Norway, the component C_3F_8 (PFC-218) is used for this purpose. The actual emissions of C_3F_8 have been calculated at only 55 kg in 2004, corresponding to almost 387 tonnes of CO_2-equivalents. Consumption of halocarbons is also described in Section 4.6.

Table 2.7 Emissions of PFCs in Norway 1990-2004 in tonnes. Total CO2-eq.are in million tonnes. Source SSB/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
CF_4	467	379	322	287	287	283	230	230	210	196	186	188	201	126	122
C_2F_6	36.2	28.0	21.4	17.4	18.3	18.1	13.9	15.1	13.3	12.3	11.6	11.9	14.0	10.1	9.4
C_3F_8	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	0.1	0.1
Total CO2-eq.	**3.37**	**2.72**	**2.29**	**2.02**	**2.03**	**2.01**	**1.62**	**1.63**	**1.49**	**1.39**	**1.32**	**1.33**	**1.44**	**0.91**	**0.88**

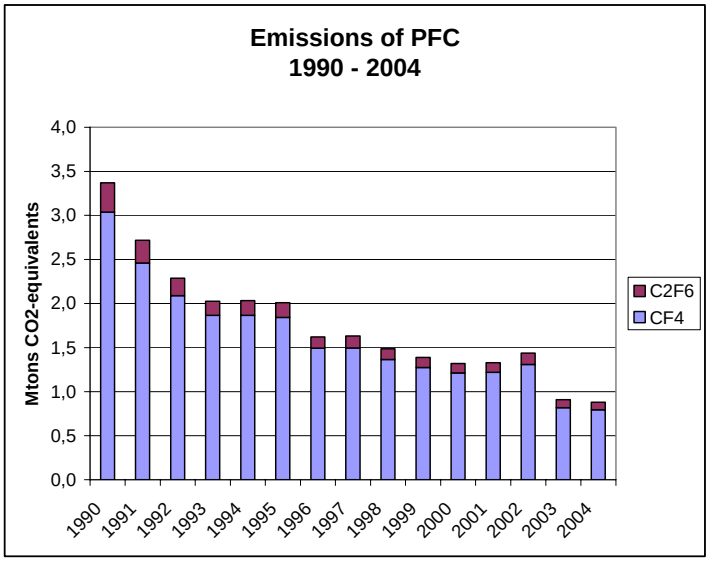


Figure 2.11 Emissions of PFCs in Norway 1990-2004. Million tonnes CO_2-equivalents. Source: SSB/SFT

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 2004, the SF_6 emissions were 87 per cent lower than in 1990. 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.

However, the emissions of SF_6 increased by 17 per cent from 2003 to 2004.

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 8 SF_6 emissions in Norway 1990-2003.In tonnes. Source SSB/SFT

Emissions. tonnes	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Magnesium production	89.7	84.5	23.6	21.8	23.1	17.7	18.9	18.3	24.3	30.3	32.3	27	5.9	7.2	8.6
Aluminium production	0	0	3.1	6	10	3.6	0.9	0	0	0	0	0	0	0	0
GIS and other products	2.3	2.5	2.8	3.1	3.6	4.1	4.3	6	6.1	6.2	6.7	6.1	4	2.6	2.9
Total	**92**	**87**	**29.5**	**30.9**	**36.7**	**25.4**	**24**	**24.3**	**30.4**	**36.7**	**39.1**	**33.1**	**10**	**9.8**	**11.5**

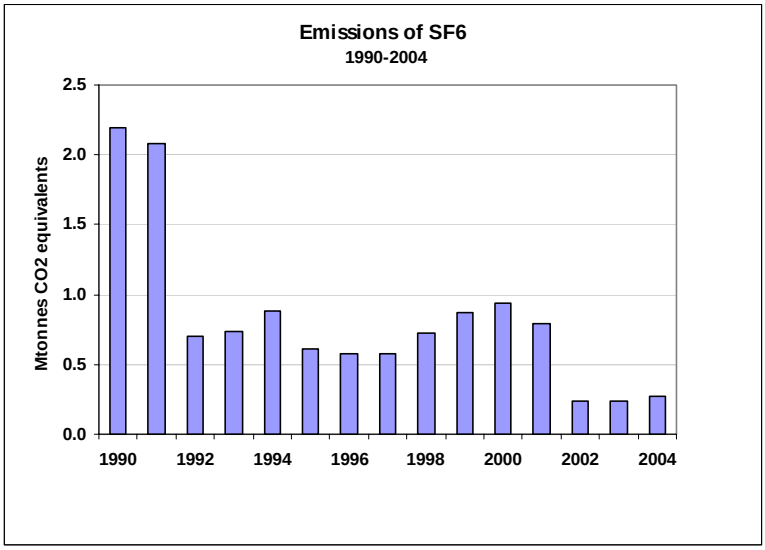


Figure 2.12 Emissions of SF6 in Norway 1990-2003. Mtonnes CO2-equivalents. Source: SSB/SFT

2.2.6. Hydroflorocarbons (HFCs)

The total actual emissions from HFCs used as substitutes for ozone depleting substances amounted to 0.4 million tonnes of CO_2-equivalents in 2004. Compared to the emissions in 2003, this represents an increase of about 6 per cent. 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/foam blowing and fire extinguishing contributed small amounts to the overall emissions. Tier 2 methodology was used to calculate the emissions. Figure 2.13 displays the development of the emissions of HFCs in the period 1990-2004. Table 2.9 shows the actual emissions of different HFCs over the same period.

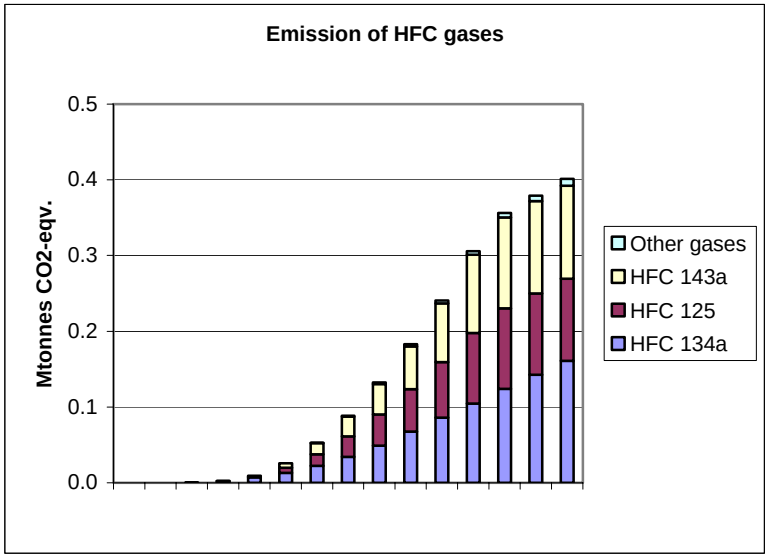


Figure 2.13 Actual emissions of HFCs in Norway 1990-2004. Mtonnes CO_2-equivalents. Source: SSB/SFT

Table 2.9 Actual emissions of HFCs in Norway 1990-2004 calculated using the Tier 2 methodology. In tonnes. Source SSB/SFT

Emissions (Tier 2)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFC 134a	-	0.0	0.2	1.8	5.4	10.2	17.2	26.1	37.7	52.0	66.1	80.4	95.3	109.7	123.8
HFC 125	-	-	-	-	0.5	2.4	5.5	9.7	14.8	20.0	26.2	33.4	37.9	38.4	38.8
HFC 143a	-	-	-	-	0.2	1.5	3.9	6.9	10.5	14.9	20.5	27.1	31.6	32.0	32.3
HFC 32	-	-	-	-	0.0	0.0	0.0	0.1	0.3	0.6	1.0	1.5	2.0	2.0	2.2
HFC 23	-	-	-	-	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2
HFC 152a	0.1	0.4	0.7	0.8	0.8	1.0	1.5	2.4	5.6	8.9	12.3	16.2	19.0	23.3	29.4
HFC 227ea	-	-	-	-	-	-	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3
Total (in Mtonnes CO2-eq.)	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.03**	**0.05**	**0.09**	**0.13**	**0.18**	**0.24**	**0.31**	**0.36**	**0.38**	**0.40**

Last years reporting showed a reversed downward trend in the emissions of HFC after the tax on HFC was introduced in January 2003. This years calculations, which are based on interim results from an on-going project, indicate that the emission are still increasing but at a slower rate.

2.3. Emission trend by source

2.3.1. Total emissions by source classification

Figure 2.14 illustrates the total emissions of GHG in Norway in 2004 in UNFCCC classification of sources. The Energy sector is by far the most important, contributing with 70% of the total emissions.

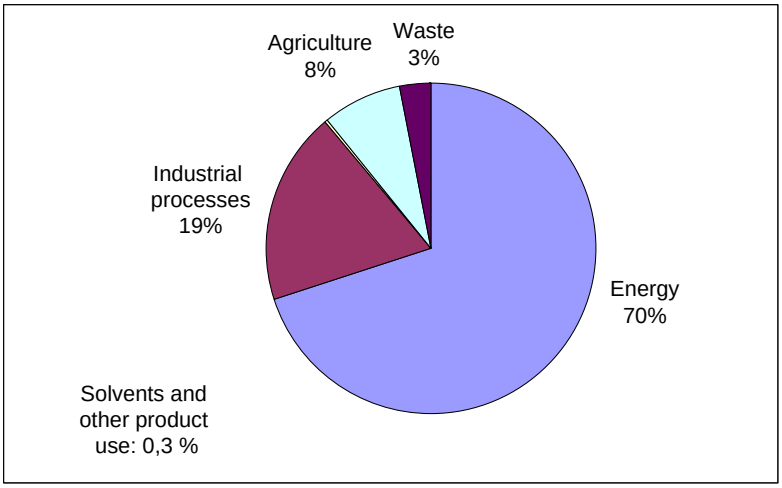


Figure 2.14 Total emissions of GHG in Norway in 2004 by sources

Figure 2.15 shows the changes in greenhouse gas emissions by sectors in the period 1990 to 2004. The Energy sector is divided in its' five main sub-sectors: Fuel combustion in energy industries, fuel combustion in manufacturing industries and construction, fuel combustion in transport, and fuel combustion in other sectors. Fugitive emissions from fuels comes in addition.

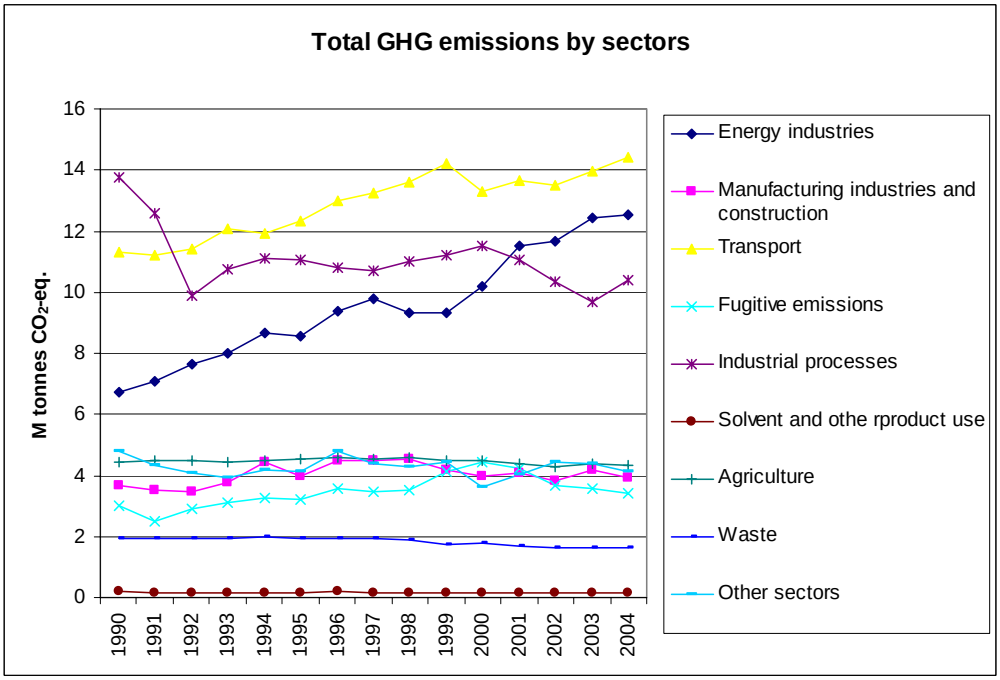


Figure 2.15 Development of emissions of all GHG, given as CO2-equivalents, from the different sectors. (source: SFT/SSB)

2.3.2. Energy

Figure 2.16 displays the distribution of GHG emissions in 2004 on the main sub categories within the Energy sources.

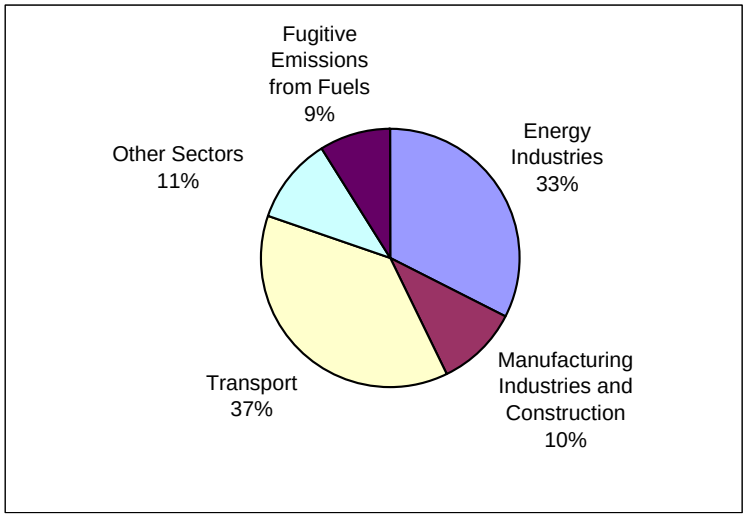


Figure 2.16 Greenhouse gas emissions in 2004 from the energy sector distributed on the different source categories. Source: SSB/SFT)

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.
Within the Energy sector is the fuel combustion in the **Transport sector** the biggest emitter of GHG with a share of 37 %. Number two is fuel combustion in **Energy industries,** with a share of 33 %. This sector is almost completely dominated by fuel combustion in the oil-and gas extraction and related activities.
The total emissions of greenhouse gases from the energy sector over the period 1990-2004 are listed in Table 2.10. The emission changes detected in the various source categories in the energy sector between 1990 and 2004 compared to the 1990 level, are illustrated in Figure 2.17 and discussed in the following.

Table 2.10 Total emissions of greenhouse gases from the energy sector in Norway 1990-2004. Million tonnes CO_2-equivalents. Source: SSB/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Energy Industries	6.7	7.1	7.7	8.0	8.7	8.5	9.4	9.8	9.3	9.3	10.2	11.5	11.7	12.4	12.5
Manufact.Industries and Construction	3.7	3.5	3.5	3.8	4.4	4.0	4.5	4.5	4.6	4.2	4.0	4.1	3.8	4.2	3.9
Transport	11.3	11.2	11.4	12.1	11.9	12.3	13.0	13.2	13.6	14.2	13.3	13.6	13.5	14.0	14.4
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	4.4	4.4	4.1
Fugitive Emissions from Fuels	3.0	2.5	2.9	3.1	3.3	3.2	3.6	3.5	3.5	4.1	4.4	4.2	3.7	3.6	3.4
Total	29.5	28.6	29.5	30.8	32.5	32.2	35.3	35.3	35.3	36.2	35.5	37.4	37.1	38.5	38.4

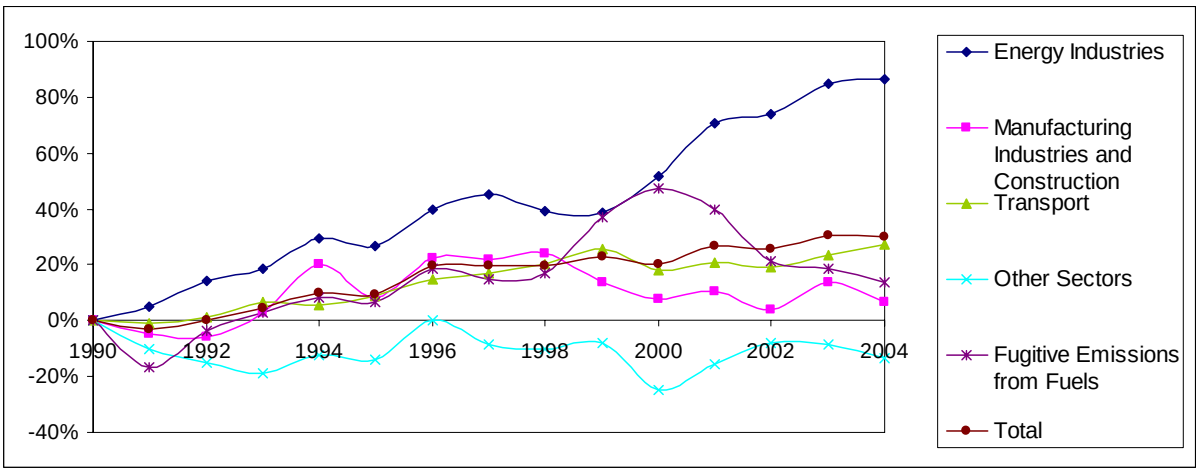


Figure 2.17 Changes in emissions in the various source categories in the energy sector between 1990 and 2004 compared to the 1990 level. Source: SSB/SFT

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 2004 the total emission level in the energy sector was 30 per cent higher than in 1990, or almost 9 million tonnes. There were short, temporary emission reductions in 1991, 1995, 2000 and 2002 followed 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. The small decrease in 2004 is due to lower electricity prices.

Emissions from fuel combustion in **Energy industries** have increased by 86 per cent from 1990 to 2004, and by about 1 per cent from 2003 to 2004. The main source is offshore oil- and gas extraction. 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.
In 2004 the emissions from energy use in offshore oil and gas extraction contributed about 20 per cent to the total GHG emissions in Norway. In 1990 the corresponding contribution was 11 per cent. The growth can be explained by increased production of oil and gas and more energy demanding extraction due to aging of oil fields a transition from oil to gas. During the period 1990-2004 the total greenhouse gas emissions from energy production offshore doubled.

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.
Industrial emissions related to fuel combustion[2] originate to a large extent from the production of raw materials and semi-manufactured goods. e.g. alloys, petrochemicals, paper and minerals. Emissions from **Manufacturing industries and construction** increased 7 per cent

[2] 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.

in the period 1990-2004. In this period activity within the petrochemical industry (starting up of a new methanol production plant) and the pulp and paper industry increased. From 2003 to 2004 a reduction in emissions by 6 per cent took place , primarily due to small reductions in energy related emissions in several industrial sectors. Substitution of oil with electricity is supposed to be the main explanation

Emissions from **Transport** showed an overall increase of about 28 per cent from 1990 to 2004, while the emissions increased by 3 per cent from 2002 to 2004 (see Table 2.11 and Figure 2.18). The share of transport in the total GHG emissions has increased from 23 per cent in 1990 to 26 per cent in 2004. Road traffic accounts for more than 2/3 of the total mobile emissions. Emissions from navigation increased by 24 per cent from 1990 to 2004, mainly because of increased activity related to the oil- and gas extraction sector.
Emissions from civil aviation have increased by 39 per cent since 1990. Reduction in the number of flights contributed to an emission decline in the years 2000, 2001 and especially 2002. In 2003 there was a new growth. The emissions were not changed from 2003 to 2004. The substitution of older planes with new,more energy efficient planes has also played an important role to limit the emission growth. Domestic civil aviation contributed to the total national GHG emissions by about 1.7 per cent in 2004.
Due to the fact that most railways are electrified in Norway, emissions of GHG from this source are insignificant.

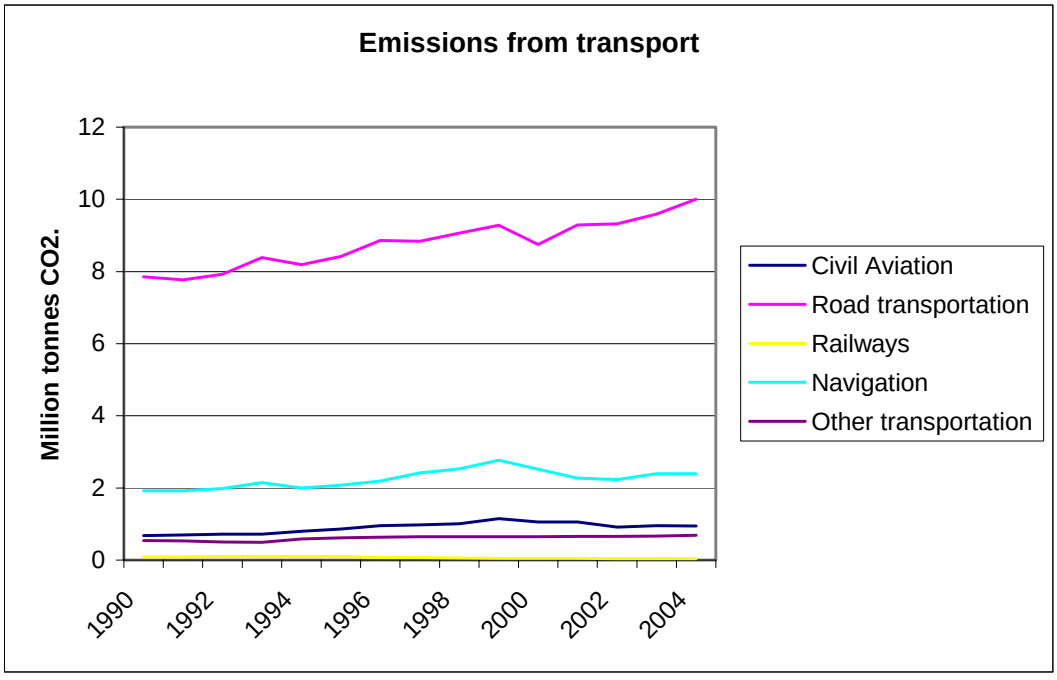


Figure 2.18 Changes in CO_2-emissions from different modes of transport in 1990-2004. Source: SSB/SFT

Table 2.11 Total emissions of greenhouse gases from the transport sector in Norway 1990-2004. Million tonnes CO_2-equivalents. Source: SFT/SSB

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
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	0.95
Road transp.	7.85	7.77	7.92	8.38	8.20	8.41	8.86	8.84	9.07	9.28	8.75	9.29	9.33	9.59	10.00
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	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	2.24	2.40	2.40
Other transp.	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	0.67	0.69
Total	**11.1**	**11.0**	**11.2**	**11.8**	**11.7**	**12.1**	**12.7**	**13.0**	**13.3**	**13.9**	**13.0**	**13.3**	**13.2**	**13.7**	**14.08**

The source category **Other Sectors** (table 2.10)includes fuel combustion in agriculture, forestry and fisheries, fuel combustion from residential sources and fuel combustion from commercial/institutional sources**.** The total emission from this sector was 4.1 million tonnes CO_2-equivalents in 2004. Fuel combustion in agriculture, forestry and fisheries accounts for about half of the emissions of this sector. These emissions have been rather stable throughout the period 1990-2004.

CO_2-emissions from residential sources accounted in 2004 for about 24 per cent of other sector's total. Emissions were 0.5 million tonnes less in 2004 than 1990 due to electrification of heating infrastructure. However, new technologies and occasional electricity shortages have at times reversed this trend. Recent examples of fluctuations are the relatively low emissions from residential sources in 2000 due to the mild winter which led subsequently to relatively low consumption of fuels. In 2003 the emissions from residential sources increased due to high electricity prices and a cold winter. In 2004, the emissions were reduced by 10% compared to 2003, due to a.o. lower electricity prices.

Emissions from commercial/institutional sources make up the last 23 % of this category. The development in emissions has been a 7 per cent increase from 1990 to 2004, and a reduction of 18 per cent between 2003 and 2004. The same fluctuation that has occurred for emissions from the residential sources has also occurred in the commercial/institutional sources.

The source category termed **Fugitive emissions from fuels** refers to emissions from oil and gas activities such as 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. These emissions are reported to 3.4 million tonnes CO_2-equivalents in 2004. 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 14 per cent from 1990 to 2004. However, the emission level in 2004 is 23 % lower than the one in 2000 mainly due to reduced flaring off shore and reducing spill of NMVOC during loading and unloading of crude oil tankers.

2.3.3. Industrial processes

The industrial process sector accounted for 19 per cent of the national greenhouse gas emissions in 2004. The emissions from this source category have decreased by 24 per cent from 1990 to 2004 and increased by 7.7 per cent from 2003 to 2004.

Metal production 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), contributing with about 62% of the total emissions from Industrial processes. Chemical industry contributes with 24 per cent of the emissions from Industrial processes.

Figure 2.19 shows the variation in the different industies' contribution to greenhouse gas emissions from 1990 to 2004. Table 2.11 provides figures for the total greenhouse gas emissions from the Industry sector for the same period.

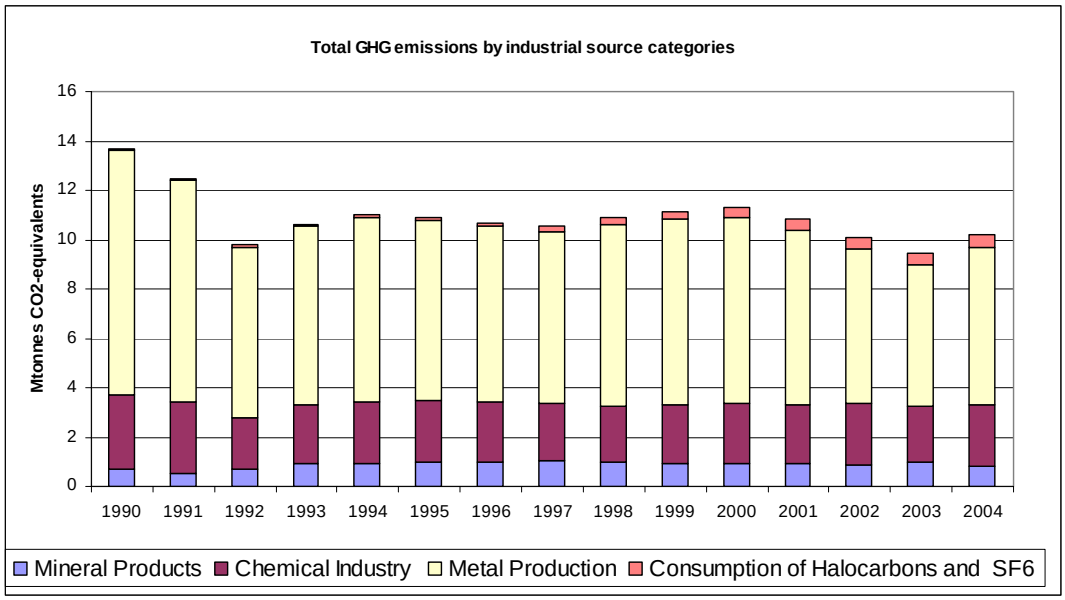


Figure 2.19 Total greenhouse gas emissions in the industrial source categories in Norway during the period 1990-2004. Source: SSB/SFT

Table 2.12 Total greenhouse gas emissions from the industry sector in Norway 1990-2004. Million tonnes CO_2-eq. Source: SSB/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Mineral Products	0.72	0.54	0.71	0.91	0.92	0.96	0.96	1.02	0.97	0.95	0.96	0.92	0.90	0.98	0.84
Chemical Industry	2.97	2.87	2.05	2.37	2.49	2.49	2.45	2.34	2.30	2.35	2.42	2.36	2.49	2.28	2.45
Metal Production	9.92	9.02	6.94	7.26	7.51	7.33	7.12	6.97	7.36	7.52	7.52	7.12	6.26	5.74	6.42
Other Production	0.08	0.12	0.12	0.13	0.12	0.13	0.13	0.15	0.10	0.08	0.23	0.22	0.23	0.23	0.24
Consumption of Halocarbons and SF_6	0.06	0.06	0.07	0.08	0.10	0.13	0.16	0.23	0.28	0.33	0.40	0.45	0.45	0.44	0.47
Total	**13.73**	**12.60**	**9.89**	**10.75**	**11.13**	**11.05**	**10.82**	**10.71**	**11.00**	**11.23**	**11.53**	**11.07**	**10.33**	**9.67**	**10.42**

During the first half of the 19th century, a large-scale industrialisation took place 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.

Within the **Metal production** category, which accounted for 62 per cent of the sector's emissions in 2004, aluminium production is the main source of emissions. 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 1.6 per cent, and CO2-emissions accounted for 3.8 per cent of the national total GHG emissions in 2004, giving a total contribution to the GHG emissions of 5.4 per cent.

Production ferroalloys the second most important source within the category of metal production. Norway is a major producer of ferroalloys with 12 plants in operation in 2004. The GHG emissions from ferroalloy production accounted for 5.1 per cent of the national total GHG emissions in 2004. The emissions from this sector has increased by 6,7 per cent since 1990..

Other metals produced in Norway today are nickel, zinc and magnesium, one plant of each. Emissions from theses sources are minor compared to other metal producers.

The major source of SF_6 emissions is magnesium production. There is one magnesium manufacturing plant in Norway. The plant closed down the production of primary magnesium in 2002 but the production of secondary cast magnesium is continuing.
SF_6 from magnesium foundries accounted in 2004 for 0.37 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 mainly due to the closure of the primary magnesium plant in 2002, and improvements in technology and in process management.

The chemical industry is the industry sector's second most important category, accounting for 24 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 18 per cent in the period 1990-2004. The detected reduction is due to improved technology in the nitric acid production. From 2003 to 2004 emissions increased by about 8 per cent, which is a result of a higher production level.

In the category **Production of minerals,** cement production is by far the main source of emissions. 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 8 per cent of the emissions in sector Industrial processes. From 1990 to 2004 the GHG emissions from cement production decreased by 17 per cent. There are annual fluctuations in the emissions related to the type of raw materials used, as well as produced volumes.

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.

2.3.4. Solvent and other product use

Use of solvents and products containing solvents result in 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.

2.3.5. Agriculture

In 2004, about 8 per cent of the total Norwegian emissions of greenhouse gases (GHG) originated from agriculture. This corresponds to 4.3 million tonnes CO_2-eqv. The emissions from agriculture are quite stable, with emissions 2.5 percent lower in 2004 than in 1990, and 1 percent lower than in 2003.

The sectors clearly biggest sources of GHG's are "enteric fermentation" (CH_4) from domestic animals, contributing with 44 per cent and "agricultural soils" (N_2O) contributing with 45 percent of the sectors emissions. These are also key categories. Manure management contributes with 10 percent.
Enteric fermentation contributed with 90.3 kilo tonnes of CH_4 emissions in 2004, corresponding to 1.896 million tonnes CO_2 equivalents, which is 3.45 per cent of the national GHG emissions. Enteric fermentation constitutes 86 per cent of the overall CH_4 emissions from agriculture and 44 percent of the sectors' GHG emissions. Emissions have been rather stable with minor fluctuations. Emissions decreased 2.6 percent in the period 1990-2004 and 2.5 percent in 2003-2004.
CH_4-emissions due to **manure management** amounted to 14.8 ktonnes in 2004, corresponding to 0.31 million tonnes CO_2 equivalents. N_2O-emissions due to manure management amounted to 0.39 kilo tonnes in 2004, corresponding to 0.12 million tonnes CO_2 equivalents. In 2004, manure management emitted 0.43 million tonnes 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 stayed at the same level in the period 1990-2004.
The emissions of N_2O in Norway from **agricultural soils** amounted to 6.4 ktonnes in 2004, or 1.9 million tonnes calculated in CO_2-equivalents. They accounted for about 43 per cent of the total Norwegian N_2O emissions in 2003 or about 3.5 per cent of the total Norwegian greenhouse gas emissions that year.

Emissions of N_2O from agricultural soils are a key category because of uncertainty, both in level and trend. The emissions decreased by 3 % in the period 1990-2004 and remained unchanged from 2003 to 2004

Table 2.13 Total greenhouse gas emissions from the agricultural sector in Norway 1990-2004. Million tonnes CO_2-eq. Source: SSB/SFT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Enteric Fermentation	1.95	1.97	1.98	1.95	1.98	2.00	2.01	1.99	2.01	2.01	1.98	1.94	1.90	1.94	1.90
Manure Management	0.43	0.45	0.45	0.44	0.45	0.46	0.47	0.46	0.47	0.46	0.46	0.45	0.44	0.43	0.43
Agricultural Soils	2.04	2.04	2.03	2.03	2.02	2.05	2.07	2.08	2.08	2.02	2.04	1.96	1.94	1.97	1.98
Field Burning of Agricultural Residues	0.03	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**4.44**	**4.49**	**4.47**	**4.44**	**4.47**	**4.53**	**4.57**	**4.55**	**4.57**	**4.50**	**4.49**	**4.36**	**4.29**	**4.36**	**4.31**

2.3.6. Waste

The waste sector, with emissions of 1.61 million tonnes CO_2-equivalents in 2004 accounted for 3 per cent of the total GHG emissions in Norway in 2004.
The sector includes emissions from landfills (CH_4), wastewater handling (CH_4 and N_2O) and small scale waste incineration (CO_2 and CH_4). 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 90.6 per cent of the sector's total emissions.
Wastewater handling and waste incineration account for approximately 8.1 and 1.3 per cent respectively.
The emissions of greenhouse gases from the waste sector were relatively stable until 1996 with emission levels of 1.96 million tonnes CO_2-equivalents. From 1997 emissions declined and in 2004 were emissions 17 % 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 2.14 and figure 2.20.

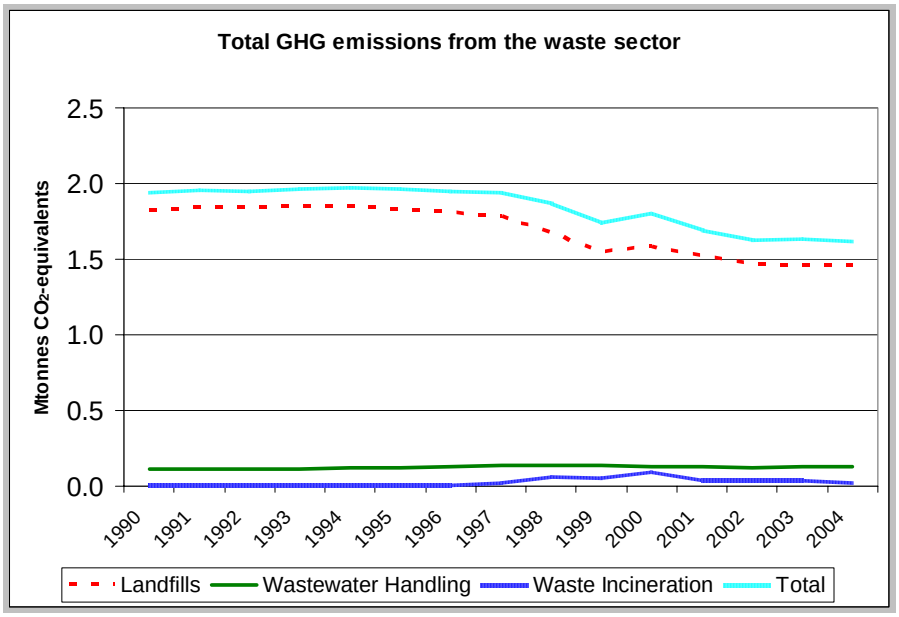


Figure 2.20 Total emissions of greenhouse gases in Norway from the waste sector 1990-2004. Million tonnes CO2-equivalents. Source: SSB/SFT

Table 2.14 Emissions from the waste sector in Norway 1990-2003. Mtonnes CO_2 –equivalents. Source:SSB/SFT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Landfills	1.83	1.84	1.84	1.84	1.85	1.83	1.81	1.78	1.67	1.55	1.58	1.52	1.47	1.46	1.46
Wastewater Handling	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.14	0.14	0.14	0.13	0.13	0.12	0.13	0.13
Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.05	0.09	0.03	0.03	0.03	0.02
Total	**1.94**	**1.95**	**1.95**	**1.96**	**1.97**	**1.96**	**1.94**	**1.94**	**1.86**	**1.74**	**1.79**	**1.69**	**1.62**	**1.63**	**1.61**

The figure shows that emissions of methane have decreased slightly since 1996. This is 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 2003.
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 1990-1998, and about 25 Mtonnes per year from 1999 to 2004. In 2004 the net sequestration was calculated at 26.3 Mtonnes of CO_2, which would offset 48 per cent of the total greenhouse gas emissions in Norway that year. The sequestration increased by approximately 81 per cent from 1990 to 2004, while the increase from 2003 to 2004 was only 1.2 per cent. Figure 2.21 shows the land areas occupied by the different land-use categories as defined by the IPCC (IPCC 2004) in 1990 and 2002.

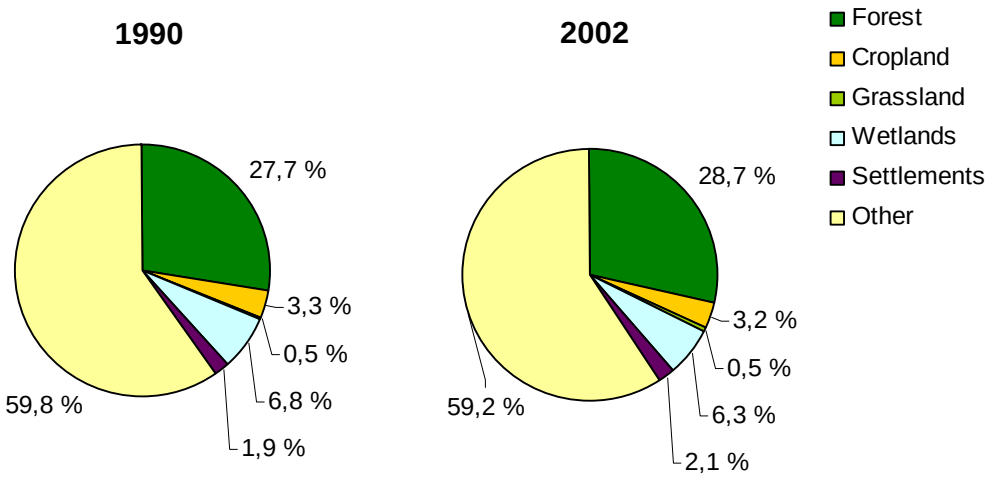


Figure 2.21 Land area by category in 1990 and 2002

As can be seen from Figure 2.21, forest land 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 2004 the land-use category forest land remaining forest land was the only category with a net sequestration, which totalled about 28.5 million tonnes CO_2. From 1990 to 2004 the sequestration increased by 66 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. The increased sequestration since 1990 is due to an active forest management policy, and to

some extent to natural factors. Emissions of CH_4 and N_2O from forest land remaining forest land are negligible compared to the CO_2 sequestration; 0.11 Gg and 0.04 Gg, respectively (corresponding to about 2 Gg and 12 Gg of CO_2-equivalents). Methane emissions were reduced by 88 % from 1990 to 2004. Emissions of nitrous oxide have remained fairly constant over the period.
Figure 2.22 illustrates the change in carbon stocks in forest living biomass, dead wood and soil organic carbon between 1990 and 2004.

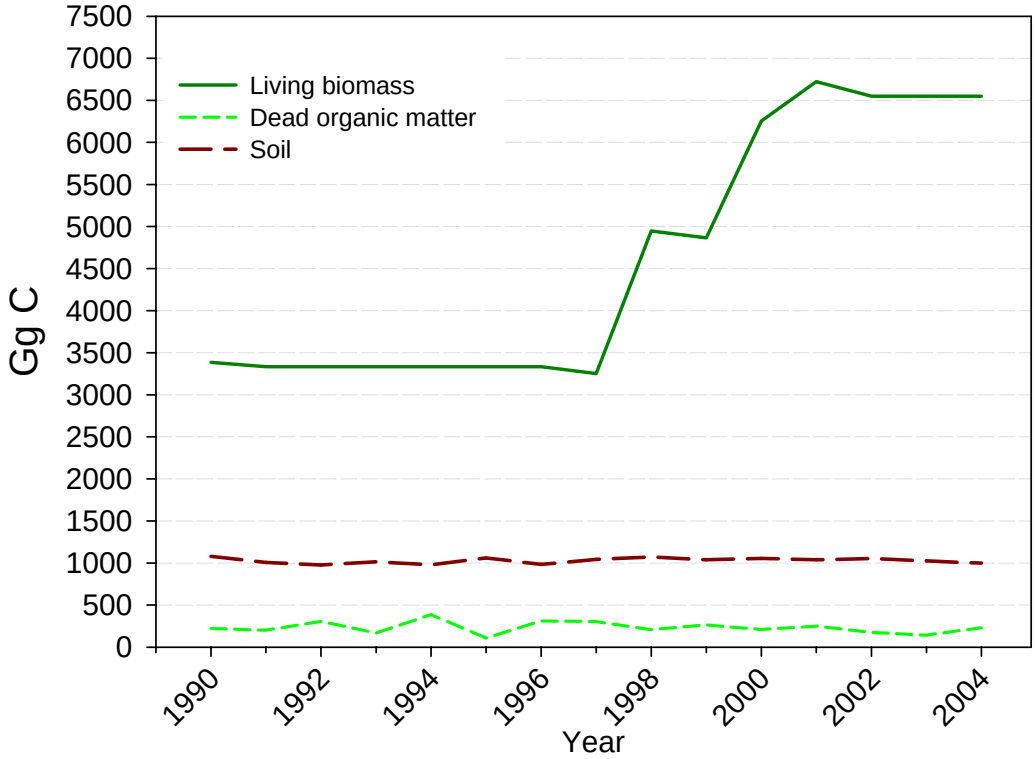


Figure 2.22 Carbon stock changes in forest living biomass, dead wood and soil organic carbon. 1990-2004.

All other land-use categories than forest remaining forest showed net emissions, they were calculated at a total of 2.2 million tonnes CO_2. Of these, the most important category was grassland remaining grassland with total emissions of 1.9 million tonnes of CO_2; while land converted to settlements (deforestation) was the second most important emissions category with 174 kilo tonnes of CO_2.

The total emissions from the land-use category cropland remaining cropland amounted to 43 kilo tonnes CO_2 in 2004. This is an increase by 25 per cent compared to 2003, but a decrease by 77 per cent compared to 1990. Regarding land converted to cropland, there is no recording after 1998 of forest area being converted to cropland.

The total emissions from grassland, including grassland remaining grassland and lands converted to grassland, were estimated at 1 876 kilo tonnes CO_2 in 2004. This is a slight increase from 1990; 0.3 per cent. Emissions from grassland remaining grassland in 2004 were estimated at 1.9 million tonnes of CO_2, which represents 84 per cent of the total emissions from the LULUCF sector that year. The emissions are considered to be constant from 1990 to 2004 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 6 kilo tonnes of CO_2 in 2004. 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 kilo tonnes of CO_2 in each year over the period 1990-2004, 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 174 kilo tonnes of CO_2 in 2004. The figure comprises only conversion from land converted to settlements. The emissions have been stable since 2001, and are 20 per cent lower than in 1990.

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.

CO_2 emissions resulting from liming of lakes and agricultural soils are reported under “Other” in the CRF-tables on LULUCF. These emissions amounted to about 113 kilo tonnes CO_2 in 2004, and increased by 50 % from 1990 to 2004.

2.5. Emission trends for indirect greenhouse gases 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) also has 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 extent included in the inventory.
The trend of these pollutants in Norway during the period 1990-2003 is presented below.

The overall **NO_x emissions** have decreased with approximately 4 per cent from 1990 to 2004. This can primarily be explained by stricter emission regulations with regard to road traffic, which has given a reduction of 47 per cent since 1990. These reductions counteracted increased emissions from oil and gas production (64 percent) and from navigation (17 per cent). The total NO_x emissions did not change from 2003 to 2004.
The **emissions of NMVOC** experienced an increase in the period from 1990 to 2001, mainly because of the rise in oil production. However, the emissions have decreased by 32 per cent from 2001 to 2004, and are now 10% lower than in 1990. This decrease has been achieved through the implementation of measures to increase the recycling of oil vapour offshore at loading and storage terminals.
Emissions of CO have decreased by 44 per cent over the period 1990-2004. This is explained primarily by the implementation of new emissions standards for motor vehicles. SO_2 emissions were reduced by 52 per cent from 1990 to 2004. This can mainly be explained by a reduction in sulphur content of all oil products and lower process emissions from ferroalloy and aluminium production as well as refineries. However, the SO2-emissions have increased slightly since 2002, and are now on the same level as in 2001. The reason for this is increasing emissions from ships and industrial activity over the last three years.

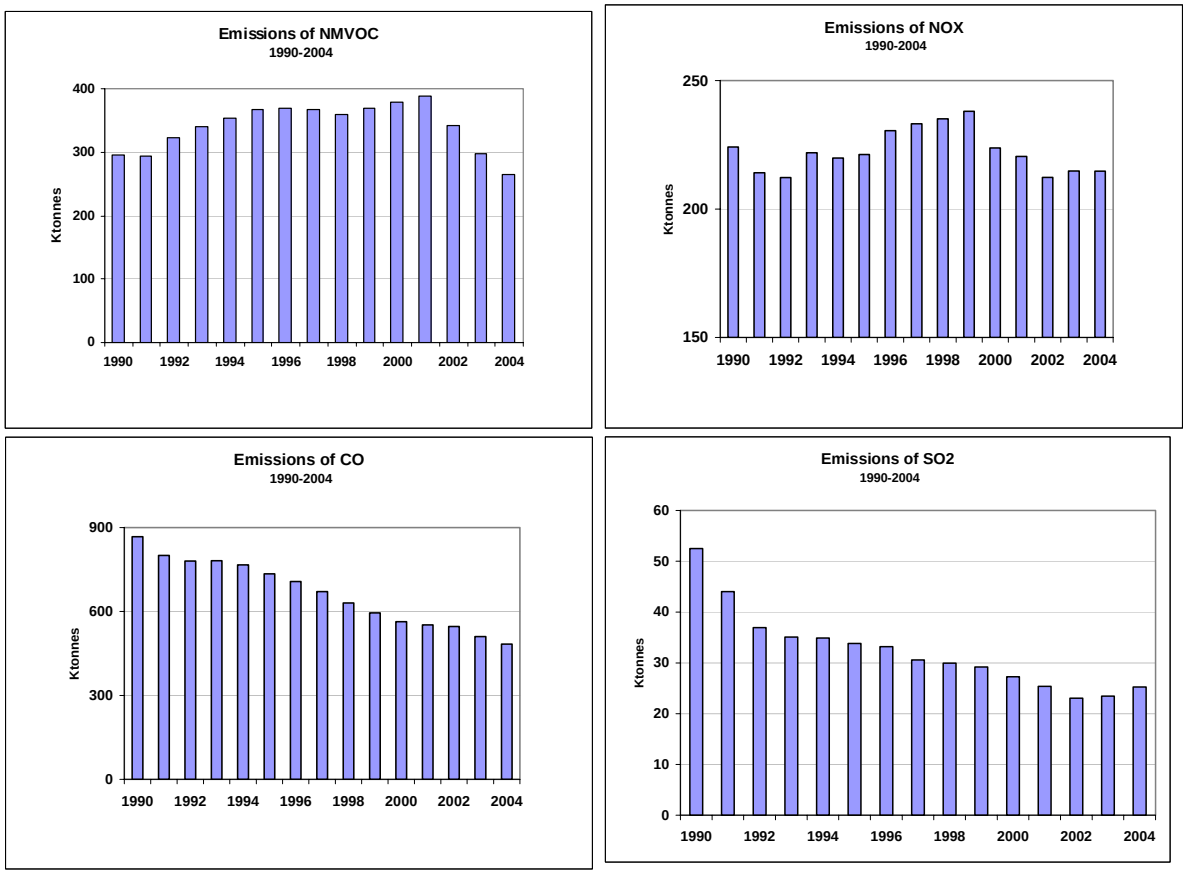


Figure 2.23 Emissions of SO_2. NOx. NMVOC and CO in Norway 1990-2004. Source: SSB/SFT

3. Energy

3.1. Overview

The Energy sector accounts for more than 2/3 of the Norwegian greenhouse gas emissions. In 2004 emissions from this sector contributed 70 per cent to the national GHG total. 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.

Despite the short, temporary emission reductions which took place in the years 1991, 1995, 2000 and 2002, emissions in the energy sector increased by 30 per cent during the period 1990-2004, primarily due to increased activity in the sectors of oil and gas extraction and transport. Total sectoral emissions in 2004 are similar with those of 2003.

Key source categories

As indicated in Section 1.5, the key category analysis performed for the years 2000 and 2004 has revealed that in terms of total level and trend uncertainty the *key categories* in the Energy sector are the following:

- Energy Industries, Gas – CO_2 (1A1)
- Energy Industries, Waste – CO_2 (1A1)
- Manufacturing Industries and Construction, Gas – CO_2 (1A2)
- Manufacturing Industries and Construction, Oil – CO_2 (1A2)
- Civil aviation – CO_2 (1A3a)
- Road Transportation – CO_2 (1A3b)
- Road Transportation – N_2O (1A3b)
- Navigation – CO_2 (1A3d)
- Other Transportation – CO_2 (1A3e)
- Other Sectors, Oil – CO_2 (1A4)
- Other Sectors, Oil – N_2O (1A4)
- Other Sectors, Wood etc. – CH_4 (1A4)
- Fugitive emissions from Oil (incl. oil refineries, gasoline distribution) – CO_2 (1B2a)
- Fugitive emissions from Oil (incl. oil refineries, gasoline distribution) – CH_4 (1B2a)
- Natural gas – CH_4 (1B2b)
- Venting and Flaring – CO_2 (1B2c)
- Venting and Flaring – CH_4 (1B2c)

Coal mining (1B1a) is not found to be a key category in the key category analysis. However, it is here regarded as a key category 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 3.3.

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 Vest. These unique operations are discussed in detail in section 3.5.

Emission allocation
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 3.4. 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.

Mode of presentation
The elaboration of the energy sector in the following starts with a description of emissions from the energy combustion sources (Section 3.2), followed by a description of fugitive emissions (Section 3.3) and a discussion on the capture and storage of CO_2 emissions at the offshore gas-condensate field Sleipner Vest (Section 3.5). Cross-cutting issues are elaborated in Section 3.6 and 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

Finally, the memo items of international bunker fuels and CO_2 emissions from biomass, are addressed in Section 3.7.

In the case of energy combustion, emissions from the individual combustion sources are discussed after a comprehensive presentation of the energy combustion sector as a whole (Section 3.2.1). The purpose for such an arrangement is to avoid repetition of methodological issues which are common among underlying source categories, and to enable easier cross-reference.

3.2. Energy Combustion

3.2.1. Overview

This section describes the calculation of GHG emissions from the combustion of fossil fuels and biomass. All known combustion activities within energy utilization in various industries and private households are included.

The energy combustion sector is dominated by the emissions of CO_2 which contribute about 98 per cent to the total of this sector. The respective contributions of N_2O and CH_4 are about 1 per cent each.

Emissions from energy combustion constituted 65 per cent of the national GHG total in 2004. They increased by 32 per cent between 1990 and 2004, primarily due to activity growth in energy industries and transport. The total emission level in 2004 remained similar to that of 2003.

This sector hosts twelve key source categories. They, along with the non-key source categories, are presented in detail in the following.

3.2.1.1. Methodological issues

Emissions from 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 method to estimate emissions from fuel combustion is multiplication of fuel consumption by source and sector by an appropriate emission factor. Exceptions are road and air transport where more detailed estimation models are used, involving additional activity data (see sections 3.2.5 and 3.2.4. respectively). Fuel consumption figures are taken from the Norwegian energy accounts. The mean theoretical energy content of fuels and their density are listed in table 3.1.

*Table 3.1. Average energy content and density of fuels**

Energy commodity	**Theoretical energy content**	**Density**
Coal	28.1 GJ/tonne	..
Coal coke	28.5 GJ/tonne	..
Petrol coke	35.0 GJ/tonne	..
Crude oil	42.3 GJ/tonne = 36.0 GJ/m^3	0.85 tonne/m^3
Refinery gas	48.6 GJ/tonne	..
Natural gas (2004)[1]	40.1 GJ/1000 Sm^3	0.85 kg/Sm^3
Liquefied propane and butane (LPG)	46.1 GJ/tonne = 24.4 GJ/m^3	0.53 tonne/m^3
Fuel gas	50.0 GJ/tonne	..
Petrol	43.9 GJ/tonne = 32.5 GJ/m^3	0.74 tonne/m^3
Kerosene	43.1 GJ/tonne = 34.9 GJ/m^3	0.81 tonne/m^3
Diesel oil, gas oil and light fuel oil	43.1 GJ/tonne = 36.2 GJ/m^3	0.84 tonne/m^3
Heavy distillate	43.1 GJ/tonne = 37.9 GJ/m^3	0.88 tonne/m^3
Heavy fuel oil	40.6 GJ/tonne = 39.8 GJ/m^3	0.98 tonne/m^3
Methane	50.2 GJ/tonne	..
Wood	16.8 GJ/tonne = 8.4 GJ/solid m^3	0.5 tonne/solid m^3
Wood waste (dry wt)	16.25-18 GJ/tonne	..
Black liquor (dry wt)	7.2-9.2 GJ/tonne	..
Waste	10.5 GJ/tonne	..

* The theoretical energy content of a particular energy commodity may vary; Figures indicate mean values.
[1] Sm^3 = standard cubic metre (at 15 °C and 1 atmospheric pressure).
Source: Energy statistics, Statistics Norway.

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 energy use 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 inventory for the different sectors is given in table 3.2 for the greenhouse gases CO_2, CH_4 and N_2O.

Table 3.2. Overview of estimated and reported greenhouse gases CO_2, CH_4 and N_2O for energy combustion activities

	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/R	E	E
b. Non-Ferrous Metals	E	E	E
c. Chemicals	E/R	E	E
d. Pulp, Paper and Print	E/R	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 (SSBow 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

R means that emission figures in the national emission inventory are based on figures reported by the plants; reported figures are by and large available for all years in the period 1990-2004. E means that the figures are estimated by Statistics Norway (Activity data * emission factor).

In the last years three documentation reports have been published describing the methodologies used for road traffic (SFT 1999c), aviation (Finstad et al. 2002b) and navigation (Tornsjø 2001).

3.2.1.2. Activity data

The energy consumption data used in the emission calculations are, with few exceptions, taken from the annual energy accounts compiled by Statistics Norway. The energy accounts survey the flow of the different energy carriers within Norwegian economic activities. These 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 Norwegian 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 amounts used of the main groups of energy carriers and the distribution between emission sources is given below, after an explanation of the difference between energy accounts and the energy balance sheets. The latter are presented in Annex IV of this report.

Energy balance sheets vs. energy accounts

There are two different ways of presenting energy balances: The energy tables presented in Annex IV are based on the energy *balance sheet*, whereas the energy figures used in the emission calculations are based on the energy *accounts*. The energy accounts follow the energy consumption in Norwegian economic activity in the same way as the National accounts. All the energy used by Norwegian enterprises and households is to be included. Energy used by Norwegian transport trades and tourists' abroad is also included, while the energy used by foreign transport industries and tourists in Norway is excluded.

The energy sources balance sheet follows the flow of energy within Norway. This means that the figures only include energy sold in Norway, regardless of the users' nationality. This includes different figures between the energy sources balance sheet and the energy account, especially for international shipping and for aviation.

The energy sources balance sheet has a separate item for energy sources consumed for transportation purposes. The energy accounts place the consumption of all energy under the relevant consumer sector, regardless of whether the consumption refers to transportation, heating or processing.

Figures from the energy sources balance sheet are reported to international organisations such as the OECD and the UN. The energy balance sheet will therefore usually be comparable with international energy statistics.

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 by 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.

Oil products

Total use of the different oil products is based on Statistics Norway's annual sales statistics for petroleum products. The data are considered very reliable since all major oil companies selling oil products have interest in and report to these statistics[3]. 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. The method used for oil products defines use as identical to sales; in practice, there will be annual changes in consumer stocks, which are not accounted for.

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. Mobile combustion is distributed among different sources, described in more detail under the transport sector (Sections 3.2.4-3.2.8). In addition to oil products included in the sales statistics, figures on use of waste oil are given in Statistics Norway's industry statistics. Statistics Norway also collects additional information directly from a few companies about the use of waste oil as a fuel source.

Coal

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 are 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 has formerly been collected from the farmers. Since 2002, there has been no use of coal in Norwegian agriculture.

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. The survey figures refer to quantities *acquired*, which not necessarily correspond to *use*. The survey gathers monthly data that cover the preceding twelve months; the figure used in the emission calculations (taken from the energy accounts), is the average of the survey figures from the year in question and the following year. 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.

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

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.

According to the Norwegian Pollution Act, each incineration plant has to report emission data for SO_2, NO_X, CO, NH_3, particles, heavy metals and dioxins, 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. Normally a plant specific emission factor is made for the component in question. This factor is based on the ratio between previous emission figures and quantities of waste burned. This factor is then multiplied with the amount of waste incinerated that specific year.

3.2.1.3. 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).

For CH_4 and N_2O, information on emission factors is generally very limited, because, unlike the CO_2 emission factors, they depend on the source of the emissions and the sector where the emissions take place. The emission inventory uses mostly default factors from 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 emission factors used in the absence of more specific ones are hereafter addressed as *general.*

The general emission factors for CO_2 used in the emission inventory are listed in table 3.3, followed by a more detailed description of the factors used for offshore operations and gas terminals.

Table 3.3. General emission factors for CO_2

	CO_2 tonne/tonne
Coal	2.52
Coke	3.19
Petrol coke	3.59
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
Natural gas (1000 Sm^3)	2.34[1]
LPG	3
Refinery gas	2.8
Blast furnace gas	1.571
Fuel gas	2.5
Landfill gas	0
Fuel wood	(1.8)[2]
Wood waste	(1.8)[2]
Black liquor	(1.8)[2]
Municipal waste	0.251
Special waste	3.2

[1] The emission factor for natural gas used in the emission inventory varies as indicated in Tables 3.4 and 3.5.
[2] Non-fossil emissions, not included in the inventory.

Source: Norwegian Petroleum Industry Association, Rosland (1987), SFT (1990), SFT (1996), Finstad et al. (2001) and Finstad et al. (2003).

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 and 2004 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 3.4 displays the time series of such emission factors, expressed as averages.

Table 3.4 Average emission factors of CO_2 from the combustion of natural gas at offshore oil fields.

	Gas turbines offshore kg CO_2/Sm^3 gas burned
1990-1994	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

For the years after 2002 reported emissions are used
Source: SFT/NPD

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 3.5. 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 3.2.1).

Table 3.5 Average emission factor for CO_2 from the combustion of gas at one gas terminal.

	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

Source: SFT

The general CH_4 and N_2O emission factors used in the emission inventory for this source are listed in Tables 3.6 and 3.8, respectively. Tables 3.7 and 3.9 display the cases where emission factors other than the general ones were used in the calculations.

Table 3.6 General emission factors for CH_4, stationary combustion. Unit: kg CH_4/tonne fuel

Source	Direct-fired furnaces	Gas turbines	Boilers	Small stoves	Flares
Coal	0.028	-	**0.28**	8.4	-
Coke	0	-	0.28	8.4	-
Petrol coke	0	-	0.28	-	-
Charcoal	-	-	-	8.4	-
Kerosene (heating)	-	-	0.17	0.3	-
Marine gas oil/diesel	0.016	0	**0.4**	-	-
Light fuel oils	-	-	**0.4**	0.4	-
Heavy distillate	0.04	-	**0.4**	0.4	-
Heavy fuel oil	0.04	-	**0.4**	-	-
Natural gas (1000 Sm^3)	**0.05**	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
Fuel gas	**0.05**	-	0.24	-	-
LPG	-	-	0.17	0.24	-
Fuel wood	-	-	-	5.3	-
Wood waste	-	-	0.25	-	-
Black liquor	-	-	0.25	-	-
Wood pellets	-	-	0.25	5.3	-
Wood briquettes	-	-	0.25	-	-
Municipal waste	-	-	0.23	-	-
Special waste	0.04	-	**0.4**	-	-

Numbers in bold have exceptions for some sectors, see Table 3.7.
Source: IPCC (1997b), SFT (1996), SINTEF (1995) and OLF (1994).

Table 3.7Exceptions 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 and synthetic rubber in primary forms, manufacture of other organic basic materials
0.03	Coal	Boilers	Coal mining Extraction of crude petroleum and natural gas Oil refineries Gas terminals 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 crude petroleum and natural gas Oil refineries Gas terminals Production and distribution of electricity

Table 3.8 General emission factors for N_2O, stationary combustion. Unit: kg N_2O/tonne fuel

Source	Direct-fired furnaces	Gas turbines	Boilers	Small stoves	Flares
Coal	0	-	0.04	0.04	-
Coke	0	-	0.04	0.04	-
Petrol coke	0	-	0.04	-	-
Charcoal	-	-	0.07	-	-
Kerosene (heating)	-	-	0.03	0.03	-
Marine gas oil/diesel	0.03	0.024	0.03	-	-
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	-	**0.02**
Refinery gas	0.024	-	0.005	-	0.024
Blast furnace gas	0.024	-	0.005	-	-
Landfill gas	0.024	-	0.005	-	0.002
Fuel gas	0.024	-	0.005	-	-
LPG	-	-	0.03	0.03	-
Fuel wood	-	-	-	0.032	-
Wood waste	-	-	0.005	-	-
Black liquor	-	-	0.005	-	-
Wood pellets	-	-	0.07	0.032	-
Wood briquettes	-	-	0.07	-	-
Municipal waste	-	-	0.035	-	-
Special waste	0.03	-	0.03	-	-

Numbers in bold have exceptions for some sectors, see Table 3.9.
Source: IPCC (1997b), SFT (1996) and OLF (1994).

Table 3.9Exceptions 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

3.2.1.4. Uncertainties

Uncertainty estimates for greenhouse gases are presented and discussed in Annex II, as well as under the individual underlying source categories described in the following.

In general, 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 it is more uncertain in households and the service sectors. 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.

3.2.1.5. Source specific QA/QC and verification

The emission sources in the energy sector are subjected to the QA/QC procedures described in section 1.6. In the last years three documentation reports have been published describing the methodologies used for road traffic (SFT 1999c), aviation (Finstad et al. 2002b) and navigation (Tornsjø 2001).

3.2.1.6. Recalculations

The various recalculations performed in the energy sector cover several source categories and are elaborated in the following.

It can, more specifically, be noted here that in the case of the energy combustion activities in 2003, most of the recalculations were due to the fact that the 2003 the energy accounts that served as the basis for last year's submission were preliminary. Final figures for the energy accounts are now available, as final energy consumption figures from the manufacturing statistics and some other final energy figures are now included in the energy accounts. This type of energy balance-related revisions is not commented specifically under each IPCC code.

3.2.1.7. Planned improvements

There are no concrete plans for further improvements in the activities related to energy combustion at the moment.

3.2.2. Energy industries (CRF source category 1A1)

3.2.2.1. Description

Energy industries include emissions from electricity and heat generation and distribution, extraction of oil and natural gas, coal production, gas terminals and oil refineries. Norway produces electricity mainly from hydropower, so emissions from electricity production are small compared to most other countries. Due to the large production of oil and gas, the emissions from combustion in energy production are high.

Emissions from the energy industries accounted for 22.8 per cent of the total GHG emissions in Norway in 2004. The increase that took place during the period 1990-2004 is as high as 86.6 per cent and is attributed primarily to the increased activity in the oil and gas extraction sector. Emissions in 2004 are 0.8 per cent higher than those of 2003.

The two key source categories that are found to reside in the energy industries sector are:

- Emissions of CO_2 from the combustion of gas, which in 2004 contributed ± 7.98 per cent and ± 11.14 per cent to the total level and trend uncertainty, respectively.
- Emissions of CO_2 from the combustion of waste, which in 2004 contributed ± 0.51 per cent and ± 0.69 per cent to the total level and trend uncertainty, respectively.

3.2.2.2. Methodological issues

A description of the method used for estimation of emissions from fuel combustion is given in Section 3.2.1.1. In the case of waste incineration, further specifications on the methodology are given below.

Waste incineration – CO_2 and CH_4
Net CO_2 emissions from wood/ biomass burning are not considered in the Norwegian inventory, because the amount of CO_2 released during burning is the same as that absorbed by the plant during growth. Carbon emitted in compounds other than CO_2, e.g. as CO, CH_4 and NMVOC, is also included in the CO_2 emission estimates. This double counting of carbon is in accordance with the IPCC guidelines (IPCC 1997b).

Waste incineration – N_2O and NO_X
Emissions of NO_X are reported from each plant to the Norwegian Pollution Control Authority. An estimated amount of 2.5 per cent of this NO_X is subtracted and reported to UNFCCC as N_2O (SFT 1996). Accordingly, the net NO_X emissions constitute 97.5 per cent of the emissions reported by the plants. For some years, emissions of NO_x have not been reported for a number of plants. In these cases, specific emission factors for the plants have been made, based upon earlier emissions and amounts of waste incinerated. These new factors have been used to estimate the missing figures.

3.2.2.3. Activity data

Electricity and heat generation and distribution
The energy producers annually report their use of different energy carriers to Statistics Norway. There is only some minor use of oil products at plants producing electricity from hydropower. Combustion of coal at Norway's only dual purpose power plant at Svalbard/Spitsbergen is of a somewhat larger size. The amount of waste combusted at district heating plants is reported annually both to Statistics Norway and the Norwegian Pollution Control Authority. The data are considered to be of high quality.

Extraction of oil and natural gas
Production of oil and natural gas is the dominating sector for emissions from combustion in the energy industries in Norway. The Norwegian Petroleum Directorate annually reports the amounts of gas combusted in turbines and 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. These activity data are used for 1990-2002. From 2003 onwards, reported emission figures from the field operators are used.

Coal production
Norway's coal production takes place on Svalbard. The only coal producing company annually reports its coal consumption and some minor use of oil products. In addition to emissions related to Norway's own coal production, also emissions from Russian activities are included in the Norwegian emission inventory. Russian activity data are scarce, and emissions from an estimated quantity of coal combusted in Russian power plants are calculated. Since 1999 there has been only one such plant, in earlier years there were two of those.

Gas terminals
Norway has two gas terminals, where natural gas from the Norwegian continental shelf is landed, treated and distributed. Annual figures on natural gas combusted in turbines and flared

are reported to the Norwegian Petroleum Directorate (figures on flaring at one plant is reported to the Norwegian Pollution Control Authority).

Oil refineries
The oil refineries annually report their use of different energy carriers to Statistics Norway. Refinery gas is most important, but there is also some use of LPG and oil products.

3.2.2.4. Emission factors

The emission factors used for the energy industries are those presented in Section 3.2.1.3. For some industries and components more information about the derivation of the emission factors is given below.

Waste incineration
The emission factors for combustion of waste (fossil part only) for CO_2 and CH_4 have been calculated by SFT (1996).

Extraction of oil and natural gas
The CO_2 emission factor for gas combustion offshore used for all years leading up to 1998 and for all fields except one, is an average factor based upon a survey carried out in the early 1990's (OLF 1993, 1994). From 1999 onwards the emission factors employed reflect increasingly field specific conditions.

3.2.2.5. Uncertainties

The uncertainty analysis performed (Annex II) has shown that for the energy industries the uncertainty in the activity data is ± 3 per cent of the mean for oil, ± 4 per cent for gas and ± 5 per cent of the mean for coal/coke and waste.

In the case of the emission factors for CO_2, the uncertainty is ±3 per cent of the mean for oil, ±7 per cent for coal/coke and gas and ± 30 per cent of the mean for waste.

Emission factors for CH_4 and N_2O are very uncertain. Distributions are strongly skewed with uncertainties which lie below and above the mean by a factor of 2 and 3, respectively.

3.2.2.6. Source specific QA/QC and verification

The energy industries are subjected to the general QA/QC procedures described in Section 1.6. Some source specific QA/QC activities were conducted in the following industries:

Extraction of oil and natural gas
From 2003 onwards field specific emission figures reported from the companies are used directly in the emission model. These figures are compared with emissions calculated on the basis of field specific activity data and emission factors.

Oil refineries
The CO_2 emissions reported from the refineries are compared with the emissions estimated by Statistics Norway on the basis of activity data and emission factors for the different energy carriers used.

Results from the above studies have so far shown that emission estimates are in agreement with the reported figures.

3.2.2.7. Recalculations

Public Electricity and Heat Production (1A1a)

- Emissions from Russian activity at Spitzbergen are included for the first time. This leads to increased combustion emissions for all years. Emission of CO_2 is increased by 151 000 tonnes in 1990 and by 76 000 tonnes in 2003. For CH_4 and N_2O the changes are minor.
- A part of the black liquor used at one pulp and paper plant has been used for electricity production since 1990. This was earlier estimated as emissions from combustion in pulp and paper industry.
- The amount of waste burned is revised for some plants for 2003, as well as for some other plants for the years 1989-1995 and 2003.
- Emission of CO_2 from combustion of landfill gas for energy purposes is excluded from the inventory, since carbon is now defined as being of biogenic origin. This was also recommended under the review of the 2005 emission inventory submission.

Petroleum refining (1A1b)

- Emissions of CO_2, CH_4 and N_2O from all oil refineries for all years are recalculated as a result of the quality control performed by SFT (see Annex III for further information). Emission figures reported by the plants to SFT are now included in the inventory for the whole time series and have replaced emission figures calculated by the inventory team based on activity data and emission factors. These changes have led to a minor decrease in the emissions of CO_2 for the whole time series. Emissions of CH_4 have increased for the years 1990 to 1999. This is caused by the higher emissions from flaring at one oil refinery. Emissions of N_2O have also increased for the years 1990 to 1999.
- Small changes have been made in the amount of refinery gas and CO-gas burned in 1990 and 2003 at two plants. This has resulted in minor revisions for CO_2.

Manufacture of Solid Fuels and Other Energy Industries (1A1c)

- Reported emissions of CH_4 to SFT from one of Norway's two gas terminals for the years 1990 to 2004, and from the other one for the years 1996 to 2004 have now replaced emissions estimated earlier by Statistcs Norway. These changes have decreased the emissions of CH_4 for the whole time series.
- The natural gas used at one plant was previously assumed to be combusted in a gas turbin. This was a mistake, since the gas is consumed in boilers. Since emission factors for CH_4 differ from turbine to boiler, there have been recalculations for both distribution turbine/boiler for reported figures and for the calculated figures. In addition, there have been revisions in reported figures for some years since 1996.
- There are made small changes in the amount of natural gas burned in 1995-1997 at two plants.
- Emission figures for CO_2 and CH_4 from combustion at one oil refinery have been revised for the period 1999-2003.

3.2.2.8. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.3. Manufacturing industries and construction (CRF source category 1A2)

3.2.3.1. Description

Emissions form the sector of manufacturing industries and construction include industrial emissions originating to a large extent from the production of raw materials and semi-manufactured goods (e.g. alloys, petrochemicals, paper and minerals). These emissions are related to fuel combustion only, that is, emissions from use of oil or gas for heating purposes. Consumption of coal as feedstock and reduction medium is not included in this sector, but it is accounted for under the industrial processes sector.

Emissions from this sector contributed 7.1 per cent to the national GHG total in 2004. During the period 1990-2004, there has been an increase of 5.4 per cent, primarily due to increased activity in the petrochemical industry (including the start up of a new methanol production plant) and the pulp and paper industry. Between 2003 and 2004 a 7.1 per cent decrease is recorded. This is mainly attributed to the substitution of oil with electricity in several industrial sectors, which led subsequently to small reductions in energy related emissions.

The two key source categories that are found to reside in this sector are:

- Emissions of CO_2 from the combustion of gas, which in 2004 contributed ± 1.48 per cent and ± 1.82 per cent to the total level and trend uncertainty, respectively.
- Emissions of CO_2 from the combustion of oil, which in 2004 contributed ± 0.61 per cent and ± 0.97 per cent to the total level and trend uncertainty, respectively.

3.2.3.2. Activity data

Most of the emission figures are calculated on the basis of activity data and emission factors. For a few plants the emission figures are based on reported figures from the plants.

Statistics Norway carries out annual surveys on energy use in manufacturing industries, which supply most of the data material for the calculation of combustion emissions in these sectors. The energy use survey covers 90 per cent of the energy use in this sector. For the remaining companies, figures are estimated based on 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. A change in methodology from 1998 has had minor consequences for the time series, since the energy use is mainly concentrated to a few major plants within the industry, from which data were collected 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 are partly projected from earlier surveys; the energy data are considered rather uncertain.

In some sectors auto diesel is mainly used in machinery and off-road vehicles, particularly in mining and construction. A special survey was undertaken to estimate the fraction used for off-road purposes in these sectors. The methods for calculating emissions are discussed in section 3.2.8. Emissions from off-road machinery in industry are currently reported under the CRF source category 1A3e – *Other Transportation*. According to the guidelines, they should be included under the source category 1A2.

3.2.3.3. Emission factor

The emission factors used in this source category are those presented in Section 3.2.1.3.

3.2.3.4. Uncertainties

Uncertainties in the activity data and the emission factors in the manufacturing industries and construction are as presented in Section 3.2.2.5. A more detailed description is presented Annex II.

3.2.3.5. Source specific QA/QC and verification

There is no specific QA/QC procedure for this source category. For a description of the general QA/QC procedure, see Section 1.6.

3.2.3.6. Recalculations

Chemicals (1A2c)
Emissions of CO_2 are reported to SFT from one plant in the sector manufacture of fertilizers, nitrogen compounds and pesticides for the years 1990 to 2004. These figures replace emission figures calculated by the inventory team used in previous submissions. These changes have led to increased emissions of CO_2 for all years. Reported emissions of CO_2 from plants to SFT in the sectors manufacture of plastic and synthetic rubber in primary forms and manufacture of other organic basic chemicals, have replaced emissions estimated by Statistics Norway. Two plants have reported figures for the years 1990 to 2004, one plant has reported figures from 1992 to 2004, one plant for 1997 to 2004 and another plant from 2001 to 2004. These changes have increased the emissions of CO_2 for the whole time series.

Pulp, paper and print (1A d)
- Emission figures reported by plants to SFT have replaced emissions estimated by Statistcs Norway. CO_2 and CH_4 figures have been reported from 9 plants for the years 1990 to 2004. One plant has reported figures from 1991 to 2004. These changes have increased the emissions of CO_2 for the period 1992 to 1994. For the other years, changes are small. Emissions of CH_4 have decreased for all years due to these changes.
- Reported emissions of N_2O from plants to SFT have replaced emissions estimated by Statistcs Norway. Figures for the years 1990 to 2004 have been reported for 8 plants. These changes have decreased the emissions of N_2O in most years.
- There have been revisions in industry statistics for wood waste for some years. In addition the average energy content in wood has been changed from 16.8 to 16.25 GJ/tonnes. The energy content is used when converting figures in the energy accounts from toe (tonnes oil equivalents) to tonnes, which is used in the emission inventory. This change in the energy content has resulted in higher amounts of wood for all years.

- There have been revisions in industry statistics for black liquor for some years. In addition the average energy content in black liquor has been changed from 14 to 9.2 and 7.2 GJ/tonnes. The energy content is used when converting figures in the energy accounts from toe (tonnes oil equivalents) to tonnes, which is used in the emission inventory. A part of the black liquor used at one plant has been used for electricity production since 1990. This part is now removed from combustion in pulp and paper industry.
- Burning of waste. For one plant, we have earlier used the conversion factor for wood waste instead of the conversion factor for waste when converting the energy unit PJ to tonnes for the years 1998-2003. (In the emission inventory we us the unit tonnes when estimating emissions). This revision has led to minor revisions for CO_2, CH_4 and N_2O.

Other (1A2f)

- Emission figures for CO_2 from two cement-producing plants have been revised to account for data reported by these plants to SFT. Figures are reported for all years since 1990. Previous calculations were based on emission factor and activity data.
- CO_2 emissions are reported to SFT for one plant in the sector of manufacture of cement, lime and plaster; these emissions are now included in the inventory. Figures are reported for all years since 1990.
- Combustion of waste oil in asphalt production was earlier assumed to be combusted in boilers, but is now assumed to be combusted in direct fired furnaces. Use of different emission factors for CH_4 and N_2O has also led to minor changes in the respective emissions.
- Burning of waste. For cement production , we have earlier used the conversion factor for wood waste instead of the conversion factor for waste when converting the energy unit PJ to tonnes for the years 1998-2003. (In the emission inventory we us the unit tonnes when estimating emissions). This revision has led to minor revisions for CO_2, CH_4 and N_2O.

3.2.3.7. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.4. Transport – Civil Aviation (CRF source category 1A3a)

3.2.4.1. Description

Emissions of CO_2 from civil aviation accounted for about 2 per cent of the total Norwegian CO_2 emissions in 2004. National emissions from civil aviation have increased by 40 per cent from 1990 to 2004. Although reduction in the number of flights resulted in an emission decline of 14 per cent from 2001 to 2002, an increase of 4.5 per cent is now detected between 2002 and 2003 due to activity growth. In 2004 emission levels remained similar to those of 2003.

Civil aviation is a key source category with respect to CO_2 emissions. The contribution of this key category to the total level and trend uncertainty in 2004 is found to be ± 1.80 per cent and ± 1.23 per cent, respectively.

Aviation is a minor emission source of CH_4 and N_2O in Norway (less than 0.01 per cent of their respective totals in 2004).

3.2.4.2. Methodological issues

The calculation methodology applied is described in Finstad et al. (2002b). 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 3.6.1.3).

3.2.4.3. Activity data

Statistics Norway annually collects data on use of fuel from the air traffic companies. 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 the minor use of aviation petrol.

3.2.4.4. Emission factors

The emission factors used in the emission inventory for civil aviation are presented in Tables 3.10-3.11.

The Norwegian Petroleum Industry Association provides emission factors for CO_2 for the combustion of jet fuel and gasoline (Finstad et al. 2002b). The CO_2 emission factor used for aviation gasoline is 3.13 tonnes CO_2/tonne fuel and has been applied to all small aircraft. All other aircraft use jet fuel (kerosene) with an emission factor of 3.15 tonnes CO_2/tonne fuel.

For N_2O a default emission factor is used for all aircraft (IPCC 2001) and is valid for both LTO and the cruise phase. 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 is emitted during the cruise phase. No methane is therefore calculated for the cruise phase and all emissions are assumed to be VOC (HC). The VOC emission factors are aircraft specific as given in EEA (2001).

Only aggregated emission factors (kg/tonnes fuel used) are used in the Norwegian inventory. The emission factors are calculated based on total emission divided by activity data for LTO and in the cruise phase, respectively.

Recalculations have been done based on the new methodology (EEA 2001 and Finstad et al. 2002b) and this led to a change in emission factors for previous years. New emission factors back to 1980 have therefore been used in the inventory. Emission factors were calculated with

activity data for 1989, 1995, and 2000. Factors for the years 1990-1994 and 1996-1999 were interpolated. Factors before 1989 and after 2000 were kept constant.

Emission factors for small aircraft are the same for the whole period.

Table 3.10 General emission factors for aviation.
Unit: CO_2: tonne/tonne fuel, CH_4 and N_2O: kg/tonne fuel.

	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		0.1854 [1]	0.1
LTO (100-1000 m)		3.15		0.0304 [1]	0.1
Cruise (Above 1000)		3.15		0	0.1
Foreign					
LTO (0-100 m)		3.15			0.1
LTO (100-1000 m)		3.15			0.1
Cruise (Above 1000)		3.15			0.1
Helicopters					
LTO (0-100 m)		3.15		3.2 [1]	0.1
LTO (100-1000 m)		3.15		3.2 [1]	0.1
Cruise (Above 1000)		3.15		0	0.1
Small aircraft					
LTO (0-100 m)	3.13		3.61		0.1
LTO (100-1000 m)	3.13		1.55		0.1
Cruise (Above 1000)	3.13		0	-	0.1

[1] Jet kerosene used on aircraft in the Defence Air Forces has an emission factor of 0.35 kg CH_4/tonne.
Source: IPCC (2001) and Finstad et. al (2002)

Table 3.11 Time series of variable CH_4 emission factors from the combustion of jet kerosene in aviation (Factors for 1989, 1995 and 2000 are estimated as given in the table. Factors for 1990-1994 and 1996-1999 are calculated by linear interpolation. Factors before 1989 and after 2000 are kept constant).

		CH_4 Emission Factor (kg/tonne fuel)		
Sector	**Source**	**1989**	**1995**	**2000**
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

3.2.4.5. Uncertainties

Activity data: 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 (Rypdal and Zhang 2000). In a recent study on emissions from aircraft (Finstad et al. 2002b), fuel consumption was also estimated bottom-up and compared to the reported figures (see also Section 3.2.4.6). 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.

Emission factors: The uncertainty in the CO_2 emission factors is ±3 per cent. The uncertainty in the emission factors for CH_4 and N_2O lies below and above the mean by a factor of 2 and 3, respectively.

3.2.4.6. Source specific QA/QC and verification

In 2002 a methodology improvement was made in the emission calculations for civil aviation (Finstad et al. 2002b). 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).

3.2.4.7. Recalculations

Recalculations have been done as recommended by the review team under the 2005 review. Emission factors for CH_4, NO_x, NMVOC and CO are calculated based on activity data for 1989, 1995, and 2000. Factors for the years 1990-1994 and 1996-1999 were interpolated. Emission factors for the years before 1989 and after 2000 were kept constant.

3.2.4.8. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.5. Transport – Road Transportation (CRF source category 1A3b)

Road traffic accounts for more than 2/3 of the total mobile emissions. Emissions from road transportation accounted for 18.2 per cent of the national GHG total in 2004. During the period 1990-2004 an increase of 27.4 per cent took place due to activity growth. Between 2003 and 2004 emissions increased by 4.2 per cent.

Two key source categories are found in this source category:

- Emissions of CO_2, which in 2004 contributed ± 9.82 per cent and ±4.35 per cent to the total level and trend uncertainty, respectively.
- Emissions of N_2O, which in 2004 contributed ± 1.65 per cent and ± 3.76 per cent to the total level and trend uncertainty, respectively.

3.2.5.1. 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 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 (3.1) and (3.2) below:

$$(3.1) \quad Q_{jk} = M_k \sum_i \left(p_{ijk} \cdot \frac{l_{jk}}{\overline{l_k}} \cdot \left(\frac{T_{ik}}{T_k} \right) \right)$$

or

$$(3.2) \quad Q_{jk} = M_k \sum_i \left(q_{ijk} \cdot \frac{1}{\overline{l_k}} \cdot \left(\frac{T_{ik}}{T_k} \right) \right)$$

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

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).

$$(3.3) \quad l_k = \sum_k l_{ik} \cdot \left(\frac{T_{ik}}{T_k} \right)$$

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 model, excluding heavy metals and POPs
- Vehicle categories: there are 10 classes, which are different combinations of vehicle type, weight, and fuel, see Table 3.12.
- Vehicle age (0-29 and 30+ years, 31 age classes in all)
- Driving mode: Five modes are considered, namely:

Driving mode	Speed limit
Urban	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 Section 3.2.5.3.

Table 3.12 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.

3.2.5.2. 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, motorized 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 made.

- 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 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.

3.2.5.3. 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.

In addition, N_2O factors were revised in 2005, based primarily on Gense & Vermeulen (2002), Riemersma *et al.* (2003), EPA (2004) and TØI (2005).

The emission factors for CO_2 used in the emission inventory are based on the carbon content of the fuel and are presented in Table 3.3. For N_2O and CH_4 the emission factors employed are listed in Tables 3.13-3.15.

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.

Table 3.13.General emission factors for road traffic

Source	Fuel	CH_4 kg/tonne	N_2O kg/tonne
Passenger cars	Motor gasoline	***1.10347***	***0.283336***
	Auto diesel	***0.04916***	***0.07053***
	Natural gas	0.261	0.0255
	LPG	0.195	0.213
Other light duty cars	Motor gasoline	***0.60836***	***0.14506***
	Auto diesel	***0.059232***	***0.043034***
Heavy duty vehicles	Motor gasoline	***0.885825***	***0.044741***
	Auto diesel	***0.10441***	***0.126303***
	Natural gas	4.29	0.0255
Mopeds	Motor gasoline	***5.854736***	***0.058547***
Motorcycles	Motor gasoline	***4.938901***	***0.051511***

Bold numbers in italics are different for different years; Table figures refer only to 2004.
Source: SFT (1999c), Bang (1993), Finstad et al. (2001), Gense & Vermeulen (2002), Riemersma et al. (2003), EPA (2004) and TØI (2005).

Table 3.14 Average N_2O emission factors from road traffic including cold start emissions and evaporation. Unit: g/kg fuel.

	Gasoline					**Autodiesel**		
Vehicle type	**Passenger cars**	**Other light duty**	**Heavy duty**	**Mopeds**	**Motorcycles**	**Passenger cars**	**Other light duty**	**Heavy duty**
1973	0.024	0.017	0.031	0.059	0.061	0.038	0.025	0.146
1980	0.026	0.018	0.032	0.058	0.058	0.037	0.025	0.136
1986	0.029	0.020	0.034	0.059	0.054	0.038	0.025	0.127
1987	0.030	0.020	0.036	0.059	0.054	0.037	0.025	0.128
1989	0.036	0.020	0.039	0.059	0.053	0.037	0.025	0.128
1990	0.049	0.020	0.041	0.059	0.052	0.037	0.025	0.128
1991	0.062	0.020	0.042	0.059	0.052	0.037	0.025	0.128
1992	0.071	0.023	0.043	0.059	0.052	0.038	0.025	0.128
1993	0.087	0.030	0.044	0.059	0.052	0.039	0.025	0.130
1994	0.107	0.040	0.045	0.059	0.051	0.039	0.025	0.128
1995	0.132	0.053	0.045	0.059	0.051	0.040	0.026	0.131
1996	0.161	0.069	0.045	0.059	0.051	0.041	0.026	0.131
1997	0.188	0.086	0.045	0.059	0.051	0.042	0.026	0.133
1998	0.207	0.100	0.045	0.059	0.051	0.044	0.027	0.129
1999	0.228	0.112	0.045	0.059	0.051	0.046	0.028	0.126
2000	0.250	0.125	0.044	0.059	0.051	0.047	0.029	0.126
2001	0.262	0.133	0.044	0.059	0.051	0.052	0.032	0.126
2002	0.273	0.138	0.044	0.059	0.051	0.058	0.036	0.126
2003	0.280	0.143	0.044	0.059	0.051	0.064	0.039	0.126
2004	0.283	0.145	0.045	0.059	0.052	0.071	0.043	0.126
2005	0.286	0.148	0.045	0.059	0.052	0.077	0.047	0.126

Source: Statistics Norway

Table 3.15 Average CH_4 emission factors from road traffic including cold start emissions and evaporation. Unit: g/kg fuel.

	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	1.331	0.833	2.310	5.855	4.939	0.080	0.092	0.136
2000	1.311	0.795	2.154	5.855	4.939	0.074	0.085	0.132
2001	1.247	0.724	1.677	5.855	4.939	0.069	0.078	0.126
2002	1.207	0.679	1.267	5.855	4.939	0.062	0.071	0.118
2003	1.159	0.645	1.038	5.855	4.939	0.055	0.065	0.111
2004	1.103	0.608	0.886	5.855	4.939	0.049	0.059	0.104
2005	1.073	0.586	0.796	5.855	4.939	0.044	0.053	0.097

Source: Statistics Norway

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.

3.2.5.4. Uncertainties

The uncertainty in the activity data and the CO_2 emissions from road transportation is found to be ±10 per cent and ±3 per cent of the mean, respectively. In the case of CH_4 and N_2O the uncertainty in the emission factors lies below and above of the mean by a factor of 2 and 3, respectively. A detailed description of the uncertainty analysis is given in Annex II.

3.2.5.5. Source specific 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 less than 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 the 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 CH_4 and N_2O the total emission is sensitive to the allocation due to different emission factors.

3.2.5.6. Recalculations

- The emission factor for N_2O from road traffic is revised for all years. The new emission factor was suggested in phase 1 of an ongoing project to improve the Norwegian road transport emission calculation model (TØI 2005, unpublished). The new emission factor is more in accordance with factors for other countries. This has lead to decreased emissions for all years, see Figure 3.1.
- The emission factor for CH_4 from road traffic has been revised for all years since 2001. This was also suggested in phase 1 of the ongoing project to improve the Norwegian road transport emission calculation model (TØI 2005, unpublished).
- Figures of fuel consumption for diesel have been recalculated for many years, and for petrol for some years due to revisions in the energy accounts.
- A small amount of LPG is used in passenger cars for the period 2000-2003. This amount was previously allocated to residential sector.

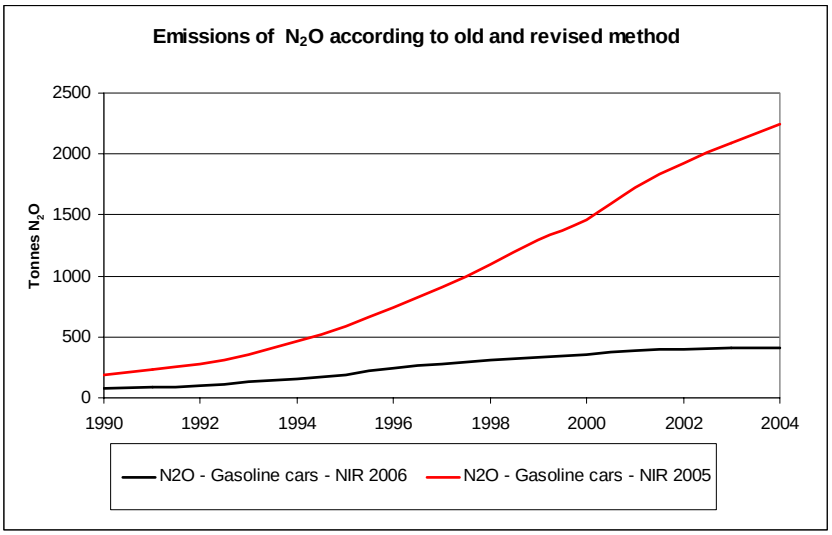


Figure 3.1. Change in N2O emissions from road traffic

3.2.5.7. Planned improvements

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

3.2.6. Transport – Railways (CRF source category 1A3c)

3.2.6.1. Description

Railway traffic in Norway uses mainly electricity (auto diesel is used at a small number of lines, for shunting etc). The greenhouse gas emissions from this source category are therefore insignificant.

3.2.6.2. Methodological issues

The general estimation methodology for calculating combustion emissions from consumption figures and emission factors is used in this source category.

3.2.6.3. Activity data

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

3.2.6.4. Emission factors

The emission factors are the same as for diesel machinery in mining and quarrying (see Section 3.2.8.2), with the exceptions of N_2O, where a value of 1.2 g/kg is used for machinery instead of 1.3 g/kg for machinery (IPCC Guidelines). For CH_4 the emission factor used for auto diesel is 0.18 kg CH_4 /tonne fuel.

3.2.6.5. Uncertainties

The consumption data are of high quality. Their uncertainty is estimated to be ±5 per cent of the mean. The uncertainty in the emission factors for CO_2 is ±3 per cent of the mean, whereas for CH_4 and N_2O the uncertainty is below and above the mean by a factor of 2 and 3, respectively.

3.2.6.6. 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" auto diesel 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" auto diesel is only for non-road use, so consumption by buses should not be the cause.

3.2.6.7. Recalculations

There were performed no specific recalculations for this sector.

3.2.6.8. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.7. Transport – Navigation (CRF source category 1A3d)

3.2.7.1. Description

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 fishing are described in Section 3.2.9.

Emissions from navigation constituted 4.4 per cent of the national GHG total in 2004. They increased by 24 per cent from 1990 to 2004, mainly because of increased activity in the oil and gas extraction sector. Emissions in 2004 are similar with those of 2003.

Navigation is a key category with respect to CO_2 emissions. The contribution of this key category to the total level and trend uncertainty in 2004 is found to be ± 2.35 per cent and ± 0.88 per cent, respectively.

3.2.7.2. Methodological issues

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 (2001). 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 (see Section 3.6.1), in accordance with the IPCC Good Practice Guidance.

Annual emissions are estimated from sales of fuel to domestic shipping, using average emission factors in the calculations. For 1993 and 1998 emissions have also been estimated based on a bottom up approach (Tornsjø 2001). 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 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 fuel consumption estimated as described in Section 3.2.7.3 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.

3.2.7.3. 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. 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 Flugsrud and Rypdal (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 (2001), 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 sales statistics. The increase in bottom up consumption and sales between 1993 and 1998 is quite similar.

3.2.7.4. 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

For N_2O and CH_4 the general/standard emission factors for liquid fuels 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 40.029 kg/1000 Sm^3 fuel.

3.2.7.5. 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 is assessed to be ±10 per cent. For CO_2 the uncertainty in the emission factors for ships and fishing vessels is ±3 per cent of the mean, while for CH_4 and N_2O it lies above and below the mean by a factor of 2 and 3, respectively (see Annex II).

3.2.7.6. Source specific QA/QC and verification

In 2001, bottom-up (from surveys) and top down data (from sales) on fuel consumption were compared (Tornsjø 2001). 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 sales 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 (Tornsjø 2001). These results have been compared with the annual estimates. The agreement is reasonable, given the uncertainty in the fuel data determined by both methods.

3.2.7.7. Recalculations

Emissions of CO_2 for 2002 have increased and emissions of CO_2 for 2003 have decreased due to revisions in the final energy accounts.

3.2.7.8. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.8. Transport – Other transportation – (CRF source category 1A3e)

3.2.8.1. Pipelines

3.2.8.1.1. Methodological issues

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

3.2.8.1.2. 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 also takes place at the production facilities. These emissions are reported under the IPCC source category 1A1.

3.2.8.1.3. Emission factors

The emission factors employed are the standard factors used for turbines fired with natural gas (see Tables 3.3, 3.6 and 3.8). The sources for the factors used are SFT/NPD and IPCC (1997b).

3.2.8.1.4. Uncertainties

The uncertainty in the activity data for pipelines and is found to be ±20 per cent of the mean. For CH_4 and N_2O the uncertainty lies below and above the mean by a factor of 2 and 3, respectively (see Annex II).

3.2.8.1.5. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. For the description of the general QA/QC procedure, see Section 1.6.

3.2.8.1.6. Recalculations

No specific recalculations have been performed for this source category.

3.2.8.1.7. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.8.2. Motorized equipment

3.2.8.2.1. 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 source categories:

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

Only consumption of gasoline and auto diesel is considered. A small amount of fuel oil used for equipment in construction is also accounted for.

3.2.8.2.2. Methodological issues

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

3.2.8.2.3. 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 is considered, based on felling data. Felling statistics are gathered by Statistics Norway. 50 per cent is supposed 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 judgments.

3.2.8.2.4. Emission factors

The emission factors used are given in Table 3.16.

Table 3.16.General emission factors for other mobile sources

		CH_4 kg/ tonne	N_2O kg/ tonne
Railway	Auto diesel	0.18	1.2
Small boats 2 stroke	Motor gasoline	5.1	0.02
Small boats 4 stroke	Motor gasoline	1.7	0.08
	Auto diesel	0.18	0.03
Motorized equipment 2 stroke	Motor gasoline	**6**	0.02
Motorized equipment 4 stroke	Motor gasoline	**2.2**	**0.07**
	Auto diesel	**0.17**	1.3
	Light fuel oils	0.17	1.3

Snow scooters have the same emission factors as those for Mopeds, see Tables 3.14-3.15.
Bold figures have exceptions for some sectors, see Table 3.17.

Sources: Bang (1993), SFT (1999c), Finstad et al. (2001), Finstad et al. (2002a) and Finstad et al. (2003).

Table 3.17 Exceptions from the general factors for greenhouse gases and precursors for other mobile sources

Component	**Emission factor (kg/tonne)**	**Fuel**	**Source**	**Sectors**
CH_4	6.2	Motor gasoline	Motorized equipment 2 stroke	Agriculture
CH_4	3.7	Motor gasoline	Motorized equipment 4 stroke	Agriculture
CH_4	7.7	Motor gasoline	Motorized equipment 2 stroke	Forestry and logging
CH_4	8.1	Motor gasoline	Motorized equipment 2 stroke	Private households
CH_4	5.5	Motor gasoline	Motorized equipment 4 stroke	Private households
CH_4	0.18	Auto diesel	Motorized equipment 4 stroke	Private households
N_2O	0.08	Motor gasoline	Motorized equipment 4 stroke	Agriculture and forestry, Fishing, Energy sectors, Mining/Manufacturing

3.2.8.2.5. Uncertainties

The estimates of consumption are considered quite uncertain, particularly for gasoline. However, the total consumption of gasoline and auto diesel is well known. Uncertainties are as described in Section 3.2.8.1.4.

3.2.8.2.6. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. For a description of the general QA/QC procedure, see Section 1.6.

3.2.8.2.7. Recalculations

No specific recalculations have been performed for this source category.

3.2.8.2.8. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.9. Other Sectors (CRF key category 1A4)

3.2.9.1. Description

The source category *Other Sectors* includes all military combustion, stationary combustion in agriculture, forestry, fishing, commercial and institutional sectors and households, motorized equipment and snow scooters in agriculture and forestry, and ships and boats in fishing.

Fuel combustion in agriculture, forestry and fisheries accounts for about half of the emissions of this source category. In 2004 total emissions were 4.1 million tonnes CO_2-equivalents. Throughout the period 1990-2004, emissions have been rather stable.

Three key source categories are found in this sector:

- Emissions of CO_2 from the combustion of oil, which in 2004 contributed ± 3.41 per cent and ± 3.35 per cent to the total level and trend uncertainty, respectively.
- Emissions of CO_2 from the combustion of wood, which in 2004 contributed ± 1.12 per cent and ± 0.75 per cent to the total level and trend uncertainty, respectively.
- Emissions of CO_2 from the combustion of oil, which in 2004 contributed ± 0.56 per cent and ± 0.69 per cent to the total level and trend uncertainty, respectively.

3.2.9.2. Activity data

Motorized equipment
Activity data are as described in section 3.2.8.2.

Households
Statistics Norway's annual survey on consumer expenditure gives figures on use of wood in households. Figures on use of coal and coal coke are derived from information from the main importer. Formerly, Norway's only coal producing company had figures on coal sold for residential heating in Norway. From about 2000, this sale was replaced by imports from abroad. Figures for LPG are collected from the suppliers. 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.

Agriculture
Data on energy use in hothouses are collected in surveys performed regularly. Sales figures are used to project the figures for consumption of oil products in the years between, while biofuels and LPG are kept constant. The Agricultural Budgeting Board has figures on the use of gasoline, auto diesel and fuel oil in agriculture excluding hothouses. A figure on the minor use of coal was previously collected annually from the only consumer. Since 2002, however, there has been no use of coal in the Norwegian agricultural activities.

Fishing
Figures on the use of marine gas fuel, heavy distillate and heavy fuel oil are identical with the registered sales to fishing in the sales statistics for petroleum products. The figures used in the emission calculations differ from the energy accounts, as the latter include also an estimated quantity on Norwegian use purchased abroad. In addition to these figures on use in large

fishing vessels, a minor figure on estimated use of gasoline in small fishing boats is also included.

Commercial and institutional sectors
Figures on energy use in wholesale and retail trade and hotels and restaurants, are based on a survey for 2000, performed by Statistics Norway. For the following years, figures from this survey have been adjusted proportionally to the development in employment in the industries in question. For earlier years, the figures are based on a survey from the mid-1980s. LPG figures for the whole period from 1990 have, however, been estimated separately after consultation with an oil company.

For most other commercial and institutional sectors, the total use of fuel oil appears as a residual after the use in all other sectors has been estimated; the distribution of this residual between sub-sectors is done by using figures on energy use per man-labour year from the energy survey from the mid-1980s.

Use of heating kerosene in commercial industries is calculated by projecting a figure on use from the mid-1980s proportionally with the registered sales to buildings in industrial industries outside the manufacturing industries. The estimated total amount is distributed between sub-sectors by using figures on energy use per man-labour year from the mid-1980s survey.

Military
Figures on fuel oil are annually collected directly from the military administration, while figures from the sales statistics for petroleum products are used for other energy carriers.

3.2.9.3. Emission factor

The emission factors used in this source category are presented in Section 3.2.1.3.

3.2.9.4. Uncertainties

Uncertainty in *fishing* is described together with navigation in section. 3.2.7.5.

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 also has been necessary to adjust figures for other sectors in order to get consumption figures for households that look reasonable. Hopefully, new surveys will improve the quality of these figures in the future.

As the total use of the different oil products is defined as equal to the registered sales, use in some sectors are given as a residual. This applies to use of heating kerosene and heavy distillates in households, and total use of fuel oil in commercial and institutional sectors. Accordingly, these quantities must be regarded as uncertain, as they are not based on direct calculations. This uncertainty, however, applies only to the distribution of use between sectors - the total use is defined as equal to registered sales, regardless of changes in stock.

There have been large variations in annual sales of military aviation kerosene; as stock changes are not taken into account, the actual annual use is uncertain.

The uncertainty in the activity data for this source category is ±10 per cent of the mean for the commercial/institutional sector, and ±30 per cent of the mean for the residential sector as well as for agriculture/forestry/fishing. Emission factors of CO_2 have an uncertainty that lies between ±3 and ±30 per cent of the mean, depending on the fuel used (see Annex II). Emission factors of CH_4 and N_2O are as usual highly uncertain.

3.2.9.5. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. For a description of the general QA/QC procedure, see Section 1.6.

3.2.9.6. Recalculations

Commercial / Institutional (1A4a)
Emission of CO_2 from combustion and flaring of landfill gas is excluded from the inventory, as the carbon is now defined as being of biogenic origin. This was also recommended by the review team in the 2005 review. Emissions of LPG in retail trade and hotels are included for all years since 2000. This has led to increased emission of CO_2 for all years.

Residential plants (1A4 i)
The estimates for the use of heating oil and heavy distillate in 2002 are revised in the energy accounts.

Off-road Vehicles and Other Machinery (1A4c ii)
There have been some revisions in the energy accounts concerning Off-road Vehicles and Other Machinery: Figures for consumption of petrol and diesel in forestry have changed for all years since 1990; Figures for use of petrol have increased for 1990-1993, and decreased for the years after; For diesel, the figures have decreased for 1990-1996 and 1987, and increased for the other years.

3.2.9.7. Planned improvements

There are no concrete plans for further improvements in this source category at the moment.

3.2.10. Other (CRF key category 1A5)

This source includes solely emissions from fuel use in military activities. 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 1990-2004 are listed in Table 3.18.

Table 3.18. Stationary and mobile emissions from military activities
Unit: CO_2 in Mtonnes, CH_4 and N_2O in tones

	CO_2	CH_4	N_2O
1990			
1A5A Military - stationary	62.4	7.9	0.6
1A5B Military - mobile	393.7	15.1	12.2
1991			
1A5A Military - stationary	53.3	6.7	0.5
1A5B Military - mobile	352.5	13.8	10.9
1992			
1A5A Military - stationary	60.1	7.2	0.6
1A5B Military - mobile	426.8	17.8	13.3
1993			
1A5A Military - stationary	44.3	5.6	0.4
1A5B Military - mobile	322.5	13.7	9.8
1994			
1A5A Military - stationary	51	6.4	0.5
1A5B Military - mobile	456.7	13.9	14.3
1995			
1A5A Military - stationary	48.1	6,1	0.5
1A5B Military - mobile	406.1	11.4	13.1
1996			
1A5A Military - stationary	62.4	7.9	0.6
1A5B Military - mobile	344.2	10,8	10.6
1997			
1A5A Military - stationary	73.6	9.2	0.7
1A5B Military - mobile	350.9	10.3	11.1
1998			
1A5A Military - stationary	49.6	6.2	0.5
1A5B Military - mobile	309.9	10.9	10.2
1999			
1A5A Military - stationary	50.3	6.3	0.5
1A5B Military - mobile	341.3	10.6	11
2000			
1A5A Military - stationary	40.6	5.1	0.4
1A5B Military - mobile	137.5	7.5	4.4
2001			
1A5A Military - stationary	54.4	6.9	0.5
1A5B Military - mobile	240.6	12.8	7.3
2002			
1A5A Military - stationary	44.1	5.5	0.4
1A5B Military - mobile	409.2	9.8	12.8
2003			
1A5A Military - stationary	58.3	7.4	0.6
1A5B Military - mobile	114.2	6.7	3.4
2004			
1A5A Military - stationary	45.5	5.7	0.4
1A5B Military - mobile	284.7	8.6	8.7

3.3. Fugitive Emissions from Coal Mining and Handling – 1B1a – CH_4 (Key Category)

3.3.1. 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. As the Norwegian GHG inventory, according to official definitions, shall include emissions from all activities at Svalbard, also emissions from Russian coal production have been estimated. Until 1998, there was production in two Russian coal mines, but since then, production takes place only in the Barentsburg mine. The production there is at present considerably smaller than the Norwegian production. Russian activity data are more uncertain than the Norwegian, which causes a correspondingly higher uncertainty in the emission figures.

At Svalbard there has been a smouldering fire in the Russian mine that was closed down in 1998. At an inspection in 2005, no emissions were registered, which indicates that the fire has burnt out. Due to lack of data, emissions for earlier years from this fire have not been estimated. However, Norwegian authorities assume that these emissions are limited.

The Norwegian coal production was almost unchanged from 1990 to 2000. In 2001 the production more than doubled and in 2004 the Norwegian coal production was almost 10 times higher than in 1990. The production and consequently the emissions was approximately the same in 2004 as in 2003.

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

3.3.2. 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 3.6.3 for more information on indirect CO_2)

CH_4
Emissions of methane from coal mining on Svalbard are calculated by multiplying the amount of coal extracted (raw coal production) with country specific emission factors (Tier 2); the factor for the Barentsburg mine differs from the factor for Norwegian coal production. The calculations are performed by Statistics Norway.

3.3.3. Activity data

Figures on Norwegian production (raw coal production) are reported by the plant to Statistics Norway. Russian figures are reported to the Norwegian authorities on Svalbard; these figures are, however, regarded as highly uncertain, consisting of a mixture of figures on production and shipments.

3.3.4. Emission factor

CH_4

For Norwegian coal production 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.

For the Russian mine in Barentsburg, the emission factor for CH_4 has been estimated in the same manner as the Norwegian factor, based on measurements by (Bergfald & Co as 2000). This is an underground mine, which causes considerably higher emissions than from the Norwegian mines; we use the factor 7.16 kg methane per tonne coal for this mine. The Russian mine that was closed down in 1998, however, was situated more like the Norwegian mines; accordingly we use the same emission factor for this as for the Norwegian mines.

3.3.5. Uncertainties

The uncertainty in the activity data concerning Norwegian coal production is regarded as being low. The uncertainty in Russian data is considerably higher.

Today, country specific factors based on measurements are used in the calculations. We assume that the uncertainty in the EF is much lower than that reported in (SN 2000), when an IPCC default emission factor was used. In (SN 2000) the uncertainty in the EF was estimated by expert judgments to as much as -50 to +100 per cent.

The EF we use for the Norwegian mines 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.

3.3.6. Source specific QA/QC and verification

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

SN 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.

3.3.7. Recalculations

Emissions from Russian activity at Svalbard are included for the first time, which causes higher emissions for all years for CH_4 and CO_2.

Figures of gross production have replaced figures of net production when estimating emissions of CH_4 from Norwegian coal production.

3.3.8. Planned Improvements

In the desk review report in 2005 Norway was encouraged to assess the feasibility of applying a measurement-based tier 3 approach to this key category. Norway have considered the advice and have so far no plans of applying a Tier 3 methodology. However, we have on the agenda to evaluate the EF based on measurements that we use in the calculation today.

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

3.4.1. Overview

Fugitive emissions from oil and natural gas contribute 6.1 per cent to the total GHG emission in Norway in 2004.

Due to increased amounts of crude oil loaded and a general growth in the production of oil and gas the emissions have increased by 14 per cent since 1990. There was a decrease in the emission of 3 per cent from 2003 to 2004 which was mainly due to decreased indirect CO_2 emissions from loading and storage of crude oil. The reduction in the indirect CO_2 emissions since 2001 is due to that NMVOC reducing technology on loading and storage of crude oil offshore has been implemented. The technology was implemented as a result of permits issued by the Norwegian Pollution Control Authority (SFT). The permits require that 95 % of the oil must be loaded with NMVOC reducing technology by the end of 2007.

In 2004 CO_2 from flaring off shore contributed with 2.2 per cent to the total GHG emissions in Norway. Despite increased production of oil and gas the CO_2 emissions from flaring were 13 per cent lower in 2004 than it was in 1990. From 2003 to 2004 the emission increased by 3.2 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 3.19 gives an overview over the calculations of the fugitive emissions of CO_2, CH_4, N_2O and NMVOC.

Table 3.19 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.

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

3.4.2.1. 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 loading of crude oil etcetera are *key categories* both in level and trend due to uncertain emission factors. The contribution to total uncertainty in level and trend is shown in Annex II.

3.4.2.2. Methodological issues

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 (the latter only to SFT) used in the calculation are annually reported by the field operators 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 annually 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 1990-2004.

Only emissions from loading and storage of the Norwegian part of oil production are 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 3.6.3 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. There is however one exception and that is CH_4 emissions from the largest refinery. The CH_4 emissions from that refinery are estimated by SFT by multiplying the yearly amount of crude oil throughput by a plant specific emission factor.

The CO_2 emissions originate 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 are calculated 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 continuously
- the density of the stack gas is 1.31 kg/Nm^3
- volume percentage of CO_2 is based on continuously 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 continuous measurements.

Both CH_4 and NMVOC emissions are based on measurement carried out by Spectracyne in 2002 and 2005.

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.

3.4.2.3. 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 Norwegian Petroleum Directorate (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 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.

Refining – 1.B.2.a.iv
The crude oil throughput is annually reported by the plant to SFT.

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

3.4.2.4. 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 SN. 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 split between 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 are estimated to be more than 50 per cent lower than they would have been without VRU. However, the VRU technology is not designed to reduce methane and ethane emissions.

Refining/Storage – 1.B.2.A.iv
The emission factor used in the calculation of methane emissions from the largest refinery is based upon measurements performed by Spectracyne in 2002 and 2005. The EF is deduced from the measured methane emissions and the crude oil throughput in 2005.

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.

3.4.2.5. Uncertainties

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

3.4.2.6. Source-specific QA/QC and verification

SN gathers data for the amount of crude oil loaded off and on shore from the 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.

3.4.2.7. Recalculations

All recalculation of fugitive emissions of CH_4 and NMVOC give change to CO_2 emissions as CH_4 and NMVOC oxidize in atmosphere to CO_2.

1 B 2 a i Exploration Production, Transport

- The emission figures for CH_4 from one crude oil terminal on shore are revised, and the new figures have replaced earlier reported emissions figures for all years since 1990. This has led to increased figures for all years. This has also changed the CO_2 emissions due to that CH_4 is oxidized to CO_2.

1 B 2 a iv Refining/Storage

- The emission figures for CO_2 from the cracker at one oil refinery have been recalculated for all years. This has led to small changes for all years, except 1991 where emission has decreased due to an error in the earlier reported CO_2 emissions.

- Emissions of CH_4 from one refinery are recalculated for all years since 1990. The time series for CH_4 from oil refining is recalculated due to revised EF that is based upon measurements conducted in 2002 and 2005. The recalculation has increased the CH_4 emissions from refineries in 1990 from 100 tonne in NIR 2005 to 1668 tonne in this submission. The revision is a response to the issue raised by the expert review team.
- Revised emissions of CH_4 from another oil refinery for all years since 1990. This has led to increased emissions for the years 1992 to 2004.
- Indirect CO_2 emissions from NMVOC from two refineries have by a mistake not been included in earlier inventories. This revision leads to increased CO_2 emissions from all years since 1990.

3.4.2.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

3.4.3. Fugitive Emissions from Natural Gas – CH_4 - 1.B.2.b (Key Category)

3.4.3.1. Description

Sector 1.B.2.b covers fugitive emissions of CH_4 and NMVOC and indirect emissions of CO_2 from the two gas terminals.

CO_2 and CH_4 from natural gas is *key category* with respect to total trend. Their contribution to total uncertainty in level and trend is shown in Annex II.

3.4.3.2. Methodological issues

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.

3.4.3.3. Activity data

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

3.4.3.4. Source-specific QA/QC and verification

Reported emissions are compared with previous years' emissions.

3.4.3.5. Recalculations

1 B 2b Natural gas

- The emission figures for CH_4 from two gas terminals have been revised. The revision has led to changed emissions of CH_4 for the whole time series. Resulting from this there are also small changes in indirect CO_2 emissions.

3.4.3.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

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

3.4.4.1. Description

Included in sector 1.B.2.c 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.B.2.c *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 3.5 CO_2 capture and storage at the oil and gas production field Sleipner Vest for further description of this source.

Most of the emissions in sector *1.B.2.c 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 NPD and SFT.

CO_2 and CH_4 from venting and flaring is *key category* 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 II.

3.4.4.2. Methodological issues

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 calculated by multiplying the amount of gas produced with an emission factor. The indirect CO_2 emissions are calculated by SN.

The vented CO_2 at Sleipner Vest 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 SN on the basis of field specific gas consumption data and country specific average emission factor, see Table 3.21. 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 method 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.

3.4.4.3. 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 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.

3.4.4.4. Emission factors

Venting
The emission factors used in the calculation of vented emissions is mostly the default emission factors listed in Table 3.20 or field specific factors. The reference for the default factors is Aker Engineering (1992). During the expert review of the NIR 2005 it was a subject whether the EF we used were default factors or field specific. Norway's response to the expert reviewer during the review made this unclear and this we can only apologize.

Table 3.20 Default 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 [4]	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

[4] The gas source is standard fuel gas.

03.21, the CO_2 emission factors for flaring off shore and at one gas terminals are shown. The other gas terminal used 2.72 tonne CO_2/tonne gas.

Emission factors used in the calculations for well testing are shown in Table 3.22.

Table 3.21 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**
2004	2.70	2.44
2003	2.70	2.41
2002	2.70	2.47
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 3.22 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	SFT (1990)
CH_4 (tonnes)	NE		0.00024	IPCC (1997b)
N_2O (tonnes)	NE		0.00002	OLF (2004)
NMVOC (tonnes)	0.0033	OLF (1994)	0.00006	OLF (2004)
CO (tonnes)	0.18	OLF (2004)	0.015	OLF (2004)

[1]The Norwegian Oil Industry Association (OLF)

3.4.4.5. Uncertainties

The uncertainty in the amount of gas flared is in (SN 2000) regarded as being low, ±4 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.

All uncertainty estimates for this source are given in Annex II.

3.4.4.6. Source-specific QA/QC and verification

SN collects the activity data used in the calculation from the 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 calculates 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.

3.4.4.7. Recalculations

1.B.2.c Venting and flaring

- Revised emission figures for CH_4 from flaring at two gas terminals are now included in the inventory. These changes have led to increased emissions of CH_4 for the whole time series. Emissions from flaring are higher then earlier estimated
- Revised emissions figures for CO_2 from one plant (?) that flare gas are now used for the period 1990 to 2004, and for another plant for the period 1996 to 2004. These changes have led to minor changes in emissions of CO_2 for the whole time series.
- For one crude oil terminal emission figures for CO_2 from flaring has not been reported since 2001. These figures are now estimated. Total figures reported from The Norwegian Petroleum Directorate have not changed. A part of what was reported as fuel, is assumed to be flared.
- Emission factors for N_2O, NMVOC and CO from flaring during wildcat drilling have been changed due to errors.

3.4.4.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

3.5. CO_2 capture and storage at the oil and gas production field Sleipner Vest (Key Category)

3.5.1. Description

The natural gas in the Sleipner Vest 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 Utsira Formation aquifer, which is located above the producing reservoirs at a depth of 800 – 1000 meters below sea level, was chosen for CO_2 storage because of its shallow depth, its large extension (which guarantees sufficient volume), and its excellent porosity and permeability (which is well suited for high injectivity). The formation is overlain by a thick, widespread sequence of Hordaland Group shales, which should act as an effective barrier to vertical CO_2 leakage, see figure 3.2 below:

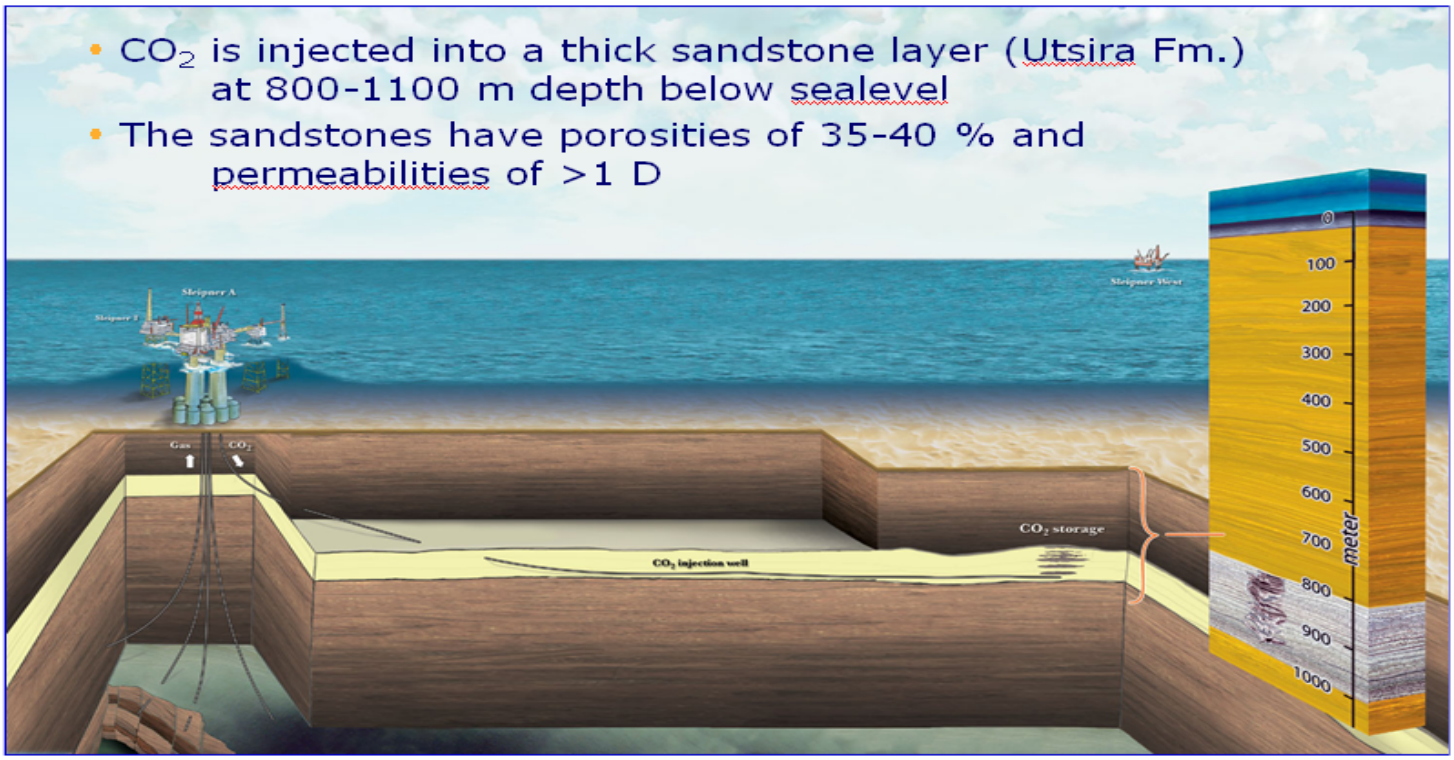


Figure 3.2 CO_2 capture and storage at Sleipner Vest Source: Statoil

The reservoir was characterised by reservoir information such as seismic surveys and information from core drillings.

In the Sleipner case it has been very important to locate the injection well and the storage site such that the injected CO_2 could not migrate back to the Sleipner A platform (SLA) and the production wells. This will both prevent corrosion problems in the production wells and minimise the risk of CO_2 leakage through production wells. The injection point is located 2.5 km east of the Sleipner A platform. Migration evaluations have been based on the Top Utsira map (see figure 2 in Annex V) with the CO_2 expected to migrate vertically to the sealing shales and horizontally along the saddle point of the structure. This will take the CO_2 away from other wells drilled from the Sleipner platform. A more detailed description of the reservoirs suitability for long term CO_2 storage is given inn Annex V.

The field and the injection program have been in operation since 1996. Statoil monitors the injected CO_2 with respect to leakages.

Investigations carried out so far show that the injected CO_2 has 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 techniques.

Table 3.23 below gives the amount of CO_2 injected since the project started in 1996.

Table 3.23 CO_2 from the Sleipner field injected in the Utsira-formation, 1000 tonnes.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CO_2 (ktonnes)	**70**	**665**	**842**	**971**	**933**	**1 009**	**955**	**914**	**750**	**858**

Source: SFT

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 3.4.4. In 2004 this emission amounted to 21 377 tonnes CO_2. The figures for the other years are given in Table 3.24.

Table 3.24 Emissions of CO_2 from the Sleipner CO_2-injection plant due to inaccessibility of the injection facilities, tonnes.

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
CO_2 (tonnes)	81 000	29 000	4 195	9 105	8 318	3 050	7 567	23 910	21 377	6 191

Source: SFT

The status by 1.1.2006 is that 8 million tonnes CO_2 has been injected into the Utsira Formation and 0.2 million tonnes CO_2 has been vented. The following figure 3.3 shows the yearly injected and vented volumes for the entire injection period on Sleipner.

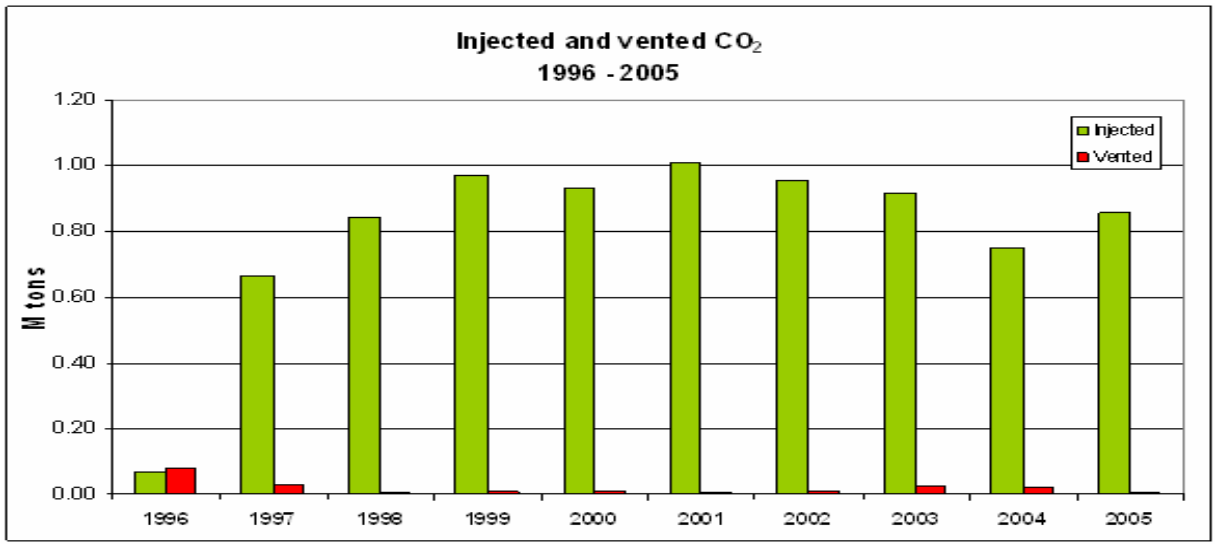


Figure 3.3 Injected and vented CO_2 at Sleipner Vest Source: SFT

3.5.2. 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 Vest 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 tonnes of CO_2 had been injected into the reservoir. This was followed by seismic surveys in 1999, 2001, 2002 and 2004. The monitoring methodology and the results of the monitoring are described in Annex V written by Statoil.

The stored CO_2 has been monitored using time lapse seismic to confirm its behaviour and evaluate

- whether any of it has leaked into the overburden seal, the ocean or the atmosphere, or
- whether any of it has migrated towards the Sleipner installations, potentially leading to corrosion problems for well casing

The results show that neither of these eventualities has occurred. So far there are no signs of CO_2 above the top of Utsira Formation.

Results from the projects are also given in several reports and articles such as: "Final Tecnical Report of the SACS2 project – EU project NNE-1999-00521, issued 30.07.2002", "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). A more detailed list of publications and presentations is given in Annex V. 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 (see figure 5 in Annex V). 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 (see figure 4 in Annex V). The data also resolve a vertical CO_2 chimney, which is regarded the primary feeder of CO_2 in the upper part of the bubble.

Flow simulation models, which match the 4D seismic data reasonably well, have been used to predict the CO_2 behaviour, see Figure 3.4.

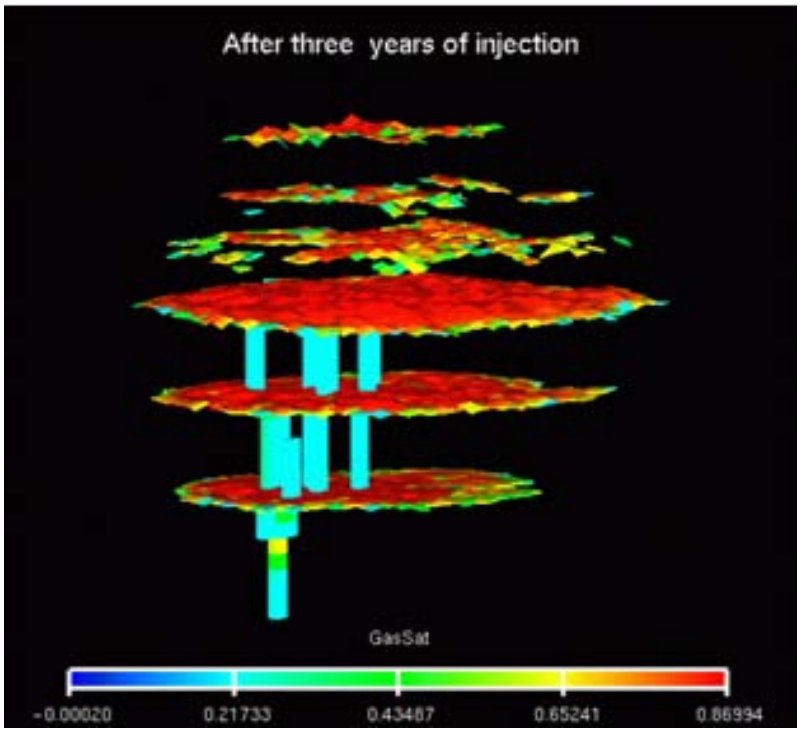


Figure 3.4 Flow simulation of CO_2 Source: Statoil

The results from the simulations indicate that cap rock shales provide a capillary seal for the CO_2 phase.

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.

Other monitoring methods Statoil is running are monitoring the injected CO_2, gravimetric monitoring, pressure measurements and well monitoring. For more details see Annex V.

3.5.3. 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.

3.5.4. Source specific QA/QC and verification

The results are promising and so far the injected gas remains in place. 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 Vest field. According to the license Statoil is obliged to monitor 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 gives a system for QA. So far the monitoring is included in the SACS/CO2STORE projects and when these projects are finalized a decision will be taken about a further monitoring program for the Sleipner injection project. The injected CO_2 is so far proven 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.

3.5.4.1. Planned improvements

There are no concrete plans for further improvements that will improve the data quality for NIR 2007.

3.6. Cross-cutting issues

3.6.1. Sectoral versus reference approach

The expert review team have recommended Norway to examine the comparison between Reference Approach (RA) and Sectoral Approach (SA). Therefore to ensure consistency with figures reported to IEA, the time series for energy data used in the RA, have been examined and corrected. In some cases, the figures used in RA differ from those reported to IEA; so there is still need for further work to coordinate the figures and this work will be performed before the next reports to both IEA and UNFCCC. We have also included more country specific factors for carbon stored in the RA calculation.

In spite of the improvements described above there are still large deviations in output from the Reference Approach (RA) and Sectoral Approach (SA) both for the energy consumption data and the CO_2 emissions throughout the years. Possible explanations to the differences are given below. The results for all years in the period 1990-2004 are displayed in Table 3.25.

In the Reference Approach fuel consumption data are systematically higher that those of the sectoral approach. In the case of CO_2 emissions, although the pattern of differences in the output from the two approaches is more variable, emissions from the reference approach are generally higher that those from the sectoral approach. For 2004 the deviation between the reference and sectoral approaches is found to be 24 per cent for the fuel consumption data and 11.3 per cent for the CO_2 emissions.

Table 3.25 Comparison of fuel consumption and CO_2 emission data between the Reference Approach (RA) and the Sectoral Approach (SA), 1990-2004.

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Fuel Consumption															
Reference approach (PJ)	501.2	516.5	523.4	571.7	553.4	540.6	534.5	582.3	600.6	631.2	616.4	673.3	549.8	658.6	652.7
Sectoral approach (PJ)	399.0	392.7	404.6	420.5	442.5	437.8	477.0	481.7	479.3	483.4	470.8	495.6	498.9	523.1	525.0
Difference (RA-SA) (%)	**25.6**	**31.5**	**29.4**	**35.9**	**25.1**	**23.5**	**12.0**	**20.9**	**25.3**	**30.6**	**30.9**	**35.9**	**10.2**	**25.9**	**24.3**
CO_2 Emissions															
Reference approach (Gg)	29372	30929	31122	33925	32217	30869	30767	33630	34727	37471	36308	39411	31178	38238	38159
Sectoral approach (Gg)	25975	25593	26129	27186	28632	28386	31060	31227	31160	31473	30461	32554	32706	34229	34279
Difference (RA-SA) (%)	**13.1**	**20.8**	**19.1**	**24.8**	**12.5**	**8.7**	**-0.9**	**7.7**	**11.4**	**19.1**	**19.2**	**21.1**	**-4.7**	**11.7**	**11.3**

Source: Statistics Norway/SFT

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. According to the Norwegian Petroleum Directorate, the uncertainties for production figures are 1 and 0.3 per cent for natural gas and crude oil, respectively. 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 reliable. There is some uncertainty connected to the carbon emission factors used in the RA; changes in the factors, particularly for crude oil, can cause great changes in the figures for actual CO_2 emissions; e.g. use of the IPCC default factor 20.0 instead of 20.33, which is used now, will reduce the emissions by 700,000 tonnes.

3.6.2. 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.

In previous submissions, Norway used a carbon storage factor of 1 for all non-energy use in the Reference Approach (CRF Table 1A(d)). Now we use factors that are based on national conditions for LPG, natural gas, coal, coke oven coke and petroleum coke. For the rest of the feedstocks we have used factors from countries that we regard having the same production profile and technology as Norway. It should be noted that fuels oxidized during industrial processes are assumed "stored". In earlier CRFs, Norway used GCVs for natural gas, misstated as NCVs, in the Reference Approach - now NCVs are actually used.

3.6.3. 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.

3.7. Memo items

3.7.1. International bunkers

3.7.1.1. Description

Emissions from international marine and aviation bunker fuels are excluded from the national totals, as required by the IPCC Guidelines. The estimated emission figures are reported separately and are presented in Table 3.26.

In 2004 CO_2 emissions from ships and aircraft in international traffic bunkered in Norway amounted to a total of 2.7 million tonnes, which corresponds to about 6 per cent of the total Norwegian CO_2 emissions.

Emissions of CO_2 from marine bunkers increased by 27 per cent in the period 1990-2004, primarily due to activity growth. A maximum was reached in 1997, when emissions doubled compared to those of 1990. The emissions in 2004 were reduced by 38 per cent from 1997, due to decreasing international sea traffic activity.

Overall activity growth has also led to increased CO_2 emissions from air traffic. In 2004 such emissions were 37 per cent higher than in 1990. However, as aircraft engines are more fuel-efficient now than they were some years ago, it follows that the increase in international air

traffic has in fact been higher than that of the emissions. Emissions experienced an increase of more than 50 per cent from 1990 to 1999, followed by a decline, which was particularly strong from 2001 to 2002. From 2003 to 2004, however, there was a 13 per cent increase, and the 2004 emissions were the third highest in the period 1990-2004, surpassed only by 1999 and 2000.

Table 3.26 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, 1990-2004.
Unit: 1000 tonnes, CO_2 in Mtonnes.

Marine	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
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	1.9	1.9
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	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	0.0
NOx	30.3	25.6	32.1	34.3	37.8	46.6	50.7	61.4	61.8	58.3	57.8	56.0	46.8	41.0	40.0
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	1.8	1.7
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	1.5	1.4
SO_2	9.9	9.7	12.3	13.5	14.0	13.8	15.4	18.8	14.9	12.9	11.5	13.1	8.0	8.3	8.1

Aviation	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
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	0.8
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	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	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	3.1
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	0.9
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	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	0.1

Source: Statistics Norway/SFT

Differences between the IEA (International Energy Agency) data and the data reported to UNFCCC 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.

3.7.1.2. Shipping

Methodological issues

Emissions are calculated by multiplying activity data with emission factors. The sales statistics for petroleum products, which is based on reports from the oil companies to Statistics Norway, has figures on sales for bunkers of marine gas oil, heavy distillates and heavy fuel oil. The same emission factors as in the Norwegian national calculations are used.

Activity data

Sales figures for international sea transport from Statistics Norway's sales statistics for petroleum products are used for marine gas oil, heavy distillates and heavy fuel oil.

Emission factors

Emission factors used for shipping are described under *Navigation* in Section 3.2.7.

3.7.1.3. Aviation

Methodological issues

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 uses. Data on domestic fuel purchase and consumption are therefore collected by Statistics Norway from all airline companies operating domestic traffic in Norway. The figures on domestic consumption from airlines are deducted from the total sales of jet kerosene to arrive at the total fuel sales for international aviation. The bottom-up approach of Norway is the detailed Tier2 CORINAIR methodology. The methodology is based on detailed information on types of aircraft and number of LTOs, as well as cruise distances.

Activity data

Statistics Norway annually collects data on use of fuel from the air traffic companies, including specifications on domestic use and purchases of fuel in Norway and abroad.

Emission factors

Emission factors used for *Aviation* are described under *Aviation* in Section 3.2.4.

3.7.1.4. Precursors

Emissions of NO_x from international sea traffic in 2004 were 40 ktonnes, which equals 19 per cent of the national Norwegian NO_x emissions. During the period from 1990 to 2004, NO_x emissions from international shipping bunkered in Norway increased by 32 per cent. However, the 2004 emissions were 35 per cent lower than in 1998, which had the highest emissions in the period. NO_x emissions resulting from international aviation amounted to 3.1 ktonnes in 2004. They increased by 48 cent from 1990 to 2004. 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.

3.7.2. CO_2 emissions from biomass

Emissions are estimated from figures in the energy accounts on use of wood, wood waste and black liquor. According to the guidelines, these CO_2 emissions are not included in the national total in the Norwegian emission inventory.

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 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 Statistics Norway. The emission factors are collected from different sources, while the activity data is from official statistics collected by SSB.

A specific QA/QC has been carried out for the industrial processes sector this year as recommended by the expert review team. The QA/QC covered the GHG emissions from the largest industrial plants to be included in the inventory. The methodology for the performances of the QA/QC is presented in Annex III. The changes in the emissions resulting from the QA/QC are described in the recalculation section for each source.

In 2004 the GHG emissions from Industrial processes contributed to 19 per cent of the total GHG emissions in Norway. The emissions from this source category decreased by 24 per cent from 1990 to 2004, while they increased by 7.7 per cent from 2003 to 2004. The decrease from 1990 to 2004 is mainly due to reduced PFC emissions from production of aluminium in and SF_6 from production of magnesium. The increase in emissions from 2003 to 2004 was due to higher CO_2 emissions from production of ferroalloy and aluminium because of increased production. There was a reduction in the PFC emissions by almost 74 per cent even if the production of aluminium in the period 1990-2004 has increased by nearly 52 per cent. The reduction in the SF_6 emissions is due to the closing down of production of cast magnesium in 2002, improvements in the GIS-sector and an almost end in the use of SF_6 as tracer gas.

Metal production contributed to about 62 per cent of the total GHG emissions from Industrial Processes in 2004, mainly from production of ferro alloys and aluminium, and in 1990 the contibution from metal production was about 72 per cent. Chemical Industry and Mineral Product are the two other main contributing sectors in 2004 with 24 and 8 per cent, respectively, of the total GHG emissions in this sector.

The Tier 2 key category analysis performed for 1990 and 2004 has revealed the key categories in terms of level and/or trend uncertainty in the sector Industrial Processes as shown in Table 4.1. However, source category 2B1, 2C4 and 2D are key categories from Tier 1 key category analysis.

Table 4.1 Key categories in the sector Industrial Processes.

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
2B4	Silicon carbide	CO_2	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
2D	Food and drink	CO_2	Tier 1/2
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC	Tier 2

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

4.2. Mineral Products – 2A

The sector category Mineral products include CO_2 emissions from production of cement, lime and limestone and dolomite use. Table 4.2 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 Statistics Norway (E), tier of method and if it key category or not.

Table 4.2. Mineral products. Components emitted and included in the Norwegian GHG inventory[1].

Mineral products	CO_2	Tier	Key category
-- Cement production	E	Tier 2	Yes
-- Lime production	R	Tier 2	No
-- Limestone and dolomite use	R	Tier 2	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 Category)

4.2.1.1. Description

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

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

In 2004, the CO_2 emissions from cement production accounted for 1.3 per cent of the total national GHG emissions and 7 per cent of the GHG emissions in the sector Industrial processes.

From 1990-2004 the CO_2 emissions from clinker production increased by 9 per cent. The emission decreased by 16 per cent from 2003 to 2004.

According the Tier 1 key category analysis cement production is defined as key category due to contribution in level to total GHG emission.

4.2.1.2. Methodological issues

The emissions of CO_2 from clinker production included in the GHG inventory are reported by the two producers in an annually report to SFT. Emissions are estimated by multiplying the annually clinker production at the plant with plant specific emission factors (SINTEF 1998a). This is regarded as a Tier 2 methodology.

4.2.1.3. Activity data

The clinker production the plant use in their calculation is reported annual from the plants to SFT.

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. These emission factors are calculated particularly for the two Norwegian factories and are reported to be 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.

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 general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.2.1.7. Recalculations

In earlier submissions the CO_2 emissions from cement production were calculated based on emission factors and clinker production data. In this submission Norway has used the emission figures reported by the plants to the SFT, because these figures are assumed to be of better quality. The figures for all years back to 1990 have been recalculated. This led to increased emission in 1990 and 1992. The recalculation has caused that the CO_2 emissions in 1990 for this sector is 0.6 per cent lower and the emissions in 2003 is 2.4 per cent lower than reported in NIR 2005.

4.2.1.8. Planned improvements

There are at the time being no plans for further improvement of the emission data for this sector.

4.2.2. Lime Production – 2A2

4.2.2.1. Description

Two plants produce lime in Norway. From one plant CO_2 is emitted from the production process of lime.

4.2.2.2. Methodological issues

One plant calculates the emissions of CO_2 based on actual production volumes of lime and plant specific emission factors for CO_2 from limestone and dolomite respectively. The emissions are reported to the Norwegian Pollution Control Authority. The other plant has reported emissions of CO_2 for 1990 and 1998-2001. Emission from 2001-2004 are estimated by SFT based on activity data and plant specific emission factors. Emissions for the years 1991-1997 are interpolated by SFT.

4.2.2.3. Uncertainties

Uncertainty estimates for greenhouse gases are given in Annex II.

4.2.2.4. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.2.2.5. Recalculations

One plant has reported emissions of CO_2 for 1990 and 1998-2001. Emissions from 2001-2004 are estimated by SFT based on activity data and plant specific emission factors. Emissions for the years 1991-1997 are interpolated by SFT.

4.2.2.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.2.3. Limestone and Dolomite Use - 2A3

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

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

4.2.3.5. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III. .

4.2.3.6. Recalculations

No recalculations have been carried out since NIR 2005.

4.2.3.7. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

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-emissions from silicon carbide are estimated figures calculated by Statistics Norway. Production of carbides causes emission of many components, but most of the activities only cause emissions of one or two components.

Table 4.3. Chemical industry. Components emitted and included in the Norwegian inventory.

	CO_2	**CH_4**	**N_2O**	**NMVOC**	**Tier**	**Key category**
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	Yes
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 (Key category)

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.

According the Tier 1 key category analysis ammonia production is defined as key category due to contribution in level.

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 but is nevertheless included in the Norwegian GHG Inventory. In 2004, approximately 220 ktonnes CO_2 were captured and sold.

4.3.1.3. Activity data

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

4.3.1.4. Emission factors

The plant emission factors used in the calculations of emissions are based on carbon content in the gases consumed.

4.3.1.5. Uncertainties

It is believed to be limited uncertainties in the figures reported by the plant. Uncertainty estimates for greenhouse gases are given in Annex II.

4.3.1.6. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

The figures reported from the plant are compared to calculations done by SSB 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

CO_2 emission from ammonia production has increased for 2002 and 2003 due to correction of errors in the emission figures. The emissions have decreased for 1998 also due to new figures from the plant.

4.3.1.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

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

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 2004 and 26.7 per cent of the emissions in sector Industrial processes.

Production of nitric acid is defined as key category both in level and trend according to the Tier 2 key category analysis.

4.3.2.2. Methodological issues

$NO_{2\ x}$
The two plants report the emissions of N_2O to 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

Uncertainty estimates for greenhouse gases are given in Annex II. The uncertainty in the measurements is estimated by the plant to ±7 (SFT 2000).

4.3.2.5. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

The plants report the production of HNO_3 to the Norwegian Pollution Control Authority. They compare the trends in the production data with the trend in N_2O emission and use this as a quality check.

4.3.2.6. Recalculations

N_2O emission from nitric acid production has increased for 1991 due to correction of errors in the emission figures.

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 (Key Category)

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.

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

$CO \xrightarrow{O_2} CO_2$

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.

According to the Tier 2 key category analysis carbide production is defined as key category due to change in trend.

4.3.3.2. Methodological issues

CO_2
Emission figures are reported annually by the three plants to the SFT.

CO_2 from process is calculated based on the following equation:

(4.3) $CO_2 = \Sigma\ Activity\ data * Emission\ factor$

The three production sites have used amount of produced crude silicon carbide as activity data in the calculation of CO_2 emissions.

Indirect emission of CO_2 is calculated based on the emission of CH_4.

CH_4
The emission of CH_4 from production of silicon carbide is calculated based on the following equation:

(4.4) $CO_2 = \sum Activity\ data_i * Emission\ factor_i$

The three production sites has used amount of produced crude silicon carbide as activity data and a plant specific emission factor.

The IPCC default method is used for the calculations. Emissions are calculated by SSB 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 SSB for the calculation of CH_4 and CO is the consumption of petrol coke as reported to SSB.

4.3.3.4. Emission factors

CO_2
All three sites have changed their emission factor to the default factor of 2.62 ton CO_2/ton crude silicon carbide (IPPC 2006) (See Table 4.4).

Documentation of the choice and uncertainties of the emission factor is given in Annex II.

CH_4
For calculation of methane emissions the plant specific emission factor 4.2 kg/tonne crude SiC is used (See 4.4).

Documentation of the choice and uncertainties of the emission factor is given in Section 4.3.3.5.

Table 4.4. Emission factor for CO_2, CH_4 and CO used for silicon carbide production.

Component	**Emission factor**	**Source**
CO_2	2.62 tonnes CO_2/tonnes crude SiC	IPCC 2006
CH_4	4.2 tonnes CH_4 /tonnes crude SiC	PS
CO	0.4 tonnes CO/tonnes petrol coke	Rosland (1987)

4.3.3.5. Uncertainties

CO_2
Activity data: The three productions sites use the amount of produced crude silicon carbide as activity data. The uncertainty of the activity data given as this production figure is calculated to be ± 3%.

Emission factor: When using the standard emission factor of 2.62 tonne CO_2/tonnes SiC, the uncertainty range is estimated to be – 16 % to - +7 %. This can be explained due to variations in raw materials as well as process variations, and is based on previous development of site specific emissions factors (SINTEF 1998 e).

Emissions: The total uncertainty of the resulting emissions of CO_2, based on uncertainties in activity data and emissions factor, is calculated to be in the range of – 20 % to + 10 %.

CH_4
Activity data: The three productions sites use the amount of produced crude silicon carbide as activity data. The uncertainty of the activity data given as this production figure is calculated to be ± 3%.

Emission factor:
The emission factor of 4.2 kg CH4/tonne SiC is used, and the uncertainty level is estimated to be ± 30%.

The following explains the calculation of emission factor and the uncertainty level:

The production of SiC is a batch process with duration of about 43 hours. The CH_4-concentration (ppm) is monitored continuously the first 6.5 hours. After this, only control monitoring is carried out. The results show that the concentration of CH_4 is peaking in the first hour of the process, giving a CH_4 concentration 10 – 15 times higher than in the last 36 hours of the process. A typical level of the concentration of CH_4 is given in figure 4.1 below.

If the CH_4-concentration is averaged over the total batch time of 43 hours, this will give an emissions factor of 4.2 kg CH_4/tonne SiC, i.e. 3.5 kg CH_4/tonne petrol coke.

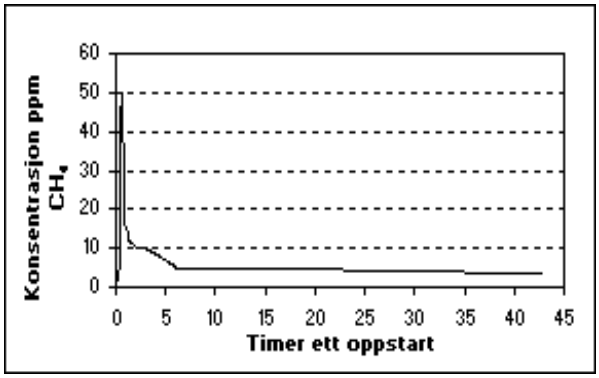


Figure 4.1 Concentration of CH4 for one batch of SiC.

To establish the uncertainty level, the following assessments was done:

- The uncertainty in monitoring of concentration is normally ± 5 (expert judgment).
- The uncertainty of monitoring of the amount of gas is within ± 15 % (type of monitoring equipment).
- The uncertainty of the production of SiC for each batch is stable, and is assessed to be within a level of ± 5 %.
- The uncertainties of raw materials and process variation add ± 5 %.

If these uncertainties are added, the estimate result of total uncertainties for the resulting emissions of CH_4 is ± 30 %.

4.3.3.6. Source spesific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.3.3.7. Recalculations

CO_2

For the three silicon carbide plants, a complete recalculation of CO_2-emissions from 1990 to 2004 has been carried out with new emission factors. This has resulted in higher emissions of CO_2 from the two of the sites, and lower emissions from the third site. The total CO_2 emissions in 1990 for this sector are 28.2 per cent higher than submitted in previous submission (NIR 2005) while the 2003 emissions is now 0.1 per cent lower.

CH_4

The time series of CH_4 emissions from the three silicon carbide plans are recalculated using the new emission factor and this has led to substantial changes in CH_4 emissions for the entire time series. The total CH_4 emissions in 1990 for this sector are 65 per cent lower than in previous submission (NIR 2005) while the 2003 emissions is now 73 per cent lower.

4.3.3.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.3.4. Production of Calcium Carbide – 2B4

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

(4.5) $CaCO_3 \rightarrow CaO + CO_2$

which takes place when limestone (calcium carbonate) is heated.

The reactions

(4.6) $CaO + C\ (petrol\ coke) \rightarrow CaC_2 + CO$

(4.7) $CO \xrightarrow{O_2} CO_2$

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 tonne/ 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

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.3.4.7. Recalculations

Revised emissions of CO_2 from the plant that produces calcium carbide is now used for the period 1990 to 2002. Reported emissions of CO_2 is now almost 60,000 tonne (50 per cent)

higher in 1990 than submitted in NIR 2005. Only minor changes have occurred for the other years. The plant was closed down in 2002.

4.3.4.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.3.5. Production of Methanol - 2B5

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 emissions of CO_2 are calculated by Statistics Norway 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

Uncertainty estimates for greenhouse gases are given in Annex II.

4.3.5.4. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.3.5.5. Recalculations

No recalculations have been carried out since NIR 2005.

4.3.5.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.3.6. Production of Plastic 2B5

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, CH4 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 emissions of CO_2 calculated by Statistics Norway 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. Uncertainty estimates for greenhouse gases are given in Annex II.

4.3.6.4. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

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 2007.

4.3.7. Production of Explosives - 2B5

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 4.5 most of the figures in the national inventory are from the plant's annually report to the SFT.

Table 4.5. Metal production. Components emitted and included in the Norwegian inventory.

	CO_2	CH_4	PFCs	SF_6	Tier	Key category
Iron and steel	R	NA	NA	NA	Tier 2	No
Ferroalloys	R	R	NA	NA	Tier 2/3	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

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

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III. CO_2 emission figures reported to SFT are compared with calculations at Statistics Norway 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 SSB.

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 2005.

4.4.1.6. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.4.2. Production of Ferroalloys - CO_2 - 2C2 (Key Category)

4.4.2.1. Description

There were 12 plants producing ferroalloys in Norway in 2004. Two plants were closed down in 2003, whereas one was started in 2003. Ferrosilicon, silicon metal, ferromanganese and silicon manganese are now produced in Norway. Ferrochromium was produced until the summer in 2001. Ferro silicon 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.

(4.8) $SiO_2 \rightarrow SiO \rightarrow Si + CO$

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. In the production of FeSi and silicon metal NMVOC and CH_4 emissions originates from the use of coal and coke in the production processes. From the production of ferro manganes (FeMn), silisium manganes (SiMn) and ferrochromium (FeCr) there is only CO_2 emissions.

The GHG emissions (CO_2, CH_4 and N_2O) from ferroalloy production accounted for 5.3 per cent of the national total GHG emissions in 1990 and 5.1 per cent in 2004. The total GHG emissions from production of ferroalloy have increased by 6.7 per cent from 1990 to 2004. The reduction was due to higher activity in the sector in spite of that plants have been closed. From 2003 to 2004 the GHG emissions from ferroalloy production increased by 19.9 per cent.

According to the Tier 2 key category CO_2 emissions from production of ferroalloys are key category 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 methods used in the calculation of CO_2 emissions form production of ferroalloy is in accordance with the method recommended by the IPCC (IPCC 1997b), GPG (IPCC 2001) and the 2006 Guidelines adopted by IPCC in April this year. Emissions are reported by each plant in an annual report to the SFT.

Two different methods for calculating CO_2-emissions are applied:

1. Mass balance; the emissions for CO_2 is calculated by adding the total input of C in raw materials before subtracting the total amount of C in products, wastes and sold gases (Tier 3)
2. Calculate emission by multiplying the amount of reducing agents in dry weight with country specific emission factors for coal, coke, petrol coke, electrodes, anthracite, limestone and dolomite. (Tier 2)

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

CH_4 and N_2O
The emissions of CH_4 and N_2O are calculated by multiplying the amount of ferroalloy produced with an emission factor. Emissions are reported by each plant in an annual report to the SFT.

Plants producing ferro manganes, silisium manganes and ferrochromium do not emit emissions of CH_4 and N_2O.

NMVOC
The emissions are estimated by Statistics Norway from the consumption of reducing agents and an emission factor.

4.4.2.3. Activity data

CO_2
Calculation of emissions is based on the consumption of gross reducing agents and electrodes in the production of ferroalloys.

CH_4 and N_2O
The gross production of different ferroalloys is used in the calculation.

NMVOC
The gross amount of reducing agents that are used for the calculation of NMVOC emissions are annually reported to Statistics Norway from each plant.

4.4.2.4. Emission factors

CO_2
The carbon content of each raw materials used in the Tier 3 calculation is from carbon certificates from the suppliers. The carbon in each product, CO gas sold etcetera is calculated from the mass of product and carbon content.

In the Tier 2 calculation the emission factors are from SINTEF (1998b, 1998c and 998d) and the factors are listed in Table 4.6.

Table 4.6. Emission factors from production of ferroalloys. Tonnes CO_2/tonne reducing agent or electrode.

	Coal	**Coke**	**Electrodes**	**Petrol coke**	**Carbonate ore**	**Dolomite Limestone**
Ferro silicon	3.08	3.36	3.36	--	--	--
Silicon metal	3.12	3.36	3.54	--	--	--
Ferro chromium	--	3.22	3.51	--	--	--
Silicon manganese	--	3.24	3.51	3.59	0.16- 0.35	0.43-0.47
Ferro manganese	--	3.24	3.51	3.59	0.16- 0.35	0.43-0.47

Source: SINTEF (1998b, 1998c, 1998d).

CH_4 and N_2O

All companies apply sector specific emission factors in the emission calculation, see Table 4.7. The factors are developed by the Norwegian Ferroalloy Producers Research Organisation (FFF) and standardized in meeting with The Federation of Norwegian Process Industries (PIL) in 2000.

Table 4.7. Emission factors for CH_4 and N_2O from production of ferroalloys. Emission factors

Emission factors						
Emissions	**Alloy**	**Unit**	**Normal operation**	**Dryss-chargering**	**Dryss-chargering > 750 °C**	**References To monitoring**
N_2O	Si-met	kg/h	0.5	0.5	0.5	1/estimated
	FeSi 90 %	kg/h	0.5	0.5	0.5	1/ estimated
	FeSi 75 %	kg/h	0.5	0.5	0.5	1/ estimated
	FeSi 65 %	kg/h	0.5	0.5	0.5	1/ estimated
	Si96	kg/h	0.5	0.5	0.5	1/ estimated
CH_4	Si-met	kg/h	1.5	1.2	0.7	estimated
	FeSi 90 %	kg/h	1.4	1.1	0.6	estimated
	FeSi 75 %	kg/h	1.3	1	0.5	2/ estimated
	FeSi 65 %	kg/h	1.3	1	0.5	estimated
	Si96	kg/h	1.5	1.2	0.7	estimated
Reference	Measured at:					
1	Estimated from SFT standard value					
2	Monitored in 1985 75% at Tinfos Notodden					
5	Monitored in 1999 75 % FeSi at Thamshavn					

NMVOC
Statistics Norway 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

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III. The reported emissions from the plants were compared with emissions data given in the green book and other relevant data available. In some cases, the emission data were verified by making control calculation based on emission factors and activity data. In all cases, the construction of charts and figures of emissions and activity data helped identifying missing data and possible errors.

All the main producers of ferroalloys in Norway were contacted and asked to supply missing emissions data and activity, and to explain any possible errors identified. The feedback from the companies made it possible to make corrections and filling of gaps in the series of data.

A complete time series from 1990 to 2004 could be established for all three relevant greenhouse gas parameters for most companies. Data from the white book and the reported company data corresponded well.

There are still a few data gaps, especially for the year 1991. Not all companies could provide data from 1991. In cases where neither information concering the consumption or raw materials nor the amount of production were present, emissions were not possible to calculate. In those cases were activity data from 1991 were present, the emissions were calculated or estimated.

Statistics Norway makes in addition 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

- The emission figures for CO_2 for the years 1990 to 2004 for almost all ferroalloy plants are revised. The plants have reported new data to the SFT, which is now used in the emission inventory. Compared with previous submission (NIR 2005) the CO_2 emissions calculated for 1990 now is 1 per cent higher and in 2003 the emissions is 2.2 per cent lower.
- The emission figures for CH_4 for the years 1990 to 2004 for ferroalloy plants are revised. The plants have reported new data to the SFT, which is now used in the emission inventory. The CH_4 emissions is in 1990 2 per cent higher and in 2003 1.4 per cent lower than reported in NIR 2005.
- The emission figures for N_2O for the years 1990 to 2004 for ferroalloy plants are for the first time included in the Norwegian GHG emission inventory. The emission figure that is included in the inventory is reported by the plants to the SFT.
- The emission figures for CO_2 from production of ferroalloys are reduced for 1993 and 1994 due to double counting.

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 2007.

4.4.3. Production of Primary Aluminium –CO_2 and PFC - 2C3 (Key Category)

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.

There has been a substantial reduction in the total PFC emissions from the seven Norwegian aluminium plants in the period from 1990 to 2004. This is mainly as a result of the sustained

work and the strong focus on reduction of the anode effect frequency in all these potlines.

PFCs emissions from production of aluminium contribute in 1990 to 6.8 per cent of the total GHG emissions in Norway. The share of the totals in 2004 is reduced to 1.6 per cent. Emissions of PFCs are decreased with 74 per cent from 1990 to 2004 and between 2003 and 2004 the emissions have decreased by 6 per cent.

The PFC emissions per tonne aluminium produced in Norway was 3.87 kg CO_2-equivalent in 1990 to 0.67 kg CO_2-equivalent in 2004 which is a reduction 82 per cent from 2002 to 2003. The reduction has been of 13.1 per cent from 2003 to 2004. This large reduction in 2004 was mainly due to that the plant that converted to Prebaked technology in 2003 increased it's proportion of the total production.

An increase in production capacity is also included in the modernisation, leading to higher emissions of CO_2.

PFCs and CO_2 emissions from aluminium production are both key category in level, PFC also in trend both according to the Tier 2 key category analysis.

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, Statistics Norway 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

(4.9) $Q = A*C*3.67$

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

(4.10) $Q = S*3.67*(K*C1+P*C2)$

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

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. 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).

During electrolysis two perfluorocarbon gases (PFCs), tetrafluormethane (CF_4) and heksafluorethane (C_2F_6), may be produced in the following reaction:

Reaction 1

$$4Na_3AlF_6 + 3C \rightarrow 4Al + 12NaF + 3CF_4$$

Reaction 2

$$4Na_3AlF_6 + 4C \rightarrow 4Al + 12NaF + 2C_2F_6$$

The national data are based on calculated plant specific figures from each of the seven Norwegian plants. We have used the Tier 2 method in our calculations, which are based on a technology specific relationship between anode effect performance and PFCs emissions. The PFCs emissions are then calculated by the so-called slope method, where a constant slope coefficient (see Table 4.8), given as kg CF_4/tonne Al/anode effect minutes per cellday, is multiplied by the product of anode effect frequency and anode effect duration (in other words, by the number of anode effect minutes per cell day), and this product is finally multiplied by the annual aluminium production figure (tonnes of Al/year). The formula for calculating the PFCs is:

$$\textbf{kg } CF_4 \textbf{ per year} = S_{CF4} \bullet AEM \bullet MP$$

and

$$\textbf{kg } C_2F_6 \textbf{ per year} = \textbf{kg } CF_4 \textbf{ per year} \bullet F_{C2F6/CF4}$$

Where :

S_{CF4} = "Slope coefficient" for CF_4, (kg $_{PFC}/t_{Al}$/anode effect minutes/cellday

AEM = anode effect minutes per cellday

MP = aluminium production, tonnes Al per year

$F_{C2F6/CF4}$ = weight fraction of C_2F_6/CF_4

Table 4.8. Technology specific slope and overvoltage coefficients for the calculation of PFCs emissions from aluminium production.

Technology [a]	**"Slope coefficient"** [b, c] **(kg $_{PFC}/t_{Al}$)/ (anode effect/cellday)**		**Weight fraction C_2F_6/CF_4**	
	S_{CF4}	**Uncertainty** (±%)	$F_{C2F6/CF4}$	Uncertainty (±%)
CWPB	0.143	6	0.121	11
SWPB	0.272	15	0.252	23
VSS	0.092	17	0.053	15
HSS	0.099	44	0.085	48

a. Centre Worked Prebake (CWPB), Side Worked Prebake (SWPB), Vertical Stud Søderberg (VSS), Horizontal Stud Søderberg (HSS).
b. Source: Measurements reported to IAI, US EPA sponsored measurements and multiple site measurements.
c. Embedded in each slope coefficient is an assumed emission collection efficiency as follows: CWPB 98%, SWPB 90%, VSS 85%, HSS 90%. These collection efficiencies have been assumed based on measured PFC collection fractions, measured fluoride collection efficiencies and expert opinion.

Slope coefficient": The connection between the anode parameters and emissions of PFC. Measurements of PFCs at several aluminium plants have established a connection between anode parameters and emissions of CF_4 and C_2F_6. The mechanisms for producing emissions of PFC are the same as for producing CF_4 and C_2F_6. The two PFC gases are therefore considered together when PFC emissions are calculated. The C_2F_6 emissions are calculated as a fraction of the CF_4 emissions.

The Tier 2 coefficients for Centre Worked Prebake cells (CWPB) are average values from about 70 international measurement campaigns made during the last decade, while there are fewer data (less than 20) for Vertical Stud Soderberg cells (VSS). The main reason for the choice of the Tier 2 method is that the uncertainties in the facility specific slope coefficients is lower than the facility specific based slope coefficients in Tier 3. This means that there is nothing to gain in accuracy of the data by doing measurements with higher uncertainties.
Med dette veletablerte forholdet mellom blussdata og PFC - utslipp kan man bruke prosessdata til å beregne PFC- utslippene i stedet for direkte å måle disse utslippene.

"Slope coefficient" is the number of kg CF_4 per tonne aluminium produced divided by the number of anode effects per cellday. The parameter cellday is the average number of cells producing on a yearly basis multiplied with the number of days in a year that the cells have been producing.

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. Emission factors

In the present calculations we have calculated the PFC emissions using the newest Tier 2 recommended values by IAI for CF_4 (the slope coefficients of 0.143 kg CF_4/tonne Al/anode effect minutes per cell day for CWPB and 0.092 for VSS). The amount of C_2F_6 is calculated from the Tier 2 values for CF_4, where the weight fraction of C_2F_6 to CF_4 is set equal to 0.121 for CWPB and 0.053 for VSS. This change alone increases the calculated CO_2-equivalent emissions by 10% for our prebake cells, because of the high global warming potential for C_2F_6.

Thus, all the values we have used in our present calculations are technology specific data, recommended by IAI. Our facility specific measured data that we have used until today are all in agreement with these data, within the uncertainty range of the measurement method employed.

4.4.3.4. Activity data

Both production data and consumption of reducing agents and electrodes is reported annually to SFT.

PFCs
The basis for the calculations of PFCs is the amount of primary aluminium produced in the potlines and sent to the cast house. Thus, any remelted metal is not included here.

4.4.3.5. Uncertainties

Uncertainty estimates for greenhouse gases are given in Annex II.

PFCs
The uncertainties in the so-called Tier 2 slope coefficients from IAI is lower (!6% and !17% for CWPB and VSS cells, respectively), compared to the measured facility specific based slope coefficients, where the uncertainties are around !20%, even when the most modern measuring equipment is used (the continuous extractive-type Fourier Transform Infrared (FTIR) spectroscopic system). Control measurements in two Hydro Aluminium plants (Karmøy and Sunndal) done by Jerry Marks in November 2004, showed that the measured values for CWPB and VSS cells were well within the uncertainty range of the Tier 2 slope coefficients.

4.4.3.6. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

CO_2
It was possible to establish data series of CO_2 from 1990 to 2004 for all plants. There are still some discrepancies between reports of process related CO_2 and energy related CO_2, especially in the beginning of the 1990s. This is because it was difficult to provide sufficient energy data to calculate the energy related combustions.

The emission figures reported by the plants are also controlled by Statistics Norway. SSB make their own estimates based on the consumption of reducing agents and production data collected in an annual survey and average emission factors.

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 analysed taking technical changes and utilisation of production capacity during the year into account. 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 represented. 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.

4.4.3.7. Recalculations

CO_2

Estimated CO_2 emissions for aluminum production, 7 plants, in 1990 to 2004, have been replaced by reported figures from the plants to SFT. This has led to decreased CO_2 emissions of 4.7 per cent in 1990 and 0.1 per cent in 2003 compared with NIR 2005.

PFCs

The former calculation method that we used was based on a fixed and constant duration of the anode effects. The main reason for this was that one of the plants, with prebake potline with the Pechiney AP18 technology, when the methodology was established did not have a process control system that could measure their anode effect durations sufficiently accurately. Another reason was that it would require a large amount of manual work to calculate the anode effect duration for the other potlines too. Presently, improvements in the recording of the process control data have made this task easier.

The reason why we now calculate higher PFC emissions for some potlines, is that the real anode effect duration has increased significantly, for instance for one Soderberg plant. This has been caused by operational problems (unstable operation) and sometimes difficulties also in reducing the anode effect frequency.

The reason for that we now choose Tier 2 rather than Tier 3 from (IPCC 2006) is that there is only a small difference between the results from Tier 2 and Tier 3 calculations. This difference is much smaller than the uncertainties in the measurements of the facility specific slope factors, and no substantial improvement in the accuracy of the reported data can therefore be achieved by using the Tier 3 method. For example the PFC emissions for one plant are reduced by 95 per cent from 1990 to 2004 when the emissions are calculated by Tier 2 and respectively 97 per cent when we use Tier 3.

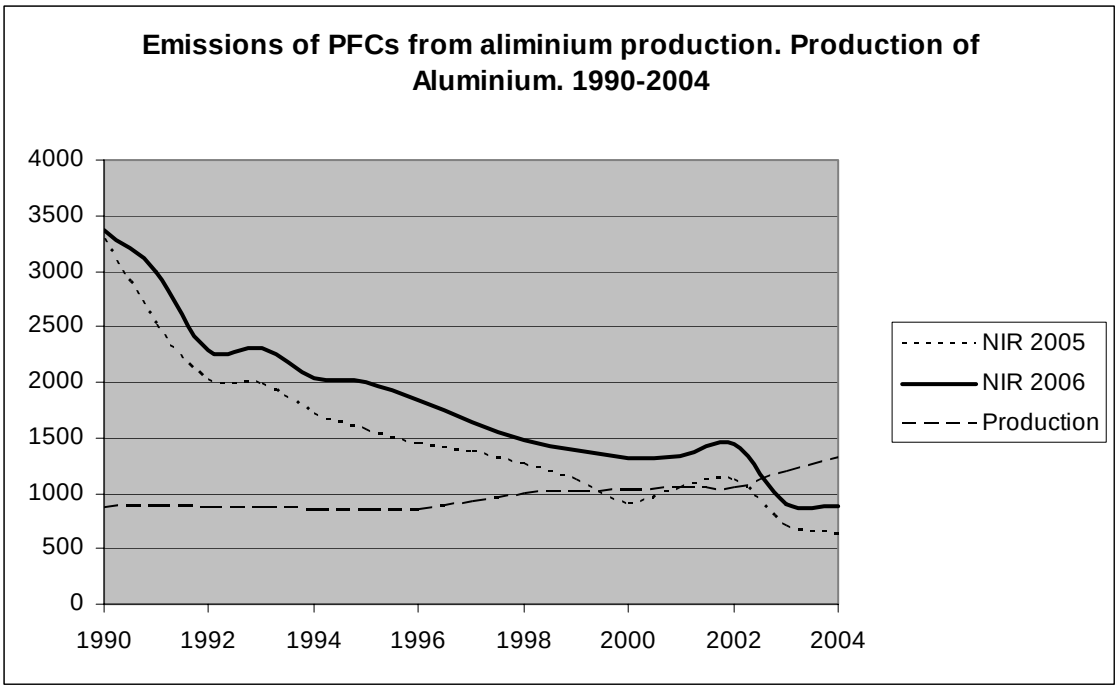
Comparison of emissions from NIR 2005 and the recalculated emissions reported in this submission are shown in table 4.9. In figure 4.2 the emissions with new and old method is shown as well as the production of aluminium.

The change in calculation method have led to that the total PFC emissions is 2.3 per cent higher in 1990 and 29.2 per cent higher in 2003 than reported in NIR2005.

Table 4.9 Comparison of the 1990 and 2003 emissions reported in NIR 2005 with recalculated emissions for the same years submitted in NIR 2006.

	NIR 2005	NIR 2006		NIR 2005	NIR 2006	
	1990	1990		2003	2003	
	tonne CO2-eq	tonne CO2-eq	per cent change	tonne CO2-eq	tonne CO2-eq	per cent change
CF4	3 114 371	3 037 816	-2,46	664 781	816 192	22,78
C2F6	180 026	332 584	84,74	38 668	92 874	140,18
Total PFC from Al production	3 294 397	3 370 401	2,31	703 449	909 066	29,23

Source: SFT



Source: SFT

Figure 4.2. PFCs emissions from aluminium production from NIR 2005 and recalculated emissions reported in this submission. PFCs emissions in 1000 tonne CO_2 equivalents. Production of aluminium in 1000 tonne. 1990-2004.

4.4.3.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.4.4. Production of Secondary Aluminium – 2C4

4.4.4.1. Description

One open mill in Norway is handling secondary aluminium production. For earlier years there have been some emissions of SF_6.

4.4.5. Production of magnesium –SF_6 - 2C4 (Key Category)

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 process related 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, according to the Tier 1 key category analysis, defined as key category in trend due to contribution to 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 reported annually 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, see Annex II.

4.4.5.6. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6.

Last years reported emission data from the plant is compared with previously reported data and the emissions are compared with the production.

4.4.5.7. Recalculations

CO_2
In 2002 one plant producing magnesium closed down the production of cast magnesium. This led to disappearance of CO_2 emissions. In the inventory Norway erroneous used the emission figure from 2002 for the years 2003 and 2004. These emissions figures are now deleted from the inventory.

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

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 are given in Annex II.

4.4.6.4. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III. 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

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 alternatives 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 two different methods:

- By calculating the total amount of anode produced with an emission factor
- Based on measurements to decide the emissions per hour of production.

4.4.7.3. Uncertainties

Uncertainty estimates for greenhouse gases are given in Annex II.

4.4.7.4. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.4.7.5. Recalculations

New time series have been calculated for both companies, giving changes in the emission figures for most years from 1990 to 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. Pulp and paper - 2D1

4.5.1.1. Description

There is CO_2 emissions from non-combustion from one plant in this sector. The emissions originate from the limestone.

4.5.1.2. Methodological issues

The CO_2 emissions are calculated by multiplying the amount of limestone by an emission factor. For the years 1990-97 the emissions are calculated by SFT based upon activity data reported to SFT by the plant and emission factor. The emissions in the period 1998-2004 are reported in the plant's application for CO2-permits within the Norwegian scheme of greenhouse gases.

4.5.1.3. Activity data

Activity data is reported by the plant to SFT. The amount of limestone is calculated from purchased amount.

4.5.1.4. Emission factors

The emission factor used in the calculation is 0.44 CO_2 per tonne limestone.

4.5.1.5. Uncertainties

No source specific uncertainty is known.

4.5.1.6. Source specific QA/QC and verification

The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.

4.5.1.7. Recalculations

One pulp and paper plant reports CO_2 emission data to SFT. These are split into emissions from process and combustion for the years 1990 to 2004. Earlier emission calculations were based on activity data and emission factors. It was assumed that the total emission originated from the combustion processes (1A2d). Emissions are now split for this plant, and CO_2 emissions from the process are included for the first time.

4.5.1.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.5.2. Food and drink - CO_2 - 2D2 (Key category)

4.5.2.1. Description

This source category includes NMVOC emissions from production of bread and beer, CO_2 from carbonic acid mainly used in breweries, export of captured CO_2 and CO_2 from production of bio protein.

As mentioned in Section 4.3.1 Ammonia Production, some CO_2 from this production is captured and in Norway mainly used as carbonic acid in carbonated beverages but most of the captured CO_2 is exported. The whole tonnage, inland use and exported volume, is reported under this category, 2D2. The largest part of the emissions takes place after the bottles is opened and not in the breweries. In 2004, about 220 ktonnes CO_2 were sold for national use and export.

This source category is according to the Tier 2 key category analysis defined as a key category due to contribution in trend.

4.5.2.2. Methodological issues

CO_2
The figures are based on the sale statistics from the ammonia producing plant.

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.

Production of Bio Protein CO_2
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 included in the national inventory

4.5.2.3. Activity data

NMVOC
Production volumes of bread and beverage are annually reported to Statistics Norway.

4.5.2.4. Emission factors

NMVOC
The emission factors are taken from (EEA 1996).

Table 4.10. 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 litre

Source: EEA (1996)

4.5.2.5. Uncertainties

NMVOC
The emission factors used is recommended by EEA (1996) and not specific for Norwegian conditions.

4.5.2.6. Source specific QA/QC and verification

NMVOC
The general QA/QC methodology is given in Section 1.6 and the specific QA/QC carried out for Industrial processes is described in Annex III.
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.5.2.7. Recalculations

Carbonic Acid to Breweries - CO_2
CO_2 from one plant producing ammonia is separated and sold as carbonic acid for different purposes as for carbonic acid in carbonated beverages. Part of the CO_2 is sold and used in Norway, whereas an other part is exported. In the previous submissions only the part used in Norway was included in the Norwegian GHG inventory. In this submission also the CO_2 exported is included, in source category 2D2 Food and drink. Reported CO_2 emissions

therefore increase for all years. This correction is in accordance with what was suggested by the review team during the 2005 review process.

NMVOC
No recalculations have been carried out since NIR 2005.

4.5.2.8. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

4.6. Consumption of Halocarbons and SF_6

4.6.1. HFCs and PFCs from Products and Processes – HFC - 2F (Key Category)

4.6.1.1. Description

HFCs and PFCs are used as substitutes for ozone depleting substances (CFCs and HCFCs) that are being phased out according to the Montreal Protocol. They are used in varied applications, including refrigeration and air conditioning equipment, as well as in foam blowing, fire extinguishers, aerosol propellants and analysing purposes. There are no production of HFCs and PFCs in Norway (However, PFCs are emitted as a by-product during the production of aluminium, see chapter 4.4.3.5). The HFCs and PFCs now used in significant quantities in Norway are HFC-23, HFC-32, 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 2005 the tax and refund were both 190,5 NOK (appr. 24 Euro) pr. tonnes of CO_2-equivalents. Work has been established to completely review the methodology based on these new realities.

This sector (2F) is according to the Tier 2 key category analysis defined as key category due to uncertainty in trend.

4.6.1.2. Method

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 import of gas and emission characteristics related to specific processes and equipment (SFT 1999). 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 for 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, export and destruction 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 3:1 in 2004.

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 HFCs, PFCs and SF6. Importers of bulk chemicals are contacted yearly by the Norwegian Pollution Control Authorithy, and are required to provide information on the types, amounts and application categories of the chemicals they import. Imported and exported amounts of chemicals in products for the years 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. Since the introduction of the tax in 2003 information on import/export in bulk and products is also available from custom statistics. This information has been used to update the imported amounts of chemicals in refrigeration and air-conditioning equipment.

4.6.1.4. Emission factors

The introduction of taxes seems to have imposed better maintenance of equipment which has to be refilled with HFCs or PFCs. Two of the emission factors established by expert judgment in 1999 (SFT 1999) are therefore changed (i.e. lowered) in the years 2003 and 2004: The application categories air conditioning aggregates and heat pumps, and water/liquid refrigerating aggregates, water-based heat pumps. These are given the lowest emission factors from the guidelines in 2003 and 2004. The assessment of sub-application area commercial and industrial applications is not completed yet, so the emission factor has not yet been changed. When the project is completed it is expected that also this factor will be changed to reflect the new realities.

Refrigerated transport is not lowered because the conditions in Norway (bad roads and high share of sea transport) are assumed to give emissions in the high end of guidelines. Emission factors used were quite low and were set to be 20.

Household refrigerators and freezers are lowered according to guidelines.

Other emission factors have not been changed.

Table 4.11. Emission factors for HFCs from products and lifetime of products

Application category	Emissions during life-time (per cent of initial charge) 1990-2002	Emissions during life-time (per cent of initial charge) 2003-2004	Lifetime of products (years)
Refrigeration and air conditioning			
Household refrigerators and freezers	1.5	1	1
Commercial and industrial applications	3.5	3.5	15
Refrigerated transport	20	20	20
Air conditioning aggregates and heat pumps	4	1	15
Water/liquid refrigerating aggregates, water-based heat pumps	5	1	15
Mobile air conditioners	10	10	12
Foam			
Polyurethane with diffusion barrier	1	1	40
Polyurethane without diffusion barrier	5	5	20
Extruded polystyrene	3	3	30
Fire extinguishers	5	5	15
Solvents	50	50	2
Aerosol propellants	50	50	2

4.6.1.5. Uncertainties

The uncertainties of the different components of the national greenhouse gas inventory have been evaluated in detail in 2006 by Statistics Norway (See annex II). Both the leakage rate (emission factor) and the stored amount of chemicals (activity data) are considered quite uncertain. The total uncertainties for the emission estimates by the consumption of halocarbons are estimated to be ±50 per cent for both HFC and PFC.

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

Introduction of taxes on imports of HFCs and PFCs in 2003 provided a new data source which was used to update activity data for the years 1998-2004. The update gave rise to slightly higher emissions because of a shift in activity data from source categories with low emission factors (eg. Household refrigerators and freezers) to categories with higher emission factors (eg. Mobile air conditioners).

Current calculations take into account the fact that parts of the chemicals imported in 2002, prior to the tax introduction, were stored for usage the following years. This resulted in lower emissions in 2002 and higher emissions in 2003 than reported in the previous submission.

4.6.1.8. Planned improvements

As mentioned a new tax on import and production of HFC and PFC was introduced in January 2003. We believe that the draft new methodology is underestimating the effect of this tax. Probably the tax has also led to better maintenance especially in the commercial and industrial sector and maybe some other sectors as well. This should lead to less leakage and therefore further decrease in emissions compared to the business-as-usual scenario. Norway will further improve the calculations on this field.

4.6.2. Emissions of SF_6 from Products and Processes – 2F

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 per cent in 2005 and 30 per cent 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 general methodology for estimating SF_6 emissions was revised in 1999 (SFT 1999d), while the sector-specific methodology for GIS has been revised in this years reporting based on new information from the agreement. Today's method for GIS is largely in accordance with the Tier 3a methodology in the IPPC Good Practice Guidance (IPCC 2000).
The method for other sources is largely in accordance with the Tier 2 methodology in the IPPC guidelines for emission inventories (IPCC 1997a,b). The calculations take into account imports, exports, recycling, banking, technical lifetimes of products, and different rates of leakage from processes, products and production processes. From 2003 and onwards 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 back to 1985. 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 4.12 and 4.13.

Table 4.12. 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 4.13 Product lifetimes and leakage rates from products containing SF_6

Product emission source	**Yearly rate of leakage**	**Product lifetime (years)**
Gas-insulated switchgear (GIS)	1	30
Sealed medium voltage switchgear	0.2	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 2004 emissions, historical data were recalculated, emission factors from different sources were established and the bank of SF_6 in existing installations was estimated. 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

New emission and stock data for the industry from 2003 onwards were introduced in the 2005 inventory. Now the time series back to 1990 has been revised to get a consistent time series. Stock end emission data from companies that are not part of the GIS agreement has been revised. The new data indicate that stocks and emissions were slightly overestimated in the old method.

4.6.2.7. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

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 result in 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.

In addition to solvents emitting NMVOC, there are other products that emit other volatile components. Creosote treated materials and tarry jointing paste cause emissions of PAH (poly-aromatic hydrocarbons). PAH and dioxin are also emitted during production of asphalt. Emissions of N_2O from anaesthesia procedures and spray cans as well as mercury from mercury-containing products are also included in the Norwegian inventory. 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 2004 and 0.4 per cent in 1990 (CRF table 3).

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 categories.

5.2.2. Methodological issues

The methodology used to estimate emissions from use of solvents and products containing solvents has been based on a solvent balance approach (Rypdal 1995a). 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:

*(5.1) 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. Completeness

No major missing emission sources are likely.

5.2.6. Source specific QA/QC and verification

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.

5.2.7. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

5.2.8. Recalculations

No recalculations are carried out since last year.

5.3. Use of solvents – 3C

5.3.1. Creosote-treated materials

5.3.1.1. Description

Creosote is mainly used in quay materials and conduction poles, but also in fence poles and roof boards. In Norway there is a requirement that all creosote in use should contain less than 50 mg/kg benzo(a)pyren (NTI 2000). PAH-components will evaporate from the creosote-treated materials in hot weather. In addition, PAH-components will evaporate during impregnation. The smallest PAH-components, like naphthalene, are most volatile, but several components used in wood treatment will not evaporate. It is assumed that 5-10 per cent will evaporate during the first 3-4 years (Evans 2000), depending on the creosote oil used.

5.3.1.2. Method

Emission of PAH is calculated based on the import of creosote oil and emission factors. For simplicity, it is assumed that all PAH is emitted the same year as the materials are produced.

5.3.1.3. Activity data

Imported data of creosote oil (product 27.07.9100) is given by statistics of foreign trade at Statistics Norway.

5.3.1.4. Emission factors

The emission factors used, are those recommended used in the Norwegian Pollution Control Authority's guidelines for reporting to the North Sea agreement and based on foreign studies (table 5.1).

Table 5.1. Emission factors for evaporating from creosote-treated materials. 10^{-6} kg/m^2/year

Name	Wood treated in "old days" 10^{-6} kg/m^2/year	Recently treated wood 10^{-6} kg/m^2/year
Benzo(a)pyrene	0.74	0.74
Benzo(b)fluoranthene	..	..
Benzo(k)fluoranthene	0.15	0.15
Indeno(1,2,3-cd)pyrene	0.016	0.016
Fluoranthene	370	520
Benzo(ghi)perylene	..	..
Fenanthrene	1400	4800
Anthracene	52	260
Pyrene	..	..
Benzo(a)fluorene	..	..
Benzo(b)fluorene	..	..
Benzo(a)anthracene	11	70
Crysene/triphenylene	13	13
Benzo(e)pyrene	..	..
Dibenzo(ah)anthracene	..	..
Dibenzo(ae)pyrene	..	..
Dibenzo(ah)pyrene	..	..
Dibenzo(ai)pyrene	..	..
Acenaphthene	..	..
Fluorene	..	..
Norwegian standard 9815	1 847 (100.0)	5 664 (100.0)
Borneff (PAH-6)	371 (20.1)	521 (9.2)
LRTAP (PAH-4)	1 (0.1)	1 (0.0)

Source: SFT (2001a).

5.3.1.5. Uncertainties

In the inventory it is assumed that all PAH is emitted the same year as the materials are used. This is however not the case since PAH will be emitted as long as the creosote-treated materials are in use. However, most of it is likely to be emitted during the first years.

5.3.1.6. Completeness

No major missing emission components or sources are likely.

5.3.1.7. Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section **Feil! Fant ikke referansekilden.** for the description of the general QA/QC procedure.

5.3.2. Tarry jointing paste

5.3.2.1. Method

Tarry jointing paste contains PAH-components and can evaporate to air. NILU/NIVA (1995) have estimated an annual emission of 125 kg/year. This estimation is based on imported tarry paste and a tar content of 16 per cent. This kind of jointing paste is mainly used at airports. There is no available PAH-profile for this emission, and due to the lack of data, the same PAH-profile as that of asphalt production is used (table 5.2). The emission is assumed to be rather constant each year.

Table 5.2. Emission of PAH from use of tarry jointing paste[1]. kg PAH/year

	kg PAH/year
Norwegian standard 9815	125
Borneff (PAH-6)	3
LRTAP (PAH-4)	0.0

[1] Emission factors are from production of asphalt.

5.3.2.2. Uncertainties

There is uncertainty regarding the PAH-profile since in lack of a specific profile, the same PAH-profile as for asphalt production is used.

5.3.2.3. Completeness

There are a couple of very minor sources of PAH that are not included in the Norwegian inventory. PAH-containing products are used in tar paper and fishing net. According to NILU/NIVA (1995), the annual emissions are low. In Rypdal and Mykkelbost (1997), emission factors of 0.3 g/tonnes and 28 g/tonnes are given for tar paper and fishing net respectively, but emissions from these sources are not included in the inventory.

Also anticorrosive paint used for treatment of ships and platforms is a potential source for PAH emissions. In Rypdal and Mykkelbost (1997), emission factors of 7.5 mg/ship/year at shipyard, 1.9 mg/ship/year at harbour and 96 mg/ship/year in service are given. This pre-supposes treatment each third year. The emissions are low compared to other sources and not included in the inventory.

5.3.2.4. Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section **Feil! Fant ikke referansekilden.** for the description of the general QA/QC procedure.

5.3.3. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

5.3.4. Recalculations

No recalculations are carried out since last year.

5.4. Production of asphalt – 3C

5.4.1. Method

PAH

Most of the asphalt produced in Norway uses the batch-method (Haakonsen et al. 1998). Emissions are calculated by multiplying the amount of asphalt produced with an emission factor.

Dioxin

Asphalt preparations and asphalt recycling are supposed to be a possible dioxin source, especially in countries using extensive recycling, and that use salt on the roads during winter. A lot of salt is used on Norwegian roads during winter, and when this asphalt is heated during recycling, it is assumed to give emissions of dioxins (Hansen 2000).

5.4.2. Activity data

The activity data used is production of asphalt in Norway. In NILU/NIVA (1995), there is a figure of production of asphalt from 1991. The same figure is used for all years due to the lack of better data.

5.4.3. Emission factors

PAH

NILU/NIVA (1995) estimated the emission of PAH to be 15 mg/tonne asphalt. This includes however naphthalene and other components not to be included in PAH after Norwegian standard (NS3815). However, if this emission factor is combined with speciation data from Jebsens miljøteknikk (1991), an emission factor of 2.8 mg/ton is found. This agrees well with the emission factor 2.0 mg/ton suggested by US. EPA (Environmental Protection Agency).

Dioxin

Two emission factors are found in the literature. OSPAR (The Oslo and Paris Convention) (SFT 2001a) suggests an emission factor of 0.047 µg/ton asphalt. This emission factor is however assumed to be very high since it is based on data from a plant only re-circulating old asphalt. Fyns Amt (2000) operates with a much lower emission factor, which probably reflects dioxin emissions from preparation of new asphalt. Since Norway both makes new asphalt and recycles old asphalt it is assumed that an emission factor in between those suggested from OSPAR and Fyns Amt would be most correct for Norwegian conditions (table 5.3).

Table 5..3.Dioxin emission factor for asphalt production. µg I- TEQ/tonne produced asphalt

Source	Emission factor
OSPAR (SFT 2001a)	0.047
Fyns Amt (2000)	0.0022
Emission factor chosen	0.025

5.4.4. Uncertainties

The activity data used are from 1991, and due to the lack of better information, the same figure has been used for all years. The emission factors used, both for estimating PAH and dioxin, are also uncertain. The annual emissions are low however, and will not have any impact on the total level of these types of emissions.

5.4.5. Completeness

No major missing emission components are likely.

5.4.6. Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section **Feil! Fant ikke referansekilden.** for the description of the general QA/QC procedure.

5.4.7. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

5.4.8. Recalculations

No recalculations are carried out since last year.

5.5. Other product use -3D

5.5.1. Use of N_2O in anaesthesia – 3D

5.5.1.1. 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.

5.5.1.2. Activity data

For this source actual sale of N_2O is used for the year 2000.

5.5.1.3. Emission factors

As mentioned, no emission factors are used since the figures are based on sales of N_2O.

5.5.1.4. 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.

5.5.1.5. 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.

5.5.1.6. Source specific QA/QC and verification

There is no source specific QA/QC procedure for this sector. See section **Feil! Fant ikke referansekilden.** for the description of the general QA/QC procedure.

5.5.2. 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 drag-racing. There is no production of N_2O for these purposes in Norway.

5.5.2.1. Methodological issues

Information on sale volumes is given from the plants to Statistics Norway. Statistics Norway assumes that all propellant is released to air.

5.5.2.2. 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.

5.5.2.3. Completeness

No major missing emission components are likely.

5.5.2.4. Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section **Feil! Fant ikke referansekilden.** for the description of the general QA/QC procedure.

5.5.2.5. Planned improvements

There is no planned activity this year that will improve the data quality for NIR 2007.

5.5.2.6. Recalculations

No recalculations are carried out since last year.

6. Agriculture

6.1. Overview

About 8 per cent of the total Norwegian emissions of greenhouse gases (GHG) originated from agriculture, in 2004. This corresponds to 4.3 million tonnes CO_2-eqv. The emissions from agriculture are quite stable, with emissions in 2004, 2.5 percent lower than in 1990, and 1 percent lower than in 2003.

The sectors clearly biggest sources of GHG's are "enteric fermentation" (CH_4) from domestic animals, contributing with 44 per cent and "agricultural soils" (N_2O) contributing with almost 45 percent of the sectors emissions. These are also key categories. 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 I of this report, the key category analysis performed in 2006 for the years 1990 and 2004 has revealed that in terms of total level and trend uncertainty the *key categories* 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)
- Manure management – N_2O
- Manure management – CH_4

6.2. Emissions from enteric fermentation in domestic livestock 4A– CH_4 (Key Category)

6.2.1. Description

An important end product from the ruminal fermentation is methane (CH_4). The amount of CH_4 produced from enteric fermentation is dependent on several factors, like animal species, production level, quantity and quality of feed ingested and environmental conditions. According to IPCC (IPCC, 2001) the method for estimating CH_4 emission from enteric fermentation requires three basic items:

· No. 1 The livestock population must be divided into animal subgroups, which describe animal type and production level.
· No 2. Estimate the emission factors for each subgroup in terms of kilograms of CH_4 per animal per year.
· No 3. Multiply the subgroup emission factors by the subgroup populations to estimate subgroup emission, and sum across the subgroups to estimate total emission.

Enteric fermentation is a key category because of uncertainty in level and trend.
Enteric fermentation contributed with 90.3 ktonnes of CH_4 emissions in 2003, corresponding to 1.896 Mtonnes CO_2 equivalents, which is 3. 45 per cent of the national GHG emissions. Enteric fermentation constitutes 86 per cent of the overall CH_4 emissions from agriculture and 44 percent of this sectors GHG emissions. Emissions have been rather stable with minor fluctuations. Emissions decreased 2.6 percent in the period 1990-2004 and 2.5 percent in 2003-2004.

6.2.2. Methodological issues

The methodology for calculating CH_4 from enteric fermentation for the main emission sources cattle and sheep has in 2006 been updated to the Tier 2 approach for all years, as recommended by the UNFCCC review team.
The methodology for calculating CH_4 from enteric fermentation for the other animal categories 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.

6.2.3. Activity data

The Tier 2 method of calculation requires subdividing the cattle and sheep populations by animal type, physiological status (dry, lactating or pregnant) live weight and age. Table 6.1 describes the animal categories used for cattle and sheep in the calculations.
For dairy cows additional information from the Cow Recording System, concerning annual milk production and proportion of concentrate in the diet has been used. The Cow Recording System also supplies information about slaughter age, slaughter weight and average daily weight gain (ADG) for growing cattle, which are utilized in the calculations for growing cattle

Table 6.1 Categories of cattle and sheep used in the Norwegian calculations of methane emission from enteric fermentation.

Categories of cattle and sheep
Dairy cows
Beef cows
Replacement heifers, < one year
Replacement heifers, > one year
Finisher heifers, < one year
Finisher heifers, > one year
Finisher bulls, < one year
Finisher bulls, > one year
Breeding sheep, > one year
Breeding sheep, < one year
Slaughter lamb, < one year. Jan-May
Slaughter lamb, < one year. Jun-Sept

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 (UMB 2001). The formula for calculating the average figure for lambs will then be:

$$(6.1) \quad Lambs * \frac{143}{365}$$

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

For cattle and sheep the following basic equation are used to calculate the CH_4 emission factor for the subgroups (Tier 2):

$EF = (GE \cdot Ym \cdot 365 \text{ days/yr}) / 55.65 \text{ MJ/kg } CH_4$

Where:
EF = emission factor, kg CH_4/head/yr
GE = gross energy intake, MJ/head/day
Ym = CH_4 conversion rate, which is the fraction of gross energy in feed converted to CH_4.

This equation assumes an emission factor for an entire year (365 days). In some circumstances the animal category may be alive for a shorter period or a period longer than one year and in this case the emission factor will be estimated for the specific period (e.g., lambs living for only 143 days and for beef cattle which are slaughtered after 540 days).

For the animal categories others than cattle and sheep, the Tier 1 default emission factors for each kind of animal (IPPC 1997a, 1997b) is 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 6.2 Emission factors for CH_4 from enteric fermentation and different animal types estimated with the Tier 1 method

Animal	Emission factor (Tonnes/animal/year)
Horses	0.018
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 per cent.

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..

6.2.6. Completeness

Major missing emission sources are not likely.

6.2.7. Source specific QA/QC and verification

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. In 2005-2006, Statistics Norway and the Norwegian Pollution Control Authority carried out a project in cooperation with the Norwegian University of Life Sciences, which resulted in an update of the emission estimations for cattle and sheep using a tier 2 method.

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.

6.3. Emissions from manure management - 4B - CH_4, N_2O

6.3.1. Description

The relevant pollutants emitted from this source category are CH_4 (IPCC 4B(a)), N_2O (IPCC 4B(b)) and NH_3 (NFR 4B).

CH_4-emissions due to manure management amounted to 14.8 ktonnes in 2004, corresponding to 0.31 Mtonnes CO_2 equivalents. N_2O-emissions due to manure management amounted to 0.39 ktonnes in 2004, corresponding to 0.12 Mtonnes CO_2 equivalents.

Manure management emitted in 2004 0.43 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 stayed at the same leve in the period 1990-2004.

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):

(6.2) $$E_i = \frac{N_i \cdot M_i \cdot VS_i \cdot B_{0_i} \cdot MCF_i}{1000}$$

E: Emissions of methane
N: Population of animals
M: Production of manure (kg/animal/year)
VS: Volatile solids (per cent)[5]
B_0: Maximum methane-producing capacity (m^3/kg-VS)
MCF: Methane conversion factor
$_i$: Species

[5] Volatile solids (VS) are the degradable organic material in livestock manure (IPCC 1997a,b).

Table 6.3 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).

N_2O

In Norway, all animal excreta that are not deposited during grazing are managed as manure. N_2O from manure are estimated in accordance with the IPCC default method (IPCC 1997b), but with Norwegian values for N in excreta from different animals according to Table 6.4.. Norwegian values are also used for the fraction of total excretion per species for each management system (MS) and for pasture. The fractions are updated every year and are given in table 6.5. The distributions between different storage systems and pasture are consistent with the distributions used for calculating NH_3 emissions

Table 6.4 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 6.5 Fraction of total excretion per specie for each management system and for pasture 2004

	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: : Data for storage systems from Statistics Norway (2004) and Gundersen and Rognstad (2001) (poultry) 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):

$$(6.3) \quad E = \sum_s \left\{ \left[\sum_i \left(N_i \cdot Nex_i \cdot MS_{i,s} \right) \right] \cdot EF_s \right\}$$

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 6.1.

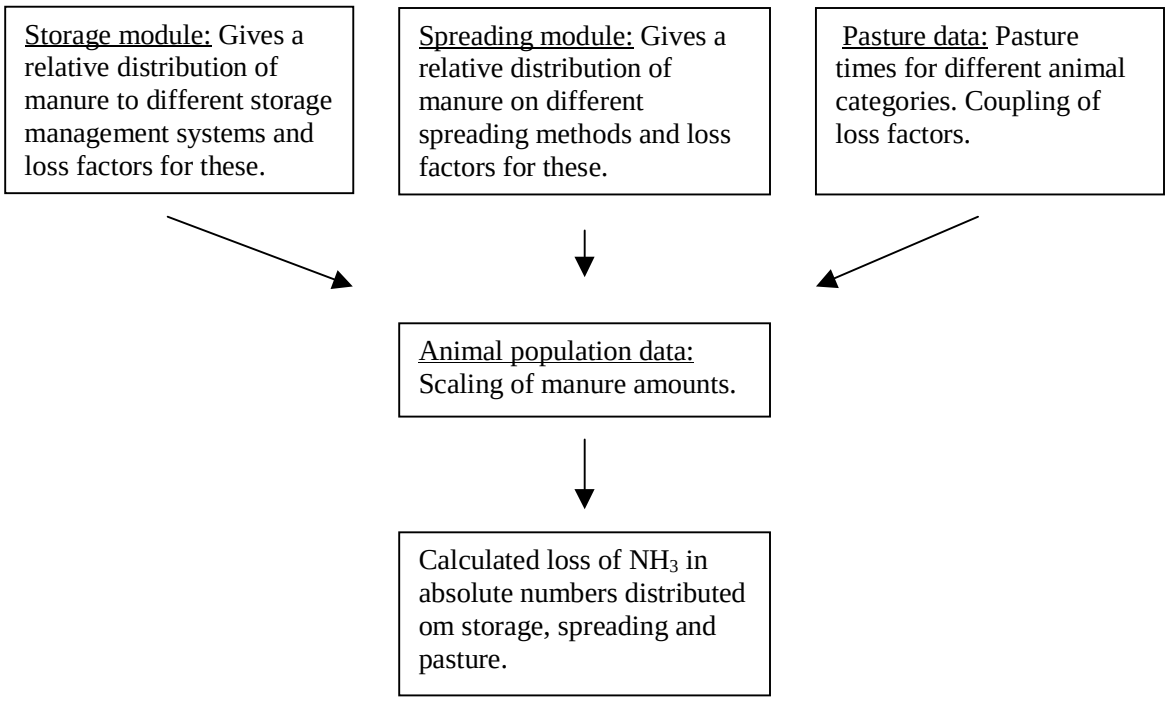


Figure 6.1 The principle of the NH_3 model

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.

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 Sample survey of agriculture and forestry 2003 (Statistics Norway 2004) and 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

6.3.4. Emission factors

CH_4
The calculated average emission factors for different animal types are shown in 0.6.
They are country specific factors which may deviate from the IPCC default values.

Table 6.6 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 6.7 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 6.8.

Table 6.8 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 (2003a).

The factors in Table 6.8 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 the Sample survey of agriculture and forestry 2003 and emission factors for NH_3 emissions from storage of manure and stalled animals are calculated for production and region (Table 6.9) 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.

Table 6.9 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

Uncertainties estimates are given in Annex II.

6.3.5.1. Activity data

CH_4

The data for the number of animals are considered to be known within ±5 per cent. 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 per cent.

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. (SFT 1999a) 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, which is considered to be within ±10 per cent, and the division between storage and pasture, which is considered to be within ±15 per cent.

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 and verification

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 2007.

6.4. Direct and indirect emissions from agricultural soils - 4D - N_2O (Key Category)

6.4.1. Description

The greenhouse gases N_2O and CO_2 are emitted from agricultural soils in Norway. Emissions of CO_2 are treated in the next section.

The emissions of N_2O in Norway from agricultural soils amounted to 6.4 ktonnes in 2004, or 1.9 Mtonnes calculated in CO_2-equivalents. They accounted for about 43 per cent of the total Norwegian N_2O emissions in 2003 or about 3.5 per cent of the total Norwegian greenhouse gas emissions that year

Emissions of N_2O from agricultural soils are a key category because of uncertainty, both in level and trend.

The emissions decreased by 3 % in the period 1990-2004 and remained unchanged from 2003 to 2004

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 results in emissions of NH_3. For the first two 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 total annual amount of fertiliser sold in Norway and its nitrogen content, corrected for the amount of synthetic fertilizer applied in forest.(this in accordance with the comments of the review team in the 2005 review) The resulting amount that is applied on agricultural fields is multiplied with the IPCC default emission factor. The emissions are corrected for 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(fig 6.1 in chapter 6.3.2) 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 using the Tier 1b method, as described in the IPCC (2001). This is a change from the method used before, in accordance with the recomandations of the review team in the 2005-review. Due to lack of national or default factors, factors from the Swedish National Inventory (Swedish Environmental Protection Agency (2005) have been used for the Residue/Crop ratio for grass and green fodder, for $Frac_{DM}$ for rapeseed, potato, roots for feed and green fodder, and for $Frac_N$ for grass, rapeseed and green fodder. Factors from the Austrian National Inventory Report (Umweltbundesamt 2005) have been used for vegetables.

$$(6.4)\ F_{CR} = \sum_i \left[Crop_i * (\mathrm{Re}s / Crop)_i * Frac_{DMi} * Frac_{Ni} * \left(1 - Frac_{BURNi} - Frac_{REMOVEDi}\right) \right]$$

F_{CR} = N in crop residue returned to soils (tonnes)
$Crop_i$ = Annual crop production of crop i (tonnes)
Res/Crop = The residue to crop product mass ratio (Table 6.10)

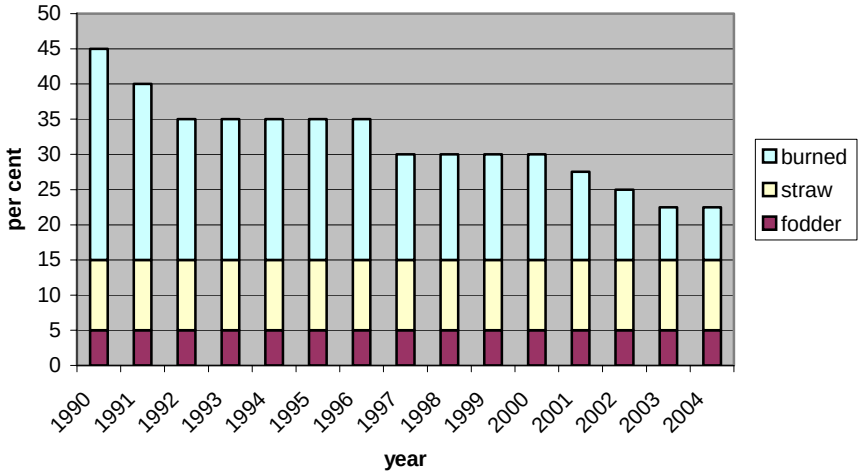
$Frac_{DM}$ =Dry matter content (Table 6.10)
$Frac_N$ = Nitrogen content (Table 6.10)
$Frac_{BURN}$ = Fraction of crop residue burned on field (Figure 6.2)
$Frac_{REMOVED}$ = Fraction of crop residue removed used as fodder and straw in animal rooms (Figure 6.2)

Table 6.10 Factors used for the calculation of the nitrogen content in crop residues returned to soils

	Residue/Crop	$Frac_{DM}$	$Frac_N$
Grass[1]	0.25	0.85	0.014
Wheat	1.3	0.85	0.0028
Rye	1.6	0.85	0.0048
Ryewheat	1.45	0.85	0.0038
Barley	1.2	0.85	0.0043
Oats	1.3	0.85	0.007
Rapeseed	1.8	0.91	0.0107
Potatoes	0.4	0.2	0.011
Roots for feed	0.3	0.2	0.0228
Green fodder	0.25	0.835	0.013
Vegetables	0.8	0.2	0.005
Peas	1.5	0.87	0.0142
Beans	2.1	0.855	0.0142

- [1] Including perennial grasses and grass-clover mixtures
- Source: IPCC (2001), Swedish Environmental Protection Agency (2005), Umweltbundesamt (2005), Statistics Norway.

Figure 6.2. Fraction of crop residue used as straw and fodder, and fraction burned



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 area estimate of organic soils is based on measurements of C in soil (Jordforsk 2004).

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 and data for pasture times (Table 6.5). The amount of N deposited during grazing is multiplied with the IPCC default emission factor.

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 that is believed to give better results under Norwegian conditions. This country specific factor has been calculated based on an estimate of the amount of nitrate leaching for the country on 33 kg N/hectare (Jordforsk 1998), which comes from a runoff model by Jordforsk (Norwegian Centre for Soil and Environmental Research),. The figure is an estimated average based on measures of N-leaching in 12 small watershed areas, and expresses the discharge to nearest surface water recipient. Behind this average figure, there is a huge variation in N-leaching, depending on weather conditions, soil types, farm practices, geographical location etc. Climate data, soil data, agricultural practices etc. are monitored closely in these 12 watershed areas. The areas are chosen so that they together make up a representative selection of Norwegian farming with regard to farming practices, geographical localization and climate and soil 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 6.11.

Table 6.11 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. These data are corrected for the amount of fertilizer used in forests. 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 0.

-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 do only exist 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 6.12.

Table 6.12 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 6.13.

Table 6.13 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 6.14.

Table 6.14 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 0 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 0). 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 6.15 Average NH_3 emission factors for cultivated fields and meadows after time of spreading and region. Per cent, Year 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 6.16. These are the same as the emission factors used in Germany (Dämmgen et al. 2002) and Denmark (Hutchings et al. 2001).

Table 6.16 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 uses 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 (SFT 1999a)). 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.

Deposition of other agricultural emissions: The data are based on national NH_3 emission figures. These are within ±30 per cent. (SFT 1999a)

Leakage of nitrogen: The upper limit for the leakage is the applied nitrogen. The uncertainty is roughly about ±70 per cent.(SFT 1999a)

6.4.5.2. Emission factors

N_2O
Uncertainty estimates used for the N_2O emission factores are given in Annex II.

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 and verification

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.

In 2006, the methodology used for estimating N_2O from crop residues has been changed to the method Tier 1b (IPCC 2001). The new method is more detailed and is supposed to better reflect the real emissions than the earlier used national method.

6.4.8. Recalculations

No recalculations have been carried out.

6.4.9. Planned improvements

No new improvements are planned before NIR 2007.

6.5. Emissions from agricultural residue burning (agricultural wastes)- 4F - CH_4 , N_2O

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. Methodological issues

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).
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).

(6.5) $CR = CRB * Fdm * Fo * Fc$

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

To calculate the emissions of CH_4, the amount of carbon released is multiplied with an emission ratio(equitation (24). 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

(6.6) $E_i = CR * ER * MW_i * (N/C)$

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

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.

Table 6.17 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)

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. (Figure 6.2, chapter 6.4.2.4).

6.5.3. Emission factors

Table 6.18 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

Uncertainty estimates are given in Annex II.

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 and verification

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 were 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

No recalculations have been carried out.

6.5.8. Planned improvements

No further improvements have been planned for NIR 2007.

6.6. Other agricultural emission sources – 4G – NH_3

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

It is estimated that 65 per cent of the NH_3 applied is not integrated with the straw, and is therefore emitted after the treatment (Morken 2003b). The same estimation is being used in Denmark.

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 0. 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 6.19 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)

This chapter provide estimates of emissions and removals from land-use, land-use change and forestry (LULUCF) and documentation of the implementation of guidelines given in "Good Practice Guidance for Estimating and Reporting of Emissions and Removals from LULUCF" (IPCC, 2004).The information is mainly based on the report "Emissions and removals of greenhouse gases from land, use, land-use change and forestry in Norway" (NIJOS, 2005). Differences from the previous submission are due to development of calculation methods and updating of calculation parameters and activity data. CRF-tables for LULUCF are updated compared to earlier submitted reports and enclosed in the NIR-submission. The work was carried out by the Norwegian Institute of Land Inventory (NIJOS), Center for International Climate and Environmental Research (Cicero) and Statistics Norway (Statistics Norway).

7.1. Overview of sector

7.1.1. Emissions and removals

The average annual net sequestration from the LULUCF sector was about 14 890 Gg CO_2 for the period 1990-1998, and about 25 120 Gg per year from 1999 to 2004. More precisely, in 2004 the net sequestration was calculated at 26 308 Gg CO_2, which would offset 48 per cent of the total greenhouse gas emissions in Norway that year. The sequestration increased by approximately 81 per cent from 1990 to 2004, while the increase from 2003 to 2004 was 1.2 per cent. In 2004 the land-use category forest land remaining forest land was the single contributor to the total amount of sequestration with 28 529 Gg CO_2. All other land-use categories showed net emissions, which totalled 2 221 Gg CO_2. Of these, the most important category was grassland remaining grassland with total emissions of 1 870 Gg CO_2, while land converted to settlements (deforestation) was the second most important emissions category with 174 Gg CO_2.

Forest land covers around one fourth of the mainland area of Norway and is the most important land use category considered managed (see Figure 2.21).The carbon sequestration in living biomass was estimated at 6 550 Gg C in 2004 (24 016 Gg CO_2). This estimate is determined with a relatively high accuracy due to the high accuracy of the stock data from the National Forest Inventory and reasonably accurate conversion factors. The sequestration in forest soils was found to be 15 per cent of the sequestration in living biomass, 999 Gg carbon in 2004. The carbon stock change in dead organic matter represents 3.5 per cent of the change in living biomass; 232 Gg carbon was sequestered in 2004. The annual carbon stock has increased for living biomass since 1997, but is quite stable for soils over the period of time. The increase in living biomass can be explained by an active forest management policy, but also to some extent by natural factors. There is an annual variation for dead organic matter which is to a large extent influenced of the annual variation in forest harvest (Figure 7.1).

Farmed organic soils (mostly for grass production) contribute with CO_2 emissions of 1 870 Gg CO_2. 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 mandatory spring-till) has contributed to a small sequestration.

Figure 7.1 below shows the calculated carbon stock changes in forest land from 1990 to 2004. The calculations of carbon stock change in living biomass are based on figures from the National Forest Inventory (NFI), which is performed for 5-year cycles. In order to smooth out the curve reported in National inventory report 2005 (NIR 2005) we have from 1996 and forward used 5 years moving average. The reported value for 1990 is based on the inventory value conducted in 1986 until 1993. The values for the period 1991-1995 have been interpolated from values for the year 1990 and 1996, as annual data are not available between 1990 and 1996. Therefore, the carbon stock change in living biomass is assumed constant. Forest harvest influences the carbon stock of living biomass (Figure 7.2). The increase in biomass is the result of an active forest management policy the last 50 years. The annual harvests are much lower than the annual increment, thus causing an accumulation of wood and other tree components biomass. Differences found between earlier submitted data are also due to development of calculation methods and updating of calculation parameters and activity data.

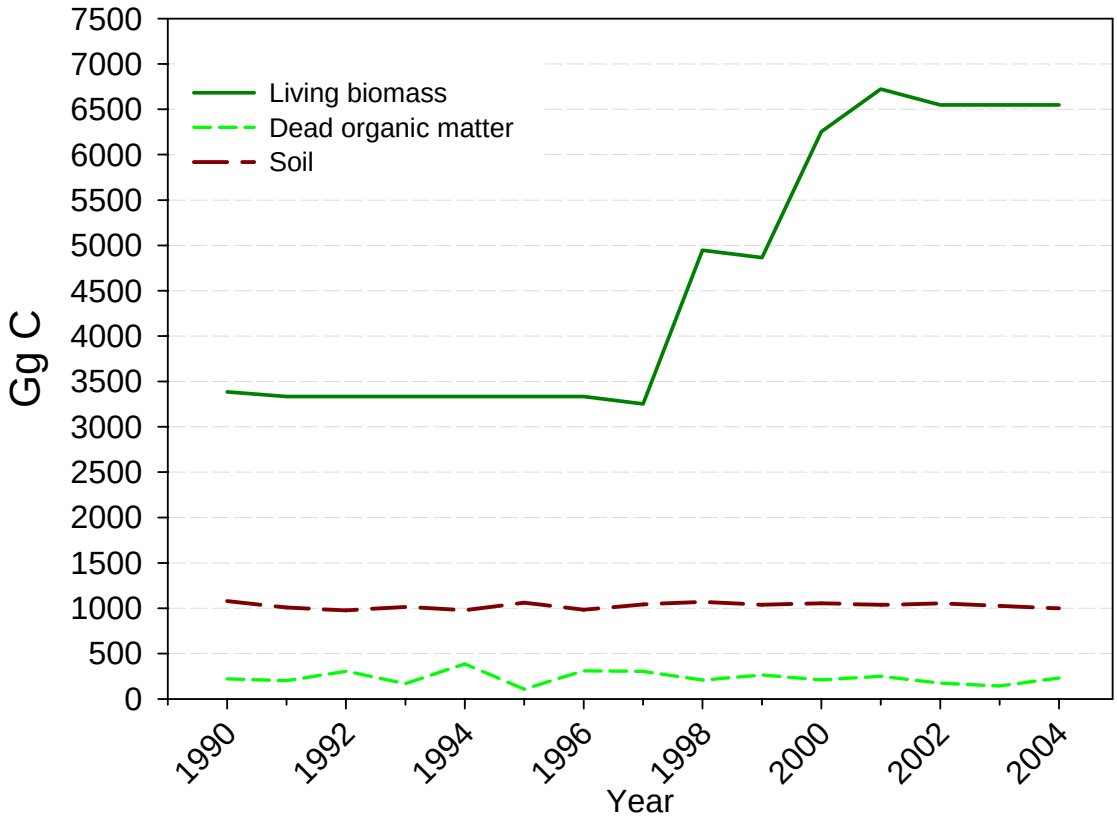


Figure 7.1 Carbon stock changes in forest living biomass, dead wood and soil organic carbon. 1990-2004

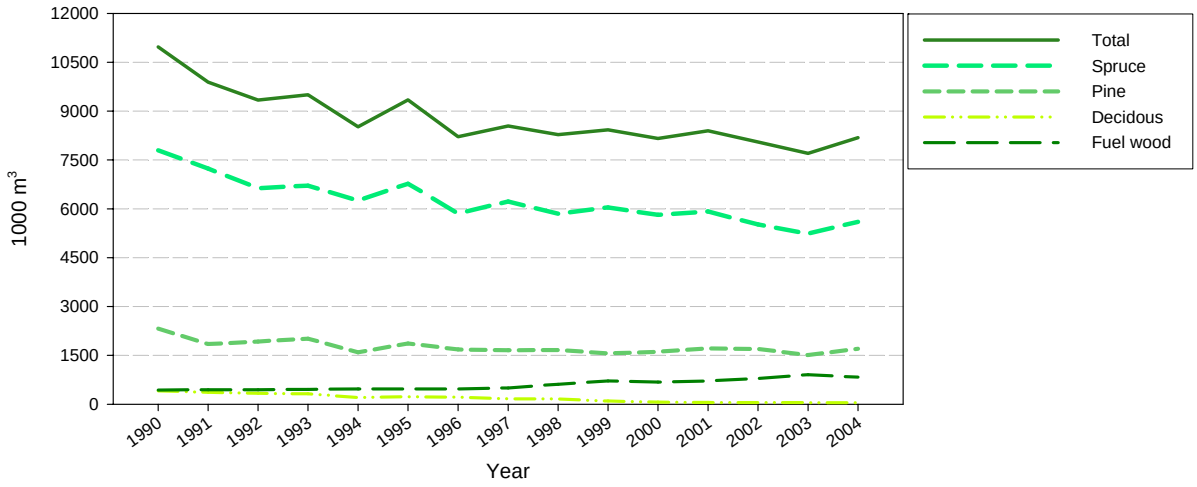
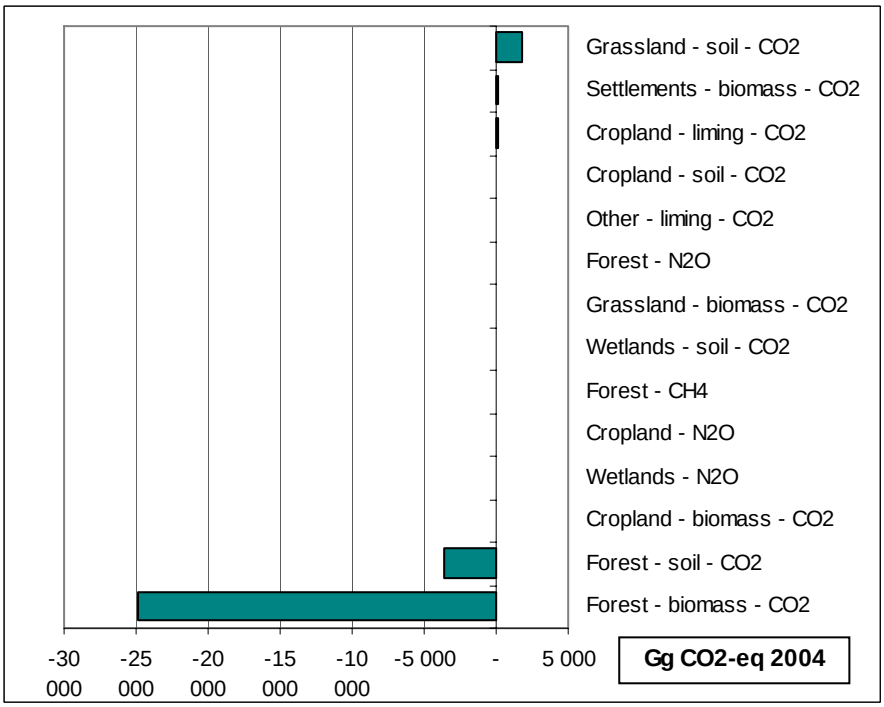


Figure 7.2 Forest harvest 1990-2004 (Statistics Norway, Forestry Statistics)

In Figure 7.3 below emissions and removals from the different LULUCF categories are compared.

a) Full scale



b) Detailed scale

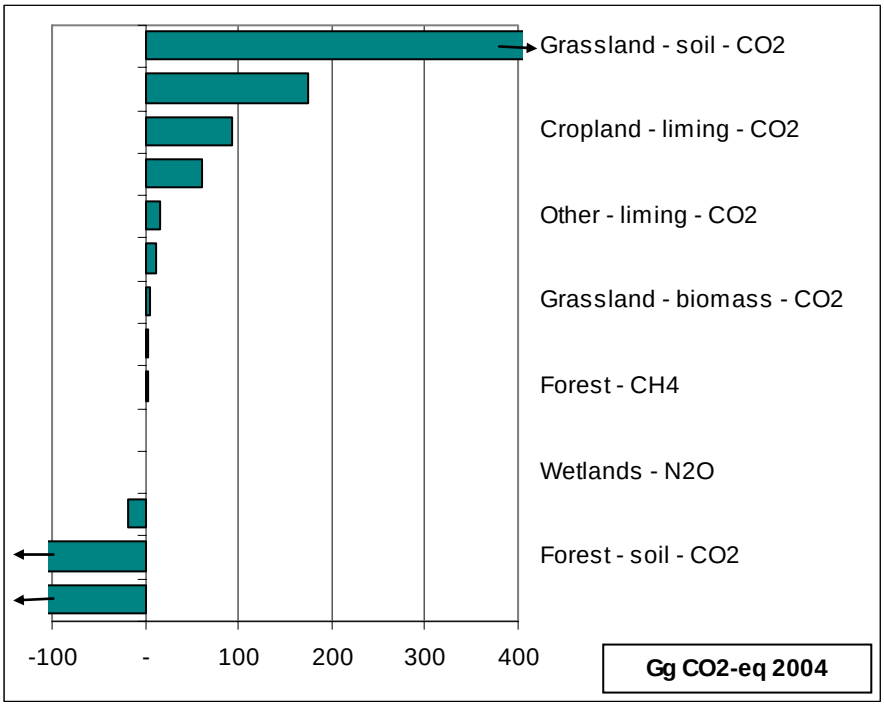


Figure 7.3 Emissions and removals in the LULUCF sector in 2004. Gg CO2-equivalents

The changes in land-use from 1990 to 2004 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 2004. The changes in areas distributed on the six IPCC categories from 1990 to 2004 are illustrated in Figure 7.4

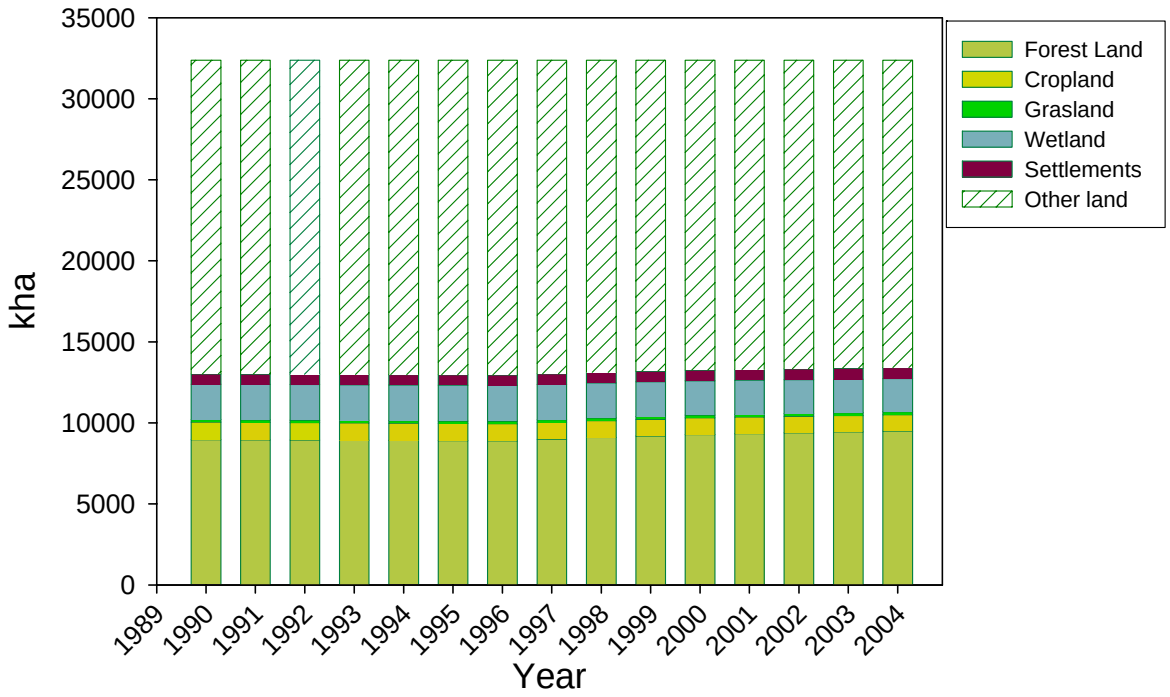


Figure 7.4 Area distribution on the IPCC land-use, land-use change and forestry categories 1990-2004 (k ha)

Table 7.1 shows the changes in carbon stocks for all categories within the LULUCF sector as defined by the IPCC (2004).

Table 7.1 CO_2 emissions and removals from Land-Use, Land-Use Change and Forestry. Gg C.

	1990	1995	1998	1999	2000	2001	2002	2003	2004
Forest remaining forest	4 686.6	4 501.6	6 224.3	6 167.8	7 515.8	8 009.1	7 777.8	7 716.2	7 780.6
- Living biomass	3 385.4	3 333.4	4 946.8	4 866.1	6 253.0	6 722.7	6 549.9	6 549.9	6 549.9
- Dead organic matter	221.8	106.4	207.9	264.8	208.5	249.1	175.2	142.5	232.0
- Soils	1 079.4	1 061.8	1 069.6	1 036.9	1 054.2	1 037.4	1 052.7	1 023.8	998.7
Land converted to forest	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cropland remaining cropland	-51.4	-31.7	-28.0	-26.4	-10.2	-7.5	-18.9	-15.5	-11.7
- Living biomass	6.8	6.3	6.0	5.9	5.7	5.5	5.4	5.0	5.0
- Dead organic matter	NA.NE	NA.NE	NA.NE	NA.NE	NA.NE	NA.NE	NA.NE	NA.NE	NA.NE
- Soils	-58.2	-38.0	-33.9	-32.2	-15.9	-13.0	-24.4	-20.5	-16.6
Land converted to cropland	-20.0	-3.6	-32.5	NA	NO	NO	NO	NO	NO
- Living biomass	-20.0	-3.6	-32.5	NA	NO	NO	NO	NO	NO
- Dead organic matter	NO	NO	NO	NO	NO	NO	NO	NO	NO
- Soils	NO	NO	NO	NO	NO	NO	NO	NO	NO
Grassland remaining grassland	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0
- Living biomass	NO	NO	NO	NO	NO	NO	NO	NO	NO
- Dead organic matter	NO	NO	NO	NO	NO	NO	NO	NO	NO
- Soils	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0	-510.0
Land converted to grassland	-	-3.7	-	-3.7	-4.6	-6.8	-1.1	-13.1	-1.7
- Living biomass	-	-3.7	-	-3.7	-4.6	-6.8	-1.1	-13.1	-1.7
- Dead organic matter	NA	NA	NA	NA	NA	NA	NA	NA	NA
- Soils	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetlands remaing wetland	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
- Living biomass	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO
- Dead organic matter	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO	NA.NO
- Soils	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Land converted 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	-60.3	-125.4	-98.5	-177.5	-60.4	-47.6	-47.6	-47.6	-47.6
- Living biomass	-60.3	-125.4	-98.5	-177.5	-60.4	-47.6	-47.6	-47.6	-47.6
- 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, NO – not occurring

7.1.2. Key categories

A key category analysis has been performed including non-LULUCF sources and the estimates for LULUCF provided in this report. The LULUCF key categories identified using Tier 2 of IPCC 2004 include the following (see also Annex I and table 7 in the CRF tables):

- Forest land remaining forest land, living biomass (5A1);
- Forest land remaining forest land, dead organic matter (5A1);
- Forest land remaining forest land, soil (other[6]) (5A1);
- Forest land remaining forest land, soil (drained organic soils) (5A1);
- Cropland remaining cropland, soil, (histosols) (5B1);
- Grassland remaining grassland, soil (histosols) (5C1);
- Forest converted to settlements, living biomass (5E2)

7.2. IPCC Land-use, Land-Use Change and Forestry categories

Six broad categories of land-use are described in the IPCC (2004), these are Forest land, Cropland, Grassland, Wetlands, Settlements and Other land.

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 IPCC 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. These are areas included in the agriculture statistics.

[6] "Other" refers to all areas except Finnmark country and drained areas

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 per cent 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. According to the IPCC, 2004 reporting is not necessary managed wetlands (for example reservoirs and drained peatlands), but emissions and removals should nevertheless be reported for transformations to and from these categories.

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. According to the IPCC (2004), reporting is not necessary for settlements but emissions and removals should nevertheless be reported for transformations to and from these categories.

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. Reporting under the category "Other land" ensures that the total area identified equals the total area of the country.

7.3. Inventory and statistical systems for LULUCF in Norway

In this section we review existing sources of information used in this report.

7.3.1. 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)[7] is responsible for the NFI. Inventory work was started in 1919 with regular inventory cycles. The last inventory cycle took place from

[7] From 1st July, 2006, NIJOS will continue its work as the Norwegian Forest and Landscape Institute, following a merger with the Norwegian Forest Research Institute and the Norwegian Genetic Resource Centre. The Norwegian Forest and Landscape Institute will be a new national institute of expertise on land resources.

2000 to 2004. 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 re-measuring 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 re-measurement is carried out in such a way that 20 per cent 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 below the coniferous forest limit. On average, the sampled area comprises about 3×10^{-5} of the surveyed 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.

Up to now there have been 8 different inventory cycles. In this report figures from the inventories carried out from 1986 to 1993 (the 6^{th} NFI), 1994 to 1999 (the 7^{th} NFI) and 2000 to 2004 (the 8^{th} NFI) are used. The years 1990, 1996 and 2002 are used as reference years for the 6^{th}, 7^{th} and 8^{th} NFI, respectively.

The 6^{th} 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 7^{th} NFI design was changed in such a way that a fraction of the field plots is measured in the entire country, except for Finnmark County and areas above the coniferous forest limit, in each year. This makes it possible to calculate single year estimates. The calculations of change in annual area estimates are based on figures form the National Forest Inventory (NFI), which is performed for 5-year cycles. From 1996 and forward we used 5 years moving average. The reported value for 1990 is based on the inventory value conducted in 1986 until 1993. The values for the period 1991-1995 have been interpolated from values for the year 1990 and 1996.

The total land area of Norway has been divided into the six categories: forest land, cropland, grassland, wetlands, settlements, and other land as described in chapter **Feil! Fant ikke referansekilden.**. The classifications are shown in Figure 7.14. The figures are based on data from NFI and Statistics Norway which provided the figures for the total land area for Norway and the land area for Finnmark County. Areas above the coniferous forest limit and Finnmark County and are now classified as “Other land”. The category “Other land” ensures that the total land area identified equals the total area of the country.

A key finding from these data is that change in land-use from 1990 to 2002 is quite small; the forest area is increasing and the agriculture area decreasing. Grassland and settlement areas have also increased.

Table 7.2 Land-use classification in 1990, 1996 and 2002, representing respectively the 6th, 7th and the 8th NFI

Classes	**Land-use in 1990** *The 6th NFI*		**Land-use in 1996** *The 7th NFI*		**Land-use in 2002** *The 8th NFI*	
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
Forest	8 969 611	27.7	8 896 579	27.5	9 394 137	29.0
Cropland	1 080 122	3.3	1 054 879	3.3	1 017 367	3.2
Grassland	155 882	0.5	155 883	0.5	174 727	0.5
Wetlands	2 186 262	6.8	2 216 918	6.8	2 084 208	6.4
Settlements	633 145	1.9	645 768	2.0	673 410	2.1
Other	19 355 178	59.8	19 410 173	59.9	19 036 351	58.8
Sum	**32 380 200**	**100.0**	**32 380 200**	**100.0**	**32 380 200**	**100.0**

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 this report. 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 report, exclusively 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.

7.3.2. Uncertainties

About 16 500 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 plots, the formulas for simple random sampling can be used to provide approximate values for the precision of the area estimates. NIJOS (2005) 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.

The uncertainties in emission and removal figures are substantially higher for all other land-use classes compared to forest. This is due to scarce of data available and all the assumptions needed to be done.

7.3.3. Auxiliary data

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 have 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. 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.

For section 7.5, the statistics concerning the area of fruit trees and tillage practices are collected by Statistics Norway. Data from the Directorate for Nature Management are used to calculate emissions from liming of agricultural soil and lakes in section 7.5.1.2 and 7.5.1.3. For section 7.11 on emissions of non-CO_2 gases, national statistics of forest area where fertilizer has been applied and statistics of drainage for forest are collected by Statistics Norway. Data on area burned in forest fires are available from the Directorate for Civil Protection and Emergency. Data on new agriculture area comes from Statistics Norway. Area data for organic soils, peat extraction and others are based on research projects at Bioforsk[8]. The different data sources are described under the respective land category.

7.4. Forest land 5.A

7.4.1. Forest land remaining forest land – 5A1 (Key Category)

Forest is the most important land-use category 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 are 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.

7.4.1.1. Methodological issues

Change in carbon stock in living biomass

The method implemented corresponds to Tier 3 of IPCC (2004); a combination of national forest inventory data and models to estimate changes in biomass. Tier 1 has been used to estimate emissions and removals in the forest of Finnmark.

The total biomass of forest trees was estimated using a set of equations developed in Sweden (Marklund, 1988, Petersson and Ståhl, 2006) for single tree biomass of Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and birch (*Betula pubecens*). These equations provide biomass estimates for the various tree biomass components; stem, stem bark, living branches,

[8] On January 01 2006, the Norwegian Centre for Soil and Environmental Research (JORDFORSK), the Norwegian Crop Research Institute and the Norwegian Centre for Ecological Agriculture were merged to form Bioforsk – the Norwegian Institute for Agricultural and Environmental Research. All references to what has been known as JORDFORSK are now referred to as Bioforsk.

dead branches, needles, stump, roots larger than 5 cm in diameter and roots less than 5 cm in diameter.

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 1.1 per cent of the stem volume, with a dry weight of 0.520 Mg m^{-3} (Lethonen et al. 2004).

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 their biomass is negligible.

The calculated of carbon stock changes in forest land from 1990 to 2004 are shown in Figure 7.1 and explained in Section 7.1.

In the centralized review of last year's submission, the ERT suggested to separate emissions from removals (increases and decreases in stocks) in CRF table 5.A. Norway explained that the increase in net emissions is a result of 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. It should be emphasized that the net emissions are calculated directly as the difference between total stock data for different periods. Although data on increase and decrease might illuminate the situation, they would not improve the quality of the net emission data. After considering the options and consequences, Norway has therefore come to the conclusion that it will not provide separate estimates of emissions and removals (increases and decreases in carbon stocks) in CRF table 5A.

Change in carbon stock in dead organic matter and in soil
Change in carbon stock in dead organic matter due to litter from standing biomass, un-recovered fellings (trees that were felled but not removed from the forest), harvested residues and natural mortality, stumps and roots from harvested trees have been calculated according to the chart in Figure 7.65. A detailed described of these calculations are given in de Wit et al. (2006). The volume and increment estimates are for NFI and removals as forest harvest are from Statistics Norway.

The dynamic soil model YASSO as described in detailed by de Wit et al. (2006), are used to calculated changes in carbon stock in soil (Figure 7.6). This model describes accumulation of soil organic matter and dead wood in upland forest soils and is designed to process data

derived from forest inventories (Liski et al. 2005). The model requests estimates of litter production and simple climate data. The model has two litter compartments that relate to physical fractions of litter and five soil components that differentiate microbial decomposition and humification processes. The litter and soil compartment can be viewed as "dead wood" and "soil organic matter". With the current parameterisation (Liski et al., 2005) the model gives an estimate of the soil organic matter down to the depth of 1 m in the mineral soil. Annual changes in the carbon stock are calculated as the changes between successive carbon stock estimates. In each time step, woody litter input to the soil is fed into the two litter compartments: Fine woody and coarse woody litter, whereas non-woody litter is directly transferred to the soil compartments. Dry matter biomass of different litter compartment (foliage, fine roots, branches, coarse roots, stems and stumps) are calculated using biomass expansion factors described for Norway in FAO/ECE (1985) and in de Wit et al. (2006). Litter is transferred to the soil compartments according to transfer rates *a* and depending on its chemical composition *c*. The soil compartments have specific decomposition rates *k.* Part of the decomposed carbon is transferred to a subsequent soil compartment according to fractionation factor *p*. Soil compartment humus-1 (slowly degradable humus) receives its contents only from the compartment of lignin-like substances, whereas compartment humus-2 (very slowly degradable humus) receives its contents only from the compartment humus-1. The required factors are given in de Wit et al., (2006).

Forest harvest (Figure 7.2) influences the amount of harvest waste and therefore also the estimate of "dead organic matter". Calculations of change in carbon stock (pools of biomass, dead organic matter) are done according to a Tier 3 method and the information is included in the corresponding table of the CRF.

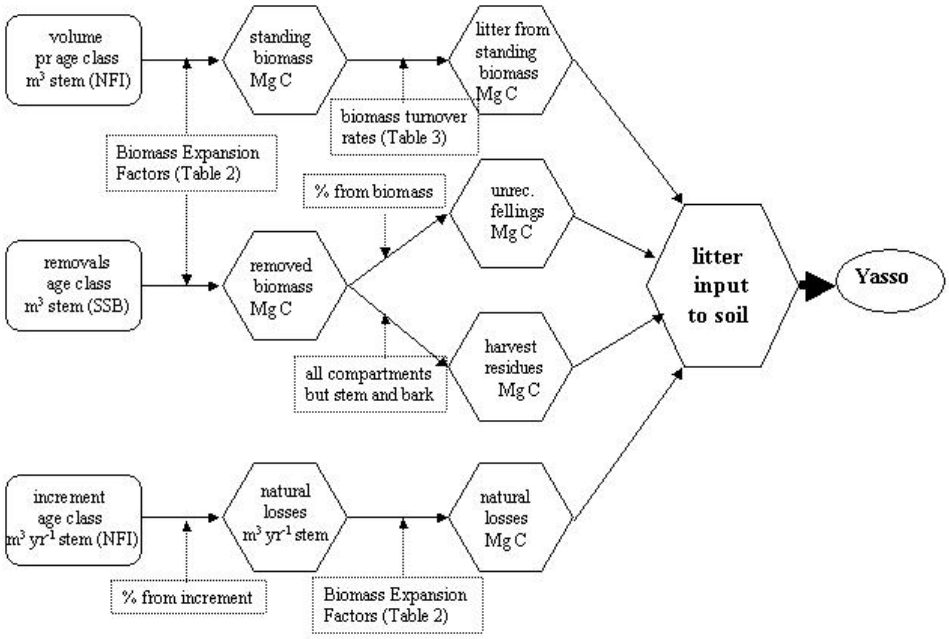


Figure 7.5 Chart for calculation of growing stock, removed volume, annual increment to litter input to soil model YASSO. Data sources are NFI and SSB=Statistic Norway (Statistics Norway). (Source: de Wit et al. 2006)

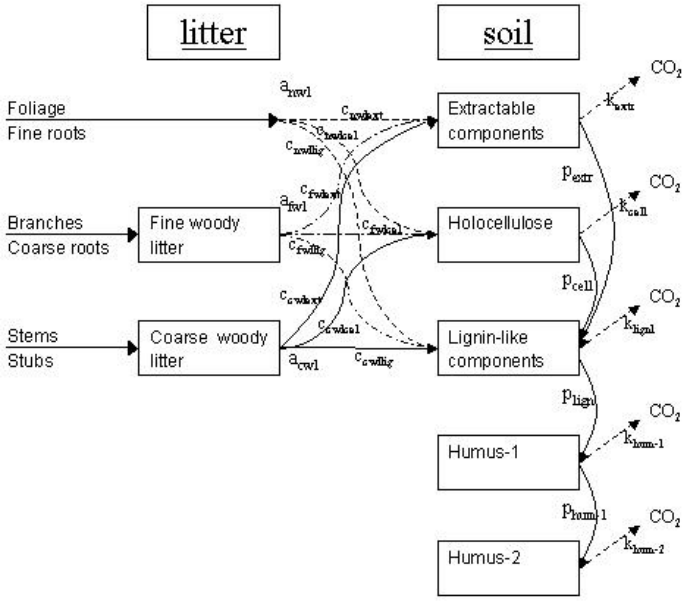


Figure 7.6 Carbon pools and fluxes in soil model Yasso. Values for the parameters are presented in Table 4 in de Wit et al. 2006.

7.4.1.2. Recalculations

The whole time-series have been recalculated due to changes of calculation methods, and updating of calculation parameters and activity data.

The sequestration in forest land remaining forest land was 28 529 Gg CO_2 in 2004, which would offset about 52 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; 0.11 Gg and 0.04 Gg, respectively (corresponding to about 2 Gg and 12 Gg of CO_2-equivalents).

From 1990 to 2004 the sequestration of CO_2 increased by 66 per cent. The increase from 2003 to 2004 was 0.8 per cent.

7.4.2. Land converted to forest land– 5A2

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.

7.4.2.1. Methodological issues

The emissions and removals from different "land categories to forest land" have been reported/calculated as described in Section 7.4 "Forest land remaining forest land". It takes time before an area change has any influence on estimates of carbon stock changes in Norway

under the existing climatic conditions. We understand that IPCC 2004 suggests considering land-use transitions over a period of 20 years.

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 (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.

7.4.2.2. Conversions

Cropland converted to forest land
The conversions between these categories are negligible. This conversion rarely goes directly most often it goes via "other land". The conversion is expected to lead to uptake of carbon, because there has been a likely carbon loss on agriculture land due to management and because forest will accumulate carbon. Studies provided by Bioforsk on soil organic matter 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 soil organic carbon, but to account for the C uptake by using the C accumulation data provided for forest soils.

Grassland converted to forest land
No conversion from grassland to forest is detected in the data. 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. In this situation the carbon in soil is expected to increase. However, it is not possible to conclude that the soil organic carbon 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 (IPCC 2004), we propose to apply the same factors for soil accumulation as for forest remaining forest and assume no direct change in soil organic matter due to the conversion.

Wetlands converted to forest land

There has been recorded a conversion from wetlands to forest land 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 per cent 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. 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. In line with IPCC (2004) we propose using the emission factors as for drained organic soils (0.16 Mg C/ha/year) also in the year of conversion. Forestry in Norway has dramatically decreased its drainage of wetlands areas for tree planting over the last decades (Statistics Norway, 1999). The area drained in 1990 was 3.5 kha and only 0.04 kha in 2000.

Settlements converted to forest land

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).

Other land converted to forest land

There has been a conversion from other land to forest land (7^{th} and 8^{th} NFI). These conversions are most likely in areas close to the timberline. Changes from other land to forest land my sometimes be real and may be partly human induced (changes in grazing). Some changes can also be due to a warmer climate. (Hofgaard, 1997,a,b). This conversion will be on vegetated "other land" (section 7.9). 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 soil organic carbon at the year of transition.

7.4.2.3. Recalculations

The whole time-series have been recalculated due to changes in of calculation methods and updating of calculation parameters and activity data.

Only area estimates are given in the CRF reporter in relation to the different land category conversions.

7.5. Cropland 5B

7.5.1. Cropland remaining cropland – 5B1 (Key Category)

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 (IPCC 2004). The soil carbon is, however, also affected by management practices (for example ploughing 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.

7.5.1.1. 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. The method implemented corresponds to Tier 1 of IPCC (2004).

Changes in living biomass have only been considered for perennial woody crops. 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 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 of fruit trees:

The IPCC default value for biomass accumulation rate is 2.1 Mg C/ha/year (IPCC 2004). 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 to other land categories:

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 7.3 CO_2 emissions due to reductions in fruit trees for agriculture production

	Area (ha)	**Annual uptake** (Mg)	**Annual C-loss** (Mg)	**CO_2 emissions** (Gg)
1989	3 267			
1990	3 220	6761.4	2998.8	11.0
1991	3 172	6661.4	2998.8	11.0
1992	3 124	6561.5	2998.8	11.0
1993	3 077	6461.5	2998.8	11.0
1994	3 029	6361.5	2998.8	11.0
1995	2 982	6261.6	2998.8	11.0
1996	2 934	6161.6	2998.8	11.0
1997	2 886	6061.7	2998.8	11.0
1998	2 839	5961.7	2998.8	11.0
1999	2 791	5861.7	2998.8	11.0
2000	2 718	5708.4	4599.0	16.9
2001	2 611	5483.3	6753.6	24.8
2002	2 593	5445.5	1134.0	4.2
2003	2 385	5009.3	13085.1	48.0.
2004	2 359	4952.9	1694.7	6.2

*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. The soil organic carbon (SOC) has been estimated by Bioforsk. 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 Bioforsk and NIJOS are shown in Tables 7.6 and 7.7. The NIJOS data and their uncertainties are explained in NIJOS (2005).

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 ploughing 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.

The measurements of carbon in soils by Bioforsk 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 ploughing practices and erosion rates from these, Singh and Lal (2001) have

estimated a net erosion rate of 2.2 Mg/ha/years under autumn ploughing. The rate in other areas is 0.44 Mg/ha/years.

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 per cent.
- 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 per cent has been used in the calculations.
(all these assumptions were taken from Singh and Lal (2001))

Finally, it is assumed that 20 per cent 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 per cent C, and enhance SOC and sequester carbon if returned to soil. There is, however, no statistics to monitor changes in crop residue management. 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. 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.

It is rather common to rotate crops in Norway. 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. 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. It is expected that when cover crops are used in combination with reduced till, the effect on reductions on carbon losses will be enhanced. 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 per cent 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 35. The fraction of area under autumn tillage was 82 per cent in 1989/2000, which was reduced to 43 per cent in 2001/2002 (based on annual surveys).

Moving to autumn ploughing 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 ploughing 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 ploughing) 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 per cent) * 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.

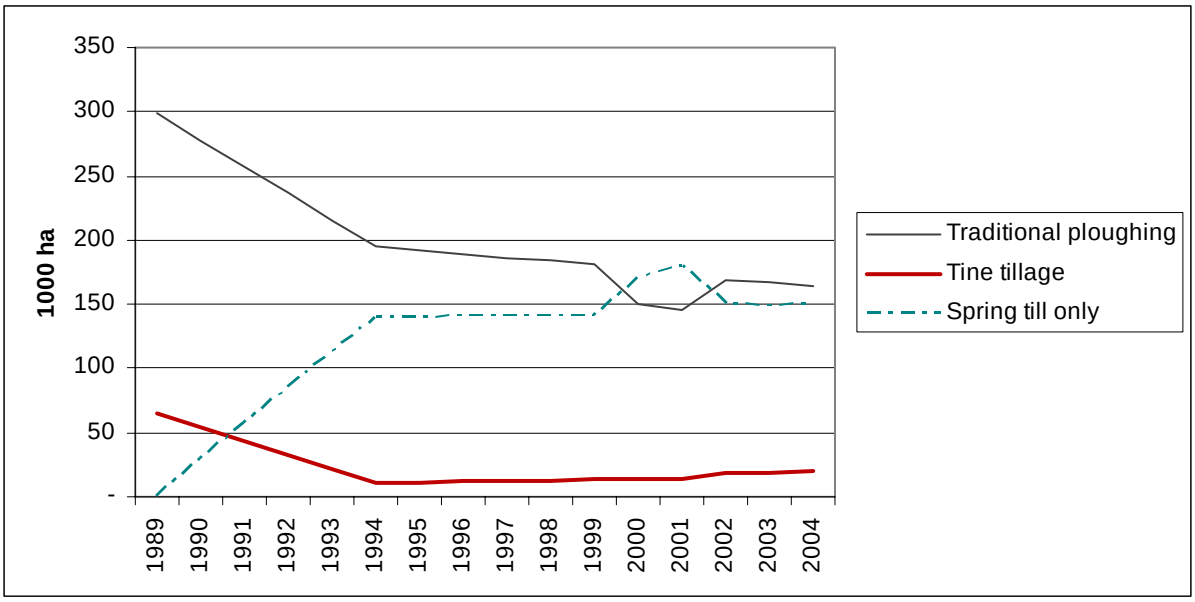


Figure 7.7 Tillage practices 1990-2004 (Statistics Norway)

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 ploughing. In fact, a small amount is also used for grass production (may subtract "surface cultivated" area, around 5 per cent). 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 soil organic carbon should be assumed. The results are shown in
*Table 7.*4.

*Table 7.4 Erosion emissions due to ploughing and uptake due to reduced ploughing in Norway**

	25 year old agriculture area (ha)	**Erosion emissions (Gg)**	**Area under tine, no till or minimum till, subtracted 1979 tine area and part of the new agriculture area (ha)**	**Carbon uptake (Gg)**
1990	151637	1.50	0	0
1991	145794	1.36	8410	4.2
1992	139696	1.21	19766	9.9
1993	133219	1.08	31553	15.8
1994	128741	0.96	42924	21.5
1995	124262	0.85	39168	19.6
1996	118839	0.81	41505	20.8
1997	113099	0.77	44012	22.0
1998	106471	0.72	46947	23.5
1999	99122	0.66	50252	25.1
2000	92132	0.61	82754	41.4
2001	85429	0.48	88316	44.2
2002	78143	0.42	65484	32.7
2003	78143	0.43	73197	36.6
2004	70208	0.40	80900	40.4

*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 15 118 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 per cent) * 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 4 166 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 IPCC (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. Bioforsk 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 per cent organic matter)	42 000 ha
Peat soils (>40 per cent 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 Bioforsk (Arne Gronlund, pers. Comm.) the soil database indicates the following distribution between crop types:

Grass: 86 per cent
Cereals: 9 per cent
Other crops (potatoes, vegetables, green fodder): 5 per cent

As soils samples are likely to be underrepresented on grass compared to cereals and more intensive productions, about 90 per cent of the farmed organic soils are used for grass. In this project we propose to assume that 10 per cent 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.

7.5.1.2. Liming of agricultural soils – 5G

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 93 ktonnes CO_2 in 2004, which represent 0.2 per cent of Norway total GHG emissions. Thus this is regarded as a non-key category in the Norwegian emission inventory. National total emissions have been reported yearly from 1990 and onwards, and are contained under the category “Other” in the CRF-tables.

7.5.1.3. Liming of lakes – 5G

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 16 ktonnes CO_2 in 2004, 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). The emissions are reported under “Other” in the CRF-tables.

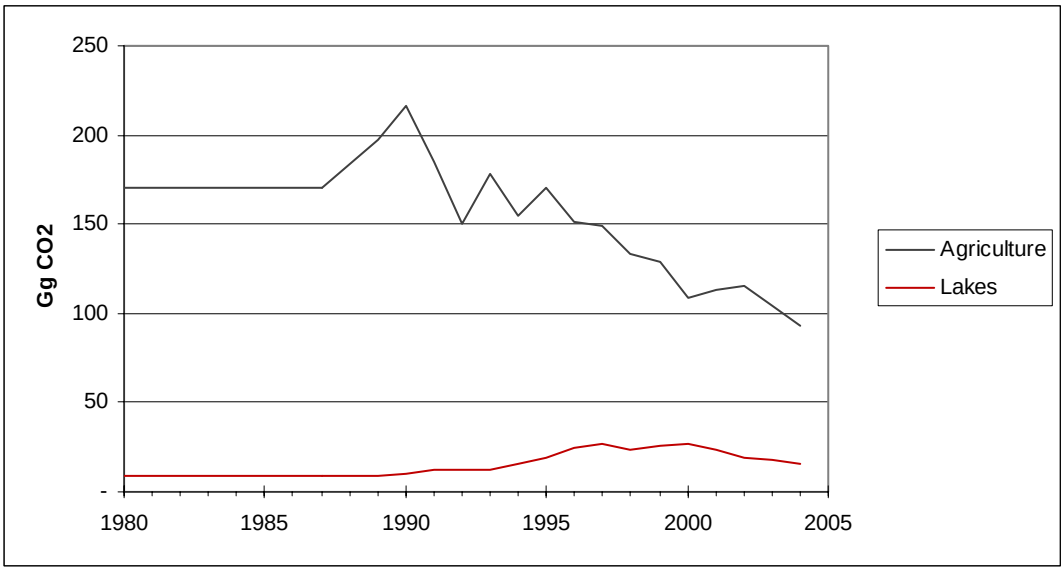


Figure 7.8 Liming of agriculture soils and lakes. 1989-2004.

Table 7.5 Amount of lime applied to agriculture area and lakes, and corresponding CO2 emissions. 1990-2004

Agriculture	**1990**	**1995**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Amount of lime applied (Mg)	492 407	388 365	294 150	245 884	257 696	263 499	23 7631	212 546
CO_2 emissions (Gg)	217	171	129	108	113	116	105	94
Lakes	**1990**	**1995**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Amount of lime applied (Mg)	23 000	42 738	59 193	60 076	54 118	42 089	41 833	36 003
CO_2 emissions (Gg)	10	19	26	26	24	19	18	16

The ERT noted that Norway uses the same emission factor as that applied to cropland, as all lime is assumed to emit CO_2. The ERT recommended that Norway provides additional information in the NIR to support the use of the agriculture emission factor for the application of lime to water. Norway does not see why lime in water should emit less CO_2 than lime in soil. These annual emissions are very minor. Until more information is available, Norway will wait to pursue this matter.

7.5.1.4. Recalculations

The whole time-series have been recalculated due to changes in of calculation methods and updating of calculation parameters and activity data.

The emissions from cropland remaining cropland were 43 Gg CO_2 in 2004, which is a reduction of 25 per cent from 2003. However, from 1990 to 2004 the emissions of CO_2 decreased by 77 per cent. The emissions from this category in 2004 represented about 2 per cent of the total emissions from the LULUCF sector.

7.5.2. Land converted to cropland – 5B2

Administrative data show that since 1990, the annual conversion to agriculture land has been reduced from about 2 000 ha to 1 200 ha annually (Statistics Norway). Most of the area is used for grass production, but part of the area (about 10 per cent) 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.

7.5.2.1. Methodological issues

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).

Change in carbon stock in living biomass
With regard to changes in carbon stocks in living biomass, we have only calculated losses for forest land converted to cropland. We assumed that all living biomass were lost the year of conversion.

Change in carbon stock in dead organic matter
When forest land is converted to cropland we assume all dead organic matter will be cleared.

Change in carbon stocks in soils
According to IPCC (2004) soil organic carbon 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 an equilibrium. The time and level of the equilibrium depend on soil, climate and management conditions. However, because Norwegian data indicate no major difference in soil organic carbon 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 Bioforsk. 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.

Bioforsk has collected data on organic matter content of 3 920 farms in Norway.

Table 7.6 Organic matter and C in farm soil. Weight % (source: Bioforsk)

% grass area	Number of farms	Soil OM (%)	Organic C (%)
0	2 009	4.2	2.3
0-80	1 442	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 per cent). 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.

7.5.2.2. Conversions

Forest land converted to cropland
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.

Grasland converted to cropland
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).

Wetland converted to cropland
Conversions between these categories are negligible. The conversion of peatland (wetlands) to agriculture land was addressed above, under cropland remaining cropland. The emissions are not immediate, but occur over time.

Other land converted to cropland
Conversions between these categories are negligible.

7.5.2.3. Recalculations

The whole time-series have been recalculated due to changes in of calculation methods and updating of calculation parameters and activity data.

No emissions were reported for 2004. Emissions are reported every year from 1990 until 1995 and in 1998. After that NFI has not recorded that forest area has been converted to cropland.

7.6. Grassland 5C

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).

7.6.1. Grassland remaining grassland – 5C1 (Key Category)

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. Changes in management have, however, influenced the vegetation on pastures. Gradually, some of this area will fall under the forest definition.

7.6.1.1. Methodological issues

Change in carbon stock in living biomass
As for agriculture, we consider changes in aboveground biomass. Changes in management have, however, influenced the vegetation on pastures.

Change in carbon stock in dead organic matter
We assume no change in dead organic matter for this category because the mass of aboveground biomass is small and is in a steady state in accordance with Tier 1 in IPCC (2004).

Change in carbon stocks in soils
As for agriculture, we consider changes in carbon stocks in soil. 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.

There will be a loss of carbon from grasslands on *organic soils*. As discussed for cropland, it is assumed that 90 per cent 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 Bioforsk at 2 cm/year[9] which is equivalent to 20 Mg C/ha.[10] Some of this reduction is due to compaction and can be attributed to a sink in the height of the soil layer[11]. The soil loss also includes

[9] Meadow. The decrease in layer is larger on field grassland. However, organic soils are rarely used for the purpose.
[10] Assuming a soil density of 0.2 kg/l, and 50 per cent C.
[11] Assuming a soil density of 0.2 kg/l, and 50 per cent C.

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 1 000 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 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 per cent 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 7.7

Table 7.7 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 peat lands) (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).

7.6.1.2. Recalculations

The whole time-series have been recalculated due to changes in of calculation methods and updating of calculation parameters and activity data.

The emissions from grassland remaining grassland in 2004 were estimated at 1 870 Gg of CO_2, which represents 3.5 of the total emissions of greenhouse gases in Norway and 89 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 constant from 1990 to 2004 since there have not been any major changes in management of grasslands in Norway during this period.

7.6.2. Land converted to grassland – 5C2

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).

7.6.2.1. 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”.

In the case of conversion of forest to grassland, losses in living biomass will be accounted for according to the methodology of estimation described in section 7.4.1 Forest land remaining forest. For other land-use change we assume no net change in carbon of living biomass. This is justified because the IPCC (2004) 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).

Change in carbon stock in dead organic matter
We assume that all dead organic matter will be cleared when land is converted to grassland.

Change in carbon stocks in soils
The soil organic carbon in grassland discussed under agriculture is probably more representative for grassland and meadows close to the farm. The soil organic carbon in grazing land and unmanaged grassland is not known. However, much of the grassland will be in mountain areas where the soil organic carbon can be low.

7.6.2.2. Conversions

Conversion of forest land to grassland
We assume that transition from forest land to grassland is rather unlikely, but assume no change in soil organic carbon if recorded.

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.

Conversion of cropland to grassland

We propose to assume that there is no change in soil organic carbon when cropland is transferred to grassland, because the changes are small and exact data are lacking. Assuming that the grassland is nominally managed and the same level of fertilization, also the IPCC (2004) default method indicates no change.

When cropland is converted to grassland the soil organic matter may change due to changes in management, for example ploughing 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. Bioforsk confirms that farms with animals (and grass production) have a slightly higher soil organic carbon than those without (NIJOS, 2005). There are no data for grassland outside home fields, but they likely have a lower soil organic carbon.

IPCC default Tier 1 method accounts for differences in soil organic carbon 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 (2004) default method indicates no change.

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.

Conversion of wetland to grassland

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. See discussion on drained organic soils under grassland remaining grassland.

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Conversion of other land to grassland

We assume no emissions or removals due to changes in soil carbon when other land-use is converted to grassland.

There is some conversion from other land to grassland. 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.

7.6.2.3. Recalculations

The whole time-series have been recalculated due to changes in of calculation methods and updating of calculation parameters and activity data.

Emissions from this category were estimated at 6.2 Gg of CO_2 in 2004, corresponding to 0.3 per cent of the total emissions from the sector that year. In 1990 and 1998 there were no emissions from this category, and the emissions in 2004 decreased by a factor of 7.7 compared to the emissions in 2003.

7.7. Wetlands 5D

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.

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). Forestry in Norway has dramatically decreased its drainage of wetlands areas for tree planting over the last decades (Statistics Norway, 1999). The area drained in 1990 was 3.5 kha and only 0.04 kha in 2000.

7.7.1. Wetlands remaining wetlands - 5D1

7.7.1.1. 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 Bioforsk, 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 7.5. The corresponding emissions are about 25 Gg CO_2 annually.

Other wetlands
Other wetlands are considered unmanaged, and no emissions and removals are estimated (in line with IPCC 2004).

7.7.1.2. Recalculations

The emissions from wetlands remaining wetlands were re-estimated to 3.4 Gg CO_2 in each year over the period 1990-2004.

7.7.2. Land converted to wetlands - 5D2

No data are available on land converted to manage wetlands. In practice, this is only relevant for reservoirs. Land taken into use for peat extraction would normally be unmanaged wetlands.

Forest land converted to wetlands:
There has been recorded a conversion from forest land to wetlands. Recorded conversions to wetland are considered as artefacts and are not used in the calculations.

Cropland converted to wetlands
The conversions between these categories are negligible. These changes are small today and would not be possible to identify through the NFI.

Grassland converted to wetlands
No conversion has been recorded.

Other land converted to wetlands

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 during field work. 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. We assume no loss or uptake of carbon.

7.8. Settlements 5E

7.8.1. Settlements remaining settlements – 5E1

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.

7.8.2. Land converted to settlements – 5E2 (Key Category)

This land-use category is considerd key category because of the contribution to the total emissions from the LULUCF sector (Tier 2). IPCC (2004) suggests a method in which only forest biomass is considered. 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 principle there will also be losses when other wooded land is converted to settlements, but these have not been estimated due to lack of data. However, settlements on other wooded land can be expected to be on a small scale (for example mountain cabins and associated infrastructure).

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.

Change in carbon stock in living biomass

We suggest that for forest land converted to settlements, only 75 per cent of the average biomass of forest is considered to be lost. The remaining 25 per cent 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.

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

Forest land converted to settlements:

Forest 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 soil organic carbon as grassland, and use the same methodology as for cropland remaining cropland in section 7.5.1 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. In this version of the inventory no change has been assumed.

Cropland converted to 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. We have assumed no change in soil organic carbon.

Grassland converted to 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. We have assumed no change in soil organic carbon.

Wetlands converted to settlements
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.

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.

Other land converted to settlements:
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. We have assumed no change in soil organic carbon.

7.8.2.1. Recalculations

The whole time-series have been recalculated due to changes in of calculation methods and updating of calculation parameters and activity data.

The emission from this category was estimated at 174 Gg CO_2 in 2004. There are annual variations of emissions from this category. The highest emission was recorded in 1999 with 651 Gg CO_2, while the lowest value, 174 Gg CO_2 was found in the period from 2001 to 2004.

7.9. Other lands 5F

7.9.1. Other land remaining other land – 5F1

7.9.1.1. Methodological issues

Change in carbon stock in living biomass
We assumed no change in carbon stock in living biomass. This is in accordance with IPCC (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. A reference study based on Tier 1 method is described in NIJOS (2005).

Change in carbon stock in dead organic matter
We assumed no change in carbon stock dead organic matter.

Change in carbon stocks in soils
We assumed no change in carbon stock in soils.

7.9.1.2. Recalculations

No emission/removals recorded

7.9.2. Land converted to other land – 5F2

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.

7.9.2.1. Methodological issues

Change in carbon stock in living biomass
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 no data exists and as discussed before, soil organic carbon for grassland and forest in Norway is quite similar. "Other wooded land" will often be in marginal areas where the soil organic carbon is lower than in agriculture land. However, the same will be true for forest or grassland in these areas.

Forest converted to other land:
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.

Cropland converted to other land:
The conversions between these categories are negligible.

Grassland converted to other land:
No conversion is detected.

Wetland converted to other land:
No conversion is detected.

7.9.2.2. Recalculations

No emission/ removals recorded.

7.10. Other 5G

Emissions of CO2 from liming of agricultural soils and lakes are included in this category. The descriptions of the methodologies are contained in Section 7.5.1.2 (under Cropland).

7.11. Emissions of non-CO_2 gases

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 IPCC (2004) have only partly been included. Methodologies have been presented in 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.

7.11.1. Forests

N_2O is produced in soils as a by-product 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.

$N_2O\text{-direct}_{fertlizer} = (F_{Statistics\ Norway} + F_{ON})*EF_1 * 44/28$

Where
$F_{Statistics\ Norway}$ = the amount of synthetic fertilizer applied to forest soil adjusted for volatilization as NH_3 and NO_x. Gg N.
F_{ON} = the 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 are national statistics on the area with fertilizer applied. This area is very small, only 7 km^2 in 2004 and 26 km^2 in 1990 (Statistics Norway, Forestry Statistics). The statistics do 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 1995-2004. 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 IPCC2004). The amount of fertilizer applied is given as total weight. The nitrogen content is depending on the type used. According to Statistics Norway, 95 per cent 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 per cent of applied N. There are no national data to improve this. 1 per cent of the N-applied is volatized as NH_3 (the ammonia model of Statistics Norway).

Table 7.8 Estimated emissions 1990-2004 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
2003	3	71		74		1.5
2004	1	71		72		1.4
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

The resulting emissions are about 2-4 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 per cent to 6 per cent. 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.

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.

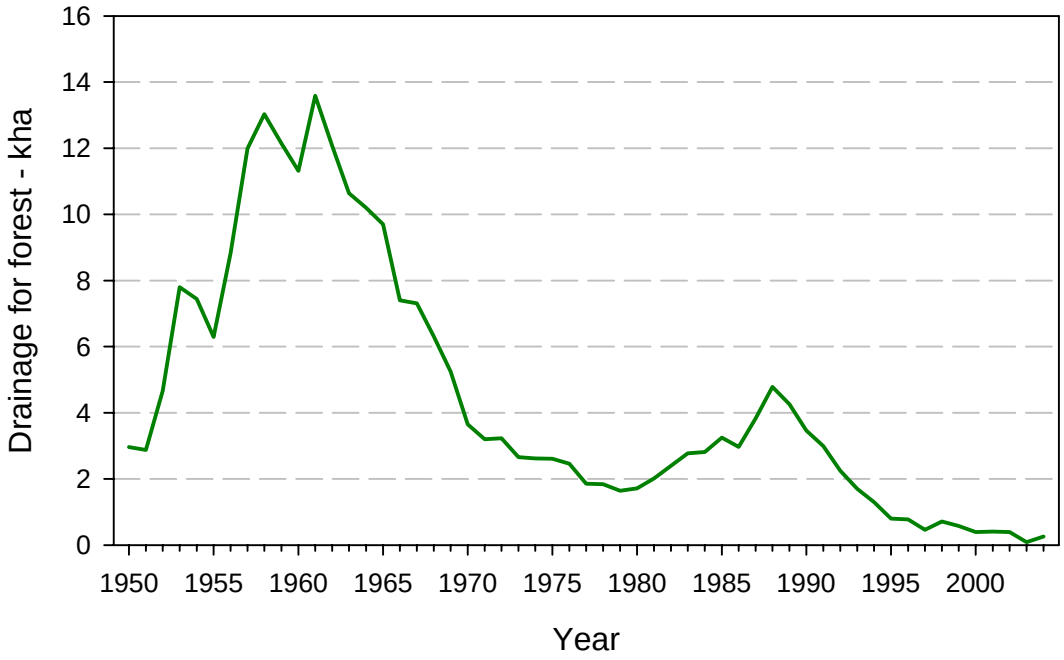

Figure 7.9 Drainage for forest. 1950-2004 (Source: Statistics Norway)

Draining back to 1950 has been taken into account (Figure 7.9). 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.

Table 7.9 Area drained and N_2O emissions from drainage of forest soil. 1990-2004

Year	Area drained (accumulated 1000 ha)	Emissions (Gg)
1990	231.8	0.04
1991	234.8	0.04
1992	237.1	0.04
1993	238.8	0.04
1994	240.0	0.04
1995	240.8	0.04
1996	241.6	0.04
1997	242.1	0.04
1998	242.8	0.04
1999	243.4	0.04
2000	243.8	0.04
2001	244.2	0.04
2002	244.6	0.04
2003	244.7	0.04
2004	244.9	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)[12]. 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 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 1993-2004. 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.

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 per cent, 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 per cent 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 7 500 kg humus per ha, we assume that 10 per cent 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.

[12] There may be some trials of burning as part of forest management, but this is only performed in small scale and is ignored here.

Table 7.10 Forest fires in Norway 1990-2004

Activity data	Number of fires	Unproductive forest (ha)	Productive forest (ha)	Total area burnt ha
1990	578	679.6*	256.4*	935.9*
1991	972	1 142.8*	431.2*	1 574.0*
1992	892	1 048.8*	395.7*	1 444.4*
1993	253	135.5	88.3	223.8*
1994	471	123.6	108.1	231.7
1995	181	77.6	35.5	113.1
1996	246	169.7	343.8	513.5
1997	533	605.8	260.6	866.4
1998	99	164.7	110.3	275
1999	148	734.0	12.7	86.1
2000	99	142.6	29.3	171.9
2001	117	84.3	5.2	89.5
2002	213	124.7	95.8	220.5
2003	198	905.6	36.8	942.4
2004	119	84.6	32.3	116.9

(Source: Directorate for Civil Protection and Emergency Planning)
* Area estimated by NIJOS (2005).

Table 7.11 CO_2 emissions from forest fires, 1990-2004. Gg

Activity data	Living biomass	Dead wood CO_2 Gg	Humus CO_2 Gg	Total CO_2 Gg
1990	17.2	0.9	1.3	19.3
1991	28.9	1.4	2.2	32.5
1992	26.5	1.3	2.0	29.8
1993	4.1	0.2	0.3	4.6
1994	4.2	0.2	0.3	4.7
1995	2.1	1.0	0.2	2.3
1996	9.4	0.5	0.7	10.6
1997	15.9	0.8	1.2	17.9
1998	5.0	0.3	0.4	5.7
1999	1.6	0.1	0.1	1.8
2000	3.2	0.2	0.2	3.6
2001	1.6	0.1	0.1	1.8
2002	4.0	0.2	0.3	4.5
2003	17.3	0.9	1.3	19.5
2004	2.1	0.1	0.2	2.4

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 uses 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 per cent for methane and 30 per cent 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 IPCC, 2004). We suggest using the emissions estimated using method 1 for CH_4 and N_2O.

Table 7.12 Estimates of CH_4 and N_2O emissions from forest fire. 1990-2004. Gg

	CH_4 (method 1)	CH_4 (method 2)	N_2O (method 1)	N_2O (method 2)*
1990	0.084	0.084	0.00058	n.e
1991	0.142	0.142	0.00097	n.e
1992	0.130	0.130	0.00089	n.e
1993	0.020	0.020	0.00014	n.e
1994	0.021	0.021	0.00014	n.e
1995	0.010	0.010	0.00007	n.e
1996	0.046	0.046	0.00031	n.e
1997	0.078	0.078	0.00054	n.e
1998	0.025	0.025	0.00017	n.e
1999	0.008	0.008	0.00005	n.e
2000	0.015	0.015	0.00016	n.e
2001	0.008	0.008	0.00006	n.e
2002	0.020	0.020	0.00014	n.e
2003	0.085	0.085	0.00058	n.e
2004	0.011	0.011	0.00007	n.e

* n.e = not estimated

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.

7.11.2. 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 N_2O 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

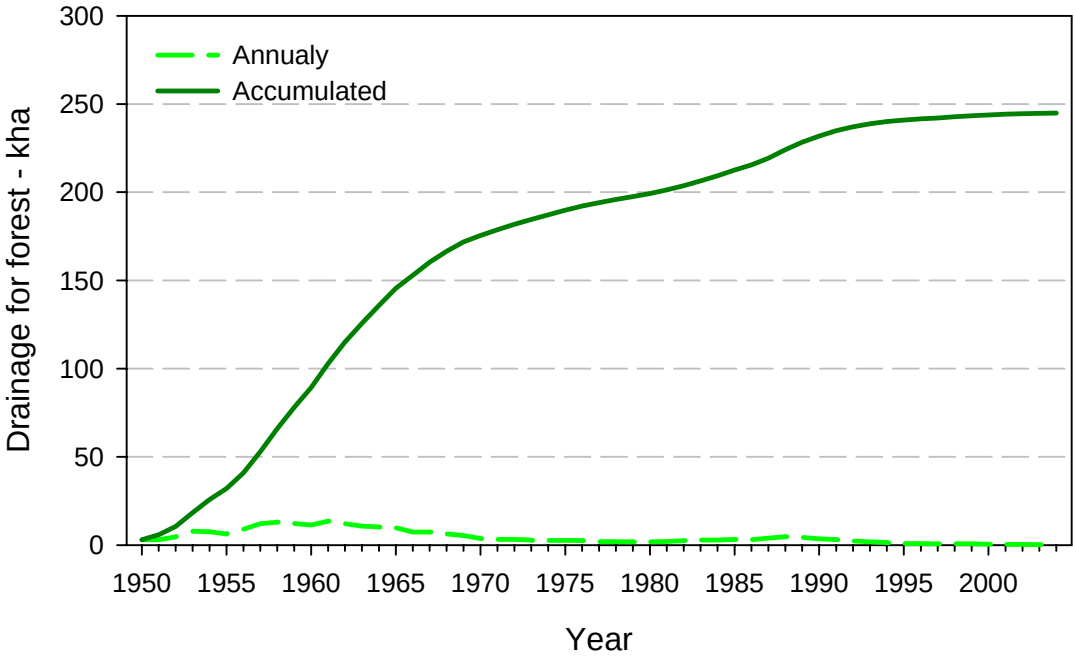

Figure 7. 10 New agriculture area (ha). Annual values and accumulated. Source: Statistics Norway.

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.

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 Bioforsk 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 7.5.1). The default emission factor from IPCC 2004 is 1.25 per cent.

Table 7.13 Area converted to cropland and related N_2O emissions. 1990-2004. Gg

	Area converted last 25 years	Emissions C Gg	Emissions N_2O Gg
1990	151 637	1.56	0.002
1991	145 794	1.50	0.002
1992	139 696	1.36	0.002
1993	133 220	1.21	0.002
1994	128 741	1.08	0.001
1995	124 262	0.96	0.001
1996	118 839	0.85	0.001
1997	113 099	0.81	0.001
1998	106 471	0.77	0.001
1999	99 122	0.72	0.001
2000	92 132	0.66	0.001
2001	85 429	0.61	0.001
2002	78 143	0.48	0.001
2003	70 208	0.42	0.001
2004	63 931	0.43	0.001

7.11.3. 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.

7.11.4. 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 7.3.1. That 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 IPCC 2004 this reduction is not accounted for in the calculations.

7.12. Uncertainties

The NIJOS (2005) study 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 up scaling 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 until recently has not been 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 study. Data are, however, quite certain for stock changes in forest remaining forest which constitute the largest removal of the inventory.

Annex II presents an updated uncertainty analysis of the Norwegian GHG emission inventory. Due to the unavailability of LULUCF data at the time of the analysis, emission data for 2003 was used. The uncertainty estimates for many LULUCF categories are not of the same quality as the rest of the inventory. More information about the uncertainty estimates for LULUCF is given in (NIJOS 2005). By including the LULUCF sector the results from the analysis show a total uncertainty of 14 per cent of the mean both in 1990 and in 2004, against 7 per cent without LULUCF. The doubling of uncertainty is caused mainly by forest biomass and grassland histosoils.

The largest uncertainties are related to N_2O from fertilizer use and land disturbances, where the uncertainty will be larger than 100 per cent. 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 per cent. Also CO_2 from agriculture soils are quite uncertain, by more than 100per cent. 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 at this moment. However, Norway will provide more information on the specific QA/QC procedures in the National System report for the Initial Report.

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

The whole time-series have been recalculated due to revision of the method used to calculate total biomass of forest trees. The methods used are described in section 7.4.1.1. New equations for below-ground biomass for *Picea abies, Pinus sylvestris, and Betual* spp. were implemented in the calculation procedure (Peterson and Ståhl, 2006). The impact of this

change in formulas is a small increase in biomass throughout the period. The method used to recalculate changes of carbon stock in living biomass is revised. We are now using annual data from 1996 to 2004. The use of moving average for smoothing the time-series results in the relative large changes from 1997 and onwards compared to the previous submission (see Table 7.14).

Table 7.14. Recalculations in 2006 submission compared to the 2005 submission. Gg CO_2-equivalents

Year	Current submission	Prevoius submission	% change
1990	-14 601	-13 427	8.7%
1991	-14 058	-13 266	6.0%
1992	-14 341	-13 551	5.8%
1993	-13 946	-13 338	4.6%
1994	-14 623	-13 918	5.1%
1995	-13 840	-13 393	3.3%
1996	-14 282	-13 814	3.4%
1997	-14 362	-21 230	-32.3%
1998	-20 209	-20 923	-3.4%
1999	-19 825	-20 922	-5.2%
2000	-25 274	-20 816	21.4%
2001	-27 129	-20 834	30.2%
2002	-26 263	-20 901	25.7%
2003	-26 017	-20 941	24.2%

7.15. Planned improvements

To confirm the extent of the area of forest and other wooded land at higher altitudes, NFI started in 2005 to establish a limited number of NFI plots above the coniferous forest limit. A complete forest inventory is conducted on these plots. It is not yet decided whether a complete 3x3 grid of plots will be installed in the future, or if the sampling intensity will remain at a lower level in this region.

In Finnmark County, the NFI have started to conduct a full forest inventory on plots in the 3x3 km grid in coniferous forest. Another method and design are under consideration for forest land and other wooded land mainly stocked with birch.

The NFI plans to use national aerial photographs to supplement the field survey. In 2006 a program will be established for repeated aerial photo acquisitions of all regions in Norway. The photographs of scale 1:35,000 will cover the entire Norway. The plan is to repeat the photo acquisition every 5 years in the regions where most economic activities take place (agricultural regions, urban areas, other lowland regions) and probably 10 years in other regions (mountain regions).

Current aerial photographs are made available through a web-based service (www.norgeibilder.no). The service can be linked to applications where any selected location can be viewed online. We plan to use these aerial photos to supplement the NFI by update and check land cover statistics and land cover change statistics by assessing plots from the 3 × 3 km grid.

A joint research and development project between NFI and The University of Life Sciences aims at developing reliable inventory methods targeted for use in areas with limited information. Airborne LiDARs (**Li**ght **D**etection **A**nd **R**anging) is a promising remote sensing method for estimation of volume, biomass and carbon, because LiDAR is able to capture the entire 3-dimensional structure of tree canopies. The aim is to develop LIDAR to an operational large scale biomass estimation method.

8. Waste

8.1. Overview

This sector includes emissions from landfills (6A), wastewater handling (6B) and small scale waste incineration (6C). 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 1.9-2.0 million tonnes CO_2-equivalents (Section 2.3). From 1997 emissions declined and in 2004 emissions were 17 per cent lower than in 1990. In spite of increasing amounts of waste the emissions of CH_4 from landfills has decreased. This is because a number of measures to reduce the amount of organic waste deposited and to increase the collection and combustion of methane from landfills have been established. Examples are: Requirement to collect methane from landfills, tax on final treatment of waste, prohibition of depositing wet organic waste gradually introduced from year 2000.

Solid waste disposal on land (Landfills) is the main category within the waste sector, accounting for about 90.6 per cent of the sector's total emissions. Wastewater handling and waste incineration account for approximately 8.1 and 1.3 per cent respectively. The waste sector accounted for 3,0 per cent of the total GHG emissions in Norway in 2004.

8.2. Managed Waste Disposal on Land – CH_4 – 6A1 (Key Category)

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 (Section 2.3). 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, sewage sludge included, 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 2003. In addition, the amounts of waste recycled have increased significantly since 1990.

Emissions of CH_4 from solid waste disposal are key category in level and trend due to uncertainty in AD and EF. The contribution 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. Methodological issues

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:

$$(8.1) \quad DDOC_{mdiss} = (DDOC_{ma(ly)} + DDOC_{md}) * (1- e^{-k})$$

$$(8.2) \quad DDOC_{ma} = (DDOC_{ma(ly)} + DDOC_{md}) * e^{-k}.$$

Equation (8.1) 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 (8.2) calculates the DDOCmass accumulated as not dissimilated ($DDOC_{ma}$), for next year’s calculations from the same basis as equation (8.1).

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

$$(8.3) \quad DDOC_{md} = W * MCF * DOC * DOC_f$$

To calculate $DDOC_m$ accumulated in the SWDS

$$(8.4) \quad DDOC_{ml} = DDOC_{md} * e^{-k*((13-M)/12)}$$
$$(8.5) \quad DDOC_{ma} = DDOC_{ma(ly)} * e^{-k} + DDOC_{ml}$$

To calculate $DDOC_m$ dissimilated

$$(8.6) \quad DDOC_{mdi} = DDOC_{md} * (1-e^{-k*((13-M)/12))}$$
$$(8.7) \quad DDOC_{mdiss} = DDOC_{ma(ly)} * (1-e^{-k}) + DDOC_{mdi}$$

To calculate methane produced from DDOC dissimilated

$$(8.9) \quad CH_{4\ prod} = DDOC_{mdiss} * F * 16/12$$

To calculate methane emitted

$$(8.10) \quad CH_4 \text{ emitted in year } T = (\sum CH_{4\ prod}(T)) - R(T)) * (1-OX)$$

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. All waste sources, including business, industry, and construction and demolition waste, are included in the waste statistics.

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.

In 2005 Statistics Norway took over the responsibility for the methane calculating model. Then considerable deviations were discovered between Statistics Norway's improved waste statistics, and the waste statistics from 1998-99 used in the model. In addition, an error in the calculation of manufacturing waste deposited at the industrial disposal sites was discovered. The error was of significant importance to the calculated methane emissions. On these backgrounds Statistics Norway in November 2005 started a quality check of the waste data in the methane model (Statistics Norway 2006) (http://www.ssb.no/emner/01/04/10/doc_200607/doc_200607.pdf).
Statistics Norway's quality check of the methane calculations also comprises an updating of the decomposition time for wood, paper and wet organic waste to meet IPCC standards, and new data series for extraction of methane from Norwegian landfills.

8.2.4. Emission factor

The emission factors used in the Norwegian model are a mixture of country-specific factors and .IPCC defaults values. The half-life of wood has in 2005 been increased to 23 years to meet IPCC recommendations, and the half-life of paper is increased to 12 years. Table 8.1 shows some of the variables used in the calculations of methane emissions from solid waste disposals.

Table 8.1 Variables used in the calculations of methane from landfills.

	Type of waste			
Variables	Food waste	Paper	Wood	Textiles
$t_{1/2}$ (half life time)	3,0 years	12 years	23 years	10.5 years
DOC	0.170 Mg/Mg	0.385 Mg/Mg	0.400 Mg/Mg	0.400 Mg/Mg
DOC_f (Part of DOC dissimilating)	0.5	0.5	0.5	0.5
Ox. Methane oxidized in top layer	0.1	0.1	0.1	0.1
F. Part of methane in generated landfill gas	0.5	0.5	0.5	0.5

Source: SFT (2005a). and Skullerud(2006)

8.2.5. Uncertainties

Uncertainty estimates for greenhouse gases are presented and discussed in Annex II.

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.

8.2.6. Source specific QA/QC and verification

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

Statistics Norway has evaluated the waste data from 1945 until today used in the Norwegian methane emission calculation model. This led to some revisions in the waste data for industrial wastes. In addition there have been some adjustments in half-life for some waste material types. In compliance with findings by the ERT, Norway has increased half-life for wood to 23 years. Half-life for paper is increased to 12 years. For the half-lives of the other materials, Norway consider differences from IPCC default values minor, and will comply with the these in the report in year 2007, when the IPCC 2006 Guidelines have been published.

As a result of these improvements the emission figures for CH_4 from waste disposal is reduced for all years since 1990 compared to the submission in 2005. Methane emissions from Norwegian landfills were reduced by 30 300 tonnes in 1990, whereas the emissions in 2004 were 25 700 tonnes lower. This implies that estimated methane emissions from landfills have been reduced by approximately a quarter. As CO_2 equivalents, the figures for 1990 and 2004 have been reduced by 637 000 and 539 000 tonnes respectively, which corresponds to about 1 per cent of Norway's total greenhouse gas emissions. The new calculations show less of a decline in emissions from 1990 to 2004.

The most substantial contributors to the changes are:

a. The by far largest contributor to the differences in calculated methane emissions from 2003 to 2004 is the recalculations of material deposited made by Statistics Norway. Most important is the recalculations of wood in deposited industrial sludge all years before 2000. Recalculations of historic amounts of MSW also make a substantial contribution. Close to 20 % of the total calculated decrease of 30 % from 2003 to 2004 is due to these recalculations. Statistics Norway has published a special documentation report (Statistics Norway 2006).

b. The second largest decrease in calculated methane emissions in 2004 is due to the increase in half-life of wood from 10,5 to 23 years. It makes up for approximately 4 % of the total decrease, and the increase of half-life for paper from 8,5 to 12 years, for approximately 3 %

The total result of the recalculation is a 30,5 per cent reduction from 2003 to 2004.

Table 8.2 The revision of the model has resulted in these recalculations for 1990 and 2004.

	NIR 2005 Tonne CH_4	NIR 2006 Tonne CH_4	Change in per cent
1990	117.295	86.979	25,8
2004	95.085	69.425	27,0

8.2.8. Planned improvements

Minor changes to half-lives and DOC of materials will be considered after publications of the IPCC 2006 Guidelines (IPCC 2006).

8.3. Unmanaged Waste Disposal Sites – 6A2

In Norway landfilling of solid waste has been regulated and controlled for some decades, and unmanaged landfills are from before 1970. Furthermore, 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

8.4.1. Description

Emissions of CH_4 and N_2O from Wastewater handling has been relative stable during the 1990 to 2004, with a small increase for CH_4. The emission trend for this period is described in Section 2.3

8.4.2. Methodological issue

CH_4
Emissions of methane from domestic and commercial waste water have 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:

$$(8.11) \quad E_i = N_i * D * B_0 * MCF$$

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 have 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

Uncertainty estimates for greenhouse gases are presented and discussed in Annex II.

The uncertainty in AD is estimated to ±1 per cent for CH_4 and ±25 per cent for N_2O. Uncertainty in EF for has been estimated to ±70 per cent both for CH_4 and N_2O.

8.4.6. Source Spesific 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.

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 2007.

8.5. Waste incineration – CO_2 – 6C

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 2004, 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. Methodological issues

Emissions from flaring of landfill gas by landfills are estimated. However, CO_2 emissions from flaring of landfills are not included in the inventory, as these are considered as being of biogenic origin. The emissions are estimated by multiplying the amount of gas flared with the emission factors shown in Table 8.2. 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 8.2. 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. CO_2 emissions from flaring of landfills are not included in the inventory, as these are considered as being of biogenic origin.

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 8.3 Emission factors for flare, cremation and hospital waste incineration

Component	Flare Landfill gas	Flare Natural gas	Cremation	Hospital waste
	kg/tonnes	Tonnes/Sm^3	Tonnes/tonnes	Tonnes/tonnes
SO_2	0.02	0	0.00037	0.0014
CO_2	0	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
Uncertainty estimates for greenhouse gases are presented and discussed in Annex II.

No new data on the amount of hospital waste has been reported since 1999. The amount of waste today may vary from the data reported in 1998 and 1999. Uncertainty is estimated to ±30 per cent.

Emission factors
Uncertainty estimates for greenhouse gases are presented and discussed in Annex II.
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. Uncertainty is estimated to ±30 per cent. See Annex II.

8.5.6. 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.

8.5.7. Recalculations

Figures for CO_2 from flaring of landfill gas have been deleted, as recommended by the review team. Emission of CO_2 from combustion and flaring of landfill gas is excluded from the inventory due to that the carbon now is defined as being of biogenic origin. This was also recommended in the review of the NIR 2005.

8.5.8. Planned improvements

No further improvements are planned before NIR 2007.

9. Recalculations

9.1. Overall description of recalculations

To account for new knowledge on activity data and emission factors and to correct for some errors in the calculations, the Norwegian greenhouse gas emission inventory has been recalculated for the entire time series 1990-2003 for all components. The figures reported in this submission are therefore consistent through the whole time series.

The most important recalculations are

1. Improved data quality for several sectors, amongst them
    a. methane emissions from animals (new Tier 2 calculation)
    b. nitrous oxide from road traffic (new emission factor) and
    c. methane from landfills (revised activity data and adjustments in half-life for some waste material types)
    d. nitrous oxide from crop residues (new Tier 1b calculation, more detailed as regards to activity data and emission factors
    e. The emission figures for PFCs for the years 1990 to 2004 are revised. New data have been reported from the aluminum industry to the SFT

2. Recalculation of land-based industry, caused by inclusion of emission figures reported to SFT has contributed to more accurate emission figures. Emissions were earlier estimated by emission factor and activity data. This year more plants have reported emission figures to the SFT. Many time series have been recalculated and checked more closely. In addition, where there have been gaps in the old time series, new data have been reported from the plants.
3. Emissions from consumption of HFCs and PFCs were recalculated in order to take into account the consequences of tax introduction on imports of these chemicals in 2003.
4. The accomplishment of a special project has resulted in better calculations for SF_6.
5. From this year onwards, the emission figures for Norway also include Russian activity on Spitzbergen , and recalculations have been carried out for the years 1990-2004 to include this. Because the Russian activity on Spitzbergen has been reduced during this period, it also reduces the rise in the total emissions since 1990.

9.2. Specific description of the recalculations

9.2.1. IPCC category 1 Energy

The various recalculations performed in the energy sector cover several source categories and are elaborated in the following.

It can more specifically be noted here that in the case of the energy combustion activities in 2003, most of the recalculations were due to the fact that the 2003 the energy accounts that served as the basis for last year's submission were "preliminary". The "final" figures for the

energy accounts are now available, as final energy consumption figures from the manufacturing statistics and some other final energy figures are now included in the energy accounts. This type of energy balance-related revisions is not commented specifically under each IPCC code.

FUEL COMBUSTION ACTIVITIES

1 A 1 a Public Electricity and Heat Production

- Emissions from Russian activity at Spitzbergen are included for the first time. This leads to increased combustion emissions for all years. Emission of CO_2 is increased by 151 000 tonnes in 1990 and by 76 000 tonnes in 2003. For CH_4 and N_2O the changes are minor.
- A part of the black liquor used at one pulp and paper plant has been used for electricity production since 1990. This was earlier estimated as emissions from combustion in pulp and paper industry.
- The amount of waste burned is revised for some plants for 2003, as well as for some other plants for the years 1989-1995 and 2003.
- Emission of CO_2 from combustion of landfill gas for energy purposes is excluded from the inventory, since carbon is now defined as being of biogenic origin. This was also recommended under the review of the 2005 emission inventory submission.

1 A 1 b Petroleum refining

- Emissions of CO_2, CH_4 and N_2O from all oil refineries for all years are recalculated as a result of the quality control performed by SFT (see Annex III for further information). Emission figures reported by the plants to SFT are now included in the inventory for the whole time series and have replaced emission figures calculated by the inventory team based on activity data and emission factors. These changes have led to a minor decrease in the emissions of CO_2 for the whole time series. Emissions of CH_4 have increased for the years 1990 to 1999. This is caused by the higher emissions from flaring at one oil refinery. Emissions of N_2O have also increased for the years 1990 to 1999.
- Small changes have been made in the amount of refinery gas and CO-gas burned in 1990 and 2003 at two plants. This has resulted in minor revisions for CO_2.

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

- Reported emissions of CH_4 to SFT from one of Norway's two gas terminals for the years 1990 to 2004, and from the other one for the years 1996 to 2004 have now replaced emissions estimated earlier by Statistcs Norway. These changes have decreased the emissions of CH_4 for the whole time series.
- The natural gas used at one plant was previously assumed to be combusted in a gas turbin. This was a mistake, since the gas is consumed in boilers. Since emission factors for CH_4 differ from turbine to boiler, there have been recalculations for both distribution turbine/boiler for reported figures and for the calculated figures. In addition, there have been revisions in reported figures for some years since 1996.
- There are made small changes in the amount of natural gas burned in 1995-1997 at two plants.
- Emission figures for CO_2 and CH_4 from combustion at one oil refinery have been revised for the period 1999-2003.

1A2 Manufacturing Industries and Construction

I A 2 c Chemicals
Emissions of CO_2 are reported to SFT from one plant in the sector manufacture of fertilizers, nitrogen compounds and pesticides for the years 1990 to 2004. These figures replace emission figures calculated by the inventory team used in previous submissions. . These changes have led to increased emissions of CO_2 for all years. Reported emissions of CO_2 from plants to SFT in the sector manufacture of plastic and synthetic rubber in primary forms and manufacture of other organic basic chemicals, have replaced emissions estimated by Statistcs Norway. Two plants have reported figures for the years 1990 to 2004, one plant have reported figures from 1992 to 2004, one plant for 1997 to 2004 and another plant from 2001 to 2004. These changes have increased the emissions of CO_2 for the whole time series.

1 A 2 d Pulp, paper and print

- Emission figures reported by plants to SFT have replaced emissions estimated by Statistcs Norway. CO_2 and CH_4 figures have been reported from 9 plants for the years 1990 to 2004, one plant has reported figures from 1991 to 2004. These changes have increased the emissions of CO_2 for the period 1992 to 1994. For the other years, changes small changes. Emissions of CH_4 have decreased for all years due to these changes.
- Reported emissions of N_2O from plants to SFT have replaced emissions estimated by Statistcs Norway. Figures for the years 1990 to 2004 have been reported for 8 plants. These changes have decreased the emissions of N_2O in most years.
- There have been revisions in industry statistics for wood waste for some years. In addition the average energy content in wood has been changed from 16.8 to 16.25 GJ/tonnes. The energy content is used when converting figures in the energy accounts from toe (tonnes oil equivalents) to tonnes, which is used in the emission inventory. This change in the energy content has resulted in higher amounts of wood for all years.
- There have been revisions in industry statistics for black liquor for some years. In addition the average energy content in black liquor has been changed from 14 to 9.2 and 7.2 GJ/tonnes. The energy content is used when converting figures in the energy accounts from toe (tonnes oil equivalents) to tonnes, which is used in the emission inventory. A part of the black liquor used at one plant has been used for electricity production since 1990. This part is now removed from combustion in pulp and paper industry.
- Burning of waste. For one plant, we have earlier used the conversion factor for wood waste instead of the conversion factor for waste when converting the energy unit PJ to tonnes for the years 1998-2003. (In the emission inventory we us the unit tonnes when estimating emissions). This revision has led to minor revisions for CO_2, CH_4 and N_2O.

1 A 2 f Other

- Emission figures for CO_2 from two cement-producing plants have been revised to account for data reported by these plants to SFT. Figures are reported for all years since 1990. Previous calculations were based on emission factor and activity data.
- CO_2 emissions are reported to SFT for one plant in sector of manufacture of cement, lime and plaster these emissions are included in the inventory. Figures are reported for all years since 1990.
- Combustion of waste oil in asphalt production was earlier assumed to be combusted in boilers, but is now assumed to be combusted in direct fired furnaces. Use of different

emission factors for CH_4 and N_2O has also led to minor changes in the respective emissions.

- Burning of waste. For cement production, we have earlier used the conversion factor for wood waste instead of the conversion factor for waste when converting the energy unit PJ to tonnes for the years 1998-2003. (In the emission inventory we us the unit tonnes when estimating emissions). This revision has led to minor revisions for CO_2, CH_4 and N_2O

1A3 Transport

1 A 3 a Aviation

Recalculations have been done as recommended by the review team in the 2005 review. Emission factors for CH_4, NO_x, NMVOC and CO are calculated based on activity data for 1989, 1995, and 2000. Factors for the years 1990-1994 and 1996-1999 were interpolated. Emission factors for the years before 1989 and after 2000 were kept constant.

1 A 3 b Road transportation

- The emission factor for N_2O from road traffic is changed for all years. The new emission factor was suggested in phase 1 of an ongoing project to improve the Norwegian road transport emission calculation model (TØI 2005, unpublished). The new emission factor is more in accordance with factors for other countries. This has lead to decreased emissions for all years.
- The emission factor for CH_4 from road traffic has changed for all years since 2001. This was also suggested in phase 1 of the ongoing project to improve the Norwegian road transport emission calculation model (TØI 2005, unpublished).
- Figures on fuel consumption for diesel have been recalculated for many years, and for petrol for some years due to revisions in the energy accounts.
- A small amount of LPG is used in passenger cars for the period 2000-2003. This amount was previously allocated to residential sector.

1 A 3 d National Navigation

- Emissions of CO_2 for 2002 have increased and emissions of CO_2 for 2003 have reduced due to revisions in the final energy accounts.

1A4 Other sectors

1 A 4 a Commercial / Institutional

- Emission of CO_2 from combustion and flaring of landfill gas is excluded from the inventory, as the carbon is now defined as being of biogenic origin. This was also recommended by the review team in the 2005 review.Emissions of LPG in retail trade and hotels are included for all years since 2000. This has led to increased emission of CO_2 for all years.

1 A 4 b i Residential plants

- The estimates for the use of heating oil and heavy distillate in 2002 are revised in the energy accounts.

1 A 4 c ii Off-road Vehicles and Other Machinery

- There have been some revisions in the energy accounts concerning Off-road Vehicles and Other Machinery: Figures for consumption of petrol and diesel in forestry have changed for all years since 1990. Figures for use of petrol have increased for 1990-1993, and decreased for the years after. For diesel, the figures have decreased for 1990-1996 and 1987, and increased for the other years.

FUGITIVE EMISSIONS FROM FUELS

Loading, unloading and storage of crude oil on the oil fields off shore and at oil terminals on shore causes emissions of CH_4 and NMVOC and indirect emissions of CO_2 caused by oxidation of the carbon in CH_4 and NMVOC to CO_2. Indirect CO_2 emissions are calculated by multiplying the calculated amount of CH_4 or NMVOC emission with the emission factor for CO_2 per tonne CH_4 or NMVOC

- *1 B 1 a Coal Mining and Handling* Emissions from Russian activity at Spitzbergen are included for the first time, which causes higher emissions for all years for CH_4 and CO_2
- Figures of gross production have replaced figures of net production when estimating emissions of CH_4 from Norwegian coal production.

1 B 2 a i Exploration, Production, Transport

The emission figures for CH_4 from one crude oil terminal on shore are revised, and the new figures have replaced earlier reported emissions figures for all years since 1990. This has led to increased figures for all years. This has also changed the CO_2 emissions due to that CH_4 is oxidized to CO_2.

1 B 2 a iv Refining / Storage

- The emission figures for CO_2 from the cracker at one oil refinery have been recalculated for all years. This has led to small changes for all years, except 1991 where emission has decreased due to an error in the earlier reported CO_2 emissions.
- Emissions of CH_4 from one refinery are recalculated for all years since 1990. The time series for CH_4 from oil refining is recalculated due to revised EF that is based upon measurements conducted in 2002 and 2005. The recalculation has increased the CH_4 emissions from refineries in 1990 from 100 tonne in NIR 2005 to 1668 tonne in this submission. The revision is a response to the issue raised by the expert review team.
- Revised emissions of CH_4 from one oil refinery for all years since 1990, and from another in 1999 and 2000. This has led to increased emissions for the years 1992 to 2004.
- Indirect CO_2 emissions from NMVOC from two refineries have by a mistake not been included in earlier inventories. This revision leads to increased CO_2 emissions from all years since 1990.

1 B 2b Natural gas

- The emission figures for CH_4 from two gas terminals have been revised. The revision has led to changed emissions of CH_4 for the whole time series. Resulting from this there are also small changes in indirect CO_2 emissions.

1 B 2 c Venting and flaring

- Revised emission figures for CH_4 from flaring at two gas terminals are now included in the inventory. These changes have led to increased emissions of CH_4 for the whole time series. Emissions from flaring are higher then earlier estimated.

- Revised emissions figures for CO_2 from one gas terminal are now used for the period 1990 to 2004, and for another gas terminal for the period 1996 to 2004. These changes have led to minor changes in emissions of CO_2 for the whole time series.
- For one crude oil terminal emission figures for CO_2 from flaring has not been reported since 2001. These figures are now estimated. Total figures reported from The Norwegian Petroleum Directorate have not changed. A part of what was reported as fuel, is assumed to be flared. kaa 47
- Emission factors for N_2O and NMVOC from flaring during wildcat drilling have been changed.

9.2.2. IPCC category 2 Industrial processes

2A Mineral Products
2 A 1 Cement Production

- In earlier submissions the CO_2 emissions from cement production were calculated based on emission factors and clinker production data. In this submission Norway has used the emission figures reported by the plants to the SFT, because these figures are assumed to be of better quality. The figures for all years back to 1990 have been recalculated. This led to increased emission in 1990 and 1992, minor or no changes other years

2 A 2 Lime Productions

- One plant has reported emissions of CO_2 for 1990 and 1998-2001. Emissions from 2001-2004 are estimated by SFT based on activity data and plant specific emission factors. Emissions for the years 1991-1997 are interpolated by SFT.

2 B 1 Ammonia Production

- CO_2 emission from ammonia production has increased for 2002 and 2003 due to correction of errors in the emission figures. The emissions have decreased for 1998 also due to new figures from the plant.

2 B 2 Nitric Acid Production

- N_2O emission from nitric acid production has increased for 1991 due to correction of errors in the emission figures.

2 B 4 Carbide Production

- For the three silicon carbide plants, a complete recalculation of CO_2-emissions from 1990 to 2004 has been carried out with new emission factors. This has resulted in higher emissions of CO_2 from the two of the sites, and lower emissions from the third site. The total CO_2 emissions in 1990 for this sector are 28.2 per cent higher than submitted in previous submission (NIR 2005) while the 2003 emissions is now 0.1 per cent lower.
- The time series of CH_4 emissions from the three silicon carbide plans are recalculated using the new emission factor and this has led to substantial changes in CH_4 emissions for the entire time series. The total CH_4 emissions in 1990 for this sector are 65 per cent lower than in previous submission (NIR 2005) while the 2003 emissions is now 73 per cent lower.
- Revised emissions of CO_2 from the plant that produce calcium carbide are now used for the period 1990 to 2002. Reported emissions of CO_2 is now almost 60,000 tonne

(50 per cent) higher in 1990 than submitted in NIR 2005. Only minor changes have occurred for the other years. The plant was closed down in 2002.

2 B 5 Other

- Emission of CH_4 from one plant in sector manufacture of dyes and pigments and other inorganic basic chemicals was by a mistake not included for 2003. This figure is now included and the emission of CH_4 for 2003 has therefore increased.
- Indirect CO_2 emissions from NMVOC and CH_4 from the same plant in sector manufacture of dyes and pigments and other inorganic basic chemicals have by a mistake not been estimated for the years after 2001. And indirect CO_2 emissions from NMVOC from two other plants have by a mistake not been included in the inventory at all. This inclusion leads to increased CO_2 emissions for all years.
- New emission figures for CH_4 for petrochemistry. One plant has reported data to the SFT for the years 1990-2004, one plant for the years 1990-2002 and another plant for the years 1997-2004. These data are now used in the emission inventory. This has led to minor increase in emission. kaa98

2C Metal Production

- The emission figures for CO_2 for the years 1990 to 2004 for almost all ferroalloy plants are revised. The plants have reported new data to the SFT, which is now used in the emission inventory. Compared with previous submission (NIR 2005) the CO_2 emissions calculated for 1990 now is 1 per cent higher and in 2003 the emissions is 2.2 per cent lower.
- The emission figures for CH_4 for the years 1990 to 2004 for ferroalloy plants are revised. The plants have reported new data to the SFT, which is now used in the emission inventory. The CH_4 emissions is in 1990 2 per cent higher and in 2003 1.4 per cent lower than reported in NIR 2005.
- The emission figures for N_2O for the years 1990 to 2004 for ferroalloy plants are for the first time included in the Norwegian GHG emission inventory. The emission figure that is included in the inventory is reported by the plants to the SFT.
- The emission figures for CO_2 from production of ferroalloys are reduced for 1993 and 1994 due to double counting.
- Estimated CO_2 emissions for aluminum production, 7 plants, in 1990 to 2004, have been replaced by reported figures from the plants to SFT. This has led to decreased CO_2 emissions of 4.7 per cent in 1990 and 0.1 per cent in 2003 compared with NIR 2005.
- The emission figures for CO_2-emissions for anode production (2 plants) have been recalculated. This has led to minor changes in the CO_2 emissions for most years.
- In 2002 one plant producing magnesium closed down the production of cast magnesium. This led to disappearance of CO_2 emissions. In the inventory Norway erroneous used the emission figure from 2002 for the years 2003 and 2004. These emissions figures are now deleted.
- The emission figures for PFCs from production of aluminium for the years 1990 to 2004 are revised due to change of methodology. New data based on this new method have been reported from each plant to the SFT. This has led to increased emission of PFC for all years, in 1990 the emission is increased with 2.3 and in 2004 with 29.2 per cent. For further details see Section 4.4.3.7.

2 D 1 Pulp and Paper

- One pulp and paper plant report CO_2 emission data to the SFT split into emissions from process and combustion for the years 1990 to 2004. Earlier emissions were based on activity data and emission factors. It was assumed that the total emission originated from the combustion processes (1A2d). Emissions are now split for this plant, and CO_2 emissions from the process are included for the first time.

2 D 2 Food and Drink

- CO_2 from one plant producing ammonia is separated and sold as carbonic acid for different purposes as for carbonic acid in carbonated beverages. Part of the CO_2 is sold and used in Norway, whereas another part is exported. In the previous submissions only the part used in Norway were reported. In this submission also the CO_2 exported is reported, under 2D2 Food and drink. Reported CO_2 emissions therefore increase for all years. This correction is in accordance with what was suggested by the review team in the 2005 review process.

2F Consumption of Halocarbons and Sulphur Hexafluoride

- Introduction of taxes on imports of HFCs and PFCs in 2003, provided a new data source which was used to update activity data for the years 1998-2004. The update gave rise to slightly higher emissions because of a shift in activity data from source categories with low emission factors to categories with higher emission factors.
- Current calculations take into account the fact that parts of the chemicals imported in 2002, prior to the tax introduction, was stored for usage the following years. This resulted in lower emissions in 2002 and higher emissions in 2003 than reported in the previous submission.

2.F.8 - Electrical equipment:

- New emission and stock data for the industry from 2003 onwards were introduced in the 2005 inventory. Now the time series back to 1990 has been revised to get a consistent time series.

9.2.3. IPCC category 4 Agriculture

New revised population numbers for reindeer for the years 1980, 1987, 1989-2001 gives minor changes in emissions for IPCC category 4A, 4B and 4D.

4A Emission from Enteric Fermentation in domestic livestock

- The methodology for calculating CH_4 from enteric fermentation from cattle and sheep is updated to IPCC's Good Practice Guidance Tier II method. The methodology used is described in Chapter 6.2 in the NIR.

4B Manure Management and 4D Agricultural Soils

- A new survey has given figures for distribution between manure storage systems for 2003, and for distribution of manure spreading between fields and meadows for 2002 and 2003, which are included in the NH_3 calculations. This influences the N_2O emissions from both 4B and 4D.
- Earlier we assumed that the distribution of manure in different types of storage systems, and the distribution between storage and pasture were constant. Now this has changed so the distribution varies from one year to the next for all the reported years. The distributions between different storage systems and pasture are consistent with the

distributions used for calculating NH_3 emissions. These changes can be seen in 4B and 4D.

4 D Agricultural Soils

- In 2006, the methodology used for estimating N_2O from crop residues have been changed to the method Tier 1b recommended in IPCC (2001). The new method is more detailed and is supposed to better reflect the real emission than the earlier used national method.
- The amount of inorganic fertilizers used in forestry is subtracted from the earlier used value for amount of inorganic fertilizers used in agriculture, due to double count.
- The emission factor used for calculating N_2O from grazing animals is not corrected for N that volatilizes as NH_3, since this is already taken into account in the IPCC default factor.

4 F Burning of agricultural residues

- Emissions figures for burning of agricultural residues are revised for 2001-2003. This is due to revised crop estimations.

9.2.4. IPCC category 5 Land-Use, Land-Use Change and Forestry (LULUCF)

The whole time-series have been recalculated due to new equations for below-ground biomass for *Picea abies, Pinus sylvestris, and Betual* spp. and the use of moving average for smoothing the time-series. This is described in further detail in Chapter 7.

9.2.5. IPCC category 6 Waste

6A Solid Waste Disposal on Land

- Statistics Norway has evaluated the waste data from 1945 until today used in the Norwegian methane emission calculation model. This led to some revisions in the waste data for industrial wastes. In addition there have been some adjustments in half-life for some waste material types. As a result of these improvements the emission figures for CH_4 from waste disposal is reduced for all years since 1990 compared to latest submission. Methane emissions from Norwegian landfills were reduced by 30 300 tonnes in 1990, whereas the emissions in 2004 were 25 700 tonnes lower. This implies that estimated methane emissions from landfills have been reduced by approximately a quarter. As CO_2 equivalents, the figures for 1990 and 2004 have been reduced by 637 000 and 539 000 tonnes respectively, which corresponds to about 1 per cent of Norway's total greenhouse gas emissions. The new calculations show less of a decline in emissions from 1990 to 2004. For more details, see Section 8.2.7.

6 C Waste incvineration

- Figures for CO_2 from flaring of landfill gas have been deleted, as recommended by the review team. Emission of CO_2 from combustion and flaring of landfill gas is excluded from the inventory due to that the carbon now is defined as being of biogenic origin. This was also recommended in the review of the NIR 2005.

9.3. Implications of the recalculations

9.3.1. Implications for emissions levels

Table 9.1 and 9.2 show the effects of recalculations on the emission figures for the greenhouse gases 1990 – 2003.

Table 9.1Recalculations in 2006 submission compared to the 2005 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	34414.1	34757.9	1.0	5159.2	4761.7	-7.7	5064.2	4702.7	-7.1
1991	33541.1	33185.2	-1.1	5194.3	4830.8	-7.0	4919.2	4707.4	-4.3
1992	33762.7	34169.5	1.2	5258.3	4918.3	-6.5	4256.2	3926.2	-7.8
1993	35408.3	35878.6	1.3	5303.4	5002.2	-5.7	4603.9	4212.9	-8.5
1994	37265.8	37847.4	1.6	5381.4	5083.1	-5.5	4722.4	4357.4	-7.7
1995	37225.2	37774.1	1.5	5389.8	5083.6	-5.7	4800.1	4396.7	-8.4
1996	40392.8	40771.3	0.9	5421.6	5110.0	-5.7	4887.0	4429.0	-9.4
1997	40565.5	40958.4	1.0	5478.0	5134.4	-6.3	4821.8	4316.4	-10.5
1998	40774.4	41055.4	0.7	5320.7	4998.6	-6.1	5102.9	4531.0	-11.2
1999	41625.6	41915.6	0.7	5226.8	4840.6	-7.4	5299.1	4672.0	-11.8
2000	41143.6	41530.5	0.9	5317.7	4953.3	-6.9	5222.9	4523.8	-13.4
2001	42664.3	42917.3	0.6	5293.4	4958.7	-6.3	5211.0	4428.0	-15.0
2002	41238.9	42036.1	1.9	5119.2	4792.0	-6.4	5419.2	4609.1	-14.9
2003	43219.1	43549.9	0.8	5056.8	4822.5	-4.6	5326.4	4436.4	-16.7

Table 9.2 Recalculations in 2006 submission compared to the 2005 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	3370.40	2.31	2202.02	2199.78	-0.10
1991	0.11	0.11	0.00	2523.63	2992.92	18.60	2084.73	2079.15	-0.27
1992	0.34	0.34	0.05	2016.46	2286.92	13.41	707.82	705.03	-0.39
1993	2.43	2.42	-0.20	1980.37	2297.72	16.02	744.65	737.71	-0.93
1994	9.23	9.20	-0.31	1710.38	2032.47	18.83	886.67	877.98	-0.98
1995	25.88	25.82	-0.21	1561.93	2007.81	28.55	617.41	607.79	-1.56
1996	52.87	52.84	-0.06	1439.84	1829.33	27.05	584.49	574.10	-1.78
1997	88.43	88.44	0.01	1376.67	1633.29	18.64	591.15	579.86	-1.91
1998	132.64	132.36	-0.21	1267.18	1485.88	17.26	738.88	726.74	-1.64
1999	179.45	182.97	1.96	1123.01	1388.80	23.67	886.71	873.96	-1.44
2000	232.10	240.57	3.65	899.24	1318.25	46.60	947.93	934.42	-1.43
2001	291.68	305.72	4.81	1043.41	1328.97	27.37	805.50	791.20	-1.77
2002	365.12	356.14	-2.46	1119.95	1437.95	28.39	253.30	238.30	-5.92
2003	240.26	379.18	57.82	703.45	909.45	29.28	232.63	234.86	0.96

9.3.2. Implications for emission trends

As a result of the different recalculations for 1990-2003 there have been some changes in the trends. The differences are shown in the tables below.

Table 9.3 Trends in emissions 1990-2003. This submission vs. previous submission. GHG. Per cent change 1990-2003

	Total GHG	CO_2	CH_4	N_2O	PFC's	SF_6	HFC's
This submission	9.12	25.29	1.28	-5.66	-73.02	-89.32	2068818
Previous submission	9.25	25.59	-2.04	5.14	-78.65	-89.44	1310837

The changes in methods have resulted in new figures, particularly for the emissions of methane and nitrous oxide. Methane emissions have been adjusted down by 5 per cent in 2003. The nitrous oxide emissions are adjusted down by 17 per cent. Emissions of PFC's have been adjusted up by 29 per cent in 2003 due to revised emission figures from SFT. There are only minor changes for CO_2. The gap between 1990 and 2003 for all the six greenhouse gases together has been increased by 500 000 tonnes CO_2 equivalents since the previous calculation.

Quality improvement is driving force

The driving force to make improvements is the hope of being able to produce emission figures of satisfying quality for the United Nation Framework Convention on Climate Change, and to give the government and others a basis for making decisions of what measures to introduce to reduce emissions.

1. Recalculation of land-based industry, caused by inclusion of emission figures reported to SFT. Emissions were earlier estimated by emission factor and activity data.
2. New methods for calculation of methane emissions from animals have contributed to higher reported emissions than in previous submissions.
3. New and improved activity data for the calculation of methane emissions from landfills have contributed to lower emission figures than reported in previous submissions.
4. New emission factor for calculation of nitrous oxide from road traffic have contributed to lower reported emissions than in previous submissions.

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Annex I - VI
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Annex I: Key Categories

This chapter outlines the Tier 2 methodologies used to find which sources are key categories in the Norwegian greenhouse gas emission inventory.

Two different methods are used for the key category analysis. First, the standard method as described in IPCC Good Practice Guidance (IPCC 2001) is used, both at the Tier 1 level and at the Tier 2 level with uncertainties. Second, a sensitivity analysis is performed using the specification of the model for the uncertainty analysis, as described in Rypdal and Zhang 2000). The uncertainty model is presented in Annex II. The discussion focuses primarily on the standard method. The sensitivity analysis is presented as supporting data.

Key categories 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 category is according to (IPCC 2001) which is based on (Statistics Norway 2001e). A Tier 2 analysis for the LULUCF sector has also been performed. However, key categories for non-LULUCF sources are based on the analysis without LULUCF.

The key category 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.

The steps taken to find key categories with respect to level and trend were the determination of uncertainties in input parameters (AD = activity data and EF = emission factors). 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 standard method does not take correlations into account. This has partly been handled by aggregating sources with the same emission factors. However, sources with similar emission factors in stationary combustion, categories 1A1, 1A2, and 1A4, were treated separately as suggested in the proposed 2006 guidelines.]. 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. In the sensitivity analysis, such correlations may be specified in the model. The sensitivity analysis also allows separate treatment of activity data and emission factors.

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 LULUCF key categories come in addition to this.

A summary of the key categories are given in Table A1-3 for the emissions categories, and a summary for removal key categories are given in Table A1-4. The results in level and trend from the Tier 1 analysis for emissions sources is in Table A1-5.

The new uncertainty analysis has caused several changes in the key categories. Several different effects can be distinguished:

- Improved methodology and reduced uncertainty estimates for 4D - N_2O from agriculture - has reduced the dominance of this source. Thus, more sources need to be included in order to reach the 90 per cent threshold.
- The energy use sectors (1A) have been treated at a more disaggregated level. The result is that some of the major sources have a lower assessment value. They are still assigned as key, but the reduced dominance has the same effect as the previous point in increasing the total number of key categories.
- Some sources have reduced uncertainty estimates, and their ranks in the analyses are lowered.
- Some sources have increased emissions due to revised methods, and their ranks are higher.

Only one source that was identified as key in the 2005 NIR is absent from the new Tier 2 analysis. The uncertainty estimate for 2C4 *SF_6 used in Aluminum and Magnesium Foundries* is significantly reduced. However, the source is still identified in the Tier 1 analysis.

Several new sources were assigned as key categories. In the Tier 2 analysis, the new sources shown in Table A1-1 were included.

*Table A1-1. Summary of **new** identified emission key categories in the Tier 2 analysis.*

1A1 Energy Industries, Waste	CO_2	level
1A3e Other (snow scooters, boats, motorized	CO_2	level (trend at T1)
1A4 Other Sectors, Wood etc.	CH_4	level, trend
1B2b Natural Gas	CH_4	trend
2B4 Carbide Production	CO_2	trend (level at T1)
2D2 Food and Drink	CO_2	trend (level at T1)
4B Manure Management	CH_4	level
4B Manure Management	N_2O	level
6B Wastewater Handling	N_2O	level

According to IPCC (2001) it is good practice to give the results at the Tier 2 level if available. However, in the proposed 2006 guidelines it is suggested that good practice reporting should include key categories from both the Tier 1 and Tier 2 analyses. The Tier 1 analysis includes the following sources which were not assigned as key at Tier 2:

*Table A1-2. Summary of **new** identified key categories in the Tier 1 analysis.*

1A1 Energy Industries, Coal/coke	CO_2	level, trend
1A1 Energy Industries, Oil	CO_2	level, trend
1A2 Manufacturing Industries and Construction, Coal/coke	CO_2	level, trend
1A4 Other Sectors, Gas	CO_2	trend
1A5b Military - Mobile	CO_2	level, trend
2A1 Cement Production	CO_2	level
2B1 Ammonia Production	CO_2	level
2C1 Iron and Steel Production	CO_2	level, trend
2C4 SF_6 used in Aluminium and Magnesium Foundries	SF_6	level, trend

The other differences between the current analysis and Statistics Norway (2000) have no bearings on the conclusions on key categories. 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).

The sensitivity analysis generally supports the results from the standard key category analysis. Using thresholds for the uncertainty importance at 0.002 for level and 0.01 for trend (Rypdal and Zhang 2000), no sources were identified that were not identified in the standard method. The sensitivity to changes in activity data and emission factors were assessed separately. In general, the uncertainty importance of activity data is lower than that of emission factors.

The analyses have been performed for 1990 and 2004 GHG emission data. The main conclusion is that there are few differences in the result for 1990 compared with 2004.

Land-use, Land-use Change and Forestry (LULUCF)
Table A1-4 shows the results of the Tier 2 key category analysis performed as described in GPG2004[1]. Uncertainties were not determined by a rigid analysis, see Section 7.12 . There are some differences between the two tiers. Tier 1 level analysis does not identify forest drained organic soil, cropland histosoils and forest converted for settlements. The reason is that these categories have large uncertainties. For the trend analysis there are small differences between the two tiers with respect to the LULUCF categories identified, and the trend analysis does not identify any additional LULUCF categories to those identified in the level analysis. Including LULUCF also influences other key categories identified. However, according to GPG2004 the LULUCF key categories are additional to those identified analyzing the inventory excluding LULUCF. In both analyses, forest remaining forest (all three pools) are among the top key categories.

[1] Tier 1 is based on only the size of emissions/removals and estimate their contribution to the level and trend. In the Tier 2 method the contribution is also multiplied with the relative uncertainty (two standard deviations).

Table A1-3. Summary of identified emission key categories. Excluding LULUCF.

	Source category	Gas	Level assessment Tier 2 1990	Level assessment Tier 2 2004	Trend assessment Tier 2 1990-2004	Method (Tier) 2004
4D1	Direct soil emissions	N_2O	**25.80**	**22.94**	**11.18**	Tier 1a
1A3b	Road Transportation	CO_2	**8.34**	**9.82**	**4.35**	Tier 2
1A1	Energy Industries, Gas	CO_2	**4.53**	**7.98**	**11.14**	Tier 2
4D3	Indirect emissions	N_2O	**5.77**	**5.24**	**2.15**	Tier 1a
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	**4.58**	**4.98**	**1.03**	Tier 2
6A	Solid Waste Disposal on Land	CH_4	**6.70**	**4.94**	**6.26**	Tier 2
4A	Enteric Fermentation	CH_4	**5.05**	**4.54**	**1.99**	Tier 1/2***
1A4	Other Sectors, Oil	CO_2	**4.33**	**3.41**	**3.35**	Tier 2
1B2c	Venting and Flaring	CH_4	**1.58**	**3.20**	**5.25**	Tier 2
1A3d	Navigation	CO_2	**2.05**	**2.35**	**0.88**	Tier 2
2C3	Aluminium Production	CO_2	**1.51**	**2.05**	**1.69**	Tier 2
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs	0.00	**1.89**	**6.25**	Tier 2
1A3a	Civil Aviation	CO_2	**1.40**	**1.80**	**1.23**	Tier 2
2C3	Aluminium Production	PFCs	**6.93**	**1.67**	**17.88**	Tier 2
1A3b	Road Transportation	N_2O	0.50	**1.65**	**3.76**	Tier 2
4D2	Animal production	N_2O	**1.70**	**1.58**	0.52	Tier 1a
1A2	Manufacturing Industries and Construction, Gas	CO_2	**0.92**	**1.48**	**1.82**	Tier 2
1B2c	Venting and Flaring	CO_2	**1.64**	**1.32**	**1.17**	Tier 2
1B2a	Oil (incl. oil refineries, gasoline dist	CH_4	0.67	**1.32**	**2.12**	Tier 2
1A3e	Other (snow scooters, boats, motorized e	CO_2	**1.12**	**1.31**	0.57	Tier 2
2B2	Nitric Acid Production	N_2O	**1.47**	**1.21**	**0.94**	Tier 2
1A4	Other Sectors, Wood etc.	CH_4	**0.88**	**1.12**	**0.75**	Tier 2
4B	Manure Management	N_2O	**1.03**	**0.87**	0.59	Tier 1
6B	Wastewater Handling	N_2O	0.69	**0.77**	0.21	Tier 1
2C2	Ferroalloys Production	CO_2	**0.78**	**0.76**	0.09	Tier 2
4B	Manure Management	CH_4	**0.77**	0.74	0.15	Tier 2
1A2	Manufacturing Industries and Construction, Oil	CO_2	**0.89**	0.61	**0.97**	Tier 2
1A4	Other Sectors, Oil	N_2O	**0.76**	0.56	**0.69**	Tier 1
1A1	Energy Industries, Waste	CO_2	0.30	0.51	**0.69**	Tier 2
2D2	Food and Drink	CO_2	0.10	0.31	**0.70**	Tier 1/2
1B2b	Natural Gas	CH_4	0.02	0.24	**0.72**	Tier 2
2B4	Carbide Production	CO_2	0.42	0.10	**1.10**	Tier 2
2A1	Cement *	CO_2				Tier 2
2B1	Ammonia Production *	CO_2				Tier 2
1B1a	Coal Mining and Handling **	CH_4				Tier 2
	Capture and storage **	CO_2				CS (Tier 2)

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

** Defined as key category from qualitative criteria

*** Tier 2 used for the significant animal groups

Table A1-4. Summary of identified LULUCF key categories Tier 2.

IPCC Category		**Gas**	**Level assessment**		**Trend assessment** 1990-2004	**Method (Tier)** 2004
			1990	2004		
5A1	Forest land remaining forest land, living biomass, other	CO_2	11.53	19.27	32.48	Tier 3
5C1	Grassland remaining grassland, soils, histosols	CO_2	13.51	11.66	6.26	Tier 2*
5A1	Forest land remaining forest land, soils	CO_2	6.34	5.09	1.81	Tier 3
5A1	Forest land remaining forest land, dead biomass, other	CO_2	2.52	2.28	1.46	Tier 3
5A1	Forest land remaining forest land, soils, drained organic soils	CO_2	2.38	2.17	1.44	Tier 1
5B1	Cropland remaining cropland, histosols, soils	CO_2	1.50	1.30	0.70	Tier 2
5E2	Forest converted to Settlements, Living biomass	CO_2	0.68	0.47	0.05	Tier 3

Table A1-5. Summary of identified key categories Tier 1. Excluding LULUCF.

	Source category	Gas	Level assessment tier 1 1990	Level assessment tier 1 2004	Cumulative assessment 2004	Key cat. tier 1 any year	Key cat. tier 1 1990	Key cat. tier 1 2004
1A1	Energy Industries, Gas	CO_2	12.28	21.22	21.22	1	1	1
1A3b	Road Transportation	CO_2	15.77	18.21	39.43	1	1	1
1A4	Other Sectors, Oil	CO_2	8.20	6.32	45.75	1	1	1
2C2	Ferroalloys Production	CO_2	5.12	4.94	50.69	1	1	1
1A3d	Navigation	CO_2	3.87	4.37	55.05	1	1	1
2C3	Aluminium Production	CO_2	2.85	3.79	58.85	1	1	1
1A2	Manufacturing Industries and Construction, Gas	CO_2	2.24	3.56	62.41	1	1	1
4A	Enteric Fermentation	CH_4	3.91	3.45	65.86	1	1	1
2B2	Nitric Acid Production	N_2O	4.14	3.36	69.22	1	1	1
1A2	Manufacturing Industries and Construction, Oil	CO_2	4.14	2.80	72.02	1	1	1
6A	Solid Waste Disposal on Land	CH_4	3.67	2.65	74.67	1	1	1
4D1	Direct soil emissions	N_2O	2.80	2.44	77.12	1	1	1
1B2a	Oil (incl. oil refineries, gasoline dist	CO_2	2.25	2.40	79.52	1	1	1
1B2c	Venting and Flaring	CO_2	3.01	2.38	81.90	1	1	1
1A3a	Civil Aviation	CO_2	1.36	1.72	83.62	1	1	1
2C3	Aluminium Production	PFCs	6.77	1.60	85.22	1	1	1
2A1	Cement Production	CO_2	1.30	1.32	86.54	1	1	1
1A3e	Other (snow scooters, boats, motorized e	CO_2	1.09	1.26	87.80	1	1	1
2B1	Ammonia Production	CO_2	1.00	0.90	88.70	1	1	1
1A1	Energy Industries, Oil	CO_2	0.47	0.81	89.51	1	1	1
4D3	Indirect emissions	N_2O	0.84	0.75	90.26	1	1	1
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs	0.00	0.73	90.99	1	.	1
1A2	Manufacturing Industries and Construction, Coal/coke	CO_2	0.93	0.70	91.69	1	1	1
1B2a	Oil (incl. oil refineries, gasoline dist	CH_4	0.33	0.64	92.32	1	.	1
2C1	Iron and Steel Production	CO_2	0.40	0.62	92.95	1	.	1
1B2c	Venting and Flaring	CH_4	0.31	0.61	93.56	1	.	1
4B	Manure Management	CH_4	0.60	0.56	94.12	1	1	1
1A5b	Military - Mobile	CO_2	0.79	0.52	94.64	1	1	1
2D2	Food and Drink	CO_2	0.13	0.42	95.06	1	.	1
4D2	Animal production	N_2O	0.45	0.41	95.47	1	1	.
2C4	SF6 Used in Aluminium and Magnesium Foundries	SF_6	4.31	0.37	95.84	1	1	.
		CO_2	0.41	0.23	97.22	1	1	.
		CO_2	0.80	0.18	97.83	1	1	.

Annex II: Uncertainties in the Norwegian Greenhouse Gas Emission Inventory

B. Hoem, K. Flugsrud and L-C. Zhang

Summary
The national greenhouse gas (GHG) emission inventory is compiled from estimates based on emission factors and activity data and direct measurements by plants. All these data and parameters will contribute to the overall inventory uncertainty. The uncertainties and probability distributions of the inventory input parameters have been assessed based on available data and expert judgements. Finally, the level and trend uncertainties of the national GHG emission inventory have been estimated using Monte Carlo simulation. The methods used in the analysis correspond to an IPCC Tier 2 method, as described in (IPCC 2001). Analyses have been made both excluding and including the sector LULUCF (land use, land-use change and forestry).
This project has been an update of the uncertainty analysis *Uncertainties in the Norwegian Greenhouse Gas Emission Inventory*, documented in (Rypdal and Zhang 2000), which also include more detailed documentation of the analysis method used, and result discussions. In this note we mainly focus on the changes since (Rypdal and Zhang 2000). This includes new methodology for several source categories as well as revised uncertainty estimates.
During the project we have been in contact with the manufacturing industries, which contribute the main emission sources in the industry sector, and other experts, and have collected information about uncertainty from them.
The results show that the uncertainty in the calculated greenhouse gas emissions for 2004 is ±6 per cent. The uncertainty estimate is lower now than earlier analyses have shown. This is partly due to a considerable work made to improve the calculation methodology. It is also partly the uncertainty estimates themselves that have been improved.

1.1. Level of the analysis

The uncertainty analysis is performed at the most detailed level of IPCC source categories (IPCC 2000). For some sources even a more detailed separation is made, e.g. where different pollutants from a source sector have to be connected to different activity measures, as for example for the source category 6B Waste water, or to be able to consider dependencies between only parts of the source groups, which for example is the case for the source categories 4D1 Direct soil emissions and 4D3 Indirect soil emissions. Energy carriers have been grouped into five main types; oil, gas, coal, waste and bio energy. In Appendix A, Table 7, source category level used in the study is listed.
For some emission sources a separation into activity and emission factors is not possible due to lack of information. Examples are estimates based on measurements, emissions reported by plants (in the cases when the plants have only reported emissions and not activity data and emission factor used), and emissions that are aggregated from sources with diverse methods (for example emissions from road traffic, which is calculated separately in a complex road traffic model). These emissions have been assigned activity equal to 1, and emission factor to be equal to the estimated value. This is possible since the total uncertainty estimate is

independent of scale for activity and emission factor.[2] Emissions from landfills, HFCs and some other sources have been transferred into the form of emission factor multiplied with activity rate, in spite of the fact that the estimates are based on more complex estimation models (e.g. taking time lag into account and using several activity data and emission factors).

1.2. Uncertainties in input parameters

1.2.1. Emission estimates

In the analysis emission estimates for the different source categories (Appendix A, Table 7) for the years 1990 and 2004 are given from the Norwegian emission inventory. Data published 09.02.2006 is used for all categories, with an exception for LULUCF, where data from the UNFCCC reporting 2005 is used (NIJOS 2005). Because of lack of LULUCF data for 2004 we had to use emission data for 2003 instead.
The emission estimates used in the analysis comes from the national GHG emission inventory and is based on Norwegian measurements, literature data or statistical surveys. Uncertainty estimates for some data are based on expert judgements. The uncertainty estimates for many LULUCF categories are not of the same quality as the rest of the inventory. More information about the uncertainty estimates for LULUCF is given in (NIJOS 2005).

1.2.2. Standard deviation and probability density

The probability densities used in this study have been divided into four types of model shapes:
1. Normal distribution
2. Truncated normal distribution
3. Lognormal distribution
4. Beta distribution

For low uncertainties all the distributions 2-4 above approach the normal distributions. For large uncertainties the normal distribution may lead to negative values. To avoid this, the distributions are when necessary truncated at 0, which means that there is a given probability of the value 0. The lognormal distribution and beta distribution are both asymmetrical distributions, giving a heavier tail of probabilities towards higher values. These two distributions are very similar in shape for low to medium size uncertainties. For higher uncertainties the beta distribution is more flat and the peak in the distribution is more close to the mean value. The beta distribution is, however, only defined for variables taking values between 0 and 1.

[2] We may state the activity in any given unit, as long as the emission factor is stated in the corresponding unit. Examples: tonnes and kg/tonne, Gg and kg/Gg, or, as in this case, unit value and total emissions in kg.

1.2.3. Activity data

The assessed standard deviations and corresponding probability densities are summarised in Table 1.

Table 1. Summary of standard deviation and probability density of activity data.

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
1A1, 1A2	Coal/coke - general	5	Normal	Expert judgement industry, Norcem (2006)
1A4B	Coal/coke - residential	20	Normal	Expert judgement, Rypdal and Zhang (2000)
1A4C	Coal/coke - agriculture	30	Normal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Wood	30	Lognormal	Expert judgement, Rypdal and Zhang (2000)
1A1A, 1A1B, 1A2	Gas - general	4	Normal	Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A1C	Gas - manufacture of solid fuels and other energy industries	1.8	Normal	Norwegian Petroleum Directorate, NPD (2006)
1A4A	Gas - commercial/institutional	10	Normal	Expert judgement, Statistics Norway
1A4B, 1A4C	Gas - residential, agriculture/forestry/fishing	30	Normal	Expert judgement, Statistics Norway
1A1, 1A2	Oil - general	3	Normal	Spread in data, Rypdal and Zhang (2000)
1A4A	Oil - commercial/institutional	20	Normal	Expert judgement, Statistics Norway
1A4B, 1A4C	Oil - residential, agriculture/forestry	10	Normal	Expert judgement, Statistics Norway
1A1A	Waste – general	5	Normal	Expert judgement, Rypdal and Zhang (2000)
1A2F, 1A4A	Waste - other manufacturing, commercial/institutional	30	Lognormal	Expert judgement, Rypdal and Zhang (2000)
1A3A, 1A3E	Transport fuel - civil aviation, motorized equipment and pipeline	20	Normal	Expert judgement, Rypdal and Zhang (2000)
1A3C	Transport fuel - railway	5	Normal	Expert judgement, Statistics Norway
1A3B, 1A3D	Transport fuel - road, navigation	10	Normal	Expert judgement, Statistics Norway
1A5A, 1A5B	Military fuel - stationary and mobile	5	Normal	Expert judgement, Statistics Norway
1B1A, 1B2B	Coal mining, extraction of natural gas	3	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2A	Extraction of oil - transport, refining/storage	3	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2A	Extraction of oil - distribution gasoline	5	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2C	Venting	-	-	See emission factor
1B2C	Flaring	4	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2C	Well testing	30	Normal	Expeert judgement, Rypdal and Zhang (2000)
2A1	Cement production	0.3	Normal	Expert judgement industry, Norcem (2006)
2A2, 2A3	Lime production, limestone and dolomite use	3	Normal	Expert judgement, Statistics Norway
2B1	Ammonia production	3	Normal	Expert judgement industry, Yara (2006)
2B2	Nitric acid production	-	-	See emission factor
2B4	Carbide production - SiC	3	Normal	Expert judgement industry, St. Gobain and Orkla Exolon (2006)
2B4	Carbide production - CaC	3	Normal	Expert judgement, Rypdal and Zhang (2000)
2B5	Methanol and plastic production	10	Normal	Expert judgement, Statistics Norway
2C1	Iron and steel production	1.23	Normal	Expert judgement industry, Tinfos (2006)
2C2	Ferroalloys production	-	-	See emission factor
2C3	Aluminium production	3	Normal	Expert judgement industry, Norsk Hydro (2006a)
2C4	SF_6 used in Al and Mg foundries	-	-	See emission factor
2C5	Mg production	0.25	Normal	Expert judgement industry, Norsk Hydro (2006b)
2C5	Ni production, anodes	10	Normal	Expert judgement, Statistics Norway
2D2	Carbonic acid, bio protein	10	Normal	Expert judgement, Statistics Norway
2F	Consumption of halocarbons and SF_6	-	-	See emission factor

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
3A, 3B, 3C, 3D	Solvent and other product use - CO_2	-	-	See emission factor
3D	Use of N_2O in anasthesia and as propellant – N_2O	-	-	See emission factor
4A	Enteric fermentation	5	Normal	Expert judgement, Statistics Norway (2006a), Division for agricultural statistics
4B1-9, 4B13	Manure management - CH_4	5	Normal	Expert judgement, Statistics Norway (2006a), Division for agricultural statistics
4B11-12	Manure management - N_2O	24	Normal	Expert judgement[2], Statistics Norway (2006a), Statistics Norway (2006b), and Statistics Norway (2006c)
4D1	Direct soil emission - fertilizer	5	Normal	SFT (1999a)
4D1	Direct soil emission - manure	20	Normal	Rypdal and Zhang (2000)
4D1	Direct soil emission - organic soil	Fac3	Lognormal	SFT (1999a)
4D1	Direct soil emission - other	64	Lognormal	Expert judgement[3], Statistics Norway and Rypdal and Zhang (2000)
4D2	Animal production	22	Normal	Expert judgement[4], Statistics Norway
4D3	Indirect soil emission - deposition	30	Lognormal	SFT (1999a)
4D3	Indirect soil emission - leakage	70	Lognormal	SFT (1999a)
4F1	Agricultural residue burning	10	Normal	Expert judgement, Statistics Norway
5A	Forest remaining forest	-	-	See emission factor
5B	Cropland remaining cropland, Forest converted to cropland	-	-	See emission factor
5C	Grassland remaining grassland, Cropland converted to grassland	-	-	See emission factor
5D1	Wetland remaining wetland, peat extraction, soil	-	-	See emission factor
5E1	Forest converted to settlements, living biomass	-	-	See emission factor
5P1	Forest fertilizer	-	-	See emission factor
5Q1, 5Q2	Forest drainage, Wetland drainage	-	-	See emission factor
5S1	Cropland disturbance	-	-	See emission factor
5T1, 5T2	Cropland liming, Other liming (lakes and rivers)	5	Normal	Expert judgement, Statistics Norway
5U1	Forest fires	20	Normal	Expert judgement, Statistics Norway
6A	Solid waste disposal	20	Normal	Statistics Norway (2006d) and SFT (2006a)
6B	Waste water treatment - CH_4	1	Normal	Expert judgement, Statistics Norway
6B	Waste water treatment - N_2O	25	Normal	Expert judgement, Statistics Norway (2006e)
6C	Waste incineration	30	Normal	Expert judgement, Statistics Norway

[1] Strongly skewed distributions are characterised as *fac3* etc, indicating that 2σ is a factor 3 below and above the mean.
[2] Population 5% (Statistics Norway 2006a), Nex 15% (Statistics Norway 2006b), distribution AWMS 10% (Statistics Norway 2006c), distribution pasture/ storage 15% (Statistics Norway 2006b)
[3] N fixation 40% and crop residues 50% (Rypdal and Zhang 2000)
[4] Population 5% (Statistics Norway 2006a), Nex 15% (Statistics Norway 2006b, distribution pasture/ storage 15% (Statistics Norway 2006b)

1.2.4. Emission factors

The assigned values and probability densities are shown in.

Table 2. Summary of standard deviation and probability density of emission factors.

IPCC Source category	Pollutant source	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment
		CO2			CH4			N2O			HFK, PFK or SF6 (specified in source/comment column)		
1A1, 1A2B, 1A2D, 1A2E, 1A2F, 1A4	Coal/coke - general	7	Normal	Spread in data, Rypdal and Zhang (2000)	Fac2	Lognormal	Spread in data, Rypdal and Zhang (2000)	Fac3	Beta	Expert judgement, Statistics Norway			
1A2A	Coal/coke – iron and steel	7	Normal	Spread in data, Rypdal and Zhang (2000)									
1A1, 1A2, 1A4	Wood				Fac2	Lognormal	Spread in data, Rypdal and Zhang (2000)	Fac3	Beta	Expert judgement, Statistics Norway			
1A1, 1A2, 1A4	Gas - general	7	Normal	Norwegian Petroleum Directorate, Rypdal and Zhang (2000)	Fac2	Lognormal	Expert judgement, Statistics Norway	Fac3	Beta	Expert judgement, Statistics Norway			
1A1, 1A2, 1A4	Oil - general	3	Normal	Spread in data, Rypdal and Zhang (2000)	Fac2	Truncated N	Spread in data, Rypdal and Zhang (2000)	Fac3	Beta	Spread in data. Expert judgement. IPCC (1997), Rypdal and Zhang (2000)			
1A1, 1A2, 1A4	Waste - general	30	Normal	Spread in data, Rypdal and Zhang (2000)	Fac2	Lognormal	Spread in data, Rypdal and Zhang (2000)	Fac3	Beta	Expert judgement, Statistics Norway			

IPCC Source category	Pollutant source	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment
1A3	Transport fuel	3	Normal	Spread in data, Rypdal and Zhang (2000)	Fac2	Lognormal	Spread in data. Expert judgement, Rypdal and Zhang (2000)	Fac3	Beta	Spread in data. Expert judgement, Rypdal and Zhang (2000)			
1A5	Military fuel - stationary and mobile	5	Normal	Expert judgement, Statistics Norway	Fac2	Lognormal	Expert judgement, Statistics Norway	Fac3	Beta	Expert judgement, Statistics Norway			
1B1A, 1B2B	Coal mining, extraction of natural gas	Fac2	Lognor mal	Expert judgement, Statistics Norway	Fac2	Lognormal	Expert judgement, Rypdal and Zhang (2000)						
1B2A	Extraction of oil - transport, refining/storage	40	Lognor mal	Expert judgement, Statistics Norway	40	Lognormal	Expert judgement, Statistics Norway						
1B2A	Extraction of oil - distribution gasoline	40	Lognor mal	Expert judgement, Statistics Norway									
1B2C	Venting	Fac2	Lognor mal	Expert judgement, Rypdal and Zhang (2000)	Fac2	Lognormal	Expert judgement, Rypdal and Zhang (2000)						
1B2C	Flaring	10	Normal	As combustion of gas, Rypdal and Zhang (2000)	Fac2	Truncated N	As combustion of gas, Rypdal and Zhang (2000)	Fac3	Beta	As combustion of gas, Rypdal and Zhang (2000)			
1B2C	Well testing	7	Normal	Expert judgement, Rypdal and Zhang (2000)	Fac2	Truncated N	Expert judgement, Rypdal and Zhang (2000)	Fac3	Beta	Expert judgement, Rypdal and Zhang (2000)			
2A1	Cement production	7	Normal	IPCC (1997)									
2A2, 2A3	Lime production, limestone and dolomite use	7	Normal	Expert judgement, Statistics Norway									
2B1	Ammonia production	7	Normal	Expert judgement industry, Yara (2006)									

IPCC Source category	Pollutant source	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment
2B2	Nitric acid production							7	Normal	Expert judgement industry, Yara (2006)			
2B4	Carbide production - SiC	10	Normal	Expert judgement industry, St. Gobain and Orkla Exolon (2006)	10	Normal	SFT (2006b)						
2B4	Carbide production - CaC	10	Normal	Spread in data, Rypdal and Zhang (2000)									
2B5	Methanol and plastic production	10	Normal	Expert judgement, Statistics Norway	Fac2	Lognormal	Expert judgement, Statistics Norway						
2C1	Iron and steel production	1.4	Normal	Expert judgement industry, Tinfos (2006)									
2C2	Ferroalloys production	3	Normal	Expert judgement, Sintef (2006)	Fac2	Lognormal	Expert judgement, Statistics Norway						
2C3	Aluminium production	10	Normal	International Aluminium Institute (IAI), Norsk Hydro (2006[a])							20	Normal	Apply to PFK. Expert judgement industry, Norsk Hydro (2006a)
2C4	SF6 used in Al and Mg foundries										0.25	Normal	Apply to SF_6. Expert judgement industry, Norsk Hydro (2006b)
2C5	Mg production, Ni production, anodes	10	Normal	Expert judgement, Statistics Norway									

IPCC Source category	Pollutant source	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment
2D2	Carbonic acid, bio protein	10	Normal	Expert judgement, Statistics Norway									
2F	Consumption of HFK										50	Lognormal	Apply to HFK. Expert judgement, Statistics Norway
2F	Consumption of PFK										50	Lognormal	Apply to PFK. Expert judgement, Statistics Norway
2F	Consumption of SF_6										60	Lognormal	Apply to SF6. Expert judgement, Statistics Norway
3A, 3B,3C, 3D	Solvent and other product use - CO_2	30	Normal	Rypdal and Zhang (2001)									
3D	Use of N_2O in anasthesia and as propellant – N_2O							10	Normal	Expert judgement, Statistics Norway			
4A1, 4A3	Enteric fermentation - cattle and sheep				25	Normal	Expert judgement, UMB (2006)						
4A4-10	Enteric fermentation - other animal				25	Normal	IPCC (1997)						
4B1-9, 4B13	Manure management - CH_4				25	Normal	IPCC (1997)						
4B11-12	Manure management - N_2O							Fac2	Lognormal	IPCC (1997)			
4D1	Direct soil emission							Fac5	Lognormal	IPCC (2001)			
4D2	Animal production							Fac2	Lognormal	IPCC (2001)			
4D3	Indirect soil emission							Fac3	Lognormal	IPCC (1997)			
4F1	Agricultural residue burning				Fac2	Lognormal	Expert judgement, Statistics Norway	Fac3	Beta	Expert judgement, Statistics Norway			
5A1	Forest remaining forest, living biomass	15	Normal	NIJOS (2005)									
5A2	Forest remaining forest, soil, drained organic soils	Fac10	Lognormal	NIJOS (2005)									

IPCC Source category	Pollutant source	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment
5A3	Forest remaining forest, dead biomass	50	Lognormal	NIJOS (2005)									
5A4	Forest remaining forest, soil, other	25	Normal	NIJOS (2005)									
5B1, 5B2, 5B3	Cropland remaining cropland, horticulture, living biomass, increase. Cropland remaining cropland, horticulture, living biomass, decrease. Forest converted to cropland, living biomass	25	Normal	NIJOS (2005)									
5B4	Cropland remaining cropland, reduced tillage, soil	Fac2	Lognormal	NIJOS (2005)									
5B5	Cropland remaining cropland, histosols, soil	Fac3	Lognormal	NIJOS (2005)									
5C1	Grassland remaining grassland, histosols, soil	Fac3	Lognormal	NIJOS (2005)									
5C2	Cropland converted to grassland, soil	Fac2	Lognormal	NIJOS (2005)									
5C3	Cropland converted to grassland, horticulture, living biomass, decrease	25	Normal	NIJOS (2005)									
5D1	Wetland remaining wetland, peat extraction, soil	Fac3	Lognormal	NIJOS (2005)									
5E1	Forest converted to settlements, living biomass	50	Lognormal	NIJOS (2005)									
5P1	Forest fertilizer							Fac5	Lognormal	NIJOS (2005)			
5Q1, 5Q2	Forest drainage, Wetland drainage							Fac10	Lognormal	NIJOS (2005)			
5S1	Cropland disturbance							Fac10	Lognormal	NIJOS (2005)			

IPCC Source category	Pollutant source	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment	(2σ). per cent[1]	Density shape	Source/ comment
5T1, 5T2	Cropland liming, Other liming (lakes and rivers)	10	Normal	NIJOS (2005)									
5U1	Forest fires				75	Lognormal	NIJOS (2005)	75	Lognormal	NIJOS (2005)			
6A	Solid waste disposal				30	Lognormal	SFT (2006a)						
6B	Waste water treatment - CH_4				70	Lognormal	IPCC (2001) and expert judgement, Statistics Norway[2]						
6B	Waste water treatment - N_2O							70	Lognormal	Expert judgement, Rypdal and Zhang (2000)			
6C	Waste incineration	30	Normal	Expert judgement, Statistics Norway	Fac2	Lognormal	Expert judgement, Statistics Norway	Fac3	Lognormal	Expert judgement, Statistics Norway			

[1] Strongly skewed distributions are characterised as *fac2, fac3, fac5 and fac10*, indicating that 2σ is respectively a factor 2, 3, 5 and 10 below and above the mean.
[2] BOD/ person 30%, Bo 30% (IPCC 2001) and fraction anaerobic treated 55%

1.3. Dependencies between parameters

Some of the input parameters (emission factors and activity data) are for various reasons not independent, that means that their values are dependent (or correlated). The problem of dependencies may be solved by appropriate aggregation of the data or explicitly by modelling. In this work we have partly designed the dataset to reduce the problem with dependencies as well as introduced a number of dependence assumptions into the model.
The determination of dependencies is sometimes a difficult task and requires some understanding of the data set and the assumptions it is based on. Initial estimates with variable assumptions have shown that the assumptions on dependencies generally have little effect on the final conclusions on uncertainties. The assumptions of dependencies of data between years are, however, crucial for the determination of trend uncertainty (Rypdal and Zhang 2000).

1.3.1. Dependencies between activity data

The activity data are in principle independent. However, the same activity data may be used to estimate more than one source category (e.g. in the agriculture sector). Also the same activity data are used for estimating emissions of more than one pollutant (especially in the case of energy emissions). For the energy sector we are aware of the dependencies between the activity data used, but we have not found a way to handle this in the statistical modelling.
The cases when activity data are assumed dependent in the statistical modelling are:

- Where the same activity data are used to estimate emissions of more than one pollutant.
- The number of domestic animals. The same population data are used for estimation of a) methane from enteric fermentation, b) methane and nitrous oxide from manure management and c) nitrous oxide from agricultural soils
- For estimation of N_2O from manure management, N_2O from manure spreading and N_2O from animal production (pasture) the following dependency estimation has been used for the activity data:
    - 70 % of emissions dependent on cattle population
    - 30 % of emissions dependent on cattle population
- For estimation of N_2O from indirect soil emissions the following dependency estimation has been used for the activity data:
    - 23 % of emissions dependent on cattle population
    - 10 % of emissions dependent on cattle population
    - 67 % of emissions dependent on amount of synthetic fertilizer used

1.3.2. Dependencies between emission factors

Where emission factors have been assumed equal, we have treated them as dependent in the analysis.
The following assumptions have been made:

- The CO_2 emission factors for each fuel type are dependent
- The methane and nitrous oxide emission factors from combustion are dependent where they have been assumed equal in the emission inventory model
- In a few cases the emission factors of different pollutants are correlated. That is in cases when CO_2 is oxidised from methane (oil extraction, loading and coal mining).
- For all direct emissions of N_2O from agricultural soils, except for N_2O from cultivation of organic soil, the same emission factor is being used, and the sources are dependent.
- There is a dependency between the emission factor used for calculating emissions from cropland liming and other liming.

We know that it also exists dependencies between other sources in LULUCF, e.g. between the activity data in the sources *5A2 Forest remaining forest* and *5Q1 Forest drainage*. But we have no estimates for the

uncertainty in activity data, and anyhow the uncertainty in the emission factors is so big that even if the activity data is given an uncertainty it will have a minimal effect on the total uncertainty estimate for the source.

1.3.3. Dependencies between data in base year and end year

The estimates made for 1990 and 2004 will to a large extent be based on the same data and assumptions.

1.3.3.1. Activity data

The activity data are determined independently in the two years and are in principle not dependent. Correlation could be considered in cases where activity data can not be updated annually or where updates are based on extrapolations or interpolations of data for another year
This implies that we have assumed that errors in activity data are random, hence that systematic method errors are insignificant. It is, however, likely that there is a certain correlation between the activity data as they have been determined using the same methods.

1.3.3.2. Emission factors

Most of the emission factors are assumed unchanged from 1990 and 2004. Those that are not are all based on the same assumptions. This implies that all the emission factors are fully correlated between the two years.
This means that we have assumed that the emission factors assumed unchanged actually are unchanged from the base to end year. In reality it is expected that most emission factors are changing, but the degree of change is usually not known.

1.4. The statistical modelling

Uncertainty analysis based on probabilistic analysis implies that uncertainties in model inputs are used to propagate uncertainties in model outputs. The result of the uncertainty estimation gives us the range and likelihood of various output values (Cullen and Frey 1999).
Having generated a data set according to the specified parametric simultaneous distribution of the data described in Table 1 and Table 2, we may calculate any desired output defined as a function of the data. This gives us one simulated random realisation of this output, according to its marginal distribution derived from the underlying simultaneous distribution of the data. Independent repetition of the simulation gives an independent sample of the desired output according to its marginal distribution. The size of the sample is given by the number of repeated simulations, and has nothing to do with the size of the original data set. Based on such an independent and identically distributed sample, we may use the sample mean as an estimate of the mean of the output; we may also use the sample standard deviation as an estimate of the standard deviation of the output.

1.5. Results of the Tier 2 Uncertainty analysis

Table 3 to 6 give the results for the uncertainties in the total emissions and trends for the GHG inventory, excluding and including the LULUCF sector.

1.5.1. Uncertainties in emission level

The estimated uncertainties of the level of total emissions and in each gas are shown in Table 3 and 4.

Table 3. Uncertainties in emission level. Each gas and total GWP weighted emissions. Excluding the LULUCF sector.

1990	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	50 mill. Tonnes	1	7
CO_2	35 mill. Tonnes	0.69	3
CH_4	4.8 mill. Tonnes	0.10	15
N_2O	5.0 mill. Tonnes	0.10	57
HFC	18 tonnes	0.00	49
PFC	3.4 mill. Tonnes	0.07	21
SF_6	2.2 mill. Tonnes	0.04	2

2004	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	55 mill. Tonnes	1	6
CO_2	44 mill. Tonnes	0.80	3
CH_4	4.8 mill. Tonnes	0.09	14
N_2O	4.9 mill. Tonnes	0.09	59
HFC	401 ktonnes	0.01	51
PFC	880 ktonnes	0.02	20
SF_6	274 ktonnes	0.00	15

Table 4. Uncertainties in emission level. Each gas and total GWP weighted emissions. Including the LULUCF sector..

1990	μ (mean)	Fraction of total emissions	Uncertainty 2σ (per cent of mean)
Total	35 mill. Tonnes	1	14
CO_2	20 mill. Tonnes	0.56	20
CH_4	4.9 mill. Tonnes	0.14	16
N_2O	5.0 mill. Tonnes	0.14	59
HFC	18 tonnes	0.00	51
PFC	3.4 mill. Tonnes	0.10	20
SF_6	2.2 mill. Tonnes	0.06	2
2004	**μ (mean)**	**Fraction of total emissions**	**Uncertainty 2σ (per cent of mean)**
Total	34 mill. Tonnes	1	14
CO_2	23 mill. Tonnes	0.67	18
CH_4	4.8 mill. Tonnes	0.14	14
N_2O	4.9 mill. Tonnes	0.14	53
HFC	401 ktonnes	0.01	52
PFC	880 ktonnes	0.03	20
SF_6	274 ktonnes	0.01	15

The total national emissions of GHG in Norway in 1990 are estimated with an uncertainty of 7 per cent of the mean. The main emission component CO_2 is known with an uncertainty of 3 per cent of the mean. In 2004, the total uncertainty has decreased to 6 per cent of the mean. The highest uncertainty change between 1990 and 2004 is in the uncertainty estimates for the SF_6 emissions, which has increased from 2 to 15 per cent of the mean. However, the SF_6 emissions are strongly reduced. For N_2O and HFC there are a minor increase in the uncertainty between the years, for CH_4 and PFC a minor decrease, while the uncertainty for CO_2 remained constant.

By including the LULUCF sector the results from the analysis show a total uncertainty of 14 per cent of the mean both in 1990 and in 2004. The doubling of uncertainty is caused mainly by forest biomass and grassland histosoils.

In the uncertainty analysis carried out in the year 2000 (Rypdal and Zhang 2000), the uncertainty for the total national emissions of GHG (LULUCF sector excluded) in 1990 was estimated to be 21 per cent of the mean. In the new analysis the uncertainty estimate is reduced to one third. There are several reasons for the new lower estimate. One reason is that Statistics Norway and the Norwegian Pollution Control Authorities have increased the inventory quality by using higher tiers for some key categories and also improved methodologies for other sources. But the main reason for the reduced uncertainty is that Statistics Norway has collected new and lower uncertainty estimates for some activity data and emission factors that contributed substantially to the total uncertainty in the emission estimate. This means that the total uncertainty of the inventory have not been reduced as much as the estimates indicates, since it is partly the uncertainty estimates themselves that have been improved. The main reduction lies is in the estimate of the uncertainty for the N_2O emissions. In 2000 the uncertainty in this components estimate was estimated to 200 per cent

of the mean. In this years' analysis the uncertainty estimate is reduced to 57 per cent of the mean, see explanation to this reduction in the paragraph below. For CO_2 the uncertainty estimate is unchanged between the two analyses (3 per cent), while all the other emission components show a decrease in the uncertainty estimates in the new analysis compared to the analysis from 2000.

The main reason for the high uncertainty estimate for the N_2O emissions in the 2000 analysis was the high uncertainty estimate used for the emission factor used for estimating N_2O from agricultural soils (2 orders of magnitude). This uncertainty is in the new analysis reduced to an uncertainty of factor 5 for direct soil emission, factor 2 for animal production and factor 3 for indirect soil emission. These new uncertainty estimates are collected from the guidelines IPCC (2001) and IPCC (1997b), where also the emission factor used is collected.

As mentioned above, another reason for the reduced uncertainty is that in the years between the two analyses important inventory improvement work has been carried through. New emission sources have also been included to make the greenhouse gas inventory for Norway more complete, and the inventory is today even more in line with the IPCC Guidelines than the case was in 2000.

1.5.2. Uncertainties in emission trend

The estimated uncertainties of the trend of total emissions and each gas are shown in Table 5 and 6.

Table 5. Uncertainty of emission trend. 1990-2004. Excluding the LULUCF sector.

	per cent change $((\mu_{2004}-\mu_{1990})*100/\mu_{1990})$	Uncertainty $(2*\sigma*100/\mu_{1990})$
Total	10	4
CO_2	26	4
CH_4	-1	11
N_2O	-2	18
HFC	-	-
PFC	-74	15
SF_6	-88	0

Table 6. Uncertainty of emission trend. 1990-2004. Including the LULUCF sector.

	Per cent change $((\mu_{2004}-\mu_{1990})*100/\mu_{1990})$	Uncertainty $(2*\sigma*100/\mu_{1990})$
Total	-2.1	7
CO_2	18	11
CH_4	-1	12
N_2O	-2	20
HFC	-	-
PFC	-74	15
SF_6	-88	0

The result shows that the increase in the total GHG emissions from 1990 to 2004 is 10 ±4 per cent when the LULUCF sector is not included. Norway has by the ratification of the Kyoto Protocol obliged to limit the emissions of greenhouse gases in the period 2008-2012 to 1 per cent over the emissions in 1990 after trading with CO_2 quotas and the other Kyoto

mechanisms is taken into account. It is important to keep in mind that the emission figures reported in connection to the Kyoto Protocol has an uncertainty connected to the reported values.

In (Rypdal and Zhang 2000) the increase from 1990 to 2010 (in a given projection scenario) was 21 ±4 per cent. It is reasonable that the emission increase was higher in the 2000 analysis, since it was estimated for a longer period.

With the sector LULUCF included in the calculations there has been a decrease in the total trend uncertainty with -2 ±7 per cent.

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1.7. Appendix A

Table 7. Source category level used in the analysis.

1.7.1. IPCC Source

Category	Pollutant source	
1A1A	Public electricity and heat prod	General fuel combustion- Coal/coke
1A1A	Public electricity and heat prod	General fuel combustion- Wood
1A1A	Public electricity and heat prod	General fuel combustion- Gas
1A1A	Public electricity and heat prod	General fuel combustion- Oil
1A1A	Public electricity and heat prod	General fuel combustion- Waste
1A1B	Petroleum refining	General fuel combustion- Gas
1A1B	Petroleum refining	General fuel combustion- Oil
1A1C	Manufacture of solid fuels and other energy	General fuel combustion- Gas
1A1C	Manufacture of solid fuels and other energy	General fuel combustion- Oil
1A2A	Iron and steel	General fuel combustion- Coal/coke
1A2A	Iron and steel	General fuel combustion- Wood
1A2A	Iron and steel	General fuel combustion- Gas
1A2A	Iron and steel	General fuel combustion- Oil
1A2B	Non-ferrous metal	General fuel combustion- Coal/coke
1A2B	Non-ferrous metal	General fuel combustion- Wood
1A2B	Non-ferrous metal	General fuel combustion- Gas
1A2B	Non-ferrous metal	General fuel combustion- Oil
1A2C	Chemicals	General fuel combustion- Wood
1A2C	Chemicals	General fuel combustion- Gas
1A2C	Chemicals	General fuel combustion- Oil
1A2D	Pulp, paper, print	General fuel combustion- Coal/coke
1A2D	Pulp, paper, print	General fuel combustion- Wood
1A2D	Pulp, paper, print	General fuel combustion- Gas
1A2D	Pulp, paper, print	General fuel combustion- Oil
1A2E	Food processing, beverages, tobacco	General fuel combustion- Coal/coke
1A2E	Food processing, beverages, tobacco	General fuel combustion- Wood
1A2E	Food processing, beverages, tobacco	General fuel combustion- Gas
1A2E	Food processing, beverages, tobacco	General fuel combustion- Oil
1A2F	Other	General fuel combustion- Coal/coke
1A2F	Other	General fuel combustion- Wood
1A2F	Other	General fuel combustion- Gas
1A2F	Other	General fuel combustion- Oil
1A2F	Other	Waste combustion- other manufacturing
1A3A	Transport fuel - civil aviation	
1A3B	Transport fuel - road transportation	
1A3C	Transport fuel - railway	

1A3D	Transport fuel - navigation	
1A3E	Transport fuel - motorized equipment and pipeline	
1A4A	Commercial/institutional	General fuel combustion- Wood
1A4A	Commercial/institutional	Gas combustion- commercial/institutional
1A4A	Commercial/institutional	General fuel combustion- Oil
1A4A	Commercial/institutional	Waste combustion - commercial/institutional
1A4B	Residential	Coal/coke combustion- residential
1A4B	Residential	General fuel combustion- Wood
1A4B	Residential	Gas - residential
1A4B	Residential	General fuel combustion- Oil
1A4C	Agriculture/forestry/fishing	Coal/coke combustion- agriculture
1A4C	Agriculture/forestry/fishing	General fuel combustion- Wood
1A4C	Agriculture/forestry/fishing	Gas combustion - agriculture/forestry/fishing
1A4C	Agriculture/forestry/fishing	General fuel combustion- Oil
1A5A	Military	Military fuel - stationary
1A5B	Military	Military fuel - mobile
1B1A	Coal mining, Extraction of natural gas	
1B2A	Extraction of oil - transport	
1B2A	Extraction of oil - refining/storage	
1B2A	Extraction of oil - distribution gasoline	
1B2B	Coal mining, Extraction of natural gas	
1B2C	Venting	
1B2C	Flaring	
1B2C	Well testing	
2A1	Cement production	
2A2	Lime production	
2A3	Limestone and dolomite use	
2B1	Ammonia production	
2B2	Nitric acid production	
2B4	Silicium carbide production	
2B4	Calcium carbide production	
2B5	Methanol and plastic production	
2C1	Iron and steel production	
2C2	Ferroalloys production	
2C3	Aluminium production	
2C4	SF6 used in Al and Mg foundries	
2C5	Mg production	
2C5	Ni production, anodes	
2D2	Carbonic acid, bio protein	
2F	consumption of halocarbons and SF6	
3A	Paint application	
3B	Degreasing and dry cleaning	
3C	Chemical products, Manufacture and processing	
3D	Other	
4A1	Enteric fermentation - cattle	
4A10	Enteric fermentation - other animal	
4A3	Enteric fermentation - sheep	
4A4	Enteric fermentation - goat	
4A6	Enteric fermentation - horse	
4A8	Enteric fermentation - swine	
4A9	Enteric fermentation - poultry	
4B1	Manure management - CH4 -cattle	
4B11	Manure management - N2O - Liquid storage	
4B12	Manure management - N2O - solid storage	
4B13	Manure management - CH4 - other animal	
4B3	Manure management - CH4 - sheep	
4B4	Manure management - CH4 -goat	
4B6	Manure management - CH4- horse	
4B8	Manure management - CH4- swine	
4B9	Manure management - CH4- poultry	
4D1	Direct soil emission - Fertilizer	
4D1	Direct soil emission - Manure	
4D1	Direct soil emission- Organic soil	
4D1	Direct soil emission- Other	
4D2	Animal production	
4D3	Indirect soil emission- Deposition	
4D3	Indirect soil emission - Leaching, other	

4F1	Burning of straw
5A1	Forest remaining Forest, Living biomass
5A2	Forest remaining Forest, Soil, Drained organic soils
5A3	Forest remaining Forest, Dead biomass
5A4	Forest remaining Forest, Soil, Other
5B1	Cropland remaining Cropland, Horticulture, Living biomass, increase
5B2	Cropland remaining Cropland, Horticulture, Living biomass, decrease
5B3	Forest converted to Cropland, Living biomass
5B4	Cropland remaining Cropland, Reduced tillage, Soil
5B5	Cropland remaining Cropland, Histosols, Soil
5B6	Cropland remaining Cropland Erosion of new agriculture land Soil, net change
5C1	Grassland remaining Grassland, Histosols, Soil
5C2	Cropland converted to Grassland, Soil
5C3	Cropland converted to Grassland, Horticulture, Living biomass, decrease
5D1	Wetland remaining Wetland, Peat extraction, Soil
5E1	Forest converted to Settlements, Living biomass
5P1	Forest Fertilizer
5Q1	Forest Drainage
5Q2	Wetland Drainage
5S1	Cropland Disturbance
5T1	Cropland Liming
5T2	Other Liming (Lakes and rivers)
5U1	Forest Fires
6A	Managed waste disposal on land
6B	Waste water -CH4
6B	Waste water - N2O pipeline
6B	Waste water - N2O plant
6C	Waste incineration

Annex III: QA/QC performed for GHG emissions from industrial plants included in the national GHG inventory

Introduction

This annex presents the methodology for the performance of QA/QC on time series from 1990 to 2004 of greenhouse gas (GHG) emissions from the largest industrial plants in Norway.

The work was carried out by Section for climate and energy at the State Pollution Control Authority in the period from February to April 2006. The following sectors of industry were covered: Cement production, mineral fertilizers, carbide industry, production of ferroalloys, production of primary aluminium, anode manufacture, production of iron and steel, nickel production, pulp and paper manufacture, oil refineries, gas terminals, lime production, other mineral production, methanol production, plastics, other chemical industry and production of magnesium.

The goal of this work was to establish final time series of greenhouse gas emissions from 1990 to 2004 for these sectors. The main documentation from this work is contained in Excel spread sheets giving the resulting time series for each plant included in this revision, and in a documentation report (SFT 2006).

Method for establishing and verifying data series of emissions

The following work procedure was established to verify data series:

1. For each plant; a first time series of emission data as well as activity data were established with basis on existing sources of data (see section on data sources).

2. The first time series of emission data and activity data were presented in both a table format as well as a graphic presentation. See figures AIII.1 and AIII.2 for examples.

3. Based on the table with compiled data and the graphic presentation, it was possible to identify:
    - Lack of emission data and activity data for any year or time series.
    - Possible errors in the reported data. Possible errors were typically identified if there were discrepancies between reported activity data (consumption of raw materials, production volumes etc) and emissions, or if there were large variations in the existing time series of emissions.

4. The emission data where supplemented and/or corrected if possible by one or more of the following sources of information:
    - Supply of new data from the company
    - Supplementary data from SFT paper archives.
    - Verification of reported emission data by new calculations based on reported activity data.
    - Calculation of missing emissions (if sufficient activity data were present).

5. A final time series of greenhouse gas emissions from 1990 to 2004 were established, and presented both as a tables and a figure. The origin of the data was documented by the use of colour codes. (see chapter 3.1.2)

6. The differences between former and new time series of emissions were identified and documented.

In the tables, colour codes were used to describe the source and type of the data. See figure AIII.1 as an example of a data table with the explanations of the colour codes.

Figure AIII.1 – Examples of presentation in data tables and the use of colour codes

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO2 process (1000 ton)	218,0	232,6	252,0	256,0	243,6	273,0	271,9	242,0	265,4	272,7	272,5	218,0	129,1	209,0	229,5
CH4 (ton)	79,5	69	72	77	74	84	84	80	88	86	87	74	52	69	76
N2O (ton)	26,5	26	27	29	27	31	31	30	33	32	33	28	20	28	31
Activity data -whitebook(1000 ton)	69,68								84,33	85,1	84,55	70,05			
Activity data -Inkosys (1000 ton)		61	64	78,6	80,2	87,9	85,4	73,2	79,7	80,3	79,8	53,5	45,6	72,4	

Time Serie	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
total CO2 (1000 tons)	47	32	64	84	161	151	207	207	202	185	128	213	153	135	137
CO2 combustion (1000 tons)	38	23	55	75	152	143	199	198	193	177	119	205	145	127	127
CO2 process (1000 tons)	9	9	9	9	9	9	9	9	9	8	9	8	8	9	10
CH4 (ton)	2,0	2,2	2,5	0,9	7,4	7,0	9,8	9,9	9,6	8,7	5,8	10,1	7,1	6,0	6,2
N2O (ton)	0,40	0,42	0,43	0,63	1,33	1,33	1,83	1,83	1,80	1,60	1,10	1,90	1,4	1,1	1,2
Activity data white book (1000 tons)	12,2								60,5	55,4	37,2	64,1			
Activity data Inkosys (1000 tons)			17,3	7,4	48,1	45,1	62,6	63,0	60,7	55,4	35,6	64,1	45,7	39,4	41,3

Data from:	**Color code**
White book on GHG	
Inkosys database	
Former time serie reported to Statistics Norway	
New, calculations by SFT	
New, by intrapolation	
New, provided by company	

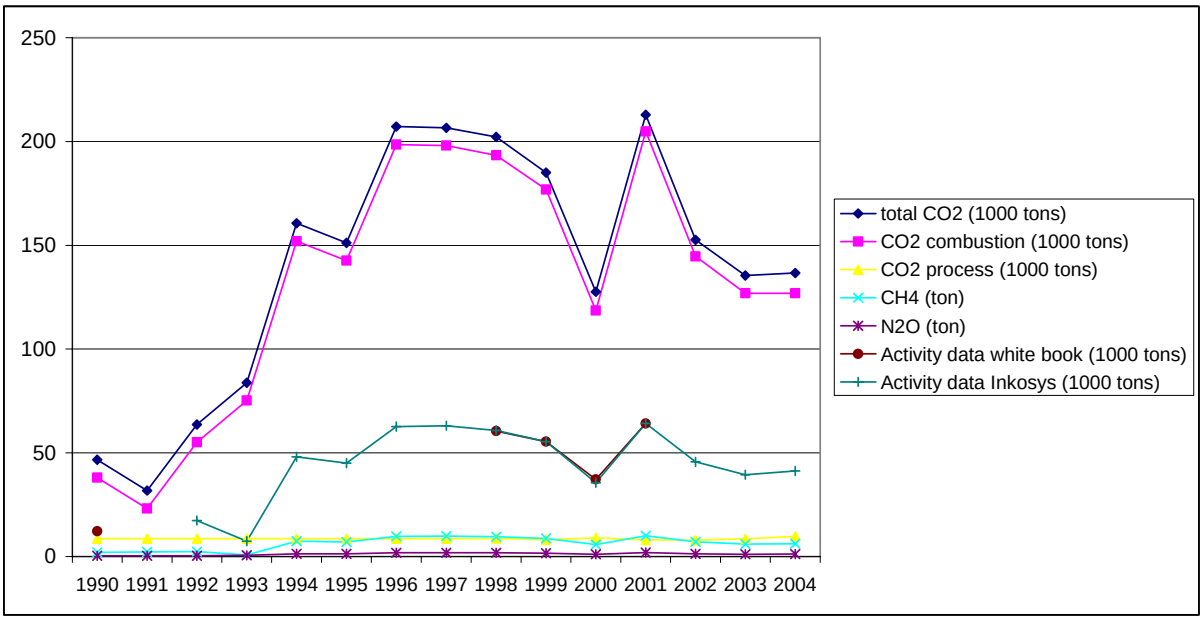
Figure AIII.1 illustrates different data tables with indication of the data sources with colour codes.

As the figure shows, there were six main sources of final data to the time series;
the white book of climate gases, the Inkosys database (described in section on data sources), new data calculated by SFT based on reported activity data, new data provided by company, and new data based on intrapolation between. Intrapolation was typically used as a method to establish data for the year 1991, if the emissions from 1990 and 1992 were given.

The emission data and the activity data were presented in graphic presentation for a visual presentation.

Figure AIII.2 illustrates a presentation of the emissions and activity data from a pulp and paper plant.

Figure AIII.2 – Example of graphic presentation



Data sources

The Inkosys Database

Data from the annual company emission reports are stored in the SFT database INKOSYS. The database contains data from 1992, and holds emission and activity data from all companies reporting emissions to SFT. The Inkosys database holds reported emissions and activity data from Norwegian companies. The companies report the data according to a manual (SFT, 2004). In SFT, the respective responsible officer in the State Pollution Control Authority undertakes a control of the data, before they are inserted in the database.

The white book on climate gases from Norwegian process industry

The white book on climate gases from Norwegian process industry was initiated by the Federation of Norwegian Process industry (PIL), Norwegian Chemical Industrial Worker's Union (NKIF) and Norwegian Oil- and Petrochemical Worker`s Union (NOPEF). The work was carried out by DNV and Sintef, who collected, compiled, controlled and verified all emissions of climate gasses from these industrial plants for the years 1990, 1998, 1999, 2000 and 2001. The method of work as well as the main results are described in the reports from this project (Federation of Norwegian Process Industry 2003). The main data files and verification tables from this work have been made available for the State Pollution Control Authority. The white book includes data from 60 process industry plants.

Since the emission data in this white book has gone through a thorough verification process, these emissions were assumed to be correct, unless any other information proved them incorrect. If several data sources reported different series of emissions, the data series from the white book were used.

The white book on climate gases from Norwegian pulp and paper industry
The white book on climate gases from Norwegian pulp and paper industry work was initiated by the Norwegian Pulp and Paper Association, and was carried out by DNV, Sintef and the Norwegian Association of Energy Users and Suppliers. They collected, compiled, controlled and verified all emissions of climate gasses from the relevant pulp and paper plants for the years 1990, 1998, 1999, 2000 and 2001. The method of work as well as the main results are described in the reports from this project (Norwegian Pulp and Paper Association 2003). The main data files from this work have been made available for the State Pollution Control Authority.

Since the emission data in this white book has gone through a thorough verification process, these emissions were assumed to be correct, unless any other information proved them incorrect. If several data sources reported different series of emissions, the data series from the white book were used.

Other sources
Other data sources also available for this work were:

- Annual update of the climate gas inventories based on annual reports from Norwegian industry. Reported to Statistics Norway.
- Yearly (paper) reports from industry of emission to air, water and soil (Egenrapportering).
- Applications for CO_2-permits for the Norwegian emissions trading scheme..

Documentation of calculations and time series

The main documentation from the work is contained in Excel spread sheets giving the resulting time series for each plant included in this revision. Each spread sheet includes emission data and activity data from the relevant data sources for each production plant. It includes the proposed time series for the relevant greenhouse gases, and states the sources for this information. Relevant information related to the QA/QC process for the specific site is noted as a comment or as a text box for each plant.

Annex IV: Energy balance Sheets 1990 - 2004

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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	5 141	9	.	37	3 412	50	1 119	514	.	.
2	Imports	258	20	28	0	69	140	-	-	1	-
3	Exports	4 368	7	4	0	2 897	373	1 028	-	58	-
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)	947	21	23	38	521	-204	92	514	-57	-
8	Energy converted	1 094	1	1	2	539	36	0	514	1	-
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	575	-	-	-	539	36	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	1	1	-	1	-	-	-	-	-	-
8.5	In district heating plants	2	-	-	1	-	0	0	-	1	-
8.6	In hydropower plants	514	-	-	-	-	-	-	514	-	-
1.2	Production of derived energy bearers	1 036	.	6	.	.	542	45	.	439	5
9	Consumption by energy sector	152	-	-	-	-	4	141	-	7	-
10	Consumption for non-energy purposes	36	.	.	.	.	36	-	-	-	-
11	Losses in transport and distribution	29	..	..	.	..	..	2	-	25	2
12	Statistical differences (7-8+1.2-9-10-11-13)	-30	-1	0	-0	-18	12	-22	-	-0	0
13	Net domestic consumption	702	21	27	36	-	251	15	-	349	3
13.1	Manufacturing, mining and quarrying	272	21	27	15	-	29	15	-	163	1
13.2	Transport	161	-	-	-	-	159	-	-	2	-
13.3	Other sectors	269	0	0	20	-	62	0	-	183	2
14	Calculated energy consumption3)	537	17	22	23	-	109	14	-	349	3
14.1	Manufacturing, mining and quarrying	251	17	22	10	-	25	14	-	163	1
14.2	Transport	42	-	-	-	-	40	-	-	2	-
14.3	Other sectors	243	0	0	13	-	44	0	-	183	2
15	Energy losses in final consumption (13-14)	165	4	5	12	-	142	1	-	-	-
15.1	Manufacturing, mining and quarrying	20	4	5	5	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	5 603	9	.	36	3 899	49	1 142	468	.	.
2	Imports	251	17	26	0	69	128	-	-	12	-
3	Exports	4 861	8	3	0	3 459	333	1 036	-	22	-
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)	991	19	23	36	518	-168	106	468	-10	-
8	Energy converted	1 019	1	2	2	510	35	0	468	1	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	545	-	-	-	510	35	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	1	1	-	1	-	-	-	-	-	-
8.5	In district heating plants	2	-	-	1	-	0	0	-	1	-
8.6	In hydropower plants	468	-	-	-	-	-	-	468	-	-
1.2	Production of derived energy bearers	980	.	5	.	.	527	42	.	400	6
9	Consumption by energy sector	150	-	-	-	-	4	138	-	8	-
10	Consumption for non-energy purposes	32	.	.	.	.	32	-	-	-	-
11	Losses in transport and distribution	28	..	..	.	..	..	2	-	24	2
12	Statistical differences (7-8+1.2-9-10-11-13)	49	0	0	-	8	48	-7	-	-0	-0
13	Net domestic consumption	693	18	26	34	-	240	15	-	356	4
13.1	Manufacturing, mining and quarrying	263	18	26	15	-	27	15	-	161	1
13.2	Transport	159	-	-	-	-	157	-	-	2	-
13.3	Other sectors	271	0	0	18	-	56	0	-	193	3
14	Calculated energy consumption3)	533	15	20	22	-	102	14	-	356	4
14.1	Manufacturing, mining and quarrying	244	14	20	10	-	23	14	-	161	1
14.2	Transport	42	-	-	-	-	39	-	-	2	-
14.3	Other sectors	247	0	0	12	-	39	0	-	193	3
15	Energy losses in final consumption (13-14)	160	4	5	12	-	138	1	-	-	-
15.1	Manufacturing, mining and quarrying	19	4	5	5	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	6 241	10	.	37	4 473	53	1 172	496	.	.
2	Imports	215	17	25	0	47	121	-	-	5	-
3	Exports	5 429	5	4	-	3 916	419	1 050	-	36	-
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)	977	18	21	37	580	-265	122	496	-31	-
8	Energy converted	1 119	1	1	5	572	43	0	496	1	-
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	615	-	-	-	572	43	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	4	-	-	2	-	0	0	-	1	-
8.6	In hydropower plants	496	-	-	-	-	-	-	496	-	-
1.2	Production of derived energy bearers	1 069	.	6	.	.	584	51	.	423	6
9	Consumption by energy sector	160	-	-	-	-	4	148	-	8	-
10	Consumption for non-energy purposes	31	.	.	.	.	31	-	-	-	-
11	Losses in transport and distribution	29	..	..	.	..	-	3	-	25	2
12	Statistical differences (7-8+1.2-9-10-11-13)	15	-1	0	-	8	0	8	-	0	-0
13	Net domestic consumption	692	18	26	32	-	240	14	-	358	4
13.1	Manufacturing, mining and quarrying	258	18	25	14	-	26	14	-	160	1
13.2	Transport	164	-	-	-	-	162	-	-	2	-
13.3	Other sectors	270	0	0	18	-	53	0	-	196	3
14	Calculated energy consumption3)	531	15	20	21	-	100	14	-	358	4
14.1	Manufacturing, mining and quarrying	240	15	20	9	-	22	13	-	160	1
14.2	Transport	44	-	-	-	-	41	-	-	2	-
14.3	Other sectors	248	0	0	12	-	37	0	-	196	3
15	Energy losses in final consumption (13-14)	161	4	5	11	-	140	1	-	-	-
15.1	Manufacturing, mining and quarrying	18	4	5	5	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	6 528	8	.	41	4 747	87	1 140	507	.	.
2	Imports	229	20	25	0	56	125	-	-	2	-
3	Exports	5 700	6	5	0	4 212	436	1 009	-	31	-
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)	1 002	23	20	41	561	-251	131	507	-28	-
8	Energy converted	1 127	1	1	5	570	43	0	507	1	-
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	-	1	-
8.6	In hydropower plants	507	-	-	-	-	-	-	507	-	-
1.2	Production of derived energy bearers	1 083	.	7	.	.	585	53	.	432	6
9	Consumption by energy sector	168	-	-	-	-	5	156	-	8	-
10	Consumption for non-energy purposes	37	.	.	.	.	37	-	-	-	-
11	Losses in transport and distribution	33	..	..	.	..	..	3	-	29	2
12	Statistical differences (7-8+1.2-9-10-11-13)	7	2	-0	1	-9	2	9	-	3	-0
13	Net domestic consumption	713	21	26	35	-	248	16	-	363	4
13.1	Manufacturing, mining and quarrying	268	21	26	15	-	26	15	-	164	1
13.2	Transport	172	-	-	-	-	170	-	-	2	-
13.3	Other sectors	272	0	0	21	-	51	0	-	197	3
14	Calculated energy consumption3)	545	17	21	23	-	102	15	-	363	4
14.1	Manufacturing, mining and quarrying	249	16	21	10	-	22	15	-	164	1
14.2	Transport	46	-	-	-	-	44	-	-	2	-
14.3	Other sectors	250	0	0	13	-	36	0	-	197	3
15	Energy losses in final consumption (13-14)	168	4	5	12	-	145	1	-	-	-
15.1	Manufacturing, mining and quarrying	19	4	5	5	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	7 229	8	.	43	5 251	194	1 255	477	.	.
2	Imports	249	22	27	0	45	138	-	-	17	-
3	Exports	6 400	5	4	0	4 709	530	1 133	-	18	-
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)	1 035	26	23	43	575	-230	122	477	-0	-
8	Energy converted	1 120	1	2	6	593	40	0	477	1	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	633	-	-	-	593	40	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	4	-	-	2	-	0	0	-	1	-
8.6	In hydropower plants	477	-	-	-	-	-	-	477	-	-
1.2	Production of derived energy bearers	1 082	.	7	.	.	611	50	.	408	6
9	Consumption by energy sector	184	-	-	-	-	6	166	-	11	-
10	Consumption for non-energy purposes	37	.	.	.	.	37	-	-	-	-
11	Losses in transport and distribution	33	..	..	.	..	..	3	-	28	2
12	Statistical differences (7-8+1.2-9-10-11-13)	12	1	-0	-	-18	40	-11	-	0	0
13	Net domestic consumption	732	24	29	38	-	257	14	-	366	4
13.1	Manufacturing, mining and quarrying	282	24	29	16	-	34	14	-	164	1
13.2	Transport	171	-	-	-	-	169	-	-	2	-
13.3	Other sectors	279	0	0	22	-	54	0	-	200	3
14	Calculated energy consumption3)	561	19	23	25	-	111	13	-	366	4
14.1	Manufacturing, mining and quarrying	260	19	23	10	-	29	13	-	164	1
14.2	Transport	46	-	-	-	-	44	-	-	2	-
14.3	Other sectors	255	0	0	14	-	38	0	-	200	3
15	Energy losses in final consumption (13-14)	171	5	6	13	-	146	1	-	-	-
15.1	Manufacturing, mining and quarrying	21	5	6	6	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	7 748	8	.	44	5 636	239	1 303	519	.	.
2	Imports	260	26	29	0	59	137	-	-	8	-
3	Exports	6 883	5	4	0	5 155	533	1 154	-	32	-
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)	1 093	29	25	44	531	-179	149	519	-24	-
8	Energy converted	1 112	1	2	6	542	41	0	519	1	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	583	-	0	-	542	41	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	4	-	-	3	-	0	0	-	1	-
8.6	In hydropower plants	519	-	-	-	-	-	-	519	-	-
1.2	Production of derived energy bearers	1 056	.	6	.	.	559	42	.	443	6
9	Consumption by energy sector	181	-	-	-	-	6	166	-	10	-
10	Consumption for non-energy purposes	38	.	.	.	.	38	-	-	-	-
11	Losses in transport and distribution	30	..	..	.	..	..	3	-	26	2
12	Statistical differences (7-8+1.2-9-10-11-13)	45	1	-1	-	-11	37	11	-	8	0
13	Net domestic consumption	742	27	30	38	-	257	12	-	374	4
13.1	Manufacturing, mining and quarrying	286	26	30	16	-	31	12	-	170	1
13.2	Transport	175	-	-	-	-	173	-	-	2	-
13.3	Other sectors	280	0	0	22	-	54	0	-	201	3
14	Calculated energy consumption3)	568	21	24	25	-	109	11	-	374	4
14.1	Manufacturing, mining and quarrying	265	21	24	11	-	26	11	-	170	1
14.2	Transport	47	-	-	-	-	45	-	-	2	-
14.3	Other sectors	256	0	0	14	-	38	0	-	201	3
15	Energy losses in final consumption (13-14)	173	5	6	13	-	148	1	-	-	-
15.1	Manufacturing, mining and quarrying	22	5	6	6	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	8 788	6	.	45	6 323	271	1 702	441	.	.
2	Imports	291	23	30	0	56	133	-	-	48	-
3	Exports	7 971	4	5	0	5 787	590	1 570	-	15	-
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)	1 040	26	23	45	565	-226	132	441	32	-
8	Energy converted	1 100	1	1	6	601	48	0	441	1	-
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	648	-	-	-	601	47	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	2	0	-	1	-
8.6	In hydropower plants	441	-	-	-	-	-	-	441	-	-
1.2	Production of derived energy bearers	1 065	.	7	.	.	626	49	.	377	6
9	Consumption by energy sector	193	-	-	-	-	6	180	-	7	-
10	Consumption for non-energy purposes	39	.	.	.	.	39	-	-	-	-
11	Losses in transport and distribution	32	..	..	.	..	..	3	-	28	1
12	Statistical differences (7-8+1.2-9-10-11-13)	-25	-1	-1	-	-36	24	-16	-	3	-0
13	Net domestic consumption	767	26	30	39	-	283	13	-	371	5
13.1	Manufacturing, mining and quarrying	282	26	30	17	-	37	13	-	158	1
13.2	Transport	183	-	-	-	-	181	0	-	2	-
13.3	Other sectors	302	0	0	23	-	65	0	-	211	4
14	Calculated energy consumption3)	583	21	24	26	-	124	12	-	371	5
14.1	Manufacturing, mining and quarrying	259	21	24	11	-	32	12	-	158	1
14.2	Transport	50	-	-	-	-	47	0	-	2	-
14.3	Other sectors	275	0	0	15	-	45	0	-	211	4
15	Energy losses in final consumption (13-14)	184	5	6	14	-	158	1	-	-	-
15.1	Manufacturing, mining and quarrying	23	5	6	6	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	9 089	11	.	48	6 329	325	1 906	470	.	.
2	Imports	299	24	27	0	66	150	-	-	31	-
3	Exports	8 232	5	3	0	5 818	662	1 725	-	18	-
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)	1 117	28	24	48	591	-238	181	470	14	-
8	Energy converted	1 135	1	2	6	597	59	0	470	1	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	655	-	-	-	597	58	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-	1	-
8.6	In hydropower plants	470	-	-	-	-	-	-	470	-	-
1.2	Production of derived energy bearers	1 092	.	7	.	.	626	51	.	401	6
9	Consumption by energy sector	201	-	-	-	-	7	184	-	11	-
10	Consumption for non-energy purposes	49	.	.	.	.	40	9	-	-	-
11	Losses in transport and distribution	34	..	..	.	..	..	4	-	29	2
12	Statistical differences (7-8+1.2-9-10-11-13)	17	1	-1	-	-6	5	17	-	0	0
13	Net domestic consumption	772	26	30	42	-	277	19	-	374	5
13.1	Manufacturing, mining and quarrying	289	26	30	18	-	33	19	-	163	1
13.2	Transport	187	-	-	-	-	185	0	-	2	-
13.3	Other sectors	296	0	0	24	-	59	0	-	209	4
14	Calculated energy consumption3)	587	21	24	27	-	119	18	-	374	5
14.1	Manufacturing, mining and quarrying	266	21	24	12	-	28	18	-	163	1
14.2	Transport	51	-	-	-	-	49	-	-	2	-
14.3	Other sectors	270	0	0	16	-	41	0	-	209	4
15	Energy losses in final consumption (13-14)	185	5	6	15	-	158	1	-	-	-
15.1	Manufacturing, mining and quarrying	23	5	6	6	-	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 per cent of the potential energy is lost in production.
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 coefficients.

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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	8 846	9	.	44	6 053	311	1 937	492	.	.
2	Imports	282	27	29	0	81	115	-	-	29	-
3	Exports	7 915	8	3	0	5 553	607	1 728	-	16	-
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)	1 201	29	26	45	605	-217	209	492	13	-
8	Energy converted	1 144	1	2	6	598	44	0	492	1	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	641	-	-	-	598	43	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-	1	-
8.6	In hydropower plants	492	-	-	-	-	-	-	492	-	-
1.2	Production of derived energy bearers	1 083	.	7	.	.	599	50	.	421	7
9	Consumption by energy sector	192	-	-	-	-	8	176	-	8	-
10	Consumption for non-energy purposes	54	.	.	.	.	37	17	-	-	-
11	Losses in transport and distribution	37	..	..	.	..	..	5	-	30	2
12	Statistical differences (7-8+1.2-9-10-11-13)	60	-1	1	-	6	11	42	-	0	-
13	Net domestic consumption	799	29	29	39	-	283	20	-	395	5
13.1	Manufacturing, mining and quarrying	304	28	29	16	-	35	19	-	175	1
13.2	Transport	192	-	-	-	-	190	0	-	2	-
13.3	Other sectors	303	0	0	23	-	59	0	-	217	4
14	Calculated energy consumption3)	611	23	23	25	-	121	19	-	395	5
14.1	Manufacturing, mining and quarrying	281	23	23	10	-	30	18	-	175	1
14.2	Transport	53	-	-	-	-	50	-	-	2	-
14.3	Other sectors	277	0	0	15	-	41	0	-	217	4
15	Energy losses in final consumption (13-14)	188	6	6	13	-	162	1	-	-	-
15.1	Manufacturing, mining and quarrying	23	6	6	5	-	5	1	-	-	-
15.2	Transport	140	-	-	-	-	140	0	-	-	-
15.3	Other sectors	25	0	0	8	-	17	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
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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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	9 006	11	.	47	6 025	317	2 090	516	.	.
2	Imports	284	26	29	0	89	115	-	-	25	-
3	Exports	7 981	8	2	0	5 436	621	1 883	-	32	-
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)	1 273	29	27	47	678	-226	207	516	-7	-
8	Energy converted	1 185	1	2	6	607	53	0	516	0	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	658	-	-	-	607	52	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	2	0	-	0	-
8.6	In hydropower plants	516	-	-	-	-	-	-	516	-	-
1.2	Production of derived energy bearers	1 135	.	7	.	.	628	51	.	442	7
9	Consumption by energy sector	192	-	-	-	-	8	176	-	9	0
10	Consumption for non-energy purposes	51	.	.	.	.	32	19	-	-	-
11	Losses in transport and distribution	37	..	..	.	..	..	5	-	30	2
12	Statistical differences (7-8+1.2-9-10-11-13)	133	1	5	-	72	16	39	-	0	-0
13	Net domestic consumption	811	27	28	41	-	293	20	-	395	6
13.1	Manufacturing, mining and quarrying	302	27	28	17	-	33	20	-	176	1
13.2	Transport	203	-	-	-	-	201	0	-	2	-
13.3	Other sectors	305	0	0	23	-	60	0	-	217	5
14	Calculated energy consumption3)	615	22	22	26	-	124	19	-	395	6
14.1	Manufacturing, mining and quarrying	280	22	22	11	-	29	19	-	176	1
14.2	Transport	56	-	-	-	-	53	-	-	2	-
14.3	Other sectors	279	0	0	15	-	42	0	-	217	5
15	Energy losses in final consumption (13-14)	196	5	6	14	-	170	1	-	-	-
15.1	Manufacturing, mining and quarrying	22	5	6	6	-	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.
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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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	9 654	18	.	46	6 505	302	2 182	603	.	.
2	Imports	235	26	29	0	43	132	-	-	5	-
3	Exports	8 439	16	1	0	5 822	566	1 960	-	74	-
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)	1 388	28	29	46	690	-161	222	603	-69	-
8	Energy converted	1 270	1	2	6	580	76	0	603	2	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	656	-	-	-	580	75	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-	2	-
8.6	In hydropower plants	603	-	-	-	-	-	-	603	-	-
1.2	Production of derived energy bearers	1 196	.	7	.	.	616	50	.	515	7
9	Consumption by energy sector	212	-	-	-	-	9	196	-	8	0
10	Consumption for non-energy purposes	53	.	.	.	.	33	19	-	-	-
11	Losses in transport and distribution	48	..	..	.	..	..	5	-	41	1
12	Statistical differences (7-8+1.2-9-10-11-13)	218	0	6	-	110	70	32	-	-0	-0
13	Net domestic consumption	784	27	28	40	-	268	21	-	395	5
13.1	Manufacturing, mining and quarrying	307	27	28	16	-	31	20	-	184	1
13.2	Transport	188	-	-	-	-	185	0	-	3	-
13.3	Other sectors	289	0	0	24	-	51	0	-	209	5
14	Calculated energy consumption3)	602	22	23	26	-	112	20	-	395	5
14.1	Manufacturing, mining and quarrying	286	22	23	10	-	27	19	-	184	1
14.2	Transport	52	-	-	-	-	49	-	-	3	-
14.3	Other sectors	265	0	0	16	-	36	0	-	209	5
15	Energy losses in final consumption (13-14)	182	5	6	14	-	156	1	-	-	-
15.1	Manufacturing, mining and quarrying	22	5	6	5	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	9 853	50	.	49	6 485	415	2 341	513	.	.
2	Imports	262	23	27	1	41	131	-	-	39	-
3	Exports	8 789	42	0	0	6 006	683	2 031	-	26	-
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)	1 358	26	28	49	581	-160	310	513	13	-
8	Energy converted	1 140	1	1	7	538	78	0	513	2	0
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	616	-	-	-	538	77	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	7	-	-	4	-	1	0	-	2	0
8.6	In hydropower plants	513	-	-	-	-	-	-	513	-	-
1.2	Production of derived energy bearers	1 079	.	7	.	.	577	47	.	439	8
9	Consumption by energy sector	218	-	-	-	-	8	201	-	9	0
10	Consumption for non-energy purposes	73	.	.	.	.	50	23	-	-	-
11	Losses in transport and distribution	44	..	..	.	..	..	4	-	38	1
12	Statistical differences (7-8+1.2-9-10-11-13)	162	1	8	-	43	3	108	-	-	0
13	Net domestic consumption	801	24	26	42	-	278	22	-	403	7
13.1	Manufacturing, mining and quarrying	297	24	26	17	-	33	21	-	175	1
13.2	Transport	192	-	-	-	-	189	0	-	3	-
13.3	Other sectors	313	0	0	25	-	56	1	-	225	6
14	Calculated energy consumption3)	615	19	21	28	-	118	20	-	403	7
14.1	Manufacturing, mining and quarrying	275	19	21	11	-	29	20	-	175	1
14.2	Transport	52	-	-	-	-	50	-	-	3	-
14.3	Other sectors	288	0	0	16	-	40	1	-	225	6
15	Energy losses in final consumption (13-14)	186	5	5	15	-	160	1	-	-	-
15.1	Manufacturing, mining and quarrying	21	5	5	6	-	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 per cent of the potential energy is lost in production.
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 coefficients.
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)	Elect-ricity	District heating
1.1	Production of primary energy bearers	10 161	60	.	51	6 223	485	2 792	550	.	.
2	Imports	223	18	27	1	27	131	-	-	19	-
3	Exports	9 120	58	2	0	5 733	697	2 576	-	54	-
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)	1 234	23	25	52	512	-108	216	550	-35	-
8	Energy converted	1 141	1	1	7	502	79	0	550	2	0
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	579	-	-	-	502	77	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	0	-
8.5	In district heating plants	7	-	-	4	-	1	0	-	2	0
8.6	In hydropower plants	550	-	-	-	-	-	-	550	-	-
1.2	Production of derived energy bearers	1 085	.	7	.	.	551	48	.	470	9
9	Consumption by energy sector	216	-	-	-	-	6	202	-	8	0
10	Consumption for non-energy purposes	68	.	.	.	.	51	17	-	-	-
11	Losses in transport and distribution	39	..	..	.	..	..	4	-	34	2
12	Statistical differences (7-8+1.2-9-10-11-13)	68	1	6	-	10	28	22	-	-0	-0
13	Net domestic consumption	788	21	25	45	-	278	20	-	392	7
13.1	Manufacturing, mining and quarrying	281	21	25	16	-	31	19	-	168	1
13.2	Transport	192	-	-	-	-	189	0	-	3	-
13.3	Other sectors	315	0	0	29	-	58	1	-	221	6
14	Calculated energy consumption3)	601	17	20	29	-	117	18	-	392	7
14.1	Manufacturing, mining and quarrying	262	17	20	11	-	27	18	-	168	1
14.2	Transport	52	-	-	-	-	49	-	-	3	-
14.3	Other sectors	287	0	0	19	-	41	1	-	221	6
15	Energy losses in final consumption (13-14)	187	4	5	16	-	161	1	-	-	-
15.1	Manufacturing, mining and quarrying	20	4	5	6	-	4	1	-	-	-
15.2	Transport	140	-	-	-	-	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 per cent of the potential energy is lost in production.
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 coefficients.
Source: Statistics Norway.

Energy balance sheet1).
2003
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)	Elect-ricity	District heating
1.1	Production of primary energy bearers	10 245	83	.	52	5 930	611	3 120	449	.	.
2	Imports	260	19	24	2	26	140	-	-	48	-
3	Exports	9 183	76	3	0	5 372	858	2 853	-	20	-
4	Bunker oil	25	-	-	-	-	25	-	-	-	-
5	Changes in stocks (+ net decrease, - net increase)	-39	-3	-1	..	-28	-7	.	.	.	.
7	Net domestic supply (1.1+2-3-4+5)	1 259	23	20	54	556	-139	267	449	28	-
8	Energy converted	1 109	1	1	9	560	88	0	449	1	0
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	645	-	-	-	560	85	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	4	1	-	4	-	-	-	-	0	-
8.5	In district heating plants	8	-	-	5	-	2	0	-	1	0
8.6	In hydropower plants	449	-	-	-	-	-	-	449	-	-
1.2	Production of derived energy bearers	1 071	.	8	.	.	616	50	.	387	10
9	Consumption by energy sector	230	-	-	-	-	6	215	-	9	0
10	Consumption for non-energy purposes	77	.	.	.	.	53	24	-	-	-
11	Losses in transport and distribution	39	..	..	.	..	..	3	-	34	2
12	Statistical differences (7-8+1.2-9-10-11-13)	97	2	3	-	-4	43	53	-	-0	-0
13	Net domestic consumption	778	21	24	45	-	287	22	-	371	8
13.1	Manufacturing, mining and quarrying	287	21	24	17	-	34	21	-	170	1
13.2	Transport	195	-	-	-	-	191	0	-	3	-
13.3	Other sectors	297	0	0	29	-	61	1	-	199	7
14	Calculated energy consumption3)	590	16	19	29	-	125	21	-	371	8
14.1	Manufacturing, mining and quarrying	267	16	19	11	-	30	20	-	170	1
14.2	Transport	55	-	-	-	-	52	-	-	3	-
14.3	Other sectors	268	0	0	19	-	43	1	-	199	7
15	Energy losses in final consumption (13-14)	188	4	5	16	-	162	1	-	-	-
15.1	Manufacturing, mining and quarrying	20	4	5	6	-	4	1	-	-	-
15.2	Transport	140	-	-	-	-	139	0	-	-	-
15.3	Other sectors	28	0	0	10	-	18	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
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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 coefficients.
Source: Statistics Norway.

Energy balance sheet1).
Preliminary data 2004
PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy2)	Elect-ricity	District heating
1.1	Production of primary energy bearers	10 394	82	.	53	5 868	585	3 343	463	.	.
2	Imports	266	22	25	1	18	145	-	-	55	-
3	Exports	9 200	77	1	0	5 261	786	3 061	-	14	-
4	Bunker oil	24	-	-	-	-	24	-	-	-	-
5	Changes in stocks (+ net decrease, - net increase)	15	-1	0	..	6	9	.	.	.	.
7	Net domestic supply (1.1+2-3-4+5)	1 451	25	25	54	631	-71	282	463	41	-
8	Energy converted	1 097	1	2	10	533	87	0	463	2	0
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	619	-	-	-	533	86	-	-	-	-
8.3	In thermal power plants	1	-	-	1	-	0	-	-	-	-
8.4	In combined heat and power plants	4	1	-	3	-	-	-	-	-	-
8.5	In district heating plants	8	-	-	5	-	1	0	-	2	0
8.6	In hydropower plants	463	-	-	-	-	-	-	463	-	-
1.2	Production of derived energy bearers	1 062	.	6	.	.	598	49	.	398	11
9	Consumption by energy sector	238	-	-	-	-	6	222	-	10	0
10	Consumption for non-energy purposes	70	.	.	.	.	43	28	-	-	-
11	Losses in transport and distribution	37	..	..	.	..	..	3	-	32	2
12	Statistical differences (7-8+1.2-9-10-11-13)	266	2	4	-	99	105	55	-	0	-
13	Net domestic consumption	806	23	25	45	-	286	24	-	395	9
13.1	Manufacturing, mining and quarrying	298	23	25	16	-	30	22	-	182	1
13.2	Transport	203	-	-	-	-	200	0	-	3	-
13.3	Other sectors	304	0	0	29	-	56	1	-	211	7
14	Calculated energy consumption3)	614	18	20	29	-	120	22	-	395	9
14.1	Manufacturing, mining and quarrying	278	18	20	10	-	26	21	-	182	1
14.2	Transport	58	-	-	-	-	55	-	-	3	-
14.3	Other sectors	278	0	0	19	-	39	1	-	211	7
15	Energy losses in final consumption (13-14)	192	5	5	16	-	165	2	-	-	-
15.1	Manufacturing, mining and quarrying	20	5	5	6	-	4	1	-	-	-
15.2	Transport	146	-	-	-	-	145	0	-	-	-
15.3	Other sectors	27	0	0	10	-	16	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
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Source: Statistics Norway.

Annex V: CO_2 capture and storage at Sleipner Vest Field – storage site characterisation, monitoring methodology and results

1. The reservoir's ability to store CO_2 over time

Key goals for geological CO_2 storage site selection and characterization are to; assess how much CO_2 can be stored at a potential storage site, demonstrate that the site is capable of meeting required storage performance criteria; and establish a baseline for the management and monitoring of the CO2 injection and storage.

Excess CO_2 from the Sleipner Vest Field is injected into the Utsira Formation for storage. The Utsira Formation aquifer, which is located above the producing reservoirs at a depth of 800 – 1000 m below sea level, was chosen for CO_2 storage because of its large extension (which guarantees sufficient volume), and its excellent porosity and permeability (which is well suited for high injectivity). Furthermore, the formation is overlain by a thick, widespread sequence of Hordaland Group shales, which should act as an effective barrier to vertical CO_2 leakage, see figure below:

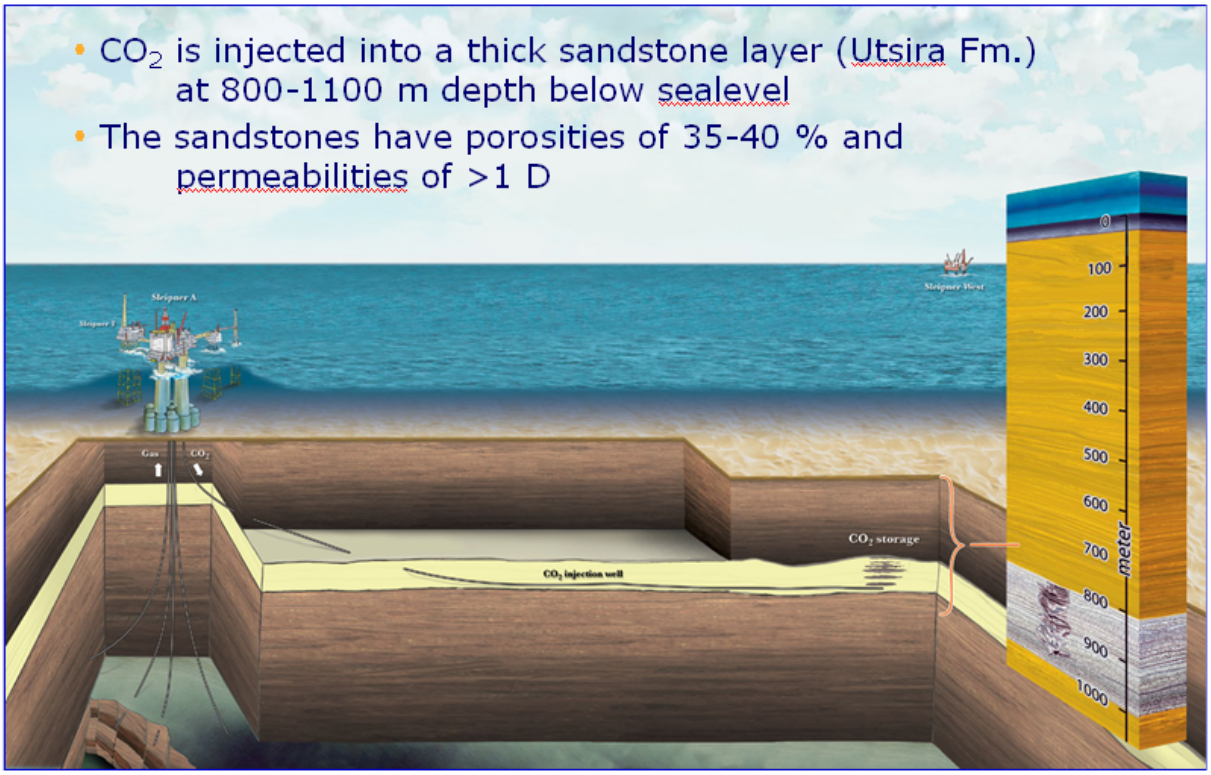

Figure 1 CO_2 capture and storage at Sleipner Vest

The Utsira formation has the following properties:

- Dome type of structure
- Large extension
- Thickness: 150 – 200 m

- Temp. = 37 degC, P = 104 bar (hydrostatic)
- Unconsolidated fine-grained sand
- High permeability (~ 2 D) and high porosity (35-40%)
- Homogeneous
- Water filled

It also contains several thin intercalated shale layers (1-1.5m), as well as a 5 m thick shaly interval about 20 m below the top.

In the Sleipner case it has been very important to locate the injection well and the storage site such that the injected CO_2 could not migrate back to the Sleipner A platform (SLA) and the production wells. This will both prevent corrosion problems in the production wells and minimise the risk of CO_2 leakage through production wells. The injection point is located 2.5 km east of the Sleipner A platform. Following is a figure illustrating the distance between the injection point and the Sleipner installation. Migration evaluations have been based on the Top Utsira map (figure below) with the CO_2 expected to migrate vertically to the sealing shales and horizontally along the saddle point of the structure. This will take the CO_2 away from other wells drilled from the Sleipner platform.

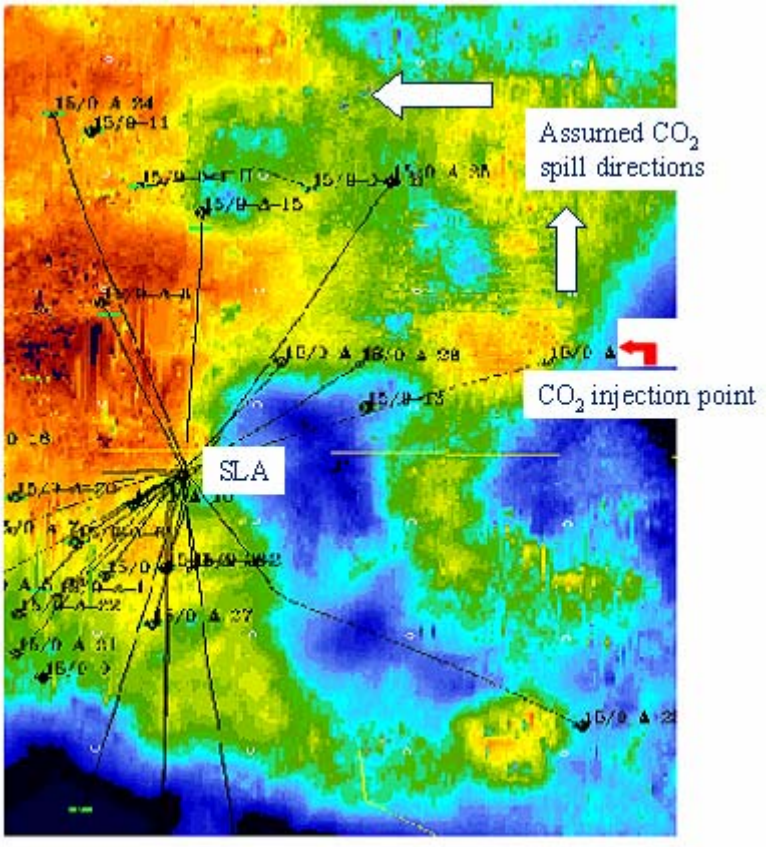

Figure 2 Position of CO_2 injection point and expected migration direction of CO_2

2. Applied methods for monitoring the injected CO_2:

a) 4D seismic monitoring:

- Baseline seismic survey was shot prior to injection in 1994.
- Repeat time lapse seismic monitoring have been acquired in 1999, 2001, 2002 and 2004

b) Gravimetric monitoring:

- Pre-installed 30 concrete benchmarks in 2002 across the CO_2 bubble
- Repeat survey 2005.

c) Pressure measurements:

The need for reservoir measurements of pressure and temperature in the injection well is being continuously evaluated. Up until now, these measurements have not been deemed critical, but plans are in place to have these measurements taken later in 2006.

d) Well monitoring, safety precautions (leakage):

The wells in the Sleipner area are plotted on a chart to indicate the positioning relative to the CO_2 injection well. The relative distances are given at the top of the Utsira formation. . The labels numbered "900" indicate where the wells are penetrating the 900 meter depth level (top of Utsira formation).

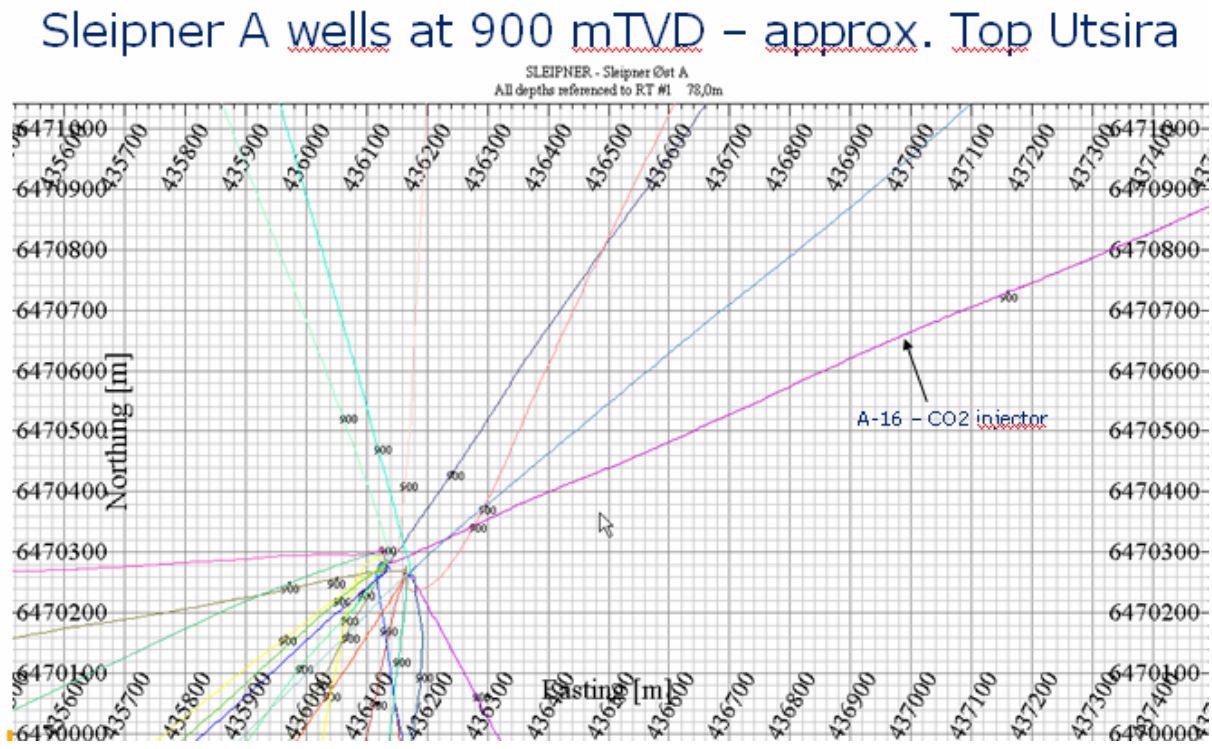

Figure 3 Positions of Sleipner production wells relative to the CO_2 injection well.

The figure shows that the distance from the CO_2 injection well to the closest neighbouring well is 1000 metres at top of the Utsira formation. Note that the extension of the CO_2 plume is found to be extending NE-SW from the injection point, based on seismic data, and that no production wells (other than the injector) are exposed to the CO_2 plume. This is in accordance with the simulations carried out for the injection on Sleipner.

The main well design at Utsira level:

- 18 5/8" casing set above Utsira Formation
- 13 3/8" casing through Utsira Formation
  - 13 Cr casing from 10 m MD below to 50 m MD above Utsira Formation
  - cemented into 18 5/8" casing

The material quality chosen for the casing through Utsira formation, increases the wells' resistance against CO_2 corrosion.

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.

3. Results of the monitoring programme:

a) 4D seismic monitoring:

The stored CO_2 has been monitored using time lapse seismic to confirm its behaviour and evaluate

- whether any of it has migrated towards the Sleipner installations, potentially leading to corrosion problems for well casing, or
- whether any of it has leaked into the overburden seal, the ocean or the atmosphere

The results show that neither of these eventualities has occurred.

The seismic response to the CO_2 is remarkably clear and the bounding geometry of the plume is well defined, see figure below.

Several high-amplitude reflective horizons, which occur at various levels are interpreted to arise from thin layers of high-saturation CO_2 trapped beneath the intercalated Utsira Formation shales.

There are no signs of CO_2 above the top of Utsira Formation.

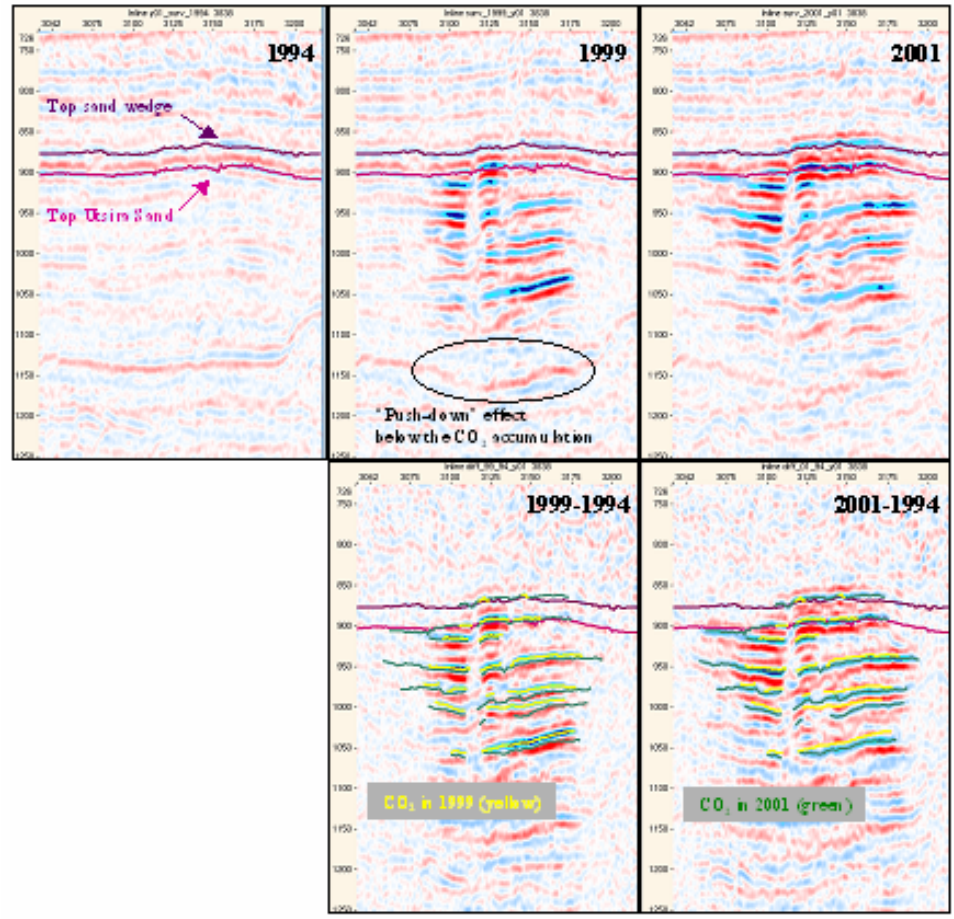

Figure 4 Results of seismic monitoring 1994 – 2001

The figure above is based on seismic data from 1994 – 2001. Data from seismic mapping carried out after that is not available in this format.

Based on the seismic data, the extent of the CO_2 plume has been estimated. The figure below shows the CO_2 plume extension in the years 1999, 2001 and 2002.

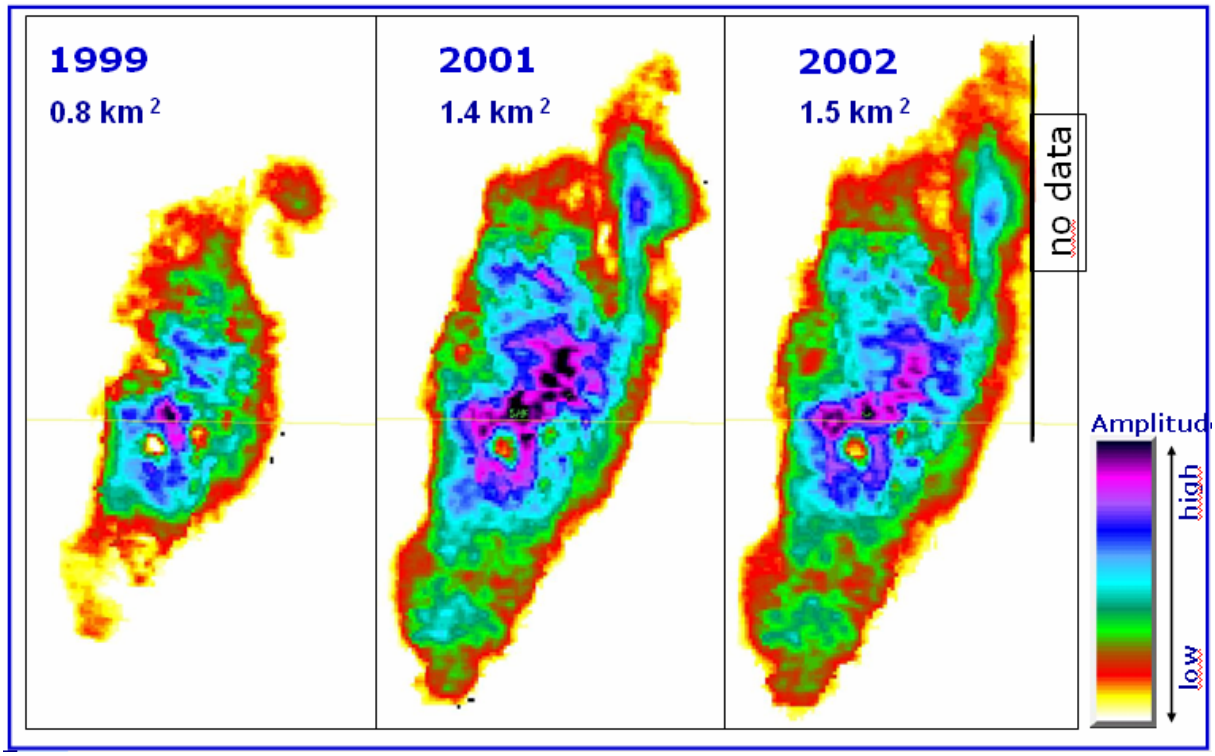

Figure 5 CO_2 plume extension in 1999, 2001 and 2002

The label "No data" in the above figure marks the eastern edge of the mapped area.

In 2004, after close to 7 million tonnes had been injected during the last eight years, the maximum lateral migration from the injection point was 1.5 km to the northeast, and the area of the CO_2 plume was about 2 km^2. Since the injection started, the plume has steadily grown, and has adopted a preferred NE-SW elongation, which is believed to be caused by the topography of the aquifer/cap rock interface and the inherent buoyancy of the injected CO_2 within the saline aquifer.

b) Gravimetric monitoring:

There is a large uncertainty on in-situ CO_2 density, related to temperature, which cannot be resolved by seismic measurements. CO_2 is close to critical point, and possible densities range from 0.2 to more than 0.7. The gravity data supports a low-density/high temperature CO_2 plume.

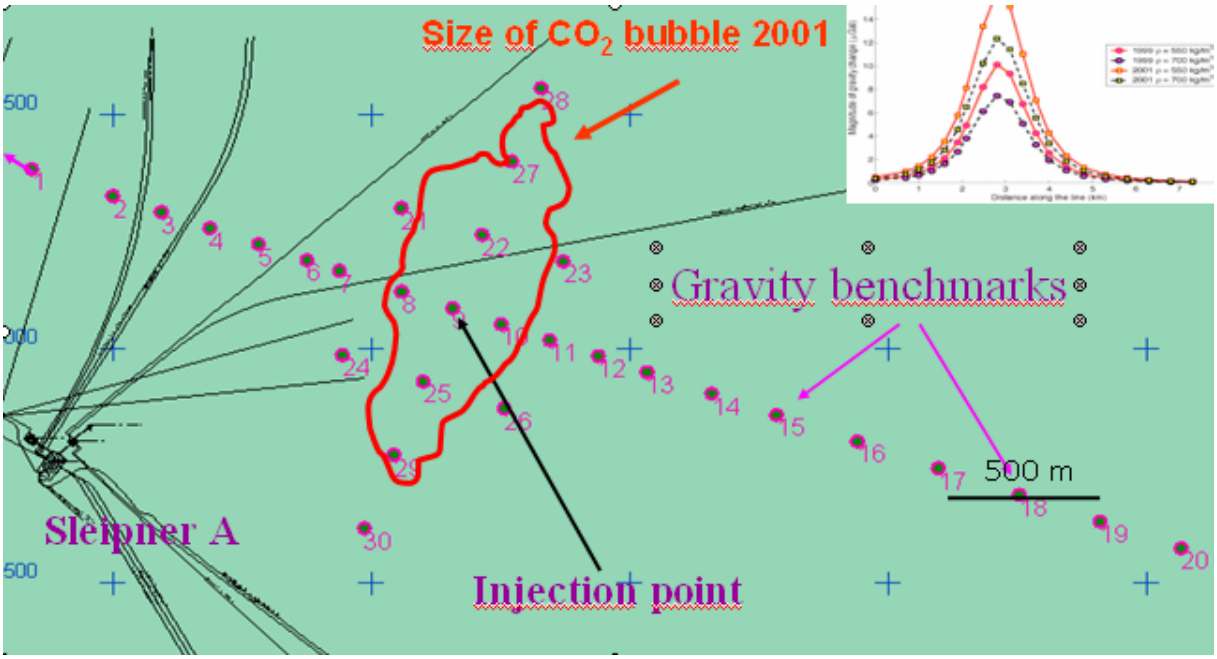

Figure 6 Gravimetric monitoring

c) Reservoir simulation:
Flow simulation models, which match the 4D seismic data reasonably well, have been used to predict the CO_2 behaviour. The figure below illustrates results from the simulation model.

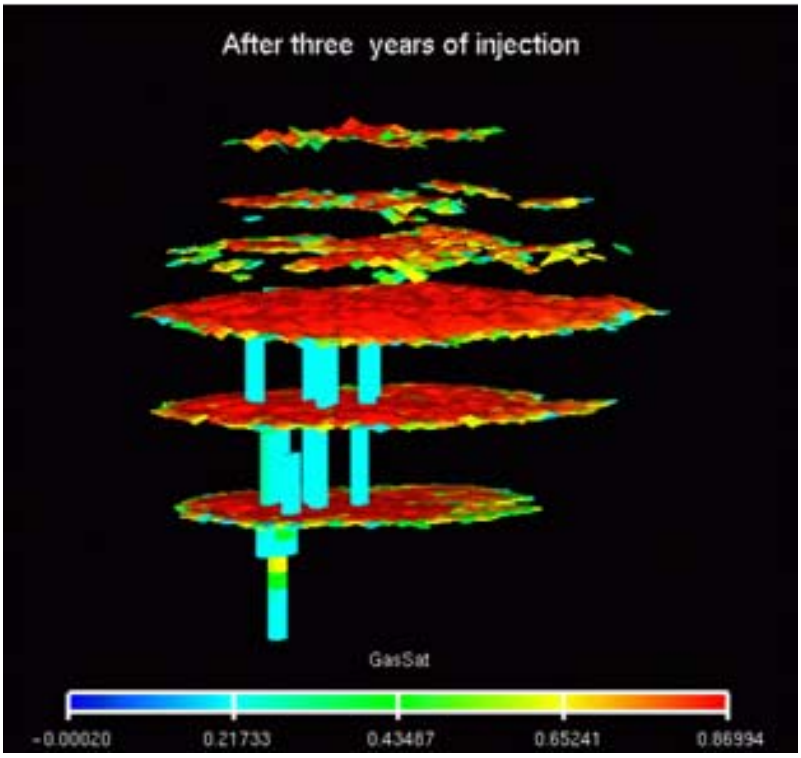

Figure 7 Flow simulation of CO_2

The results from the simulations indicate that cap rock shales provide a capillary seal for the CO_2 phase.

Dissolution of CO_2 from the gas cap into the underlying brine column will have a most pronounced effect. The brine on top of the column, which becomes enriched in CO_2, is denser than the brine below due to the special volumetric properties of the CO_2 – brine system. This instability could induce convection currents and enhance the dissolution of CO_2.

The following figure shows simulation results (seen from above) without taking into account the effect of CO_2 dissolution. This gives a conservative estimate of the extent of the CO_2 plume, as dissolution of the CO_2 will contribute to the CO_2 "sinking" inside the Utsira formation, thus reducing the size of the plume. The figure assumes stop of CO_2 injection after 25 years.

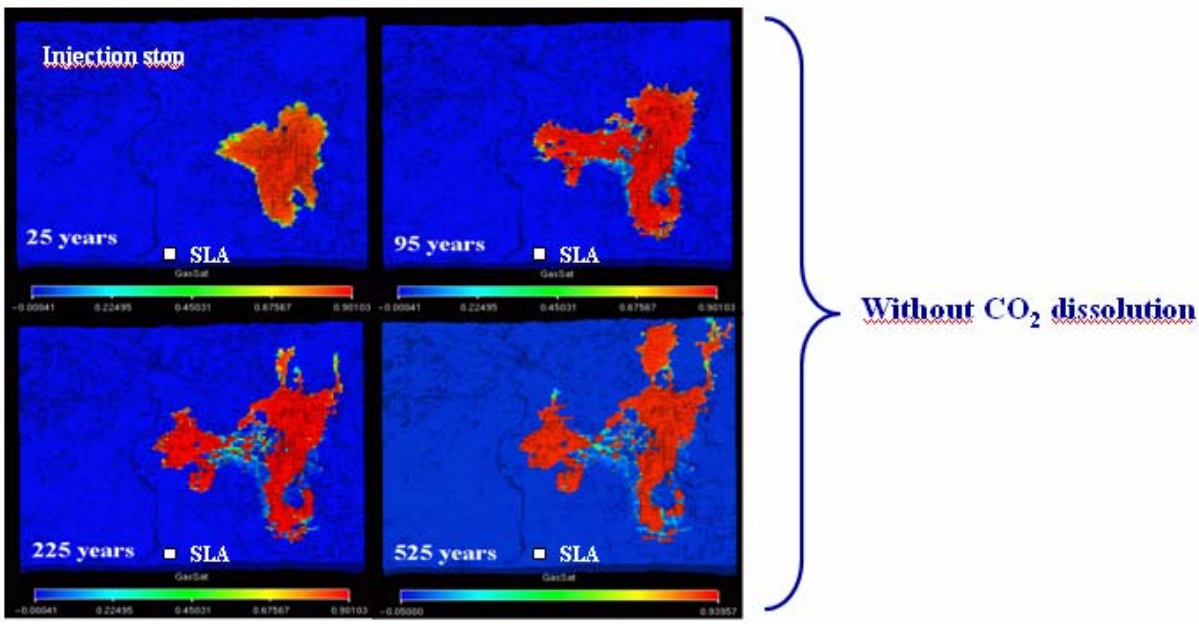

Figure 8

Dependent on the model parameters, most of the free CO_2 will have dissolved into the aquifer after between 5000 and 50000 years.

Note that the CO_2 migrates away from the SLA platform. The migration route is controlled by the topography of the Utsira Formation/cap rock interface. This means that no production wells on Sleipner are exposed too the CO_2 plume.

4. Injected and vented CO_2 volumes - the Sleipner fields:

Status 1.1.2006:

- 8 million tonnes CO_2 has been injected into the Utsira Formation
- 0.2 million tonnes CO_2 has been vented.

The following figure shows the yearly injected and vented volumes for the entire injection period on Sleipner.

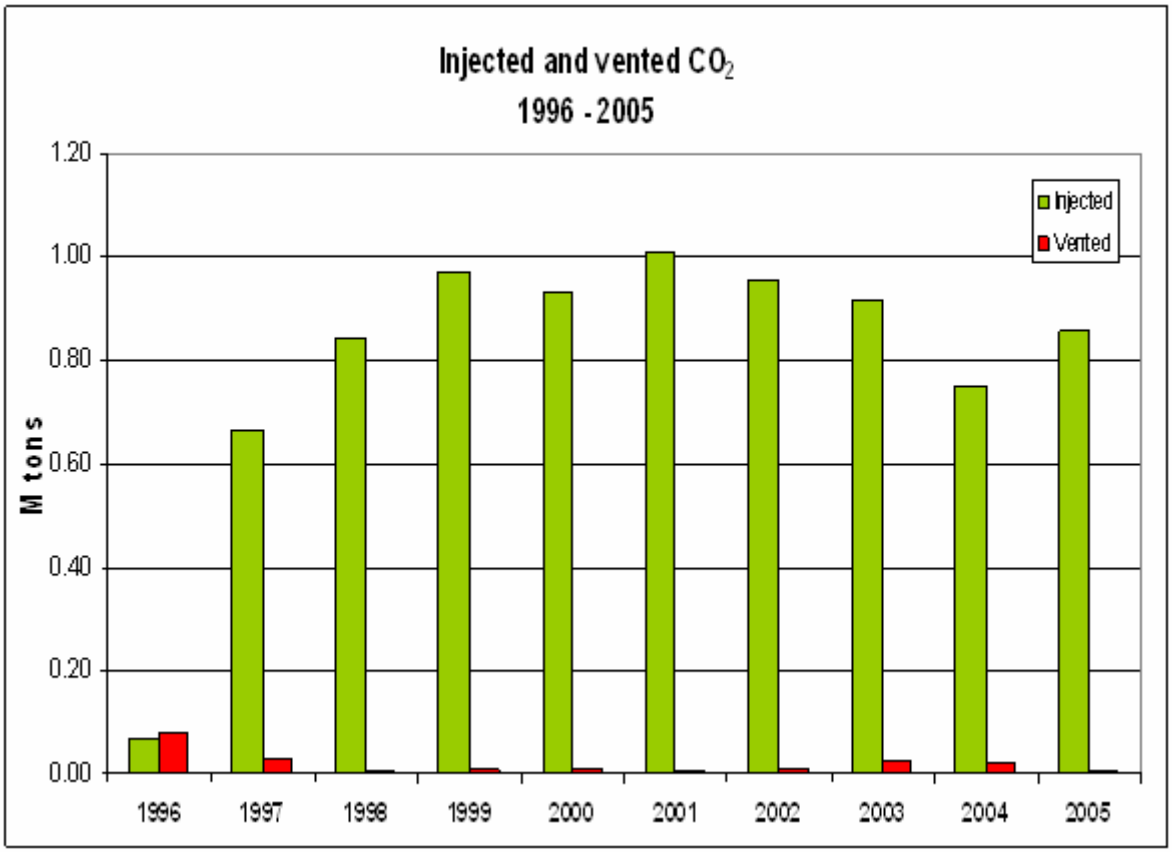

Figure 9 Injected and vented CO_2 at Sleipner Vest

5. Publications and conference presentations

Publications:

- Gale, J., Christensen, N. P., Cutler, A., & Torp, T.A., 2001: Demonstrating the Potential for Geological Storage of CO_2: The Sleipner and GESTCO Projects. Environmental Geosciences, 8 (3), 160 –165.
- Chadwick, A., Holloway, S. & Riley, N., 2001: Deep subsurface CO_2 sequestration - a viable greenhouse mitigation strategy. Geoscientist, vol 11, No 2, Feb 2001, 4-5.
- Zweigel, P. & Gale, J., 2000: Storing CO_2 underground shows promising results.- EOS, Transactions, American Geophysical Union, 81 (45), 529 & 534. (Reprinted with added figure in Earth in Space, 13 (6), 8-9.)
- Carstens, H. (& Torp, T.), 2000: Send CO2 tilbake til undergrunnen. GEO, 3, (6), 12-15.
- Zweigel, P., Lindeberg, E., & Eiken, O., 2000: 4D seismikk løser gåten. GEO, 3, (6), 16-18.

Conference presentations:

Greenhouse Gas Technology-8, Trondheim:

- Nooner et al. (in press, 2006): Constraining the density of CO2 within the Utsira formation using time-lapse gravity measurements. Extended abstract.

Offshore Europe, SPE conference 6-9 september 2005, Aberdeen, Scotland:

- Hansen, H.,Eiken, O. and Aasum, T.O, 2005: Tracing the path of the carbondioxide from a gas-condensate reservoir, through an amine plant and back into a subsurface acquifer. Case study: The Sleipner area, Norwegian North Sea

2nd Annual Conference on Carbon Sequestration, 5-8 May 2003, Alexandria, VA, US:

- Gaus, I., Azarounal, M., & Czernichowski-Lauriol, I., 2003: Reactive transport modeling of dissolved CO2 in the cap rock base during CO2 sequestration (Sleipner site, North Sea). Abstracts of the 2nd Annual Conference on Carbon Sequestration, 5-8 May 2003, Alexandria, VA, US.

6th Greenhouse Gas Control Technologies Conference (GHGT6), October 2003, Kyoto:

- Arts; R., Eiken, O., Chadwick, A., Zweigel, P., van der Meer, L., & Zinszner, B., 2002: Monitoring of CO2 Injected at Sleipner Using Time Lapse Seismic Data. Abstracts of the 6th International conference on Greenhouse Gas Control Technology (GHGT-6), Kyoto, Japan, 1-4 October 2002

- Chadwick, A., Zweigel, P., Gregersen, U., Kirby, G., & Johannessen, P., 2002: Geological Characterisation of CO2 Storage Sites: Lessons from the Sleipner, Northern North Sea. Abstracts of the 6th International conference on Greenhouse Gas Control Technology (GHGT-6), Kyoto, Japan, 1-4 October 2002

- Czernichowski-Lauriol, C.A. Rochelle, E. Brosse, N. Springer, K. Bateman, C. Kervevan, J.M. Pearce, B. Sanjuan, 2002: Reactivity of injected CO_2 with the Utsira Sand reservoir at Sleipner. Abstracts of the 6th International conference on Greenhouse Gas Control Technology (GHGT-6), Kyoto, Japan, 1-4 October 2002, p 341.

- Lindeberg, E., Bergmo, P., & Moen, A., 2002: The Long-term Fate of CO2 Injected into an Aquifer. Abstracts of the 6th International conference on Greenhouse Gas Control Technology (GHGT-6), Kyoto, Japan, 1-4 October 2002. Short abstract. Extended abstract

- Torp, T.A. & Gale, J. 2002: Demonstrating Storage of CO2 in Geological Reservoirs: The Sleipner and Sacs Projects. Abstracts of the 6th International conference on Greenhouse Gas Control Technology (GHGT-6), Kyoto, Japan, 1-4 October 2002

EAGE Annual meeting 2002, Florence:

- Arts, R., Elsayed, R., van der Meer, L., Eiken, O., Østmo, S., Chadwick, A., Kirby, G., Zinszner, B., 2002: Estimation of the mass of injected CO2 at Sleipner using time-lapse seismic data. EAGE, Annual meeting 2002, Florence, Italy.

Geological Society of London, '3D Seismic Data: Advances in the Understanding of Stratigraphic and Structural Architecture' conference, 14-16 November 2001

- Chadwick, A., Williamson, P., Zweigel, P., Arts, R., Eiken, O., 2001: Time-lapse geophysical monotoring of a subsurface CO2 bubble in the Utsira Sand, Sleipner, northgern North Sea. Presentation at '3D Seismic Data: Advances in the Understanding of Stratigraphic and Structural Architecture' conferece at the Geological Society of London, Burlington House, 14-16 November 2001.

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- Eiken, O., Brevik, I., Art, R., Lindeberg, E., Fagervik, K. 2001: Seismic monitoring of CO2 injected into a marine aquifer. American Association of Petroleum Geologists, Annual Meeting, June 2001, Denver, abstract volume.

- Zweigel, P., Arts, R., Bidstrup, T., Chadwick, A., Eiken, O., Gregersen, U., Hamborg, M., Johanessen, P., Kirby, G., Kristensen, L., & Lindeberg, E., 2001: Results and experiences from the first Industrial-scale underground CO_2 sequestration

case (Sleipner Field, North Sea). American Association of Petroleum Geologists, Annual Meeting, June 2001, Denver, abstract volume (CD) 6p.

European Union of Geosciences (EUG), XI meeting, April 2001, Strasbourg

- Chadwick, A., Kirby,G., Holloway, S., Zweigel, P., & Arts, R. 2001: The case for underground carbon dioxide sequestration in Northern Europe.- European Union of Geosciences, XI meeting, April 2001, Strasbourg, Abstract volume, 172.
- Czernichowski-Lauriol, I., Rochelle, C.A., Brosse, E., Springer, N., Pearce, J.M., Bateman, K.A., Sanjuan, B., Kervévan, C., 2001: Disposal of CO2 in deep aquifers: geochemical investigations of water-rock-CO2 interactions at Sleipner (North Sea) as part of the SACS project. European Union of Geosciences, XI meeting, April 2001, Strasbourg, Abstract volume, 172.

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Authors: Frangeul, Johann, Long Nghiem, Emmanuel Caroli, Sylvain Thibeau
Conference: AAPG Annual Meeting, Dallas USA, April 18-21, 2004
Publication: AAPG Bulletin Vol. 88 (2004), No. 13 (Supplement)
Abstract: available at AAPG
Website:http://www.searchanddiscovery.com/documents/abstracts/annual2004/Dallas/Frangeu.htm

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Geology

- Rock mechanical tests of shale samples from the cap rock of the Utsira Sand in well 15/9-A11 – A contribution to the Saline Aquifer CO2 Storage (SACS) project. Pillitteri et al. 2003. (PDF 1.7MB)
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- Preliminary modelling of the geochemical impact of CO_2 injection on the caprock at Sleipner. Gaus et al. 2002. (PDF 254 KB)
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Geophysics

- Multi-component seismic monitoring of CO2 gas cloud in the Utsira Sand: A feasibility study (Report Work Area 5.6) . Liu et al. (April 2001). (PDF 1586 KB)

Annex VI: CRF Summary 2 Tables 1990 - 2004

This annex contains Summary II-tables for the whole period 1990-2004. The full CRF tables for 1990 and 1998-2004 are enclosed in a zip-file.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1990
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**20 156,91**	**4 779,36**	**4 717,76**	**0,03**	**3 370,40**	**2 199,78**	**35 224,24**
1. Energy	**28 607,97**	**623,33**	**264,97**				**29 496,27**
A. Fuel Combustion (Sectoral Approach)	25 974,57	247,26	260,86				26 482,69
1. Energy Industries	6 647,60	48,64	25,12				6 721,36
2. Manufacturing Industries and Construction	3 638,62	6,51	26,95				3 672,08
3. Transport	11 102,55	69,85	120,96				11 293,37
4. Other Sectors	4 129,61	121,78	83,87				4 335,25
5. Other	456,19	0,48	3,95				460,62
B. Fugitive Emissions from Fuels	2 633,40	376,07	4,11				3 013,58
1. Solid Fuels	7,37	56,49	NA,NO				63,86
2. Oil and Natural Gas	2 626,03	319,58	4,11				2 949,73
2. Industrial Processes	**6 005,29**	**24,14**	**2 134,48**	**0,03**	**3 370,40**	**2 199,78**	**13 734,12**
A. Mineral Products	715,32	NA,NO	NA,NO				715,32
B. Chemical Industry	899,40	8,95	2 061,50	NO	NO	NO	2 969,85
C. Metal Production	4 314,46	15,19	72,98		3 370,40	2 143,83	9 916,86
D. Other Production	76,11						76,11
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				0,03	NA,NO	55,95	55,98
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**144,49**		**35,53**				**180,02**
4. Agriculture		**2 268,13**	**2 176,45**				**4 444,57**
A. Enteric Fermentation		1 946,11					1 946,11
B. Manure Management		298,17	133,36				431,53
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 036,21				2 036,21
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		23,85	6,88				30,72
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-14 601,03**	**17,69**	**15,20**				**-14 568,15**
6. Waste	**0,19**	**1 846,08**	**91,13**				**1 937,40**
A. Solid Waste Disposal on Land	NA,NO	1 826,56					1 826,56
B. Waste-water Handling		19,51	91,07				110,58
C. Waste Incineration	0,19	0,01	0,06				0,27
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 474,82**						**4 474,82**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	49 792,39
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	35 224,24

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1991
Submission 2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**19 127,61**	**4 860,51**	**4 724,55**	**0,07**	**2 992,92**	**2 079,15**	**33 784,81**
1. Energy	**27 677,27**	**649,72**	**262,00**				**28 589,00**
A. Fuel Combustion (Sectoral Approach)	25 592,88	233,62	259,13				26 085,63
1. Energy Industries	6 981,49	50,81	28,85				7 061,14
2. Manufacturing Industries and Construction	3 478,94	5,12	22,68				3 506,74
3. Transport	11 019,14	67,73	124,46				11 211,33
4. Other Sectors	3 707,56	109,53	79,60				3 896,69
5. Other	405,75	0,43	3,55				409,73
B. Fugitive Emissions from Fuels	2 084,38	416,11	2,87				2 503,36
1. Solid Fuels	7,84	60,08	NA,NO				67,92
2. Oil and Natural Gas	2 076,55	356,03	2,87				2 435,45
2. Industrial Processes	**5 382,55**	**20,08**	**2 128,76**	**0,07**	**2 992,92**	**2 079,15**	**12 603,53**
A. Mineral Products	535,61	NA,NO	NA,NO				535,61
B. Chemical Industry	796,78	7,65	2 068,42	NO	NO	NO	2 872,85
C. Metal Production	3 931,07	12,44	60,34	NO	2 992,92	2 019,55	9 016,31
D. Other Production	119,10						119,10
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				0,07	NA,NO	59,60	59,67
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**125,23**		**35,30**				**160,53**
4. Agriculture		**2 299,21**	**2 190,12**				**4 489,33**
A. Enteric Fermentation		1 974,31					1 974,31
B. Manure Management		306,16	142,03				448,19
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 042,69				2 042,69
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		18,74	5,41				24,15
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-14 057,62**	**29,75**	**17,22**				**-14 010,65**
6. Waste	**0,19**	**1 861,75**	**91,13**				**1 953,07**
A. Solid Waste Disposal on Land	NA,NO	1 842,12					1 842,12
B. Waste-water Handling		19,60	91,07				110,67
C. Waste Incineration	0,19	0,03	0,06				0,28
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 372,77**						**4 372,77**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	47 795,46
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	33 784,81

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1992
Submission 2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**19 828,18**	**4 945,60**	**3 943,03**	**0,21**	**2 286,92**	**705,03**	**31 708,97**
1. Energy	**28 516,00**	**747,87**	**269,76**				**29 533,62**
A. Fuel Combustion (Sectoral Approach)	26 128,55	235,31	267,11				26 630,97
1. Energy Industries	7 581,27	54,74	31,60				7 667,60
2. Manufacturing Industries and Construction	3 433,80	5,20	25,75				3 464,76
3. Transport	11 235,51	68,23	128,72				11 432,46
4. Other Sectors	3 391,05	106,61	76,73				3 574,39
5. Other	486,91	0,53	4,31				491,75
B. Fugitive Emissions from Fuels	2 387,45	512,56	2,64				2 902,66
1. Solid Fuels	6,51	49,90	NA,NO				56,41
2. Oil and Natural Gas	2 380,94	462,66	2,64				2 846,25
2. Industrial Processes	**5 523,71**	**20,57**	**1 354,73**	**0,21**	**2 286,92**	**705,03**	**9 891,17**
A. Mineral Products	714,61	NA,NO	NA,NO				714,61
B. Chemical Industry	749,99	7,92	1 291,15	NO	NO	NO	2 049,06
C. Metal Production	3 940,45	12,64	63,58	NO	2 286,92	638,25	6 941,85
D. Other Production	118,66						118,66
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				0,21	NA,NO	66,78	67,00
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**129,62**		**35,21**				**164,83**
4. Agriculture		**2 294,10**	**2 175,28**				**4 469,38**
A. Enteric Fermentation		1 976,53					1 976,53
B. Manure Management		307,31	141,02				448,32
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 031,31				2 031,31
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		10,26	2,96				13,22
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-14 341,33**	**27,30**	**16,91**				**-14 297,12**
6. Waste	**0,19**	**1 855,76**	**91,14**				**1 947,09**
A. Solid Waste Disposal on Land	NA,NO	1 836,01					1 836,01
B. Waste-water Handling		19,71	91,07				110,78
C. Waste Incineration	0,19	0,04	0,06				0,29
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 088,76**						**4 088,76**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	46 006,09
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	31 708,97

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1993
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 932,20**	**5 006,42**	**4 226,92**	**2,45**	**2 297,72**	**737,71**	**34 203,44**
1. Energy	**29 691,11**	**848,71**	**285,99**				**30 825,81**
A. Fuel Combustion (Sectoral Approach)	27 185,60	251,13	282,92				27 719,64
1. Energy Industries	7 891,13	56,71	31,10				7 978,94
2. Manufacturing Industries and Construction	3 745,08	5,66	29,37				3 780,12
3. Transport	11 847,43	67,96	141,95				12 057,34
4. Other Sectors	3 335,16	120,39	77,33				3 532,88
5. Other	366,79	0,40	3,16				370,35
B. Fugitive Emissions from Fuels	2 505,51	597,58	3,07				3 106,16
1. Solid Fuels	7,22	55,33	NA,NO				62,55
2. Oil and Natural Gas	2 498,29	542,25	3,07				3 043,61
2. Industrial Processes	**6 058,07**	**22,00**	**1 629,27**	**2,45**	**2 297,72**	**737,71**	**10 747,23**
A. Mineral Products	913,69	NA,NO	NA,NO				913,69
B. Chemical Industry	802,19	7,91	1 560,54	NO	NO	NO	2 370,64
C. Metal Production	4 216,43	14,09	68,73	NO	2 297,72	663,23	7 260,19
D. Other Production	125,77						125,77
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				2,45	NA,NO	74,49	76,94
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**129,28**		**35,94**				**165,22**
4. Agriculture		**2 268,71**	**2 167,34**				**4 436,05**
A. Enteric Fermentation		1 949,05					1 949,05
B. Manure Management		305,56	137,87				443,43
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 025,40				2 025,40
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		14,10	4,07				18,16
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-13 946,42**	**4,23**	**13,97**				**-13 928,22**
6. Waste	**0,16**	**1 862,77**	**94,42**				**1 957,35**
A. Solid Waste Disposal on Land	NA,NO	1 842,90					1 842,90
B. Waste-water Handling		19,83	94,35				114,19
C. Waste Incineration	0,16	0,04	0,07				0,27
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 397,99**						**4 397,99**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	48 131,66
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	34 203,44

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1994
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 223,96**	**5 087,43**	**4 371,32**	**9,16**	**2 032,47**	**877,98**	**35 602,32**
1. Energy	**31 260,39**	**888,74**	**311,24**				**32 460,38**
A. Fuel Combustion (Sectoral Approach)	28 632,41	259,71	308,05				29 200,18
1. Energy Industries	8 596,27	58,48	33,06				8 687,82
2. Manufacturing Industries and Construction	4 375,03	6,30	38,38				4 419,71
3. Transport	11 675,53	66,33	158,69				11 900,55
4. Other Sectors	3 477,93	128,17	73,34				3 679,44
5. Other	507,65	0,43	4,58				512,65
B. Fugitive Emissions from Fuels	2 627,98	629,03	3,19				3 260,20
1. Solid Fuels	7,20	55,18	NA,NO				62,38
2. Oil and Natural Gas	2 620,78	573,85	3,19				3 197,83
2. Industrial Processes	**6 448,00**	**24,49**	**1 740,06**	**9,16**	**2 032,47**	**877,98**	**11 132,16**
A. Mineral Products	918,93	NA,NO	NA,NO				918,93
B. Chemical Industry	815,09	8,51	1 663,15	NO	NO	NO	2 486,75
C. Metal Production	4 589,52	15,98	76,91	NO	2 032,47	791,09	7 505,98
D. Other Production	124,45						124,45
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				9,16	NA,NO	86,89	96,05
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**138,88**		**38,50**				**177,38**
4. Agriculture		**2 303,30**	**2 167,47**				**4 470,76**
A. Enteric Fermentation		1 984,30					1 984,30
B. Manure Management		308,88	144,58				453,47
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 019,96				2 019,96
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		10,12	2,92				13,04
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-14 623,49**	**4,38**	**13,94**				**-14 605,17**
6. Waste	**0,18**	**1 866,52**	**100,11**				**1 966,81**
A. Solid Waste Disposal on Land	NA,NO	1 846,53					1 846,53
B. Waste-water Handling		19,94	100,05				119,99
C. Waste Incineration	0,18	0,05	0,07				0,29
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 709,36**						**4 709,36**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	50 207,49
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	35 602,32

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1995
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 934,13**	**5 085,69**	**4 410,42**	**25,43**	**2 007,72**	**607,79**	**36 071,17**
1. Energy	**30 980,98**	**873,49**	**330,50**				**32 184,97**
A. Fuel Combustion (Sectoral Approach)	28 385,81	255,21	327,04				28 968,06
1. Energy Industries	8 445,45	58,38	33,20				8 537,02
2. Manufacturing Industries and Construction	3 938,42	6,15	40,03				3 984,59
3. Transport	12 075,71	65,20	178,63				12 319,54
4. Other Sectors	3 472,04	125,12	70,99				3 668,16
5. Other	454,19	0,37	4,19				458,75
B. Fugitive Emissions from Fuels	2 595,17	618,28	3,47				3 216,92
1. Solid Fuels	7,09	54,32	NA,NO				61,41
2. Oil and Natural Gas	2 588,09	563,96	3,47				3 155,51
2. Industrial Processes	**6 657,80**	**25,45**	**1 720,13**	**25,43**	**2 007,72**	**607,79**	**11 044,31**
A. Mineral Products	962,00	NA,NO	NA,NO				962,00
B. Chemical Industry	844,48	8,97	1 638,35	NO	NO	NO	2 491,79
C. Metal Production	4 718,63	16,49	81,78	NO	2 007,72	509,07	7 333,68
D. Other Production	132,69						132,69
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				25,43	2,10	98,72	126,25
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**135,22**		**38,94**				**174,16**
4. Agriculture		**2 331,25**	**2 203,49**				**4 534,74**
A. Enteric Fermentation		2 004,48					2 004,48
B. Manure Management		314,23	145,84				460,07
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 054,03				2 054,03
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		12,54	3,62				16,16
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-13 840,00**	**2,14**	**13,76**				**-13 824,10**
6. Waste	**0,15**	**1 853,36**	**103,59**				**1 957,09**
A. Solid Waste Disposal on Land	NA,NO	1 833,26					1 833,26
B. Waste-water Handling		20,05	103,52				123,57
C. Waste Incineration	0,15	0,05	0,07				0,26
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 812,17**						**4 812,17**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	49 895,28
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	36 071,17

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1996
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**26 489,63**	**5 119,72**	**4 443,43**	**51,86**	**1 829,04**	**574,10**	**38 507,76**
1. Energy	**33 993,97**	**910,98**	**355,16**				**35 260,11**
A. Fuel Combustion (Sectoral Approach)	31 060,03	268,62	351,26				31 679,91
1. Energy Industries	9 295,25	62,17	35,40				9 392,83
2. Manufacturing Industries and Construction	4 443,98	6,61	42,10				4 492,68
3. Transport	12 717,03	65,26	197,09				12 979,38
4. Other Sectors	4 197,17	134,18	73,22				4 404,57
5. Other	406,60	0,39	3,47				410,46
B. Fugitive Emissions from Fuels	2 933,94	642,36	3,89				3 580,20
1. Solid Fuels	7,24	55,52	NA,NO				62,76
2. Oil and Natural Gas	2 926,70	586,84	3,89				3 517,43
2. Industrial Processes	**6 634,52**	**24,76**	**1 701,37**	**51,86**	**1 829,04**	**574,10**	**10 815,65**
A. Mineral Products	962,40	NA,NO	NA,NO				962,40
B. Chemical Industry	817,07	8,68	1 619,75	NO	NO	NO	2 445,50
C. Metal Production	4 721,07	16,09	81,62	NO	1 829,04	472,50	7 120,32
D. Other Production	133,98						133,98
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				51,86	2,10	101,60	155,55
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**142,70**		**39,51**				**182,20**
4. Agriculture		**2 343,67**	**2 222,62**				**4 566,29**
A. Enteric Fermentation		2 009,97					2 009,97
B. Manure Management		320,02	146,93				466,95
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 071,74				2 071,74
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		13,68	3,95				17,63
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-14 281,69**	**9,71**	**14,53**				**-14 257,46**
6. Waste	**0,13**	**1 830,60**	**110,24**				**1 940,98**
A. Solid Waste Disposal on Land	NA,NO	1 810,39					1 810,39
B. Waste-water Handling		20,15	110,18				130,33
C. Waste Incineration	0,13	0,06	0,07				0,26
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 832,77**						**4 832,77**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	52 765,22
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	38 507,76

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1997
Submission 2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**26 596,23**	**5 150,77**	**4 331,65**	**86,83**	**1 633,60**	**579,86**	**38 378,94**
1. Energy	**33 984,32**	**980,42**	**368,76**				**35 333,50**
A. Fuel Combustion (Sectoral Approach)	31 227,16	275,04	365,11				31 867,31
1. Energy Industries	9 660,04	66,07	35,97				9 762,08
2. Manufacturing Industries and Construction	4 423,66	7,17	43,47				4 474,29
3. Transport	12 961,47	63,22	210,46				13 235,15
4. Other Sectors	3 757,42	138,16	71,55				3 967,13
5. Other	424,57	0,41	3,67				428,65
B. Fugitive Emissions from Fuels	2 757,16	705,38	3,65				3 466,19
1. Solid Fuels	6,34	48,61	NA,NO				54,95
2. Oil and Natural Gas	2 750,81	656,78	3,65				3 411,25
2. Industrial Processes	**6 819,32**	**27,36**	**1 566,65**	**86,83**	**1 633,60**	**579,86**	**10 713,61**
A. Mineral Products	1 023,27	NA,NO	NA,NO				1 023,27
B. Chemical Industry	845,01	10,50	1 481,18	NO	NO	NO	2 336,68
C. Metal Production	4 799,92	16,86	85,47	NO	1 632,90	437,37	6 972,52
D. Other Production	151,12						151,12
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				86,83	0,70	142,49	230,02
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**137,17**		**39,44**				**176,61**
4. Agriculture		**2 325,27**	**2 222,72**				**4 547,99**
A. Enteric Fermentation		1 994,82					1 994,82
B. Manure Management		320,61	142,66				463,27
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 077,22				2 077,22
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		9,85	2,84				12,69
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-14 362,13**	**16,37**	**15,19**				**-14 330,56**
6. Waste	**17,55**	**1 801,34**	**118,90**				**1 937,79**
A. Solid Waste Disposal on Land	NA,NO	1 780,97					1 780,97
B. Waste-water Handling		20,26	118,78				139,04
C. Waste Incineration	17,55	0,11	0,11				17,78
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**5 039,81**						**5 039,81**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	52 709,50
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	38 378,94

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1998
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**20 846,42**	**5 003,80**	**4 545,29**	**131,59**	**1 486,19**	**726,74**	**32 740,03**
1. Energy	**34 018,97**	**931,50**	**366,87**				**35 317,34**
A. Fuel Combustion (Sectoral Approach)	31 159,90	264,35	363,05				31 787,29
1. Energy Industries	9 250,12	63,24	35,00				9 348,37
2. Manufacturing Industries and Construction	4 511,54	7,08	32,16				4 550,78
3. Transport	13 306,88	61,83	220,20				13 588,90
4. Other Sectors	3 731,79	131,84	72,40				3 936,02
5. Other	359,57	0,36	3,29				363,22
B. Fugitive Emissions from Fuels	2 859,07	667,15	3,82				3 530,05
1. Solid Fuels	6,59	50,52	NA,NO				57,12
2. Oil and Natural Gas	2 852,48	616,63	3,82				3 472,93
2. Industrial Processes	**6 846,62**	**28,79**	**1 781,67**	**131,59**	**1 486,19**	**726,74**	**11 001,60**
A. Mineral Products	968,11	NA,NO	NA,NO				968,11
B. Chemical Industry	599,01	10,59	1 689,28	NO	NO	NO	2 298,88
C. Metal Production	5 177,38	18,20	92,39		1 485,49	581,97	7 355,42
D. Other Production	102,13						102,13
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				131,59	0,70	144,77	277,06
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**136,54**		**39,51**				**176,05**
4. Agriculture		**2 348,29**	**2 223,80**				**4 572,09**
A. Enteric Fermentation		2 013,25					2 013,25
B. Manure Management		324,71	142,36				467,07
C. Rice Cultivation		NO					NO
D. Agricultural Soils [3]		NA,NO	2 078,45				2 078,45
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		10,34	2,98				13,32
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [1]	**-20 208,96**	**5,20**	**14,22**				**-20 189,54**
6. Waste	**53,25**	**1 690,02**	**119,22**				**1 862,49**
A. Solid Waste Disposal on Land	NA,NO	1 669,42					1 669,42
B. Waste-water Handling		20,38	119,02				139,40
C. Waste Incineration	53,25	0,22	0,21				53,67
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 655,62**						**4 655,62**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	52 929,57
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	32 740,03

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	1999
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**22 090,26**	**4 842,28**	**4 685,63**	**183,10**	**1 389,12**	**873,96**	**34 064,35**
1. Energy	**34 951,53**	**905,91**	**375,12**				**36 232,56**
A. Fuel Combustion (Sectoral Approach)	31 472,80	261,65	370,02				32 104,48
1. Energy Industries	9 211,53	58,74	34,92				9 305,19
2. Manufacturing Industries and Construction	4 151,37	7,57	24,35				4 183,29
3. Transport	13 900,66	60,32	234,87				14 195,86
4. Other Sectors	3 817,67	134,67	72,33				4 024,67
5. Other	391,56	0,36	3,55				395,47
B. Fugitive Emissions from Fuels	3 478,73	644,25	5,10				4 128,08
1. Solid Fuels	8,47	64,88	NA,NO				73,35
2. Oil and Natural Gas	3 470,26	579,37	5,10				4 054,73
2. Industrial Processes	**6 785,03**	**26,66**	**1 969,68**	**183,10**	**1 389,12**	**873,96**	**11 227,54**
A. Mineral Products	953,83	NA,NO	NA,NO				953,83
B. Chemical Industry	461,04	8,66	1 878,60	NO	NO	NO	2 348,30
C. Metal Production	5 292,31	18,00	91,08	NO	1 388,42	725,37	7 515,16
D. Other Production	77,86						77,86
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				183,10	0,70	148,59	332,39
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**133,66**		**40,20**				**173,86**
4. Agriculture		**2 336,46**	**2 166,37**				**4 502,83**
A. Enteric Fermentation		2 005,40					2 005,40
B. Manure Management		321,69	142,00				463,69
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 021,68				2 021,68
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		9,37	2,70				12,07
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-19 825,33**	**1,63**	**13,75**				**-19 809,95**
6. Waste	**45,37**	**1 571,64**	**120,51**				**1 737,52**
A. Solid Waste Disposal on Land	NA,NO	1 550,89					1 550,89
B. Waste-water Handling		20,52	120,32				140,84
C. Waste Incineration	45,37	0,23	0,19				45,78
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 825,56**						**4 825,56**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	53 874,30
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	34 064,35

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	2000
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**16 256,49**	**4 956,56**	**4 537,18**	**239,20**	**1 318,56**	**934,42**	**28 242,42**
1. Energy	**34 135,68**	**1 022,44**	**364,96**				**35 523,07**
A. Fuel Combustion (Sectoral Approach)	30 461,42	267,58	360,20				31 089,20
1. Energy Industries	10 107,46	64,57	33,81				10 205,85
2. Manufacturing Industries and Construction	3 934,96	7,15	22,50				3 964,61
3. Transport	13 024,88	58,77	233,28				13 316,92
4. Other Sectors	3 215,96	136,83	69,13				3 421,92
5. Other	178,16	0,27	1,48				179,90
B. Fugitive Emissions from Fuels	3 674,26	754,85	4,76				4 433,87
1. Solid Fuels	9,25	70,86	NA,NO				80,11
2. Oil and Natural Gas	3 665,01	683,99	4,76				4 353,76
2. Industrial Processes	**7 180,95**	**26,82**	**1 825,77**	**239,20**	**1 318,56**	**934,42**	**11 525,72**
A. Mineral Products	955,57	NA,NO	NA,NO				955,57
B. Chemical Industry	674,58	8,57	1 733,14	NO	NO	NO	2 416,29
C. Metal Production	5 319,87	18,25	92,63		1 317,86	773,17	7 521,77
D. Other Production	230,93						230,93
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				239,20	0,70	161,26	401,16
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**126,82**		**40,04**				**166,86**
4. Agriculture		**2 304,50**	**2 184,82**				**4 489,32**
A. Enteric Fermentation		1 975,88					1 975,88
B. Manure Management		318,72	144,77				463,49
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	2 037,19				2 037,19
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		9,90	2,85				12,75
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-25 274,03**	**3,25**	**13,42**				**-25 257,36**
6. Waste	**87,07**	**1 599,56**	**108,17**				**1 794,81**
A. Solid Waste Disposal on Land	NA,NO	1 578,68					1 578,68
B. Waste-water Handling		20,60	107,88				128,47
C. Waste Incineration	87,07	0,29	0,30				87,66
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**4 682,55**						**4 682,55**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	53 499,78
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	28 242,42

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	2001
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**15 787,88**	**4 960,36**	**4 441,22**	**305,41**	**1 329,29**	**791,20**	**27 615,36**
1. Energy	**35 918,28**	**1 130,80**	**390,18**				**37 439,26**
A. Fuel Combustion (Sectoral Approach)	32 554,11	280,41	386,20				33 220,71
1. Energy Industries	11 383,12	71,78	36,40				11 491,30
2. Manufacturing Industries and Construction	4 025,31	6,97	25,48				4 057,75
3. Transport	13 331,91	58,29	245,86				13 636,06
4. Other Sectors	3 518,86	142,95	76,05				3 737,87
5. Other	294,91	0,41	2,41				297,73
B. Fugitive Emissions from Fuels	3 364,17	850,40	3,98				4 218,55
1. Solid Fuels	8,39	64,30	NA,NO				72,68
2. Oil and Natural Gas	3 355,78	786,10	3,98				4 145,86
2. Industrial Processes	**6 839,15**	**24,27**	**1 780,30**	**305,41**	**1 329,29**	**791,20**	**11 069,63**
A. Mineral Products	917,75	NA,NO	NA,NO				917,75
B. Chemical Industry	658,81	9,06	1 693,84	NO	NO	NO	2 361,70
C. Metal Production	5 046,21	15,22	86,46		1 328,59	645,30	7 121,78
D. Other Production	216,39						216,39
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				305,41	0,70	145,90	452,02
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**126,82**		**40,04**				**166,86**
4. Agriculture		**2 257,80**	**2 107,07**				**4 364,87**
A. Enteric Fermentation		1 939,45					1 939,45
B. Manure Management		310,55	143,87				454,41
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	1 960,96				1 960,96
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		7,80	2,25				10,05
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-27 129,45**	**1,69**	**13,06**				**-27 114,70**
6. Waste	**33,07**	**1 545,79**	**110,57**				**1 689,44**
A. Solid Waste Disposal on Land	NA,NO	1 524,92					1 524,92
B. Waste-water Handling		20,71	110,42				131,13
C. Waste Incineration	33,07	0,17	0,16				33,40
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**5 122,42**						**5 122,42**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	54 730,06
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	27 615,36

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	2002
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**15 773,17**	**4 796,18**	**4 622,75**	**355,55**	**1 438,26**	**238,30**	**27 224,21**
1. Energy	**35 588,68**	**1 070,06**	**393,94**				**37 052,67**
A. Fuel Combustion (Sectoral Approach)	32 705,89	301,49	390,73				33 398,10
1. Energy Industries	11 573,30	74,81	38,09				11 686,20
2. Manufacturing Industries and Construction	3 779,54	6,91	24,87				3 811,31
3. Transport	13 176,32	56,65	248,21				13 481,17
4. Other Sectors	3 723,50	162,80	75,46				3 961,76
5. Other	453,23	0,32	4,10				457,65
B. Fugitive Emissions from Fuels	2 882,79	768,57	3,21				3 654,57
1. Solid Fuels	7,74	59,36	NA,NO				67,10
2. Oil and Natural Gas	2 875,04	709,21	3,21				3 587,47
2. Industrial Processes	**6 288,50**	**24,00**	**1 988,12**	**355,55**	**1 438,26**	**238,30**	**10 332,74**
A. Mineral Products	897,29	NA,NO	NA,NO				897,29
B. Chemical Industry	563,27	10,61	1 912,08				2 485,96
C. Metal Production	4 595,57	13,40	76,04		1 437,56	141,73	6 264,30
D. Other Production	232,38						232,38
E. Production of Halocarbons and SF_6				NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6 [2]				355,55	0,70	96,58	452,83
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**126,82**		**40,10**				**166,92**
4. Agriculture		**2 207,83**	**2 084,38**				**4 292,20**
A. Enteric Fermentation		1 897,31					1 897,31
B. Manure Management		304,67	140,03				444,70
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	1 942,66				1 942,66
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		5,85	1,69				7,53
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-26 262,97**	**4,17**	**13,57**				**-26 245,23**
6. Waste	**32,14**	**1 490,12**	**102,64**				**1 624,91**
A. Solid Waste Disposal on Land	NA,NO	1 469,14					1 469,14
B. Waste-water Handling		20,81	102,50				123,31
C. Waste Incineration	32,14	0,18	0,14				32,46
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**5 235,72**						**5 235,72**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	53 469,45
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	27 224,21

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	2003
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**17 532,85**	**4 840,36**	**4 450,83**	**378,36**	**909,77**	**234,86**	**28 347,03**
1. Energy	**37 042,13**	**1 060,34**	**402,77**				**38 505,24**
A. Fuel Combustion (Sectoral Approach)	34 228,85	308,19	399,68				34 936,73
1. Energy Industries	12 287,27	80,67	40,96				12 408,90
2. Manufacturing Industries and Construction	4 136,79	7,36	26,33				4 170,48
3. Transport	13 652,37	57,97	255,92				13 966,25
4. Other Sectors	3 979,95	161,90	75,26				4 217,10
5. Other	172,48	0,30	1,22				173,99
B. Fugitive Emissions from Fuels	2 813,28	752,14	3,09				3 568,52
1. Solid Fuels	11,89	91,16	NA,NO				103,05
2. Oil and Natural Gas	2 801,39	660,99	3,09				3 465,46
2. Industrial Processes	**6 349,93**	**19,53**	**1 782,44**	**378,36**	**909,77**	**234,86**	**9 674,88**
A. Mineral Products	976,22	NA,NO	NA,NO				976,22
B. Chemical Industry	563,53	7,09	1 711,08	NO	NO	NO	2 281,70
C. Metal Production	4 579,99	12,44	71,36		909,07	172,08	5 744,93
D. Other Production	230,19						230,19
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				378,36	0,70	62,78	441,84
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**126,82**		**40,69**				**167,51**
4. Agriculture		**2 257,93**	**2 100,76**				**4 358,69**
A. Enteric Fermentation		1 944,99					1 944,99
B. Manure Management		307,98	124,83				432,82
C. Rice Cultivation		NO					NO
D. Agricultural Soils[3]		NA,NO	1 974,50				1 974,50
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		4,95	1,43				6,38
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[1]	**-26 017,07**	**17,81**	**14,41**				**-25 984,85**
6. Waste	**31,04**	**1 484,75**	**109,76**				**1 625,56**
A. Solid Waste Disposal on Land	NA,NO	1 463,64					1 463,64
B. Waste-water Handling		20,94	109,61				130,54
C. Waste Incineration	31,04	0,18	0,15				31,38
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**5 324,88**						**5 324,88**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	54 331,88
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	28 347,03

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party	NORWAY
Year	2004
Submission	2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**17 659,10**	**4 803,49**	**4 604,19**	**400,41**	**880,60**	**275,68**	**28 623,47**
1. Energy	**36 927,12**	**1 088,92**	**409,02**				**38 425,06**
A. Fuel Combustion (Sectoral Approach)	34 278,81	311,52	405,74				34 996,07
1. Energy Industries	12 405,65	84,06	38,67				12 528,38
2. Manufacturing Industries and Construction	3 885,79	7,20	25,99				3 918,97
3. Transport	14 081,20	58,64	264,65				14 404,50
4. Other Sectors	3 575,93	161,32	73,59				3 810,85
5. Other	330,24	0,30	2,84				333,38
B. Fugitive Emissions from Fuels	2 648,30	777,41	3,28				3 428,99
1. Solid Fuels	7,61	58,34	NA,NO				65,95
2. Oil and Natural Gas	2 640,69	719,07	3,28				3 363,03
2. Industrial Processes	**6 907,83**	**21,60**	**1 931,80**	**400,41**	**880,60**	**275,68**	**10 417,91**
A. Mineral Products	838,57	NA,NO	NA,NO				838,57
B. Chemical Industry	600,46	6,29	1 844,66				2 451,41
C. Metal Production	5 227,25	15,30	87,14		879,90	205,54	6 415,14
D. Other Production	241,54						241,54
E. Production of Halocarbons and SF_6				NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6 [2]				400,41	0,70	70,14	471,25
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**126,82**		**41,19**				**168,00**
4. Agriculture		**2 211,63**	**2 099,48**				**4 311,11**
A. Enteric Fermentation		1 895,95					1 895,95
B. Manure Management		310,13	122,01				432,14
C. Rice Cultivation		NO					NO
D. Agricultural Soils [3]		NA,NO	1 975,88				1 975,88
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		5,55	1,60				7,15
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [1]	**-26 322,54**	**2,21**	**12,83**				**-26 307,50**
6. Waste	**19,88**	**1 479,13**	**109,88**				**1 608,88**
A. Solid Waste Disposal on Land	NA,NO	1 457,93					1 457,93
B. Waste-water Handling		21,05	109,75				130,80
C. Waste Incineration	19,88	0,15	0,12				20,16
D. Other	NA,NO	NA,NO	NA,NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	NA,NO	NA,NO	NA,NO				NA,NO
Aviation	NO	NO	NO				NO
Marine	NA,NO	NA,NO	NA,NO				NA,NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**5 252,80**						**5 252,80**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry [5]	54 930,97
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry [5]	28 623,47

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

[5] These totals will differ from the totals reported in table 10, sheet 5 if Parties report non-CO_2 emissions from LULUCF.