Greenhouse Gas Emissions in Norway 1990-2002

Reporting according to the UNFCCC guidelines

TA-2017/2004

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 2004. The report has been prepared in accordance with the UNFCCC Reporting Guidelines on Annual Inventories adopted in November 2002 by the Conference of the Parties to the Convention (Decision 18/CP.8). The methodologies used to calculate emissions and removals are in accordance with the *Revised IPCC 1996 Guidelines for National Greenhouse Gas Inventories* and the *IPCC Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* as approved by the UNFCCC.

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

SFT, Oslo, April 2004

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National Inventory Report

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Executive Summary

Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) requires the Parties to the Convention to develop, update and submit to the UNFCCC annual inventories of greenhouse gas emissions by sources and removals by sinks. In response to this requirement, Norway has prepared the National Inventory Report (NIR) 2004 for the period 1990-2002.

The report and the associated Common Reporting Format (CRF) tables are 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* prepared by the Intergovernmental Panel on Climate Change (IPCC). As recommended by the IPCC Guidelines country specific methods have been used where appropriate and where they provide more accurate emission data.

This report presents the national inventory of greenhouse gas (GHG) emissions and removals from 1990 to 2002. Emissions of the following greenhouse gases are covered in the report:

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

In addition, the inventory includes calculations of emissions of the precursors NOx, NMVOC and CO as well as SO_2. This year we have included more comprehensive descriptions of the methodologies used in the report. In some cases the most detailed descriptions are added in annexes. The last annex contains the Common Reporting Format (CRF) tables. For the years 1990 and 1998-2002 full CRF-sets are made available. For the years 1991 to 1997 we have provided summary tables (Summary II) due to the fact that emission figures are only available in another electronic format than that required by the UNFCCC. The emissions figures for these years are calculated by the same methodology as for the 1990 and 1998-2002 figures.

The IPCC adopted the report on Good Practice Guidance for the Land Use Change and Forestry sector (LUCF) in November last year. The report was considered by the UNFCCC at COP 9 in December 2003, and it was decided that the methodology and tables related to reporting under the Convention should be employed. We are aware that our reporting of the Norwegian LUCF sector has some limitations. A project on incorporating the Good Practice methodology for this sector in Norway has recently been initiated. This project also includes reporting relevant to the Kyoto Protocol, provided that COP 10 adopts the guidelines for the Kyoto Protocol reporting. The project will be finalised later this year, hence the inventory to be submitted in 2005 will according to our plans contain figures calculated by the updated Good Practice methodology for LUCF.

In October 2002 the Norwegian emission inventory system was inspected by an expert review team (ERT) hosted at SFT (in-country review). The team concluded that the national inventory submission was in conformity with the UNFCCC reporting guidelines, and that Norway has an excellent inventory program that systematically reviews and targets areas of improvement through key source identification. It was also commented that the existing institutional arrangement facilitates consistency in reporting.

The team noted some deficiencies and areas for improvement in the Norwegian emission inventory system. The present report addresses these elements to the extent that that has been possible. In particular, the various sectors are described in more detail now than in last year's report, especially those of agriculture and LUCF. CO_2 capture and storage, which is of relevance for Norway, is also described in this report. Furthermore, the use of notation keys is now more extensive than before.

Trends in emissions and removals

In 2002, the total emissions of greenhouse gases in Norway amounted to about 55.3 million tonnes CO_2–equivalents. 74% of this was CO_2, while methane and nitrous oxide contributed 12 and 10 per cent respectively. PFCs accounted for about 2%, while the share of HFCs and SF_6 together was ca. 1 per cent.

Table 1 below shows the overall trend in the total emissions by gas during the period 1990-2002, and preliminary emission figures for 2003. From 1990 to 2002 the emissions increased by about 6 per cent, while they decreased by about 2.5 % between 2001 and 2002. Norway experienced economic growth during the period since 1990, which explains the general growth until 2002. The decline from 2001 to 2002 takes place in spite of this, and 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.

Table 1. Emissions and removals of greenhouse gases for the years 1990-2002 and preliminary figures for 2003. Mill tonnes CO_2–equivalents. Source: SN/SFT

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003***	**1990-2002**
CO_2	34.7	33.6	33.9	35.6	37.3	37.4	40.6	40.6	40.8	41.3	40.9	42.1	40.9	42.8	18 %
CH_4	6.4	6.5	6.6	6.8	6.8	6.9	7.0	7.0	7.0	6.9	7.0	7.0	6.9	6.9	8 %
N_2O	5.5	5.4	4.7	5.0	5.1	5.2	5.2	5.2	5.4	5.7	5.5	5.6	5.8	5.7	5 %
PFC	3.3	2.5	2.0	2.0	1.7	1.6	1.4	1.4	1.3	1.1	0.9	1.0	1.1	0.7	-67 %
SF_6	2.2	2.1	0.7	0.7	0.9	0.6	0.5	0.5	0.7	0.8	0.9	0.8	0.2	0.3	-91 %
HFC	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.1	-
Total without LUCF	**52.1**	**50.1**	**47.9**	**50.1**	**51.9**	**51.7**	**54.8**	**54.8**	**55.3**	**56.0**	**55.4**	**56.7**	**55.3**	**56.5**	**6 %**
LUCF	-9.5	-11.8	-13.2	-13.5	-15.6	-15.5	-17.4	-16.3	-17.4	-17.6	-18.6	-18.8	-19.9	-	109 %

* Preliminary figures

Preliminary calculations of the GHG emissions in 2003 indicate an increase of about 2 per cent since 2002. The increase in CO_2-emissions was as much as 4 per cent during this period, while emissions of most other greenhouse gases decreased.

The growth in CO_2-emissions from 2002 to 2003 can mainly be explained by increased offshore oil and gas production and increased sales of mineral oil for heating because of high prices on electricity, due to dry and cold conditions creating scarcity of hydropower. Other factors which contributed are growth in the sales of auto diesel for cars as well as of marine gas oils in domestic navigation. The emissions of PFCs showed a strong decrease of about 36 per cent from 2002 to 2003. PFC-emissions originate primarily from the production of aluminium. At the same time CO_2-emissions from aluminium production increased, offsetting the decrease from this sector by about 50 per cent. Emissions of N_2O decreased between 2002 and 2003, first and foremost because of reduced emissions from production of fertiliser. HFC-emissions also decreased, which may be an effect of the tax on import of HFC that entered into force 1 January 2003. SF_6-emissions were strongly reduced from 2001 to 2002, but increased again in 2003, because of increased secondary magnesium production.

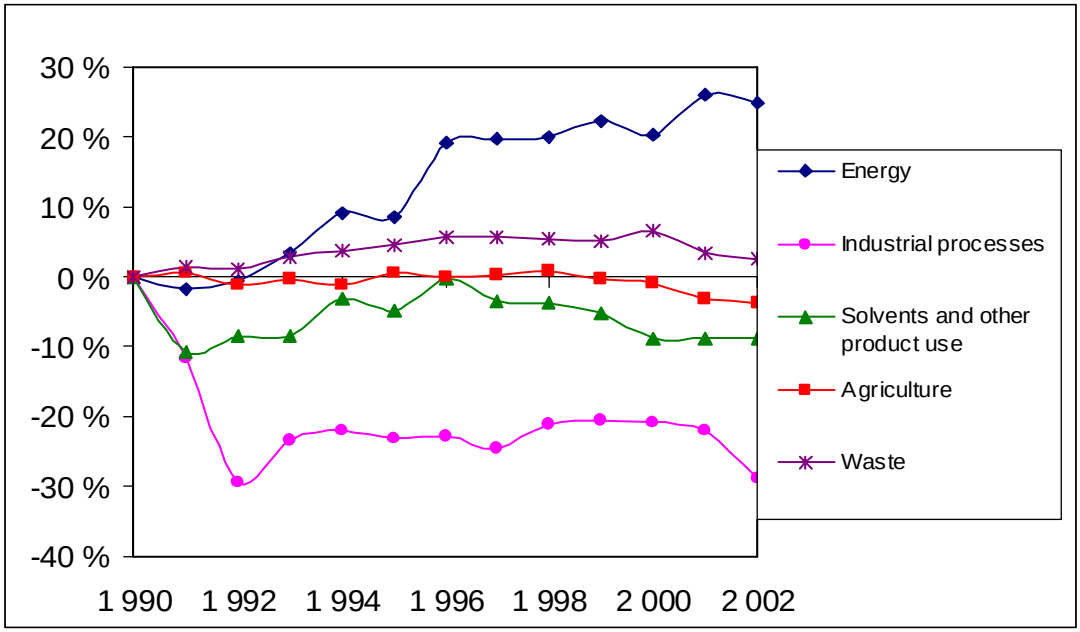


Figure 1. Changes in greenhouse gas emissions by UNFCCC sector 1990-2002 compared to 1990. Source: SN/SFT

The figure above shows the percentage change in emissions of greenhouse gases from 1990 to 2002 for the different UNFCCC sectors, compared to emissions in 1990. In the following we will briefly go through the development for each of the sectors since 1990 with regard to greenhouse gas emissions, and describe the most important sources.

The Energy sector accounts for about 2/3 of the total Norwegian greenhouse gas emissions. Road traffic and offshore gas turbines (electricity generation and pumping of natural gas) are the largest single contributors, while coastal navigation and energy commodities used for the production of raw materials are other major sources. During most of the 1990s and until 2002 energy related emissions have been increasing, mainly due to higher activity in the offshore-

and transport sectors. From 1990 to 2002 the increase in emissions from the energy sector was 25 per cent. The emission growth has been particularly strong in the petroleum sector, where emissions increased by almost 60 per cent from 1990 to 2002. Emissions from Norway except the petroleum sector were relatively stable in the same period; these emissions were reduced by 2.7 per cent from 1990 to 2002.

The second most important sector with regard to the size of emissions of greenhouse gases in Norway is industrial processes. This sector accounts for 18 per cent of the total national emissions of greenhouse gases. Production of raw materials is the main source of process-related industrial emissions of both CO_2 and other greenhouse gases such as N_2O (fertiliser production), SF_6 (magnesium foundries) and PFCs (aluminium production). Between 1990 and 2002 the sector has experienced an overall decrease of 29 per cent. However, from 1992 onwards these emissions have been relatively stable, with the downward trend of PFCs emissions being counterbalanced by rising emissions of CO_2.

The contribution of the agricultural sector to the total emissions of greenhouse gases is 9 per cent. This sector has experienced a reduction over the period 1990-2002, which amounts to 4 per cent. Agricultural practices mainly result in emissions of methane and nitrous oxide, as well as indirect emissions of CO_2. The largest sources in this sector are N_2O from soil processes and CH_4 from enteric fermentation.

The waste sector contributes about 7 per cent of total Norwegian greenhouse gas emissions. There has been a slight increase in these emissions since 1990, amounting to about 2 per cent. Waste volumes have increased quite significantly over the period, but this has been counteracted by increased recycling of waste and increased burning of methane from landfills. As a consequence the emissions from waste treatment have been relatively stable over the period.

Solvent and other product use accounts for only 0.2 per cent of the total emissions of greenhouse gases in the country. This contribution has been more or less unchanged since 1990.

In the land-use change and forestry sector (LUCF**)**, the gross increment of carbon in Norwegian forests was estimated at 36 million tonnes of CO_2 in 2002. A total of 16 million tonnes CO_2 was emitted due to harvesting or depletion, which resulted in a net removal of 20 million tonnes CO_2. The sequestration of CO_2 in forest and agricultural soil and harvested wood products is not included in these figures. However, the emissions from liming of agricultural soils (0.1 million tonnes) have been calculated. Comparing the removals with the total emissions of greenhouse gases, one finds that as much as about 36 per cent of the emissions are offset by CO_2 uptake due to forest regrowth. This considerable accumulation is due to a large increment in the standing volume of forests.

In 2002, CO_2 emissions from international marine and aviation bunkers amounted to 2.9 million tonnes. These emissions are not included in the national totals, but reported separately as required by the UNFCCC reporting guidelines. From 1990 to 2002, the CO_2 emissions from ships in international traffic increased by 48 per cent, while CO_2 emissions related to international aviation increased by 19 per cent over the same period. The reason for this increase is simply a growth in traffic. Aircraft are more fuel efficient now than they were earlier in the period, which means that the growth in international air traffic has been even higher than what is indicated by the growth in emissions. Between 2001 and 2002 emissions

from marine and aviation bunkers were reduced by 12 and 16 per cent respectively, continuing the downward trend which started in 1998 for international shipping and in 2000 for aviation.

Precursors and SO_2

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

NO_x emissions decreased by about 5 per cent from 1990 to 2002, primarily because of stricter emission regulations with regard to road traffic, which counteracted increased emissions from oil and gas production and from navigation. The emissions of NMVOC experienced an increase of 17 per cent in the same period, mainly because of the rise in oil production (over 50 per cent of the emissions originates from this sector). However, the emissions decreased by 12 per cent from 2001 to 2002 because of increased recycling of oil vapour offshore at loading and storage terminals. Emissions of CO have decreased by 39 per cent over the period 1990-2002. The explanation is primarily new emissions standards for motor vehicles. With regard to emissions of SO_2, they were reduced by 58 per cent from 1990 to 2002. This can mainly be explained by a reduction in sulphur content of all oil products and lower process emissions from ferroalloy and aluminium production and refineries.

Emissions trends compared to GDP

The figure below shows the development of the total emissions of greenhouse gases in Norway, of CO_2 alone as well as of Norway's GDP during the period 1990-2002 compared to the situation in 1990. We see that the growth in GDP has been more prominent for the whole period than the growth in emissions of total greenhouse gas emissions and only CO_2-emissions.

The total growth in GDP from 1990-2002 was about 50 per cent, which by far outpaces the 6 per cent growth in total greenhouse gas emissions over the same period. Looking at the figure below, we see that GDP and CO_2-emissions grew with about the same rate between 1992 and 1996. After 1996 the growth in GDP has continued, while CO_2 as well as the total GHG-emissions have more or less stabilised.

If we consider another indicator; emissions per capita, we find a small reduction from 12.3 tonnes CO_2-equivalents per capita in 1990 to 12.2 tonnes in 2002. Calculating the per capita emission factor by using the preliminary total emissions figure for 2003, we find that the figure is back at 12.3 tonnes CO_2-equivalent in 2003.

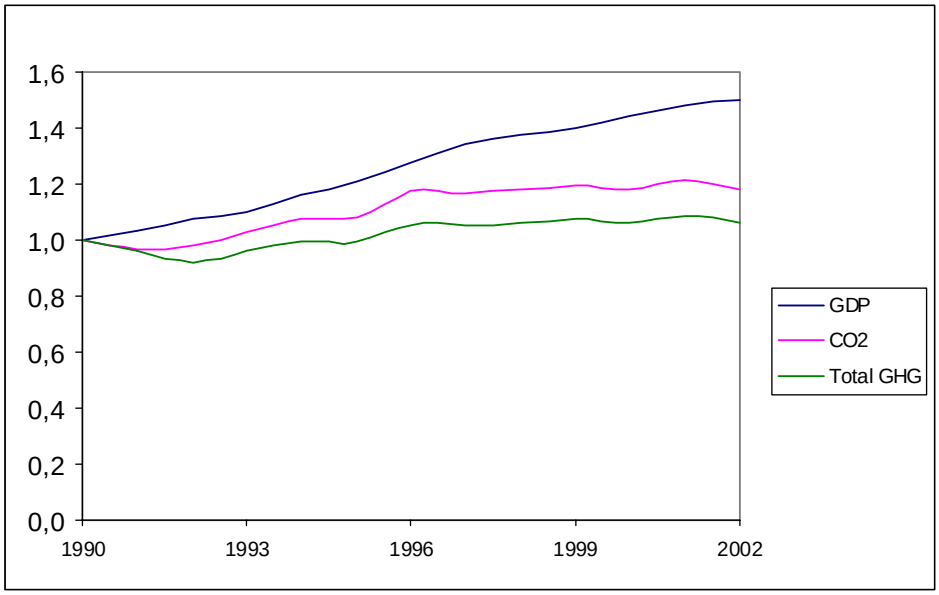


Figure 2. Development of total emissions of greenhouse gases in Norway, of CO_2 alone and of Norway's GDP during the period 1990-2002 compared to the situation in 1990. Source: SN/SFT.

Chapter 1. Introduction

1.1 Background

The 1992 United Nations 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 under the Convention is that Parties are required to report on their national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using methodologies agreed upon by the Conference of the Parties to the Convention (COP).

With the adoption of the Kyoto Protocol in 1997, Norway is faced with the requirement to restrict the increase of its collective greenhouse gas emissions to not more than 1 per cent from the 1990 level by the commitment period 2008-2012. Norway ratified the Kyoto Protocol on 30 May 2002.

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 three desk reviews, in 2000, 2001 and 2003 respectively. In addition, an in-depth country review held in Oslo in October 2002. We have tried to include information on issues commented upon by the reviewers in the report.

The present report together with the associated Common Reporting Format (CRF) tables is Norway's contribution to this round of reporting under the Convention, and it covers emissions and removals in the period 1990-2002. 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* 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 Change and Forestry sector (LUCF), the IPCC is currently preparing a "Good Practice Guidance" report due later this year. We are aware of the fact that the current reporting of this sector has some limitations, but it will be improved when the IPCC report is finalised. The next NIR will most likely contain updated LUCF figures calculated with the new methodology.

The greenhouse gases included in the national inventory are the following: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). We have also included calculations of emissions of the precursors NOx, NMVOC and CO as well as SO_2, which should be included according to the reporting guidelines. 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

There are two main actors in the reporting of national GHG emissions to the UNFCCC; the Norwegian Pollution Control Authority (SFT) and Statistics Norway (SN). The flow of information and distribution of responsibilities between the two institutions is illustrated in Figure 2.

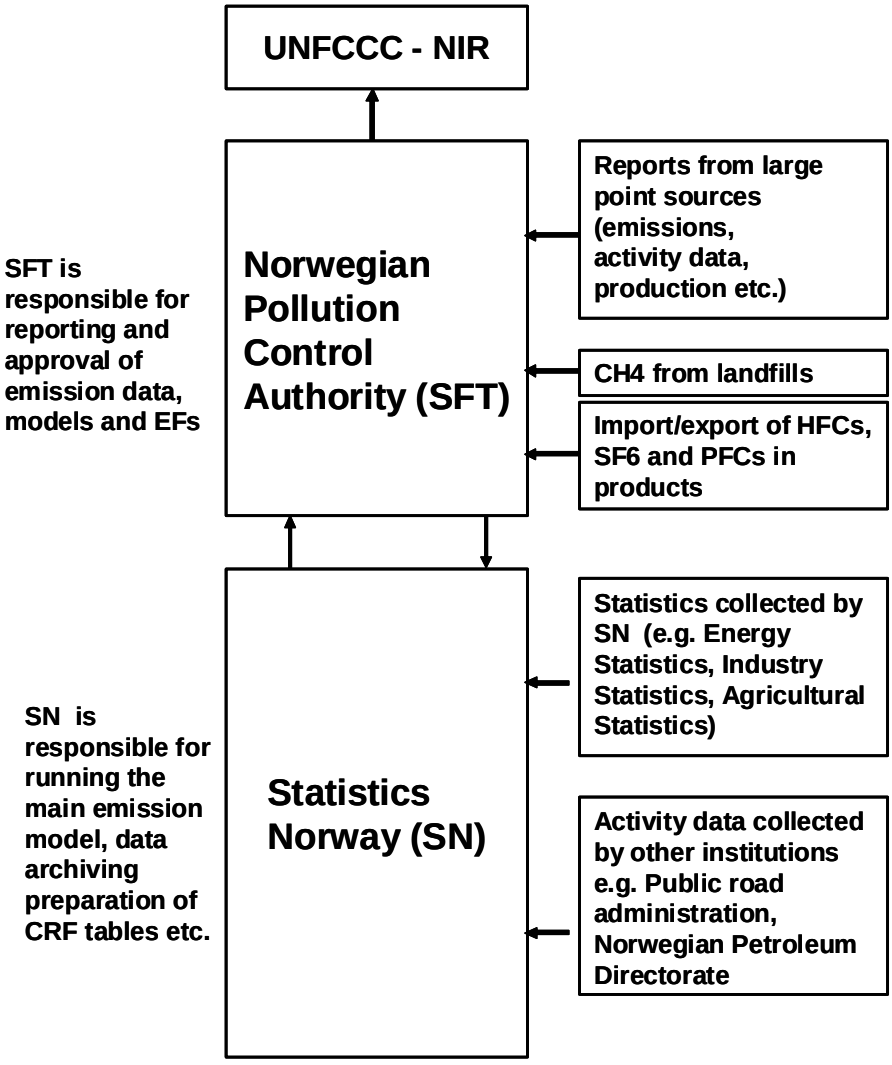


Figure 3. Information flow in the Norwegian emission inventory system for reporting to the UNFCCC.

SFT has the overall responsibility for the annual reporting to the UNFCCC. SFT is also responsible for the approval of emission data, models and emission factors (EFs). Additional responsibilities include the supply of:

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

SN has the responsibility for most of the emission calculations described in the report. Furthermore, Statistics Norway is responsible for:

- Collection of activity data;
- Operation and further development of models for emission estimation;
- Production of CRF tables.

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

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

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

* The preliminary and final[1] emissions figures are published in a joint SN/SFT press release

1.3 The process for inventory preparation

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). With only one exception; the SFT model calculating emissions from landfills, these models are operated by Statistics Norway. Their structure is described in detail in the reports SN/SFT 2000 and SFT 1999b.

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

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 over the last years been under continuous development 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 should provide activity data, emission figures and information about the particular source and it should address compliance with current environmental standards. SFT supplies SN with data from INKOSYS relevant for the preparation of the national emission inventory.

Data collection, processing and storage

SN collects the bulk of data necessary to run the general emission model, namely, activity levels, emission factors, aggregated results from the side models and emission figures for point sources.

The collected data are subjected to the 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 SN. Relevant information including dates and procedures followed are also recorded.

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

1.4 Methodologies and data sources used

The estimation methods of all greenhouse gases are harmonised with the current IPCC Guidelines for National Greenhouse Gas Inventories and are in accordance with IPCC's 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.

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

The emissions in the Norwegian inventory are calculated by a four-dimensional cube model, with the axes components, technical emission sources, emission carriers (e.g. fuels) and

economic sectors. This model includes the greenhouse gases CO_2, CH_4 and N_2O and in addition the precursors NO_X, SO_2, NMVOC, CO and some other gases such as heavy metals and particles. Thus, emissions can be listed by a multitude of combinations of fuels, sources and sectors. Emissions from combustion are calculated by combining the fuel consumption distributed on emission sources and economic sectors with fuel-, source-, sector- and pollutant specific emission factors. Whenever measured emissions are available, these are used instead of the calculated figures. Aggregated emission factors are input to the main emission model. Non-combustion emissions are estimated by combining activity data with emission factors through more complicated calculations. They are then fitted into the cube model by an appropriate emission carrier, emission source and economic 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 calculations of greenhouse gas emissions measured as CO_2 equivalents are based on data on global warming potentials (GWP) for the different GHG, calculated for a time horizon of 100 years, from IPCC's Second Assessment Report from 1995, as required by the UNFCCC reporting guidelines.

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

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

- *Activity levels* – these are mostly taken from official statistical sources available internally in SN and other material available from external sources (see also Section 1.2). When such information is not available, research reports are used or extrapolations are made from expert judgements.
- *Emission factors* – these are taken primarily from reports on Norwegian conditions and are either estimated from measurements or taken from 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 taken from 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 (based on measurements or calculations at the plants).

1.5 Key source categories

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

A key source analysis was performed in March 2004, see the table below for identified key sources. It was performed at the level of IPCC source categories and each greenhouse gas from each source category was considered separately with respect to total GWP weighted emissions. The advantage in using a Tier 2 rather than the Tier 1 methodology is that uncertainties are taken into account so the ranking shows where uncertainties can be reduced. In addition, the Tier 1 method can identify sources that are not actually key sources according to Tier 2 (SN 2001e).

Table 2. Summary of identified key sources.

IPCC	Source category	Gas	Level assessment		Trend assessment
			1990	2000	2000
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO_2	2.63 %	4.29 %	7.00 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO_2	1.23 %	1.08 %	1.01 %
1A3a	Civil Aviation	CO2		0.83 %	0.80 %
1A3b	Road Transportation	CO_2	7.21 %	8.61 %	4.75 %
1A3b	Road Transportation	N_2O		3.31 %	13.01 %
1A3d	Navigation	CO_2	0.91 %	1.05 %	
1B2a	Oil (incl. oil refineries, gasoline distribution)	CH_4	1.70 %	2.08 %	1.49 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO_2			1.37 %
1B2c	Venting and Flaring	CH_4		0.79 %	1.38 %
1B2c	Venting and Flaring	CO_2	0.74 %		0.71 %
2C2	Ferroalloys Production	CO_2	0.86 %	0.77 %	
2C3	Aluminum Production	PFC	6.08 %	2.05 %	20.03 %
2C4	SF6 Used in Aluminum and Magnesium Foundries	SF_6			2.20 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC		0.67 %	3.07 %
4A1	Cattle	CH4	1.66 %	1.57 %	0.82 %
4D1	Direct soil emissions	N_2O	29.33 %	47.00 %	43.05 %
4D2	Animal production	N_2O	1.31 %	3.62 %	3.52 %
4D3	Indirect emissions	N_2O	0.88 %	10.16 %	10.49 %
6A	Solid Waste Disposal on Land	CH_4	1.37 %	6.25 %	6.27 %

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. Norway provided the first greenhouse gas emissions inventory in 1993, and the emission estimation methodologies and the QA/QC procedures have been developed continuously since then. Norway has not yet implemented a formal quality assurance/quality control or verification plan, but SFT has started elaborating on elements to be included in such a plan in order to comply with the UNFCCC Guidelines on reporting and review. The established QA/QC procedures include the following:

- SFT (as the preparing agency) has the overall responsibility for coordinating the QA/QC procedures, while SN is responsible for the quality control system with regard to technical activities of the inventory preparation
- A Tier 1 general inventory level QC procedures, as listed in Table 8.1 of the IPCC Good Practice Guidance is performed each year
- Source category-specific QC procedures are performed for most sources, for both emission factors, activity data and uncertainty estimates (Tier 2)

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. As we understand it, this means that we perform a basic expert peer review (Tier 1). We have started discussing whether or not also to perform more extensive external peer reviews and/or audits (Tier 2), as a part of the elaboration of steps and procedures to be included in a QA/QC plan.

There is no formalised procedure of verification of emission data in Norway. This is another element to be assessed during the elaboration of a QA/QC and verification plan.

SN, SFT and NIJOS (LUCF) each 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 this year compared to previous years since we have incorporated information on methodologies used in this inventory report. Nevertheless, we will consider a joint, formalised procedure with regard to archiving when developing the QA/QC plan.

1.6.2 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 next update is made about one year after the inventory year. At this stage, statistics are available for more sources and emissions data from point sources have been subjected to 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 compiled. In itself, this stepwise procedure is a part of the QA/QC 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 are for the first time recognised as a source, SFT delivers all relevant information to SN. This information is then thoroughly checked by two members of the inventory team at SN. All changes in methodologies or data are documented and kept up to date.

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 SN control and verify emission data reported to SFT by industrial enterprises, registered in INKOSYS. First SFT checks the data received from these plants, and if errors are discovered, they may then ask the plants' responsible to submit new data. Subsequently, SN makes, where possible, comparable emission calculations based on activity data sampled in official statistics and deviations are explained through contact with the plants.

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

All parameter values are compared with values used in previous years and with any preliminary figures available. Whenever large deviations are detected, the value of the parameter in question is first checked for typing errors or unit errors. Changes in emissions from large plants are compared with changes in activity level. If necessary, the primary data

suppliers (e.g. NIJOS, OD, VD, various plants etc) are contacted for explanations and possibly corrections.

Check the integrity of database files
A schematic presentation of the structure of the data flow is included in Annex 2. For each step of the process control checks are made that appropriate data processing steps and data relationships are correctly represented. Furthermore, it is verified that data fields are properly labelled and have correct design specifications and that adequate documentation of database and model structure and operation are archived. SN has started a process on updating the documentation of the model, which will be finalised later this year.

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

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

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

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

Check methodological data changes resulting in recalculations
Emission time series are recalculated every year in order to account for methodological changes. The recalculated emission data for a year is compared with the corresponding figures estimated the year before. For example, CO_2 data calculated for 1990 in 2002 are compared with the 1990 CO_2 data calculated in 2003. All major differences are explained. 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 (Ch. 1.8.). There may of course, exist sources of greenhouse gases which are not covered. However, we are quite certain that emissions from potentially additional sources are very small or negligible.

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

1.6.3 Source category-specific QC procedures

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

The QC procedures with regard to emissions data, activity data and uncertainty estimates for the different emission sources are described in the QA/QC-chapters of the relevant source-categories. The source category-specific analyses have primarily been performed for key sources on a case-by-case basis, which is described as being good practice. We realise that the QA/QC process for many of the sources should be improved, and will work on this in the future.

1.6.4 Verification studies

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

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

been. These errors have been corrected in later reports to the UNFCCC. We do realise that this method of verification only considers consistency compared with what other countries report. It is not a verification of the scientific value of the inventory data themselves.

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

1.6.5 Documentation, archiving and reporting

As already mentioned, SN, SFT and NIJOS (LUCF) have established procedures with regard to documentation and archiving of the information which have been used to produce the national emissions inventory estimates. For example, all input data used in model runs, the versions of the models used and the model output, as well as dates and procedures followed are stored at SN. Furthermore, we believe that the transparency of the inventory has been improved this year compared to previous years since we have incorporated information on methodologies used in this inventory report. We will consider a joint, formalised procedure with regard to archiving when developing the QA/QC plan.

1.6.6 Confidentiality issues

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

1.7 Uncertainty evaluation

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

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

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

The major elements of the most recent work on emission uncertainties in Norway (SN, 2000) are summarised in the tables presented in Annex 6. These tables list the standard deviation

and probability density of the activity data and emission factors found under the various IPCC source categories, as well as the estimated uncertainties in emission level and in trend for the greenhouse gases under consideration.

1.8 General assessment of the completeness

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

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

In the case of temporal coverage, the major point to be addressed is that CRF tables are reported for the years 1990, 1998, 1999, 2000, 2001 and 2002. For the years 1991 to 1997 we have only included Summary II CRF tables. Complete set of emission figures do exist, but are only available in another electronic format than the one presently required by the UNFCCC. Norway plans to submit a complete set of CRF tables for all years in the next round of reporting. We assume that we will start using the new reporting format by then, which will make the reporting work less time consuming.

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

- Emissions of N_2O from aerosol propellant used in spray box and emissions from technical N_2O used in scientific work and in workshops. These emissions amount to about 10,000 kg N_2O/year and will be included in next year's submission.

- Emissions of N_2O from ferroalloys production. These emissions are estimated to almost 300 tonnes and will be included in the next year's submission.

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

- Removals of CO_2 in forest and agricultural soils (category 5D) and non-CO_2 gas emissions and removals from forest soils and residues.

- Emissions/removals of greenhouse gases from abandonment of managed lands (category 5C) is only partially included since the inventory is focused on forest land. However, land use changes (category 5B and 5C) occur at a very small scale in Norway (see Section 7.1).

- Carbon stock change of harvested wood products and from the cultivation of mineral, organic and forest soil. The IPCC default method is used, where harvested wood is counted as emissions the year the harvest takes places.

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. Regarding LUCF, a project has been initiated this year, with the aim to find data and prepare the reporting in this sector, following the new Guidelines. We believe that this work will make us able to include calculations regarding the two last bullets in next year's submission.

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

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

In October 2002 the Norwegian emission inventory system was inspected by an expert review team (ERT) hosted at SFT (in-country review). The team concluded that the national inventory submission was in conformity with the UNFCCC reporting guidelines, and that Norway has an excellent inventory program that systematically reviews and targets areas of improvement through key source identification. It was also noted that the existing institutional arrangement facilitates consistency in reporting.

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

a) Need for inclusion into the NIR of supporting information on choices for and sources of emission factors and data to aid explanation of information gaps.
b) Lack of notation keys in some CRF tables
c) Lack of full transparency in the LUCF sector in terms of documenting underlying processes, use of notation keys, values assigned to different parameters, and documentation on the decision-making process.
d) Lack of full CRF time series (in particular for the years 1991-1997)
e) Lack of calculation sheets[2]
f) Lack of clear indication of methods used in some sectors (e.g. agriculture, waste)
g) Lack of clear indication of the rationale and complexity of the methodologies used
h) Lack of some CRF tables referring to agriculture and LULUCF (Tables 4Bb, 4C, 4E, 5B, 5C and 5D).

[2] According to the UNFCCC reporting guidelines, the NIR should include calculation sheets or equivalent database information on detailed inventory calculations in each sector, for all years from the base year to the year of the current annual inventory submission, containing, *inter alia*, disaggregated national emission factors and activity data underlying the estimates (FCCC/CP/1999/7, paragraph 33(b)). This reporting requirement was, however, dropped from the revised UNFCCC reporting guidelines, which were agreed upon by the Subsidiary Body for Scientific and Technological Advice (SBSTA) at its sixteenth session.

With the exception of (e), the ERT recommended that Norway add these elements to future NIRs.

The present report addresses the above points to the extent that that has been possible. In particular, the various sectors are described in more detail now than in last year's report, especially those of agriculture and LUCF. CO_2 capture and storage, which is of relevance for Norway, is also described in this report. As mentioned earlier in this section, the use of notation keys is now more extensive than before. Furthermore, Table 4Bb is now completed with data on N_2O emissions from Manure Management. CO_2 emissions from liming of agricultural soils are reported under 5D-CO_2 Emissions and Removals from Soil, according to the Good Practice Guidance. Full CRF-tables have only been provided for the years 1990 and 1998-2002, and we have added Summary II tables for the years 1991-1997. We will participate in the test phase of the new CRF-tables later this year; hence we assume that full CRF time series will be submitted next year.

Chapter 2. Trends in Greenhouse Gas Emissions

2.1 Emission trends for aggregated greenhouse gas emissions

The total amounts of greenhouse gases emitted in Norway during the period 1990-2002 are in the following expressed in terms of contribution by gases and by sources.

Table 3 below presents emission figures for all direct greenhouse gases, expressed in CO_2 equivalent along with their change indicated for both the time periods 1990-2002 and 2001-2002. The trend in the total national GHG emissions by gas is visualised in Figure 5, and by source category in Figure 16.

Table 3. Emissions of greenhouse gases in Norway during the period 1990-2002 (without LUCF). Empty cells indicate emission not occurring. Units: CO_2 and CO_2–eq. in Mtonnes, CH_4 and N_2O in ktonnes and other gases in tonnes. Source: SN/SFT

	Year													Change	
Gas	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**90-02**	**01-02**
CO_2	34.7	33.6	33.9	35.6	37.3	37.4	40.6	40.6	40.8	41.3	40.9	42.1	40.9	18 %	-3 %
CH_4	307.1	311.5	315.6	321.8	325.9	328.7	332.4	334.9	331.0	328.9	333.7	333.4	327.4	7 %	-2 %
N_2O	17.8	17.3	15.1	16.3	16.6	16.9	16.9	16.7	17.6	18.3	17.9	17.9	18.8	6 %	5 %
CF_4	479	369	294	290	251	229	214	201	185	164	131	152	163	-66 %	14 %
C_2F_6	20	14	11	10	9	8	5	8	7	6	5	6	7	-65 %	20 %
SF_6	92	86	29	30	36	24	23	23	29	35	37	32	10	-89 %	-69 %
HFC 134a		0.0	0.2	1.8	5.4	10.2	17.2	26.2	38.2	50.2	61.1	71.8	85.8		19 %
HFC 152a	0.1	0.4	0.7	0.8	0.8	1.0	1.5	2.4	4.8	6.0	7.7	10.2	12.4		22 %
HFC 125					0.5	2.4	5.5	9.7	14.7	19.9	25.9	32.9	41.2		25 %
HFC 143a					0.2	1.5	3.9	6.8	10.4	14.7	20.3	26.9	34.7		29 %
HFC 23					0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1		6 %
HFC 32					0.0	0.0	0.0	0.2	0.3	0.6	1.0	1.5	2.2		47 %
HFC 227ea							0.0	0.1	0.2	0.2	0.2	0.3	0.8		167 %
Total CO_2-eq.	**52.1**	**50.1**	**47.9**	**50.1**	**51.9**	**51.7**	**54.8**	**54.8**	**55.3**	**56.0**	**55.4**	**56.7**	**55.3**	**6%**	**-2 %**

Total emissions show a marked decrease between 1990 and 1992 and an increase thereafter with small interruptions in 1995, 2000 and 2002. Looking at the overall trend from 1990 to 2002, we see that the emissions increased by about 6 per cent. Between 2001 and 2002, the total emissions decreased by about 2.5 %, and in 2002 the emissions amounted to 55.3 million tonnes CO_2 equivalents. So far, 2001 has been the year with the highest emissions recorded.

Norway has experienced economic growth since 1990, which explains the general growth in emissions. This has resulted in higher CO_2 emissions from most sources, but in particular from gas and oil extraction and to a lesser extent from the transport sector and the consumption of oil products in industry. The emissions of CH_4 and N_2O have been relatively stable over the same period. The overall increasing trend has to some degree been counteracted by decreased emissions of PFCs and SF_6 from aluminium and magnesium plants. By contrast, emissions of HFCs have had an explosive increase since 1990, rising from

0.02 ktonnes CO_2 equivalents in 1990 to a total of 365 ktonnes CO_2 equivalents for all HFC components of relevance in Norway in 2002.

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

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

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

The overall increase between 1990 and 2002 is 6 per cent. This means that Norway will have to reduce its national GHG emissions by 5 per cent in order to achieve the emission target of 1 per cent required by the Kyoto Protocol by the period 2008-2012 if the emissions stabilise at this level. Preliminary calculations of the GHG emissions in 2003 indicate an increase of 2 per cent since 2002. The development from 1990 to 2003 is hence an increase of 8 per cent, which is 7 per cent above the Kyoto commitment.

2.2 Emission trends by gas

As shown in Figure 4, CO_2 is by far the largest contributor to the total GHG emissions, followed by CH_4 and N_2O, and then the fluorinated gases PFCs, SF_6 and HFCs. In 2002 the relative contributions to the national totals from the different gases were; CO_2: 74 per cent, CH_4: 12 per cent, N_2O: 10 per cent, PFCs and SF_6 less than 2 per cent each and HFCs less than 1 per cent. The fluorocarbons constituted a larger fraction of the greenhouse gas emission total in the early 1990s than that in 2002. On the other hand, CO_2 represented a smaller share in 1990 than in 2002.

Figure 5 illustrates the change in emissions of greenhouse gases by gas in Norway 1990-2002, compared to 1990. We will describe these trends further for each of the six greenhouse gases in the following.

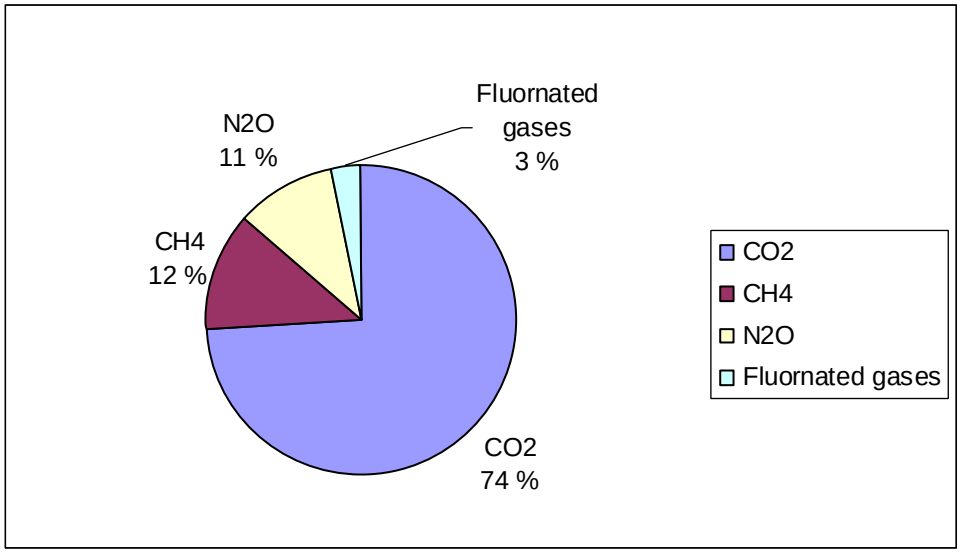


Figure 4. Distribution of emissions of greenhouse gases in Norway by gas, 2002. Source: SN/SFT

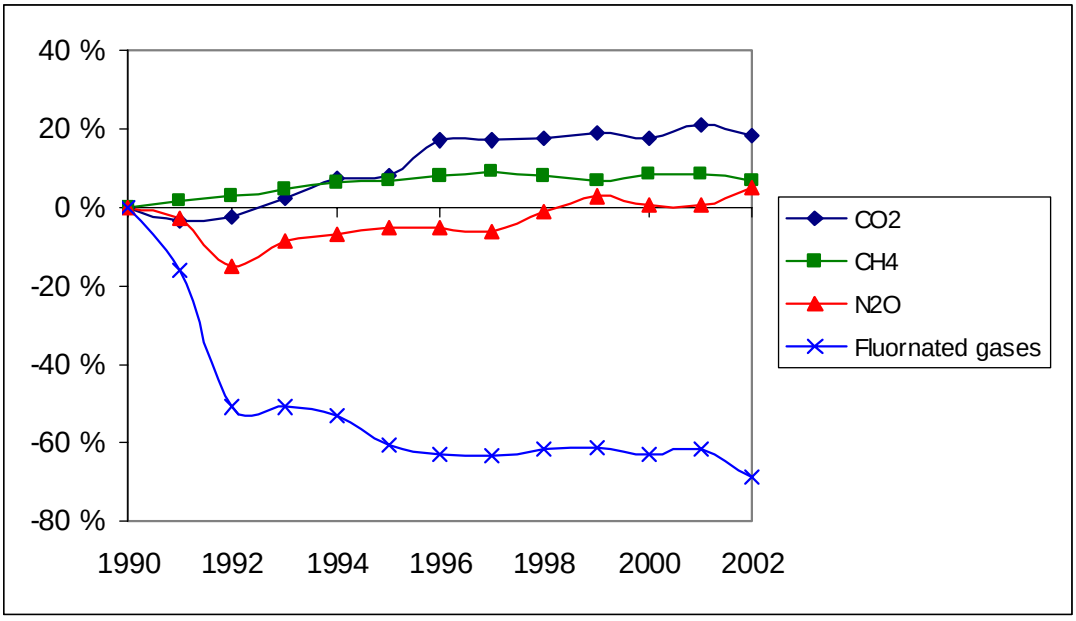


Figure 5. Changes in emissions of greenhouse gases by gas in Norway 1990-2002, compared to 1990. Source: SN/SFT

2.2.1 Carbon dioxide (CO_2)

The Norwegian CO_2 emissions originate primarily from industrial sources related to oil and gas extraction and the production of metals, as well as from the transport sector. A relatively large share of the transport-related emissions originates from coastal navigation and the fishing fleet. Since generation of electricity is almost exclusively hydroelectric, emissions from stationary combustion are dominated by industrial sources and internal energy use. Table 4 lists CO_2-emissions from each source category for the whole period 1990-2002. The

distribution of CO_2 emissions over the various source categories is shown in Figure 6, and the change in emissions from 1990 to 2002 compared to 1990 is displayed in Figure 7.
From 1990 to 2002 the total CO_2 emissions increased by 18 per cent. 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 2002 the total Norwegian emissions of CO_2 were 40.9 Mtonnes, which is a decrease of about 3 per cent from the preceding year. We see from the table below that this was caused by emission reductions related to stationary combustion, oil and gas industry and industrial processes.

Table 4. CO_2-emissions from different source categories for the period 1990-2002. Mtonnes. Source: SN/SFT

Emissions, Mtonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Stationary combustion	7.1	6.5	6.4	6.5	7.4	6.9	8.3	7.7	7.9	7.8	6.9	7.4	7.1
Oil and gas industry	7.5	7.5	7.9	8.3	9.0	9.1	9.9	10.4	10.0	9.9	11.2	11.9	11.6
Industrial processes	7.0	6.8	6.6	7.2	7.4	7.5	7.9	7.7	7.8	7.8	8.1	7.7	6.9
Road transportation	7.9	7.8	8.0	8.4	8.2	8.4	8.9	8.9	9.1	9.3	8.8	9.3	9.5
Coastal traffic and fishing	3.2	3.0	3.1	3.2	3.1	3.2	3.4	3.6	3.8	4.1	3.6	3.6	3.6
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
Total	**34.7**	**33.6**	**33.9**	**35.6**	**37.3**	**37.4**	**40.6**	**40.6**	**40.8**	**41.3**	**40.9**	**42.1**	**40.9**

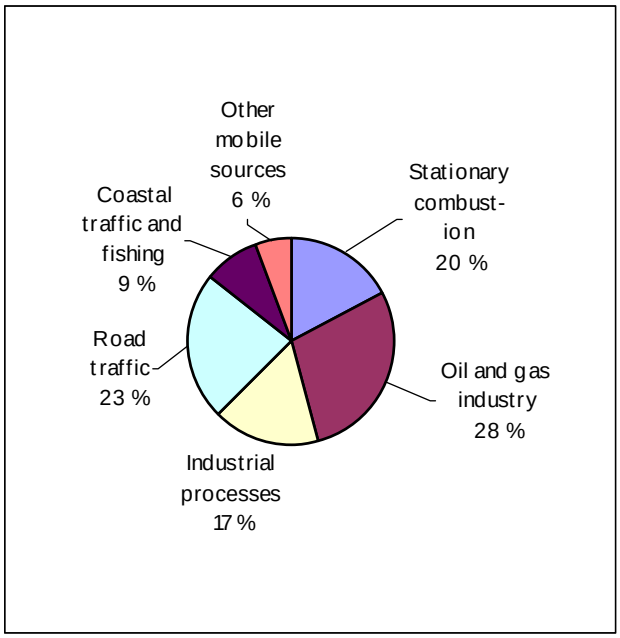


Figure 6. Distribution of CO_2 emissions in Norway by source in 2002. Source SN/SFT

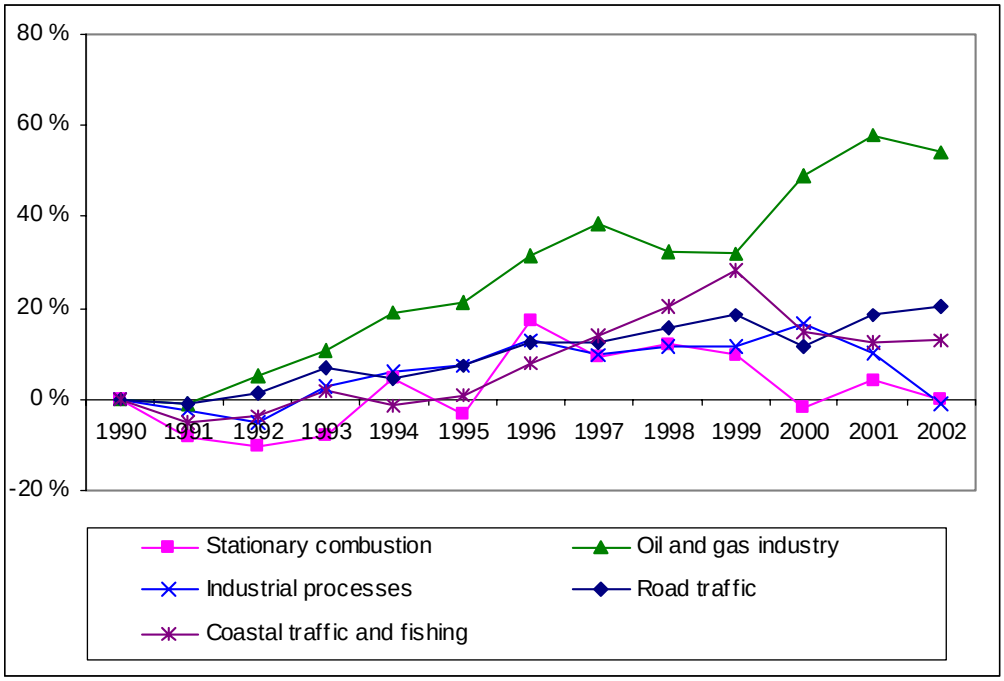


Figure 7. Changes in Norwegian CO_2 emissions 1990-2002 for major sources compared to 1990. Source: SN/SFT

Emissions from the oil- and gas industry increased by about 55 per cent since 1990 as a result of large increases in production volume of oil and gas and the export of natural gas in pipelines. However, emissions per unit produced oil/gas have been decreasing, because of technical and administrative improvements partly induced by a CO_2-taxation regime in 1991. Nevertheless, this trend has been counteracted in the last few years, due to technical factors related to a shift to older and more marginal oil-and gas fields and shift in production from oil to gas. Production of gas is more energy demanding than production of oil. From 2001 to 2002 the emissions decreased by 3 per cent, which first and foremost may be explained by lower emissions from venting and flaring offshore. This effect exceeded the counteracting effect from increased use of natural gas offshore during the same period.

Regarding road transportation, an increase of 21 per cent is detected in the CO_2 emission figures from 1990 to 2002. This rise is primarily attributed to the large increase (80 per cent) in the emissions from diesel vehicles over the years. Although emissions from gasoline vehicles decreased by 7 per cent during this period, this fall was counteracted by the significant shift from gasoline to diesel vehicles. The emissions increased by about 7 per cent between 2000 and 2001, which may partly be explained by the unusually low emission estimates for 2000 due to changes in fuel taxes as explained in Section 2.1. Between 2001 and 2002 the emissions continued the upward trend with an increase of about 2 per cent.

Emissions of CO_2 from navigation (coastal traffic and fishing) have increased by ca.16 per cent from 1990 to 2002, mainly due to increased activity in the petroleum sector. The substantial increase in the production of Norwegian oil and gas in the North Sea during the 1990s resulted in increased traffic of supply boats to and from the oil platforms until 1999. The emissions decreased by about 12 per cent from 1999 to 2000, and they have been quite stable since then until 2002.

Chemical production (industrial processes; fertilisers, carbides and petrochemicals) has had a decrease in CO_2 emissions by about 1.5 per cent from 1990 to 2002. Emissions from this source have not been this low since 1992. This reduction is mainly a result of close-downs and reductions in the ferroalloy- and magnesium industry.

In the heating sector (commercial, institutional and residential), which represent ca. 24 per cent of the stationary combustion figure, there has been a reduction in CO_2 emissions by 22 per cent from 1990 to 2002. This CO_2 emission reduction is mainly caused by increase in the use of electricity rather than oil. However, these emissions are very sensitive to winter temperatures and fuel prices, since many heating systems have the possibility to switch to oil when electricity prices are high. The winter temperatures were especially low in 2002, which resulted in a strong increase in the sales of oil for heating compared to the precedent year. Consequently, CO_2-emissions from heating were about 7 per cent higher in 2002 than in 2001.

Civil aviation is one of the sources contributing less to the national emission total than the above categories. We would, however, like to describe the emissions development since 1990. During the period 1990-2002 emissions increased by 34 per cent from this source. This development is due to rise in the number of civil flights. The steady upward trend recorded in the 1990s peaked at 1.2 million tonnes in 1999. Due to overcapacity in domestic air transport in the late nineties, one company left the market in 2000. This led to reduced activity levels and a subsequent emission reduction of about 9 per cent between 1999 and 2000/2001. We see now that emissions have continued the downward trend with a decrease on 14 per cent from 2001 to 2002.

2.2.2 Methane (CH_4)

As can be seen from Table 5 and Figure 8, about 57 and 33 per cent of the emissions of methane in 2002 originated from waste treatment and agriculture respectively. These sources are relatively stable from year to year, and are little affected by short-term economic cycles. Methane emissions from agriculture are dominated by releases from enteric fermentation contributing 25 per cent to the total methane figure in 2002. Combustion and evaporation/leakage in the oil- and gas industry accounted for 14 per cent of the total emissions in 2002, the largest fraction of which is releases of methane (venting) during the loading and unloading operations offshore. Minor sources include emissions from petrol cars, manure management domestic heating and coal mining.

The total methane emissions decreased by about 2 per cent from 2001 to 2002. During the period 1990-2002 the total CH_4 emissions increased by about 7 per cent. Figure 9 shows that this increase is primarily due to increased emissions from oil- and gas industry.

The emission trend is characterised by a slow increase in the first half of the 1990s until 1997. From 1997 until 2002 emissions have been quite stable with small fluctuations. This is primarily due to emission changes in the oil- and gas industry because of changes in production volumes. Methane emissions from waste treatment were relatively stable throughout the 1990s with a slow upward trend, but they have experienced a small decrease from 2000 to 2002 of about 2 per cent. The waste volumes have grown during the period (1990-2002), but have been offset by increased recycling of waste, increase burning of waste and increased burning of methane from landfills. Over the period 1990-2002 the overall methane emissions from agriculture decreased by approximately 1 per cent, particularly due

to reduced population of cattle with a subsequent decrease in the emissions from enteric fermentation.

Table 5. Emissions of CH_4 in Norway 1990-2002, ktonne. Source: SN/SFT

Emissions, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Landfills	181.7	184.1	184.0	186.7	187.9	189.3	191.4	190.2	187.7	187.6	188.9	185.4	184.2
Agriculture	95.7	97.3	97.5	96.5	97.6	98.8	99.8	100.0	101.0	100.3	98.7	96.1	95.0
Oil and gas extraction	15.8	17.6	22.1	25.6	27.1	27.3	27.6	30.9	28.9	27.5	32.4	37.5	33.9
Other sources	13.8	12.5	12.0	13.0	13.4	13.3	13.7	13.8	13.6	13.4	13.7	14.4	14.3
Total	**307.1**	**311.5**	**315.6**	**321.8**	**325.9**	**328.7**	**332.4**	**334.9**	**331.0**	**328.8**	**333.7**	**333.4**	**327.4**

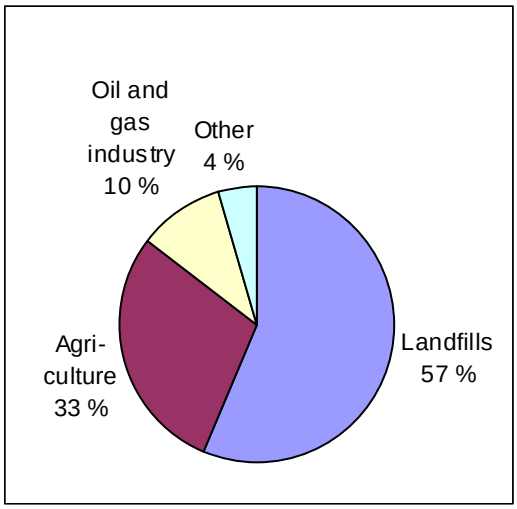


Figure 8. Distribution of Norwegian CH_4 emissions by source in 2002. Source: SN/SFT

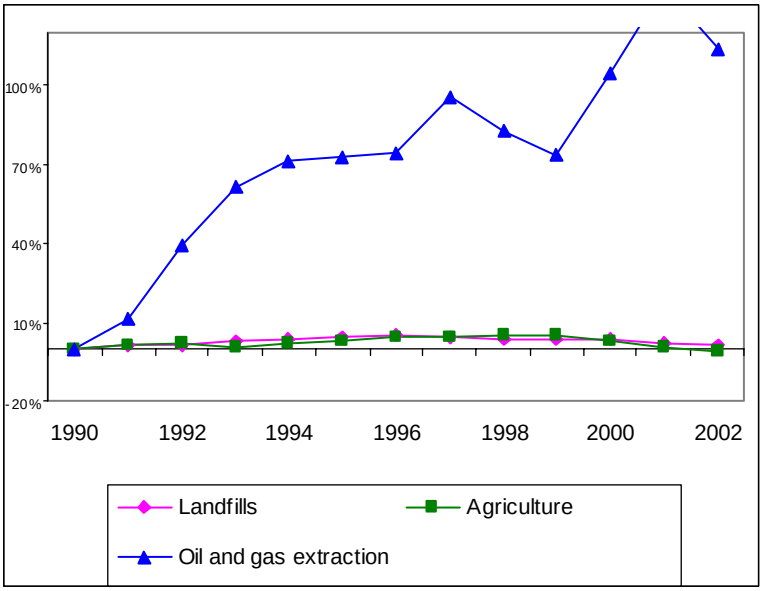


Figure 9. Changes in CH_4 emissions for major Norwegian sources between 1990 and 2002 compared to 1990. Source: SN/SFT

2.2.3 Nitrous oxide (N_2O)

From Figure 10 and Table 6 we see that almost half of the Norwegian emissions of N_2O are of agricultural origin (52 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 36 per cent of the total. The contribution from road traffic amounted to 11 per cent in 2002, with emissions originating from the use of catalytic converters in mobile sources. Included under "other sources" in the table below are emissions from e.g. fuel combustion, manure management and waste-water handling.

The overall nitrous oxide emissions increased by about 6 per cent from 1990 to 2002. Between 2001 and 2002 emissions increased by 5 per cent.

Table 6. Emissions of N_2O in Norway by major sources 1990-2002, ktonne. Source: SN/SFT

Emissions, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Agriculture	9.7	9.7	9.4	9.6	9.4	9.6	9.5	9.5	9.5	9.4	9.4	9.2	9.2
Nitric acid production	6.7	6.1	4.2	5.0	5.4	5.3	5.2	4.8	5.4	6.1	5.6	5.5	6.7
Road traffic	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.5	1.6	1.9	2.1
Other sources	1.2	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	0.8
Total	**17.8**	**17.3**	**15.1**	**16.3**	**16.6**	**16.9**	**16.9**	**16.7**	**17.6**	**18.3**	**17.9**	**17.9**	**18.8**

Emissions of nitrous oxide from agriculture have been rather stable through the 1990s and further on until 2002, with a small reduction from 2000 to 2002 of about 2 per cent. From 1990 to 2002 the total reduction in N_2O emissions from agriculture was 5 per cent. 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. A quite large raise in these emissions took place between 2001 and 2002; 22 per cent, also due to larger production volumes. The emissions from this source are now at the same level as they were in 1990.

Another factor contributing to the rise in emissions the last years is the increasing use of catalytic converters in mobile sources. Emissions of nitrous oxide from road traffic increased about 7 times during the period 1990-2002. This increase is depicted in Figure 11.

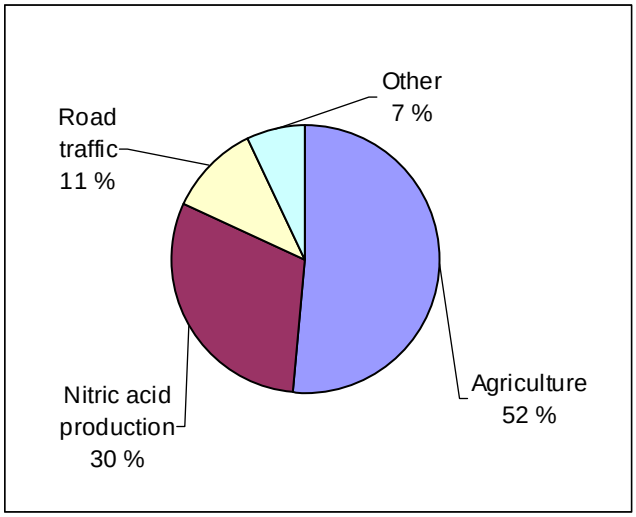


Figure 10. Distribution of Norwegian N_2O emissions by major sources in 2002. Source: SN/SFT

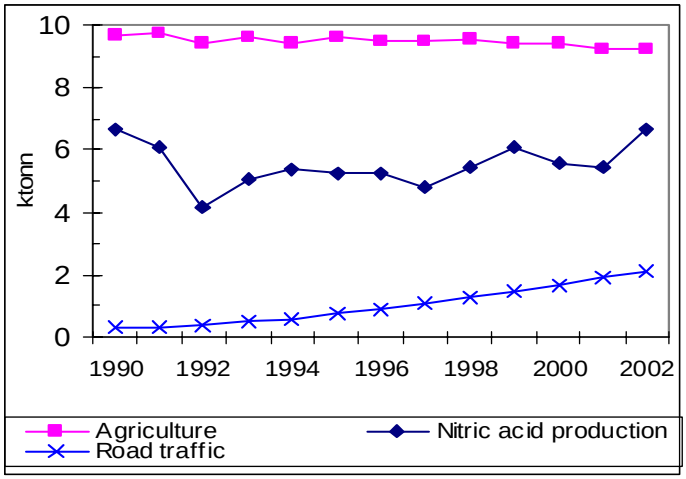


Figure 11. Changes in N_2O emissions for major Norwegian sources between 1990 and 2002. Source: SN/SFT

2.2.4 Perfluorcarbons (PFCs)

The emissions of the perfluorcarbons tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from Norwegian aluminium plants in 2002 were reported at 163 and 7 tonnes respectively, corresponding to a total of 1.1 million tonnes of CO_2-equivalents.

The total emissions of PFCs decreased by 66 per cent in the period 1990-2002 following a steady downward trend as illustrated in Figure 12. Both CF_4 and C_2F_6 decreased by the same amount. PFCs reduction is caused by improved technology and process control, which has led to a 72 per cent decrease in the amount of PFCs emitted per tonne aluminium produced during the period 1990-2002, see Section 4.2 for further details.

PFCs may be used as substitutes for ozone-depleting substances. In Norway, only one compound is used for this purpose, namely C_3F_8 (PFC-218). The actual emissions of C_3F_8

have been calculated at only 55 kg in 2002, corresponding to almost 390 tonnes of CO_2-equivalents. Consumption of halocarbons is also described in Section 4.5.

Table 7. Emissions of PFCs in Norway 1990-2002, tonnes. Source SN/SFT

Emissions, tonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CF_4	479	369	294	290	251	229	214	201	185	164	131	152	163
C_2F_6	19.6	13.7	11.4	10.3	8.9	7.9	5.1	7.7	7.1	6.2	5.1	6.2	6.6
PFC218	0	0	0	0	0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1

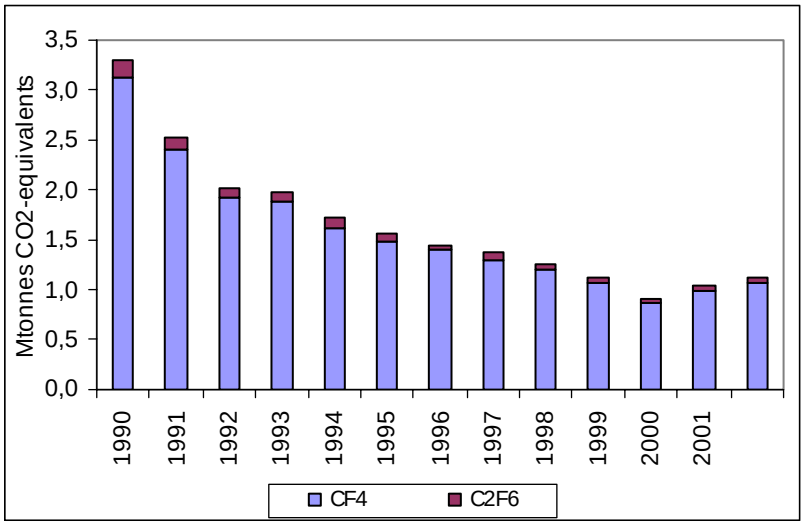


Figure 12. Emissions of PFCs in Norway 1990-2002, Mtonnes CO_2-equivalents. Source: SN/SFT

2.2.5 Sulphur hexafluoride (SF_6)

The largest source of SF_6 emissions in Norway is magnesium production, where SF_6 is used to cover the surface of liquid magnesium to prevent it from oxidising. The covering gas is emitted to air after use and no SF_6 is expected to react with the metal. The consumption of SF_6 has been reduced through the 1990s due to improvements in technology and process management. However, the process management changes from year to year and consequently also the consumption of SF_6. In 2002 the SF_6 emissions were 90 per cent lower than in 1990.

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

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

Table 8. SF_6 emissions in Norway 1990-2002, tonnes. Source SN/SFT

Emissions, tonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Magnesium production	89.4	84.0	22.8	21.6	22.8	17.4	18.6	18.0	24.0	30.0	32.0	27.0	5.9
Aluminum production	0.0	0.0	3.1	6.0	10.0	3.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Products (GIS and other products)	2.1	2.4	2.8	2.5	3.0	3.2	3.3	4.9	5.0	5.2	5.2	5.4	3.7
Total	**91.46**	**86.44**	**28.77**	**30.08**	**35.75**	**24.18**	**22.73**	**22.93**	**29.1**	**35.18**	**37.27**	**32.36**	**9.65**

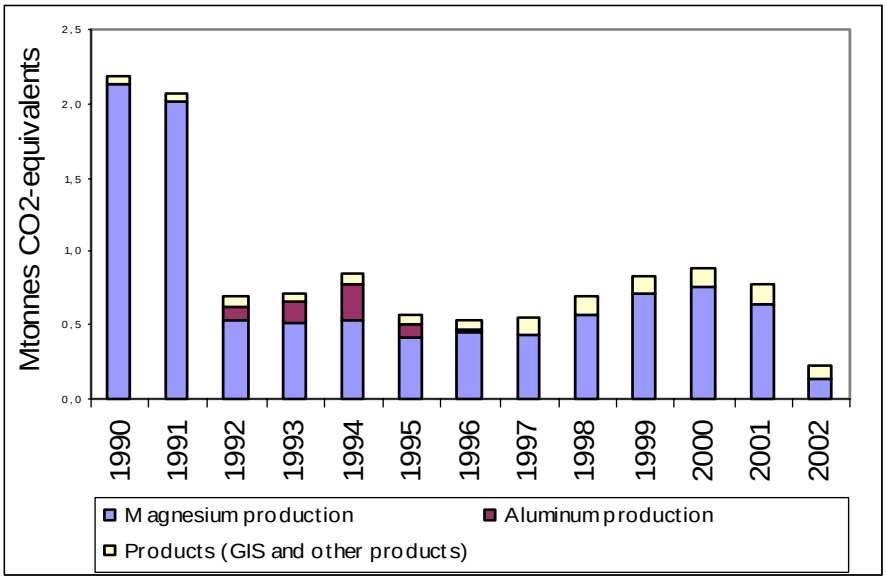


Figure 13. Emissions of SF_6 in Norway 1990-2002, Mtonnes CO_2-equivalents. Source: SN/SFT

2.2.6 Hydroflorocarbons (HFCs)

The total actual emissions from HFCs used as substitutes for ozone depleting substances amounted to 0.365 Mtonnes of CO_2-equivalents in 2002. Compared to the emissions in 2001, this represents an increase of about 25 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 and foam blowing, fire extinguishing products, and solvents and aerosol propellants contributed small amounts to the overall emissions. Tier 2 methodology was used to calculate the emissions. Figure 14 shows the emissions of HFCs in the period 1990-2002. Table 9 shows the actual emissions of different HFCs over the same period.

The potential emissions have also been calculated employing the Tier 1b methodology, which includes the import and export of chemicals in bulk and in products. The ratio between potential and actual emissions was about 23 in 1990, while it was reduced to about 4 in 2002. This shows that the consumption of HFCs still is growing, but at a much slower rate than in the 1990s. It is expected that the actual emissions will approach the potential emissions in about 20-30 years (SFT 2001b).

Table 9. Actual emissions of HFCs in Norway 1990-2002 calculated using the Tier 2 methodology, tonnes. Source SN/SFT

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

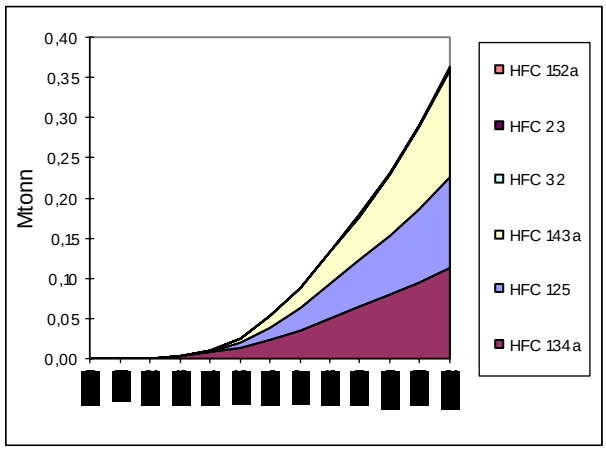


Figure 14. Emissions of HFCs in Norway 1990-2002, Mtonnes CO_2-equivalents. Source: SN/SFT

2.3 Emission trends by source

The largest contributor to the total greenhouse gas emissions in Norway is the energy sector, followed by industrial processes, agriculture and waste, see Table 10. From 1990 to 2002 the contribution of the energy sector to the emission total increased by 10 per cent. At the same time the contribution from industrial processes decreased by about 8 per cent.

The distribution of the Norwegian greenhouse gas emissions over the UNFCCC sectors in 2002 is shown in Figure 15. Emissions from the energy sector account for 2/3 of the national total, while industrial processes accounted for 18 per cent. Furthermore, emissions from agriculture contributed 9 per cent of the total, and the waste sector accounted for 7 per cent. The least important source is solvents and other products use, which accounted for only 0.3 per cent of the overall emissions.

Table 10. Total emissions of greenhouse gases by sources and CO_2 removals from LUCF in Norway 1990-2002. Mtonnes CO_2-equivalents. Source: SN/SFT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Energy	29.3	28.8	29.2	30.3	32.0	31.8	34.9	35.0	35.1	35.8	35.2	36.9	36.5
Industrial Processes	13.6	12.0	9.6	10.5	10.6	10.5	10.5	10.3	10.8	10.8	10.8	10.6	9.7
Solvent 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
Agriculture	5.0	5.1	5.0	5.0	5.0	5.1	5.0	5.1	5.1	5.0	5.0	4.9	4.9
Waste	4.0	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.1	4.1
LUCF	-9.5	-11.8	-13.2	-13.5	-15.6	-15.5	-17.4	-16.3	-17.4	-17.6	-18.6	-18.8	-19.9
Total - with LUCF	**42.6**	**38.3**	**34.7**	**36.6**	**36.3**	**36.2**	**37.4**	**38.5**	**37.9**	**38.4**	**36.8**	**37.9**	**35.4**
Total - without LUCF	**52.1**	**50.1**	**47.9**	**50.1**	**51.9**	**51.7**	**54.8**	**54.8**	**55.3**	**56.0**	**55.4**	**56.7**	**55.3**

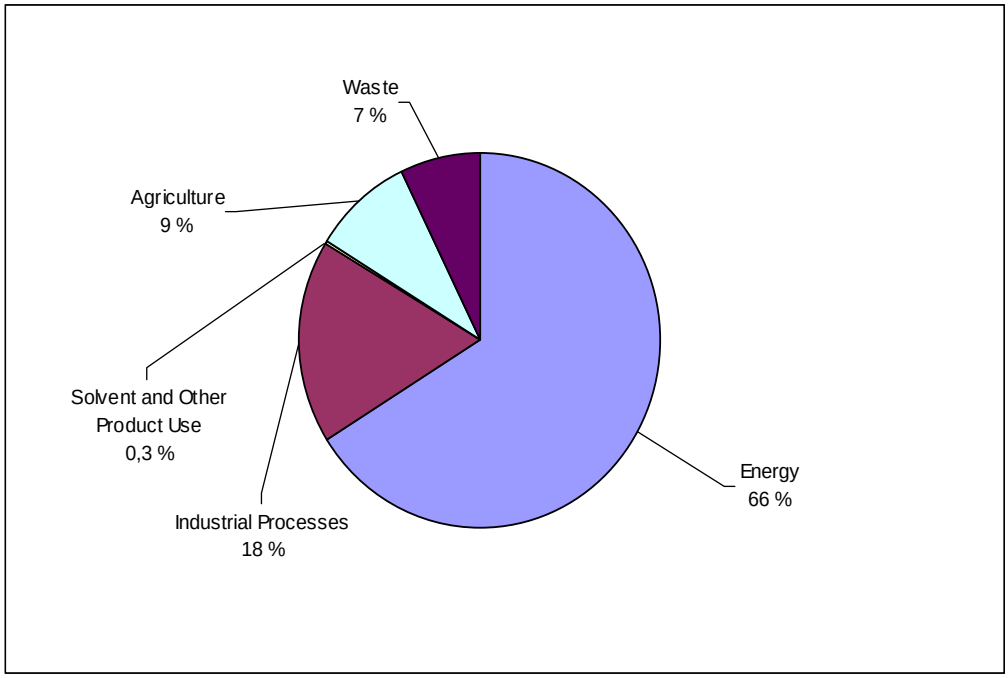


Figure 15. Emissions of greenhouse gases by UNFCCC sector in Norway in 2002. Source: SN/SFT

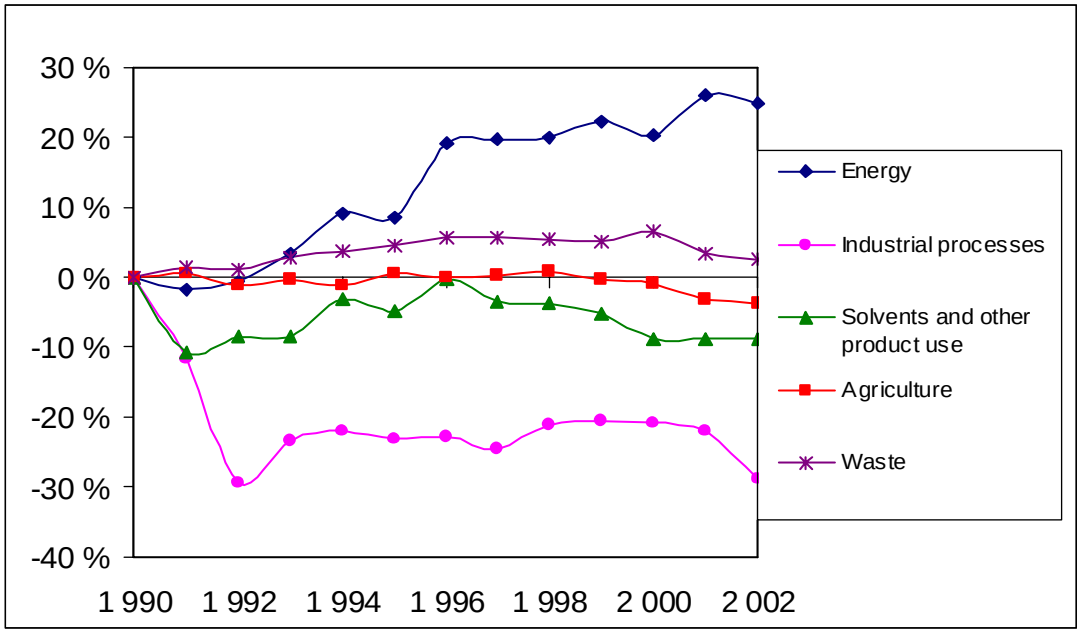


Figure 16. Changes in total greenhouse gas emissions by UNFCCC source categories during the period 1990-2002 compared to 1990. Source: SN/SFT

2.3.1 Energy

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.

The total emissions of greenhouse gases from the energy sector over the period 1990-2002 are listed in Table 11 below, and Figure 17 displays the distribution of GHG emissions in 2002 on the different source categories. The emission changes detected in the various source categories in the energy sector between 1990 and 2002, compared to 1990 are illustrated in Figure 18 and discussed in the following.

Table 11. Total emissions of greenhouse gases from the energy sector in Norway 1990-2002, ktonnes CO_2-equivalents. Source: SN/SFT

	1 990	**1 991**	**1 992**	**1 993**	**1 994**	**1 995**	**1 996**	**1 997**	**1 998**	**1 999**	**2 000**	**2 001**	**2 002**
Energy Industries	6 702	7 018	7 618	7 937	8 554	8 443	9 266	9 549	9 247	8 674	9 556	10 739	11 000
Manufacturing Ind. and Construction	3 545	3 277	3 186	3 393	4 066	3 714	4 219	4 320	4 501	4 343	4 203	4 177	3 793
Transport	11 333	11 259	11 491	12 137	12 006	12 454	13 152	13 451	13 854	14 518	13 681	14 078	14 127
Other Sectors	4 797	4 307	4 067	3 901	4 189	4 123	4 810	4 389	4 296	4 411	3 592	4 004	4 291
Fugitive Emissions from Fuels	2 922	2 902	2 795	2 975	3 135	3 073	3 443	3 341	3 232	3 891	4 193	3 937	3 335
Total	**29 300**	**28 762**	**29 156**	**30 343**	**31 950**	**31 806**	**34 890**	**35 050**	**35 130**	**35 836**	**35 224**	**36 934**	**36 546**

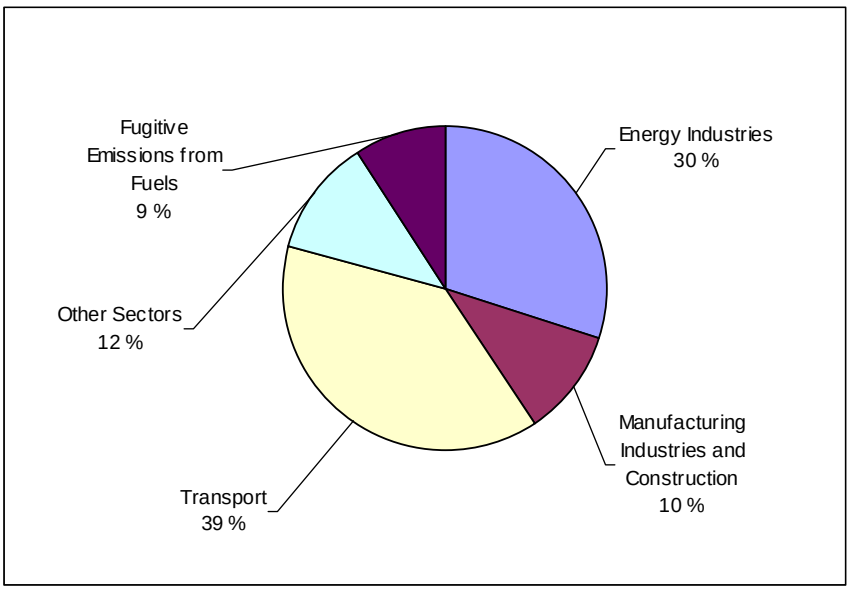


Figure 17: Greenhouse gas emissions in 2002 from the energy sector distributed on the different source categories. Source: SN/SFT

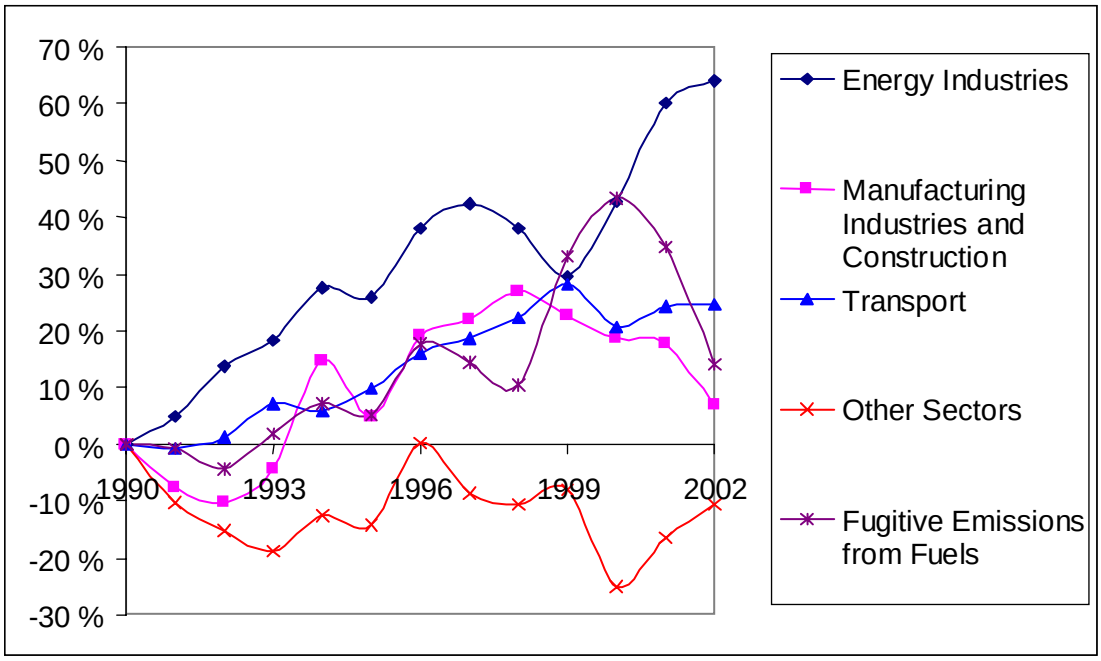


Figure 18: Changes in emission in the various source categories in the energy sector between 1990 and 2002, compared to 1990. Source: SN/SFT

We see from Table 11 that 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 2002 the total emission level in this sector was 25 per cent higher than those of 1990. After a slight, temporary emission reduction in 2000, emissions from the energy sector rose again in 2001. Between 2001 and 2002 they decreased again by about 1 per

cent, but were still higher than the 2000 level. The relatively low emission level in 2000 was caused by a mild winter and tax changes which resulted in reduced use of fuels for heating purposes and reduced fuel sales respectively. The decrease between 2001 and 2002 was due to reduced fugitive emissions from fuels and lower emissions from manufacturing industries and construction, which outpaced the increased emissions from energy industries and transport over the same period.

Emissions from **Energy industries** have increased by 64 per cent from 1990 to 2002, and by about 2 per cent from 2001 to 2002. The main source here is offshore oil- and gas extraction, contributing 87 % of the emissions. Oil and gas extraction has played an important role in the national economy in recent decades. On the offshore oil- and gas installations, electricity and pumping power is principally produced by gas turbines and, to a lesser extent, diesel engines. Emissions from these sources are accounted for under the UNFCCC sector Manufacturing of Solid Fuels and Other Energy Industries. In 2002 the emissions from oil and gas extraction off shore contributed about 17 per cent to the total GHG emissions in Norway. In 1990 the corresponding contribution was 10 per cent and the growth detected can be explained by increased production of oil and gas. During the period 1990-2002 there was a 73 per cent increase in the total greenhouse gas emissions from energy production offshore.

Onshore energy industries comprise oil refineries and gas terminals counts for about 9 per cent of the total energy industries emissions. These emissions grew by 6 per cent from 1990 to 2002. Public generation of electricity and heat is completely dominated by hydroelectric generation; hence no emissions of greenhouse gases are reported. The only important exception is waste incineration plants and a small coal combustion plant (6 MW) on the island of Spitsbergen. These emissions accounts for about 3 per cent of the energy industries figure, and they doubled from 1990 to 2002.

Industrial emissions related to fuel combustion[3] originate to a large extent from the production of raw materials and semi-manufactured goods, e.g. alloys, petrochemicals, paper and minerals. Emissions from **Manufacturing industries and construction** increased by 7 per cent in the period 1990-2002, with the most pronounced rise being in the petrochemical industry (starting up of a new methanol production plant) and the pulp and paper industry. However, between 2001 and 2002 these emissions decreased by 9 %. Emissions from all of the sources in this category contributed to the reduction, except for food processing, beverages and tobacco which increased slightly.

Emissions from **Transport** showed an overall increase of about 25 per cent from 1990 to 2002, while the emissions only showed a slight increase of 0.3 per cent from 2001 to 2002 (see Table 12 and Figure 19 below). The share of transport in the total GHG emissions was 26 per cent in 2002 and 22 per cent in 1990. Road traffic accounts for more than 2/3 of the total mobile emissions and these emissions have increased by 21 per cent since 1990. From 2001 to 2002 the emissions rose by about 2 per cent. Emissions from navigation increased by 16 per cent from 1990 to 2002, mainly because of increased activity related to the oil- and gas extraction sector. Emissions from civil aviation have increased by 34 per cent since 1990. Reduction in the number of flights resulted in an emission decline of 14% from 2001 to 2002. Domestic civil aviation contributed to the total national GHG emissions by about 1.7 per cent in 2002. Due to the fact that most railways are electrified in Norway, emissions of GHG from this source are insignificant.

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

Table 12. Total emissions of greenhouse gases from the transport sector in Norway 1990-2002, Mtonnes CO_2-equivalents. Source: SFT/SN

Emissions, Mtonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
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
Road transportation	7.85	7.77	7.92	8.38	8.19	8.41	8.86	8.84	9.06	9.28	8.75	9.29	9.47
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
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
Other transportation	0.54	0.53	0.51	0.50	0.58	0.62	0.64	0.65	0.64	0.64	0.65	0.66	0.66
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**	**13.3**

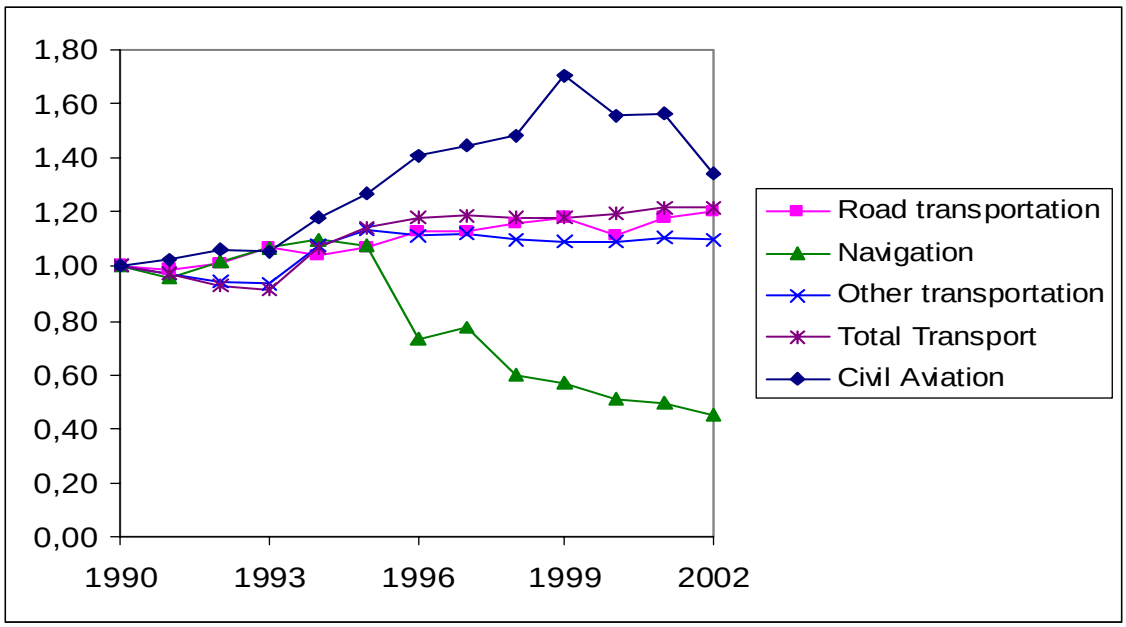


Figure 19. Changes in CO_2-emissions from different modes of transport in 1990-2002 compared to 1990. Source: SN/SFT

The category **Fuel combustion in other sectors** is dominated by emissions from agriculture, forestry and fisheries, which accounts for 54 per cent of the emissions. These emissions have been rather stable throughout the period 1990-2002. Emissions from residential sources account for about 23 per cent of the total, and they have decreased by about 37 per cent since 1990 due to electrification of heating infrastructure. However, new technologies and occasional electricity shortages have at times reversed this trend during the 1990s. A recent example is the relatively low emissions from this source category in 2000 due to the mild winter which led subsequently to relatively low consumption of fuels for heating purposes. Emissions from commercial/institutional sources make up the last 23 % of this category. The development in emissions has been a 4 per cent increase from 1990 to 2002, and a growth of 11 per cent between 2001 and 2002.

The source category termed **Fugitive emissions from fuels** in the CRF tables refers to emissions from oil and gas activities. These emissions originate from flaring of natural gas, leakages and venting of methane. Indirect CO_2 emissions from NMVOC emitted during the loading and unloading of oil tankers are also accounted for in this category. In order to minimise emissions from these activities, Norway has implemented various technical measures and a CO_2 tax. Nevertheless, due to large increases in production, emissions have increased by almost 14 per cent from 1990 to 2002. The emission level in 2002 is lower than the one in 2001 by 15 per cent mainly due to reduced flaring off shore.

2.3.2 Industrial processes

Production of raw materials is the main source of process related industrial emissions for both CO_2 and other greenhouse gases such as N_2O (fertiliser production), SF_6 (magnesium foundries) and PFCs (aluminium production). The industrial process sector accounts for about 18 per cent of the national greenhouse gas emissions. Table 13 and Figure 20 show that the total emissions from the sector have been relatively stable at about 10 Mt CO_2 equivalents after a substantial reduction in the period 1990-1992 due to technological improvements and process management. The decreasing trend in the emissions of PFCs over the years has been counteracted by the rising emissions of CO_2 from this sector.

Table 13. Total greenhouse gas emissions from the industry sector in Norway 1990-2002, Mtonnes CO_2-equivalents. Source: SN/SFT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Mineral Products	0.7	0.6	0.7	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9
Chemical Industry	3.1	2.8	2.2	2.6	2.6	2.8	2.7	2.5	2.5	2.4	2.5	2.4	2.6
Metal Production	9.8	8.5	6.7	6.9	7.0	6.6	6.7	6.5	7.0	7.2	7.0	6.8	5.7
Other Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Production of Halocarbons and SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Consumption of Halocarbons and SF_6	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**13.6**	**12.0**	**9.6**	**10.5**	**10.6**	**10.5**	**10.5**	**10.3**	**10.8**	**10.8**	**10.8**	**10.6**	**9.7**

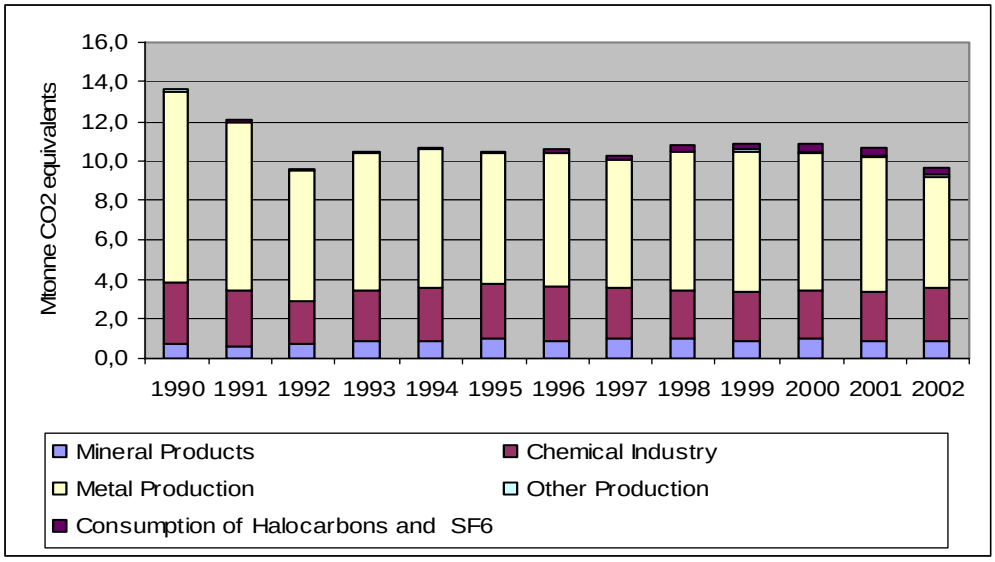


Figure 20: Total greenhouse gas emissions in the industrial source categories in Norway during the period 1990-2002. Source: SN/SFT

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

The main category within the industrial sector is **Metal production**, which accounted for 59 per cent of the sector's emissions in 2002. Aluminium production is the main source within the metal production category, accounting for 50 per cent of the total emissions of the category. Norway is one of the worlds leading producer of primary aluminium with 7 plants. Both the prebaked anode and the Søderberg (old and new) production technologies are in use. The main energy source is electricity, but CO_2 is emitted from the use of petrol coke, coke of coal and from coal electrodes. In addition, the production of aluminium gives rise to emissions of PFCs. From 1990 to 1992 the emissions of PFCs were reduced by 33 per cent. Since then there has been a stable reduction until 2001. From 2001 the emissions increased again. The reduction in PFCs emissions is caused by improved technology and process control, which has led to reduced PFC emissions per tonne aluminium produced from 3.79 to 1.07 tonnes CO_2 equivalents in the years 1990 to 2002. In 1997 the aluminium producers and the Ministry of Environment signed an agreement to reduce emissions of greenhouse gases from production. According to the agreement the emissions measured as CO_2-equivalents per tonne primary aluminium produced are to be reduced by 50 per cent in 2000 and 55 per cent from 2005. The total GHG emissions from aluminium production were reduced by 50 per cent in the period 1990-2002, which shows that the producers are in compliance.

Production of ferroalloys is the second most important source within the category of metal production, accounting for 40 per cent of the total. Norway is a major producer of ferroalloys with 15 plants in operation. CO_2 is emitted from these plants due to the use of coal and coal coke as reducing agents. The emissions decreased by about 9 per cent from 1990 to 2002 due to reduced activity and the closing of some of the plants. Between 2001 and 2002 emissions

decreased by 20 per cent, About 4.6 per cent of national total GHG emissions were CO_2 from ferroalloys production in 2002.

The major iron producing plant was closed down in 1988, but one plant still exists. The emissions from this source account for about 5 per cent of the emissions from metal production. The emissions increased by 47 per cent from 1990 to 2002, and decreased by 4 per cent from 2001 to 2002. Other metals produced in Norway today are nickel, zinc and magnesium, one plant of each, but the emissions from theses sources are minor.

The major source of SF_6 emissions is magnesium production. These emissions have been reduced through the 1990s due to improvements in technology and process-management. The emissions in 2002 were as much as 94 per cent lower than in 1990, and they contributed only about 2 per cent to the total emissions from the metal production category. From 1998 there was a significant increase in SF_6 emissions due to growth in production of magnesium as well as increased production and higher shares of primary production versus recycled metal. However, the company producing primary magnesium stopped this activity in 2002 and retained only the production of secondary magnesium, which explains the strong decrease of 88 per cent between 2001 and 2002.

The chemical industry is the sector's second most important category, accounting for 27 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 16 per cent in the period 1990-2002. The detected reduction is due to improved technology in the nitric acid production. From 2001 to 2002 emissions increased by 8 per cent, which is a result of a higher production level.

Regarding the category **Production of minerals**, cement production is by far the main source (94 %). 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. Due to growth in production the CO_2 emissions from cement production increased by 23 per cent from 1990 to 2002 and by 3 per cent between 2001 and 2002.

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

2.3.3 Solvent and other product use

The use of solvents and products containing solvent 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. Indirect CO_2 emissions from solvents represented approximately 0.2 per cent of the total greenhouse gas emissions in 2002. The share has been more or less unchanged since 1990.

2.3.4 Agriculture

From Table 14 below wee see that the emissions from agriculture were relatively stable between 1990 and 2002, with emission levels of around 5 million tonnes CO_2-equivalents.

Greenhouse gas emissions from agriculture comprise direct emissions of methane and nitrous oxide and oxidised emissions of CO_2. The greenhouse gas emissions from this sector accounted for 9 per cent of the overall Norwegian greenhouse gas emissions in 2002. Between 1990 and 2002 there has been a 4 per cent decrease attributed to reduced emitted amounts of N_2O. Also between 2001 and 2002 emissions decreased, by about 1 per cent.

The largest sources for agricultural greenhouse gas emissions are N_2O from agricultural soils and CH_4 from enteric fermentation from cattle, sheep, reindeer and other animals. These source categories account for about 56 and 35 per cent of the total emissions from the agricultural sector. The remaining emissions in this sector constitute mostly of CH_4 and N_2O from manure management (about 9 per cent).

Over the period 1990-2002 the nitrous oxide emissions from agriculture decreased by about 5 per cent. The reduction originates primarily from the source direct soil emissions, and may be explained by reductions in the amount of N in agricultural products, which in turn decreases the N_2O emissions from crop residues. The methane emissions are more or less unchanged over the same period. These figures reflect the stability of the production in the agricultural sector, as well as the absence of improvements in technology resulting in lower emissions of greenhouse gases.

Table 14. Total greenhouse gas emissions from agriculture in Norway 1990-2002, ktonnes CO_2-equivalents. Source: SN/SFT

Emissions, ktonnes CO2-equv.	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Enteric fermentation	1713	1737	1740	1721	1741	1761	1775	1779	1795	1784	1754	1707	1689
Manure management	407.9	418.8	419.8	416.9	420.5	427.1	434.2	434.4	439.6	436.1	431.4	419.6	414.7
Agricultural soils	2896	2904	2812	2870	2815	2869	2817	2832	2843	2800	2806	2747	2745
Field burning of agricultural residues	30.7	24.2	13.2	18.2	13.0	16.2	17.6	12.7	13.3	12.1	12.8	12.1	11.5
Total	**5047**	**5083**	**4985**	**5057**	**4989**	**5073**	**5044**	**5059**	**5091**	**5033**	**5004**	**4886**	**4860**

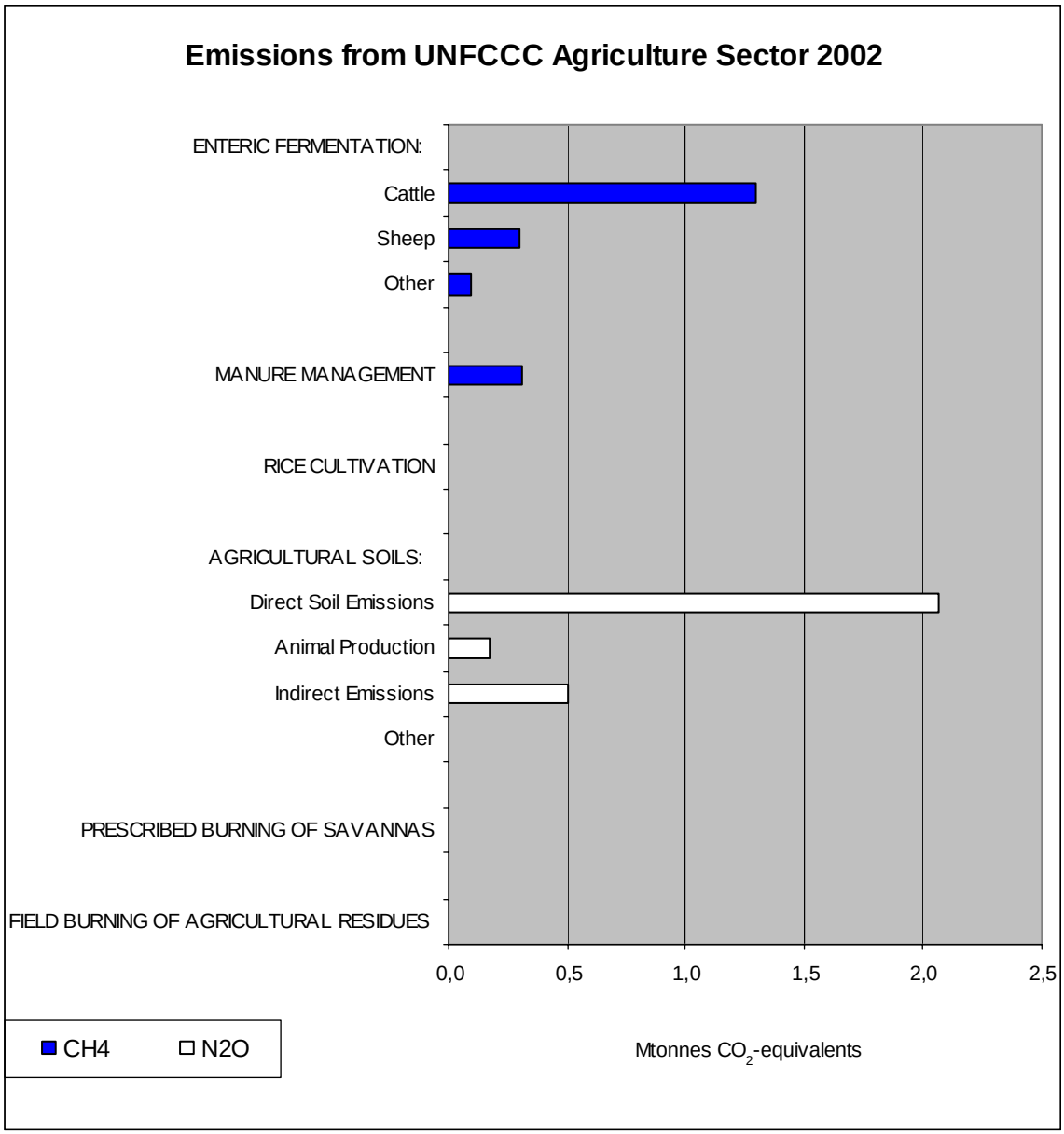


Figure 21. Emissions of greenhouse gases from the agricultural sector in Norway in 2002. Source: SN/SFT.

2.3.5 Waste

The emissions of greenhouse gases from the waste sector were relatively stable during the 1990s, with emission levels of around 4 million tonnes CO_2-equivalents, see Table 15 below. These emissions, mainly methane from landfills, accounted for 7.8 per cent of the total GHG emissions in Norway in 2002. Solid waste disposal on land (Landfills) is the main category within the waste sector, accounting for about 96 per cent of the total emissions from this source. Wastewater handling and waste incineration account for ca. 3 and 1 per cent respectively.

Table 15. Emissions from the waste sector in Norway 1990-2002, Mtonnes CO_2-equivalents. Source: SN/SFT

Emissions, Mtonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Landfills	3.9	3.9	3.9	4.0	4.0	4.0	4.1	4.0	4.0	4.0	4.0	3.9	3.9
Wastewater handling	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
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Total	**4.0**	**4.0**	**4.0**	**4.1**	**4.1**	**4.1**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.1**	**4.1**

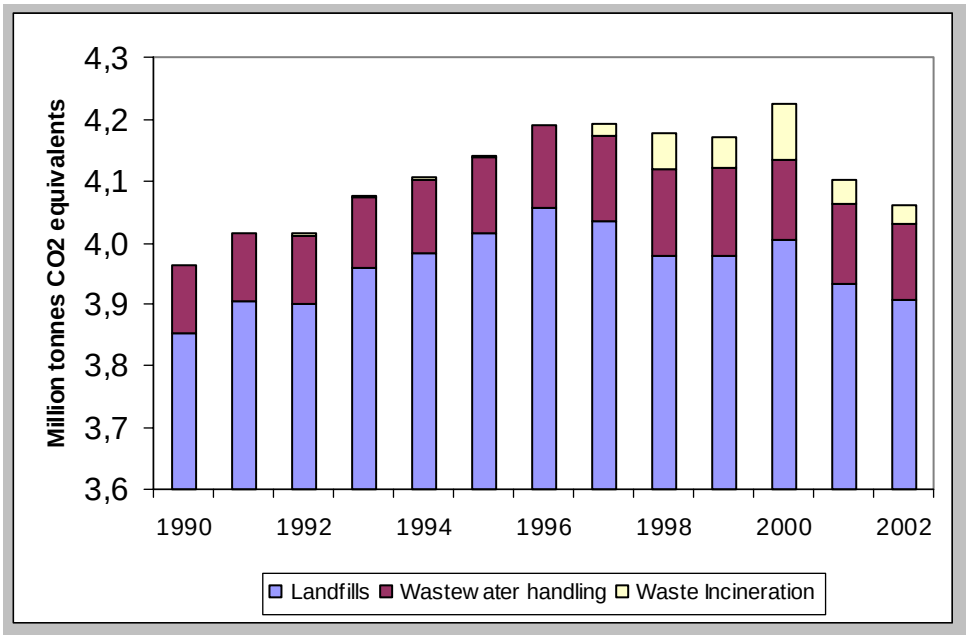


Figure 22: Total emissions of greenhouse gases in Norway from the waste sector 1990-2002, Mtonnes CO_2-equivalents. Source: SN/SFT

Figure 22 shows that emissions of methane have decreased slightly since 1996 due to reduction of the amount of waste disposed at disposal sites. This reduction is the result of several measures which were introduced in the waste sector particularly in the 1990s. With a few exceptions, it is prohibited to dispose easy degradable organic waste at landfills in Norway. In 1999 a tax was introduced on waste delivered to final disposal sites. This tax was equal to 320 NOK per tonne waste disposed at landfill sites in 2002, and increased to 327 NOK from 2003. In addition, landfills receiving biodegradable waste (waste containing degradable organic carbon (DOC)) are required to collect and treat landfill gas. In 2002 a total of 60 landfills had installed a landfill gas extraction system, and approximately 22 ktonnes of methane was recovered in 2002. In addition, the amounts of waste recycled have increased significantly since 1990.

2.4 Land Use Change and Forestry

The net removal of CO_2 from land-use change and forestry activities doubled during the 1990s. The net removal of CO_2 was about 20 million tonnes in 2002 and would offset 36 per cent of the total greenhouse gas emissions that year. This removal includes biomass above and below ground. The uptake of CO_2 in forest and agricultural soil is not included in the calculations, except for CO_2 from liming of agricultural soil (0.1 million tonnes CO_2). Emissions related to harvested wood are calculated according to the IPCC default methodology. In other words, the stored carbon is expected to be emitted to the atmosphere immediately after harvest.

In Norwegian forests, until the beginning of 1900, the harvest was of about the same size as the regrowth. Since then the standing volume has increased, it doubled from 1925 to 2002, while the harvest has been about the same (10 million m^3 per year). Figure 23 shows this development for the period 1950 onwards. The large increase in the standing volume is primarily due to active forest management. The result is a considerable net increment and hence accumulation of carbon in forests.

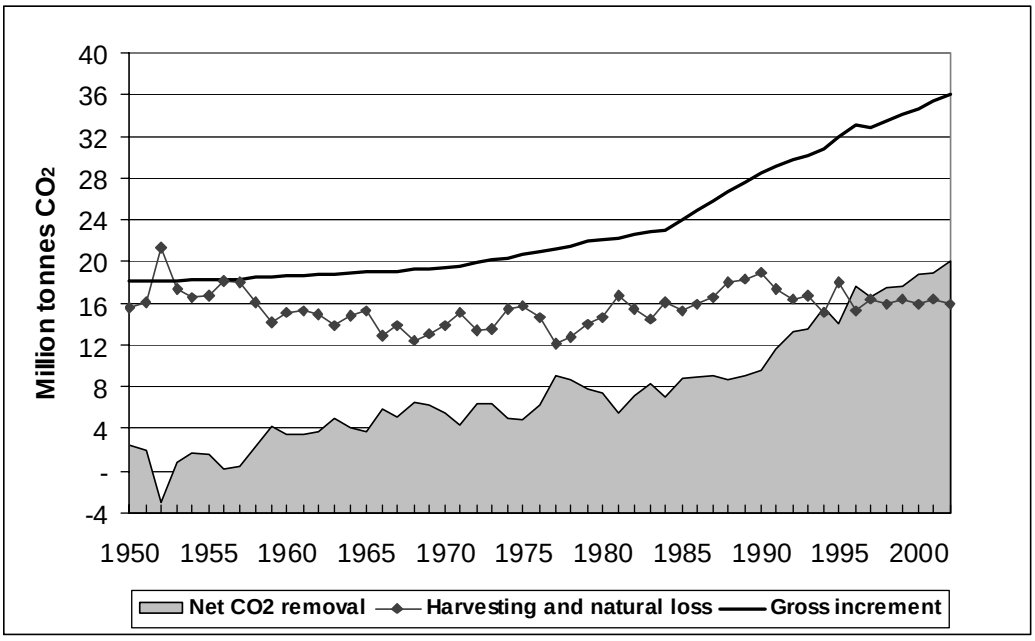


Figure 23. CO_2 removal in Norwegian forests during the period 1950-2002. Source: SN/SFT

The net CO_2 removal in forests including biomass above and below ground increased from about 10 million tonnes CO_2 in 1990 to 20 million tonnes in 2002. The explanation for this growth is a continued increase in standing volume and gross increment while the amount of carbon emitted due to harvesting and natural losses has been quite stable. In the period 1990-2002, the standing volume under bark increased from about 578 million m^3 to 724 million m^3. The gross increment of biomass above and below ground increased from about 23.7 million tonnes CO_2 in 1990 to about 36.0 million tonnes CO_2 in 2002. Emissions from harvesting and natural losses did not follow the same increasing trend, but varied between 15.9 million tonnes CO_2 in 1998 and 19.7 million tonnes CO_2 in 1990. The total gross depletion was about 16.0 million tonnes CO_2 in 2002.

2.5 Emission trends for indirect greenhouse gases and SO_2

Nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) have an indirect effect on climate through their influence on greenhouse gases, especially ozone. Sulphur dioxide (SO_2), on the other hand, affects climate through increasing the level of aerosols which have in turn a cooling effect on the atmosphere. The trend of these pollutants in Norway during the period 1990-2002 is presented in Figure 24.

Emissions of NO_X have decreased by about 1 per cent from 1990 to 2002. Reduced emissions from road traffic due to the introduction of stricter emission regulations have been counteracted by increased emissions from oil and gas production and navigation.

Emissions of NMVOCs increased by 28 per cent from 1990 to 2002 due to a growth in loading of crude oil, despite the reduced emissions from road traffic. The moderate downward trend in the emission between 1996 and 1998 is due to installation of a vapour recovery unit at one of the oil terminals onshore.

From 1990 to 2002 the emissions of CO have decreased by about 37 per cent, mainly because of new emission standards for motor vehicles.

Emissions of SO_2 were reduced by 52 per cent from 1990 to 2002. This trend has mainly been caused by the reduction in the sulphur content of all oil products and by lower process emissions from the production of ferroalloys and aluminium and from the refineries.

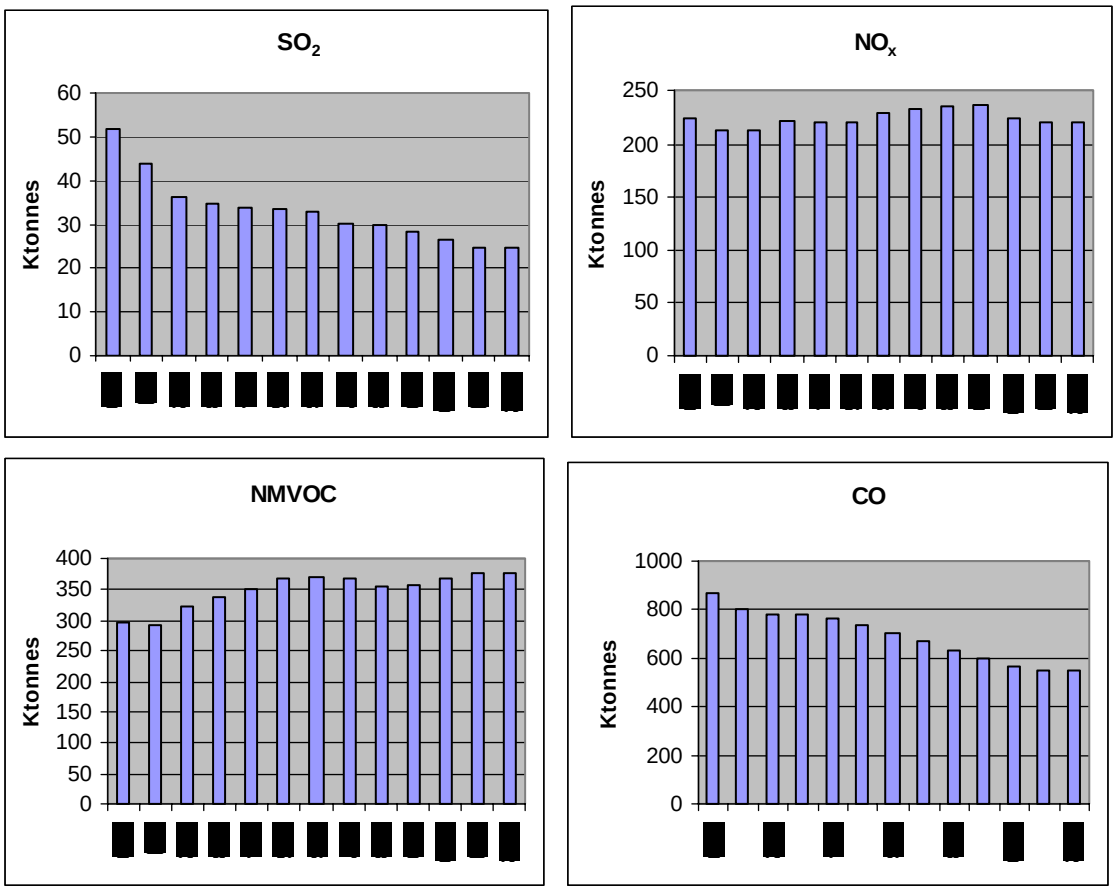


Figure 24. Emissions of SO_2, NOx, NMVOC and CO in Norway 1990-2002. Source: SN/SFT

Chapter 3. Energy

3.1 Overview

The Energy sector accounts for about 2/3 of Norwegian GHG emissions. In 2002 emissions from this sector contributed 66% to the national GHG total. Emissions increased by 25% from 1990 to 2002. From 2001 to 2002 only a small decrease of 1% is detected. Road traffic and offshore gas turbines (electricity generation and pumping of natural gas in pipelines) are the sector's largest single contributors. Other important sources are coastal navigation, energy use in the production of raw materials, as well as oil and gas operations which give rise to significant amounts of fugitive emissions.

As indicated in Table A1-4 in Annex 1 of this report, the key source analysis performed for the years 2000 an 2002 has revealed that in terms of total level and/or trend uncertainty the *key sources* in the Energy sector are the following:

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

Coal mining is not defined as a key source in the key source analysis. However, we regard coal mining as key due to "qualitative" criteria like change in trend and uncertainty in the EF.

A discussion of the above key sources is presented below, followed by a brief description of the non-key sources in this sector. Emissions from international bunker fuels are addressed subsequently. Finally, cross-cutting issues are elaborated. These comprise the following issues:

- Comparison between the sectoral and reference approach
- Feedstocks and non-energy use of fuels
- CO_2 capture and storage in the Norwegian oil and gas production field of Sleipner
- Indirect CO_2 emissions from CH_4 and NMVOC.

3.2 Stationary Fuel Combustion, Gas – CO_2 – 1A1, 1A2, 1A4

3.2.1 Description

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

CO_2 emissions from the above sources constitute a key source both in level and in trend due to uncertainties in emission factors.

Emissions of CO_2 from the above fuel combustion activities in Norway have increased by about 22% in the period 1990-2002. In 2002 they constituted about 53% of the total CO_2 emissions in the Energy sector and 45% of the national CO_2 total.

Norway produces electricity mainly from hydropower, so emissions from electricity production are small compared to most other countries. Emissions in this key source originate predominantly from the combustion of natural gas in oil and gas extraction operations offshore. At these installations, electricity and pumping power are principally produced by gas turbines and to a lesser extent, diesel engines. In 2002 the CO_2 emissions from such gas combustion were 96% of the key source total. The remaining fraction is due to the use of diesel fuel oil in gas turbines and machinery. The emission of CH_4 and N_2O in these operations is negligible.

Offshore oil and gas extraction has played an important role in the national economy in recent decades. Emissions from the combustion of gaseous fuels in such operations increased by 72% in the period 1990-2002 due to the increasing production of oil and gas. In 2002 they accounted for about 17 per cent of the national total GHG emissions.

3.2.2 Methodological issues

Emissions from energy combustion are estimated at the sectoral level (IPCC sectoral approach Tier 2/Tier 3). They are calculated by multiplying energy use by source and sector with pollutant specific emission factors.

The energy consumption data used in the emission calculations are taken from the annual energy balances/energy accounts which survey the flow of the different energy carriers within Norwegian economic activities. Energy carriers refer to both raw materials and reducing agents. The latter 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. The total use of each energy carrier is determined by summing up reported/estimated use in the different sectors. The major issues related to the estimation of emissions from gaseous fuels in the Norwegian inventory are elaborated in the following.

Activity data

Natural gas
As mentioned above, most of the combustion is related to extraction of gas on the Norwegian continental shelf. Combustion figures are reported annually to Statistics Norway by the Norwegian Petroleum Directorate. 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. These 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 direct-fired furnaces; the rest is burned in boilers.

Other gases and LPG
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 1990s. 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. Consumption of LPG in manufacturing industries is also reported from the plants. Figures on other use of LPG are based on sales figures and surveys. Sold amounts are reported to Statistics Norway on an annual basis. In the case of households, figures for LPG are collected from the suppliers.

The collection of data from the sector of Manufacturing Industries and Construction is realized through annual surveys on energy use carried out by Statistics Norway. Figures on energy use are collected from approximately 15 per cent of the activity units within mining and manufacturing. For the remaining 85 per cent, figures are estimated, based on data from the sample together with data on turnover, taking into account use of different energy carriers in the same industries and size groups. Information is collected from the major manufacturing plants, while use in smaller plants is estimated. The data on energy use in manufacturing industries is considered to be of high quality. For construction, the figures on gaseous fuel consumption are projected from earlier surveys and are, therefore, considered to be rather uncertain.

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

It is important to mention here that natural gas from the offshore gas-condensate field Sleipner West contains about 9 per cent CO_2. To reduce the CO_2 content in the natural gas to an acceptable level before transported to consumers onshore approximately 1 million tonnes of CO_2 are captured and then stored in a sandstone saline aquifer not fare from the gas field. In the cross cutting Section 3.11.3 the methodology for this part of the inventory is described.

Emission factors

Emission factors for CO_2 are independent of technology and are based on the average carbon content of fuels used in Norway (SFT, 1990; Norwegian Oil Industry Association –OLF,

1994). The emission factors for CO_2 from combustion of various energy commodities are listed in Table 16 below.

Table 16. Emission factors for CO_2 from combustion of gaseous fuels. Tonnes CO_2/tonne gas combusted. Source: SN/SFT

Source	Sector	Natural gas	LPG	Refinery gas	Blast furnace gas	Fuel gas	Landfill gas
General	General	2.34	3	2.8	1.5712	3	0.275
Gas turbines	Gas terminals	2.04	.	.	.	.	.
Boilers	General	.	.	.	.	.	.
	Chemical	.	.	.	.	2.5	.
	Metals	.	.	.	.	2.5	.
	Refuse disposal	.	.	.	.	.	.
Flaring	Gas terminals	2.04	.	.	.	.	.

3.2.3 Uncertainties

An analysis of the uncertainty in both activity data and emission factors for all emission sources has been carried out by Rypdal and Zhang (SN, 2000) and summary tables with the results are displayed in Annex 6. The uncertainty in the activity data is ± 4 per cent and in the CO_2 emissions factor ± 7 per cent. The uncertainty in the emission factor is relatively high as emissions are dominated by the oil and gas extraction operations and gas composition can vary according to field. The contribution of this key source to the total level and trend uncertainty is estimated to be 4.29 per cent and 7 per cent, respectively.

The consumption of energy in the sectors of energy and manufacturing industries is well known, while in the household and service sectors it is more uncertain. However, the energy use in the most uncertain sectors has been adjusted in the official energy statistics so that the sum of the energy use in all sectors equals the total sales.

3.2.4 Source specific QA/QC and verification

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

3.2.5 Recalculations

The consumption of natural gas in turbines offshore reported from the Norwegian Petroleum Directorate has been revised for the years 2000 and 2001. Most of the recalculations for 2001 are caused by revisions in the energy accounts from "preliminary" in last submission to "final" in this submission. Minor revisions in the energy accounts have also been carried out.

3.2.6 Planned improvements

Norway will this year evaluate the use of a standard emission factor for natural gas burned in gas turbines off shore. Most probably the result of the evaluation will be that from next years submission we will use emissions data reported to SFT by each field operator in the national inventory. This is data that is based on field specific CO_2 emission factors.

3.3 Stationary Fuel Combustion, Oil – CO_2 – 1A1, 1A2, 1A4

3.3.1 Description

The key source analysis performed by Statistics Norway has shown that CO_2 emissions from the stationary combustion of liquid fuels constitute also a key source in both level and trend due to uncertainties in activity data and emission factors. Liquid fuels are consumed in all activities in the Energy sector.

Emissions of CO_2 from liquid fuel combustion increased by 0.6% between 1990 and 2002. In 2002 they constituted about 38% of the total CO_2 emissions in the Energy sector and 22% of the national greenhouse gas total.

3.3.2 Methodological issues

As for gaseous fuels, the general method to estimate emissions from this key source is to multiply energy use by source and sector by an appropriate emission factor. Consumption data are taken from the annual energy balances/energy accounts as described in Section 3.2.2.

Activity data

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[4]. In contrast to the other energy carriers, there is thus a given total, which the use in the different sectors must sum up to. Stationary combustion takes place in boilers and, in some manufacturing industries, in direct-fired furnaces. There is also some combustion in small ovens, mainly in private households. In addition to oil products included in the sales statistics, a separate survey gives figures on use of waste oil.

As described in Section 3.2.2, activity data are based on the consumption figures reported by the Norwegian Petroleum Directorate for all platforms on the Norwegian part of the continental shelf, including the Norwegian economic part of platforms shared with the UK. Data reports include the amounts of diesel burned in turbines and direct-fired furnaces on the oil and gas fields. The data are of high quality due to the CO_2 tax on fuel combustion. The same situation applies for combustion of natural gas in turbines at gas terminals onshore.

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

For construction, the figures on liquid fuel consumption are taken partly from the sales statistics for petroleum products and partly projected from earlier surveys; the energy data are, therefore, considered to be rather uncertain.

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

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

deal of uncertainty regarding the quality of these figures, particularly for fuel oil, which is the most important of these three energy carriers. Even more so, as it from the late nineties has been necessary to adjust also 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.

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

Emission factors

For liquid fuels the CO_2 emission factors used reflect the average carbon content of Norwegian fuels (SFT 1990 and OLF 1994). They are presented in Table 17 below.

Table 17. Emission factors for CO_2 from the combustion of liquid fuels. Unit: Tonnes CO_2/tonne liquid fuel combusted. Source: SN/SFT

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

3.3.3 Uncertainties

The uncertainty in both the activity data and the emission factors is estimated to be ± 3 per cent. The contribution of this key source to the total level and trend uncertainty is estimated to be ± 1.08 per cent and ± 1.01 per cent, respectively.

3.3.4 QA/QC and verification

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

3.3.5 Recalculations

In the sector of Manufacturing Industries and Construction CO_2 emissions estimated by Statistics Norway have been substituted by figures reported directly by the companies for the period 1990-2002. The reported figures have been quality checked with calculations done by SN. Minor revisions in the energy accounts have also been carried out.

3.3.6 Planned improvements

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

3.4 Civil aviation – CO_2 – 1A3a

3.4.1 Description

Emissions of CO_2 from civil aviation accounted for about 2 per cent of the total Norwegian CO_2 emissions in 2002. Aviation is a minor emission source of methane and nitrous oxide in Norway (less than 0.01 per cent and 0.3 per cent of their respective totals in 2002).

National emissions of CO_2 from civil aviation have increased by more than 34 per cent from 1990 to 2002. Reduction in the number of flights resulted in an emission decline of 14% from 2001 to 2002.

Civil aviation is a key source with respect to both level and trend due to uncertainties in the activity data.

3.4.2 Methodological issues

The types of fuel used in aircraft are both jet fuel (kerosene) and gasoline. The latter is used in small aircraft only. Consumption of aviation gasoline is based on sales figures. Domestic consumption of jet kerosene has been reported to SN 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.

The calculation methodology applied is described in report SN 2002. According to the IPCC Good Practice Guidance the methodology used is Tier 2 based on the detailed methodology in EEA (2001). This methodology allows estimation of emissions and fuel consumption for different types of aircraft according to the average flying distance and numbers of landings and take-offs (LTO). All movements under 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 as required according to the IPCC Guidelines (see Section 3.10).

Activity data

Statistics Norway collects data on the use of fuel from the air traffic companies annually. These data include specifications on domestic use and amounts bought in Norway and abroad. Emissions from the consumption of jet kerosene in domestic air traffic are based directly on these reported figures. Sales figures are used for some minor use of aviation petrol. This reporting started up in the mid-nineties so the data for 1990 are based on estimates and are more uncertain.

Emission factors

The Norwegian Petroleum Industry Association provides emission factors for CO_2 from the combustion of jet fuel and gasoline (SN 2002). A default emission factor for N_2O for all aircrafts is used (IPCC, 2001) and is valid for both LTO and cruise. EEA (2001) and IPCC (2001) suggest using an emission factor for CH_4, given in Oliver (1991), to be 10 per cent of total VOC. This is, however, only valid for LTO since studies indicates that only insignificant amounts of methane is emitted during cruise. No methane is therefore calculated for cruise and all emission is assumed to be VOC (HC).

Only aggregated emission factors (kg/tonnes fuel used) are used in the Norwegian Inventory, see Table 18 below. The emission factors are calculated based on total emission divided by activity data for respectively LTO and cruise.

Table 18. Emission factors for aviation used from 1997. kg/tonnes fuel. Source: IPCC (2001) and Finstad et. al (2002)

	CO_2	CH_4	N_2O	NMVOC
Charter/scheduled flights including helicopters				
Domestic				
LTO (0-100 m)	3.15	0.24	0.1	2.16
LTO (100-1000 m)	3.15	0.21	0.1	1.88
Cruise (Above 1000)	3.15	0	0.1	3.49
Foreign				
LTO (0-100 m)	3.15	0.39	0.1	3.53
LTO (100-1000 m)	3.15	0.07	0.1	0.61
Cruise (Above 1000)	3.15	0	0.1	0.5
Small aircraft				
LTO (0-100 m)	3.15	3.61	0.1	32.52
LTO (100-1000 m)	3.15	1.55	0.1	13.95
Cruise (Above 1000)	3.15	0	0.1	19.48

Recalculations have been done based on the new methodology (EEA, 2001 and Finstad et al, 2002) and this led to a change in emission factors for previously years. New emission factors back to 1989 have therefore been included in the inventory; see Table 19. Emission factors for 1989-1992 are based on aircraft data from 1989 while emission factors for 1993-1997 are based on aircraft data from 1995. Emission factors for small aircraft are the same for the whole period.

Table 19. Emission factors for aviation used before 1997. kg/tonnes fuel

	CH_4	NMVOC
Charter/scheduled flights including helicopters		
1989		
Domestic		
LTO (0-100 m)	0.21	1.86
LTO (100-1000 m)	0.19	1.74
Cruise (Above 1000)	0	3.87
Foreign		
LTO (0-100 m)	0.16	1.41
LTO (100-1000 m)	0.03	1.25
Cruise (Above 1000)	0	3.87
1995		
Domestic		
LTO (0-100 m)	0.26	2.32
LTO (100-1000 m)	0.22	1.96
Cruise (Above 1000)	0	3.51
Foreign		
LTO (0-100 m)	0.34	3.03
LTO (100-1000 m)	0.05	0.48
Cruise (Above 1000)	0	3.5

3.4.3 Uncertainties

The uncertainty in the activity data for civil aviation is estimated to be ±20 per cent of the mean, primarily due to the difficulty in separating domestic emissions from emissions from fuel used in international transport (SN, 2000). The uncertainty in the CO_2 emission factors is ±3 per cent. The contribution of this key source to the total level and trend uncertainty is respectively 83 and 80 per cent.

In a recent study on emissions from aircraft (SN, 2002), fuel consumption was also estimated bottom-up and compared to the reported figures (source specific QA/QC). 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.

3.4.4 Source specific QA/QC and verification

All inventory elements in this source category are subjected to QA/QC routines described in Section 1.6. Moreover, an improvement in the emission estimation methodology was carried out in 2002 and is described in the report SN 2002. According to the IPCC Good Practice Guidance the methodology used is Tier 2 based on the detailed methodology in EEA (2001). This methodology allows estimation of emissions and fuel consumption for different types of aircraft according to the average flying distance and numbers of landings and take-offs (LTO).

3.4.5 Recalculations

Since the previous calculation, there has been an increase in all years' emissions as a result of revised activity data for aviation petrol. In previous calculations activity data included only the amount purchased in the investment group "aviation". Now data from all investment groups, and therefore total sale of aviation petrol, are included in the calculations. This has resulted in increased activity data and therefore emissions for the whole time series.

3.4.6 Planned improvements

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

3.5 Road Transportation – CO_2, N_2O – 1A3b

3.5.1 Description

CO_2
Emissions of CO_2 from road traffic dominate the total emission in the transport sector and are an important part of the national GHG total. In 2002 they contributed 71% to the sectoral total and 17% to the total national GHG emissions.

Emissions have increased by 21% between between1990 and 2002 due to the increasing number of vehicles and annual mileage driven. Since 2001 emissions of CO_2 increased by about 2%.

This source category is a key source in both level and trend primarily due to uncertainties in activity data.

N_2O
Emissions of N_2O from road traffic accounted for about 11 per cent of the N_2O total and 1 per cent of the national GHG emissions in 2002. Since 1989 they have been increasing rapidly due to the introduction of catalytic converters. In 2002 N_2O emissions were more than six times greater than the 1990 levels. From 2001 to 2002 a 10 per cent increase is detected.

This source category is a key source with respect to total level and trend primarily due to uncertainties in emission factors.

Historical trends of emissions from road traffic, as well as the relationship between emissions and vehicle age in Norway are discussed in the report SN 2000.

3.5.2 Methodological issues

Emissions from road traffic are estimated by a model operating at Statistics Norway (SFT 1993; SFT/SN 1999b). A detailed description of its present structure is presented in (SN/SFT 2000). The calculation is based on detailed vehicle types and technologies, annual mileage per type and driving modes. Emissions from cold start and evaporation are estimated separately. The model results (expressed as average emission factors) are used as input to the general emission model.

Activity data such as vehicle numbers and mileage are used to allocate fuel consumption to usage classes. They are, as far as possible, taken from official registers, public statistics and surveys. However, some data are based on assumptions.

The emission factors are derived from driving cycle measurements made in Norway and other countries. The most important sources, besides Norwegian measurements reported to SFT (SFT, 1993), are data from (Eggleston et al. 1991, EEA 1997) and (Hassel et al. 1994). Emissions from warm engines and additional emissions from evaporation and cold starts are calculated separately. Evaporative emissions are estimated by the method described in the Corinair Guidebook (EEA 1996). Cold start emissions are calculated using factors from the COPERT Programme and from Sérié & Joumard (1996), taking into account detailed driving patterns and regional temperature data. Changes in emission factors due to ageing of vehicles have been taken into account by introducing ageing factors per 10,000 km.

Activity data

The annual sales statistics for petroleum products gives the total use of petrol and auto diesel. After subtraction of use in other sources, i.e. motorized equipment, railways, small boats and snow scooters, the remainder is split between different road vehicles in a separate road traffic model, taking into account lots of available information on car sizes, annual mileage and specific consumption. In some sectors, e.g. agriculture, all use of auto diesel is placed on motorized equipment, while keys to split the use between equipment and cars are used in some manufacturing industries (based on occasional surveys). Some petrol and auto diesel is used in small boats and snow scooters in households. Most of the petrol and auto diesel, however, is used in vehicles. In the late 1990s, natural gas was introduced locally, and on a very small scale, in some road vehicles.

Emission factors

For CO_2 the standard emission factors based on carbon content is used, see Table 17.

Emission factors for N_2O and CH_4 vary from year to year due to changes in the vehicle population. The factors are listed in Tables 20 and 21 below.

Table 20. Average CH_4 emission factors. Road traffic. Cold start emissions and evaporation included. g/kg fuel. Source: SN

	Gasoline					***Autodiesel***		
Vehicle type	*Passenger cars*	*Other light duty*	*Heavy duty*	*Mopeds*	*Motorcycles*	*Passenger cars*	*Other light duty*	*Heavy duty*
1973	1.759	1.279	1.983	5.896	4.926	0.119	0.156	0.208
1980	1.684	1.259	1.964	5.843	4.940	0.119	0.155	0.208
1986	1.601	1.043	1.994	5.850	4.946	0.120	0.145	0.193
1987	1.601	1.032	2.014	5.850	4.944	0.122	0.147	0.194
1989	1.615	1.050	2.115	5.855	4.938	0.126	0.152	0.192
1990	1.589	1.052	2.168	5.855	4.939	0.128	0.154	0.190
1991	1.565	1.049	2.234	5.855	4.939	0.126	0.155	0.189
1992	1.610	1.079	2.303	5.855	4.939	0.125	0.151	0.188
1993	1.591	1.056	2.350	5.855	4.939	0.117	0.142	0.183
1994	1.565	1.027	2.395	5.855	4.939	0.108	0.130	0.174
1995	1.537	0.996	2.406	5.855	4.939	0.103	0.119	0.167
1996	1.498	0.951	2.404	5.855	4.939	0.098	0.111	0.158
1997	1.442	0.914	2.388	5.855	4.939	0.091	0.104	0.150
1998	1.382	0.877	2.362	5.855	4.939	0.085	0.098	0.142
1999	1.332	0.833	2.310	5.855	4.939	0.080	0.092	0.136
2000	1.301	0.790	2.154	5.855	4.939	0.074	0.085	0.132
2001	1.231	0.716	1.698	5.855	4.939	0.069	0.078	0.126
2002	1.186	0.670	1.314	5.855	4.939	0.063	0.073	0.120

Table 21. Average N_2O emission factors. Road traffic. Cold start emissions and evaporation included. g/kg fuel. Source: SN

	Gasoline					***Autodiesel***		
Vehicle type	*Passenger cars*	*Other light duty*	*Heavy duty*	*Mopeds*	*Motor-cycles*	*Passenger cars*	*Other light duty*	*Heavy duty*
1973	0.068	0.063	0.031	0.059	0.061	0.138	0.166	0.146
1980	0.074	0.067	0.032	0.058	0.058	0.129	0.161	0.136
1986	0.085	0.074	0.034	0.059	0.054	0.132	0.185	0.127
1987	0.086	0.075	0.036	0.059	0.054	0.125	0.181	0.128
1989	0.094	0.075	0.039	0.059	0.053	0.112	0.168	0.128
1990	0.119	0.075	0.041	0.059	0.052	0.109	0.165	0.128
1991	0.151	0.075	0.042	0.059	0.052	0.109	0.164	0.128
1992	0.188	0.079	0.043	0.059	0.052	0.107	0.162	0.128
1993	0.243	0.096	0.044	0.059	0.052	0.119	0.163	0.130
1994	0.315	0.124	0.045	0.059	0.051	0.130	0.166	0.128
1995	0.404	0.164	0.045	0.059	0.051	0.139	0.174	0.131
1996	0.505	0.217	0.045	0.059	0.051	0.149	0.183	0.131
1997	0.622	0.281	0.045	0.059	0.051	0.159	0.190	0.133
1998	0.743	0.352	0.045	0.059	0.051	0.167	0.189	0.129
1999	0.880	0.429	0.045	0.059	0.051	0.176	0.182	0.126
2000	1.020	0.508	0.044	0.059	0.051	0.183	0.174	0.126
2001	1.165	0.584	0.044	0.059	0.051	0.192	0.167	0.126
2002	1.305	0.664	0.044	0.059	0.051	0.200	0.159	0.126

3.5.3 Uncertainties

With regard to CO_2 emissions from road transportation, the uncertainty in the activity data and emission factors is found to be ±20 per cent and ±3 per cent of the mean, respectively. This source category contributes 8.61 per cent to the total level and 4.75 per cent to the total trend uncertainty. In the case of N_2O the uncertainty in the activity data is ±20 per cent, but the uncertainty in the emission factors is as high as ±110 per cent. The contribution of this category to the total uncertainty in level and in trend is 3.31 per cent and 13.01 per cent, respectively.

3.5.4 QA/QC and verification

Source category elements undergo the general QA/QC routines described in Section 1.6. Top down and bottom up data on fuel consumption are compared for gasoline and diesel vehicles on an annual basis.The consumption of petrol 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; SFT/SN 1999b) performs bottom-up estimates of consumption which can then be compared with those from the top-down approach. For petrol, the agreement is very good (difference less than 5% for most years). For auto diesel the agreement is poorer with the top-down estimate up to 40% above the bottom-up estimate. The reason for this discrepancy is on the one hand uncertainties in the amount of off-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 off-road use. For N_2O, as well as for CH_4, the total emission is sensitive to the allocation due to different emission factors.

3.5.5 Recalculations

Revisions in the energy accounts give revisions in the emission figures for 2001. For 1980-1987 some gasoline consumption in forestry was moved from machinery to road transportation. A reallocation of auto diesel consumption between light and heavy vehicles has also been performed.

3.5.6 Planned improvements

This source category is very important for the trend. It has, therefore, been prioritised in the inventory improvements the last years (SN 2000). The future improvement of the estimate of N_2O from road traffic is dependent on the availability of measurement data that are applicable for Norwegian conditions. Recent studies have indicated that the increase in N_2O emissions factors is reduced for the newer types of technology. Norway will consider changing the emission factor if this documentation is confirmed by more studies.

3.6 Navigation – 1A3d

3.6.1 Description

Emissions of CO_2 from navigation in Norway increased by 16 per cent in the period 1990-2002 due to the general growth in economy activity, primarily in the oil and gas extraction sector. Since 2000 emissions have been stable. In 2002 they accounted for 4 per cent of the total GHG emissions in Norway. The contribution of CH_4 and N_2O to the total emission in this sector is insignificant.

Navigation is a key source in level due to uncertainties in the activity data.

3.6.2 Methodological issues

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

The levels and the spatial distribution of emissions from national sea traffic are estimated by an updated and improved methodology presented in the report SN 2001. This methodology is based on the work performed by Statistics Norway (SN, 1996; SN, 1998 and 2001a). The improvement is due to the collection of new data on fuel use for the different vessel categories and the registration of changes in regular coastal trade (connections/distances). Mobile drilling rigs are also included in the calculations. Emissions from international marine bunkers are excluded from the national totals and are reported separately (Section 3.10) and in accordance with the IPCC Good Practice Guidance.

Annual emissions are estimated from sales of fuel to domestic shipping and fishing and an average emission factor. For 1993 and 1998 emissions have also been estimated based on a bottom up approach (SN 2001a)[5]. In particular, 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. The fuel use is used to verify the use estimated from sales figures. Emissions were estimated from ship and size specific emission factors and the fuel use. From this, average emission factors were estimated for application in the annual update based on fuel sales.

Activity data

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

[5] This approach is too resource demanding to perform annually.

companies. The consumption figures for other types of ships and boats are mainly taken from the report SN 1996.

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

Emission factors

For CO_2 the standard emission factors based on carbon content are used, see Table 17. The EFs we use for ships are 0.08 kg N_2O/tonne fuel and 0.23 kg CH_4/tonne fuel. The factors are from IPCC/OECD. The factors are uncertain and they ought to be evaluated when new information is available.

3.6.3 Uncertainties

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

The uncertainty in the activity data and the CO_2 emission factors is assessed to be ±10 and ±3 per cent of the mean, respectively. The contribution of this source category to the total level uncertainty is 1.05 per cent.

3.6.4 Source specific QA/QC and verification

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

3.6.5 Recalculations

Revisions in the energy accounts resulted in small revisions in the emission figures for 2000-2001.

3.6.6 Planned improvements

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

3.7 Fugitive emissions from Coal mining and Handling – 1B1a

3.7.1 Description

There are today two coal mines at the island Spitsbergen operated by a Norwegian company. Mine number two was opened in 2001. Emissions from the mines are included in the Norwegian Inventory.

Emissions from all activities at Svalbard are by Norwegian authorities defined to be included in the Norwegian GHG Inventory. This includes *inter alia* the emissions from the Russian coal mining in Barentsburg but due to lack of data the emissions are not estimated.

At there is also a smouldering fire in an abandoned coal mine. This mine was operated by the Russians and was closed down in 1999. Due to lack of data neither emission from this mine when it was in production nor from the smouldering fire are estimated. However, Norwegian authorities assume that the emission from the smouldering fire is limited.

The total production of coal in 2002 was 2.1 million tonnes, which is seven times higher than in 1990. The emissions of CH_4 from coal mining were 995 tonnes in 2002.

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

3.7.2 Methodological issues

Emissions of methane from coal mining in Norway are calculated by multiplying the amount of coal extracted with a country specific emission factor (Tier 2). Indirect CO_2 emissions from methane oxidized in atmosphere is calculating by multiplying the calculated CH_4 emission with the factor 2.75 tonne CO_2 per tonne CH_4.

Activity data

The amount of coal extracted is reported by the plant to SN.

Emission factor

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 by (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 coalmines 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 we therefore conclude to use the 0.54 kg methane per tonne coal as emission factor when calculating methane emission from coal mining in Norway.

According to IPCC`s Good Practice Guidance the Norwegian mines at Spitsbergen has characteristics that should define the mines as underground mines. While 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 meter *above* sea level. The rock at Spitsbergen is porous and therefore methane has been aired through many years.

3.7.3 Uncertainties

The uncertainty in the activity data is regarded as being low. On the other hand there is great uncertainty in the emission factor; maybe as much as -50 to +100 per cent (SN 2000) and (IPCC 1997).

There is great uncertainty in the emission factor. In (SN 2000) the uncertainty in the EF was estimated by expert judgments to as much as -50 to +100 per cent. We then used an IPCC default emission factor in the calculation. Today we use a country specific factor based on measurements. Therefore we assume that the uncertainty in the EF now is much lower than in (SN 2000).

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

3.7.4 Source-specific QA/QC and verification

Internal checks of the emission time-series is carried out by SN and SFT and corrections are made when errors are detected.

Independent methods to estimate the EF used in the calculation is described above in this Section.

3.7.5 Recalculations

No recalculations of the emission data are performed since previous submission to UNFCCC.

3.7.6 Planned improvements

Emissions from the Russian mine will be included in the Norwegian GHG Inventory in NIR 2005. We received the data too late to incorporate the emissions in this submission.

3.8 Fugitive emissions from oil and natural gas - 1B2a-c

The Norwegian Greenhouse Gas Inventory has been reviewed by international experts nominated by UNFCCC in several occasions. The review teams have asked Norway to document the calculated emissions better. In this year's NIR we will make an effort to meet the review team's remarks to this sector.

3.8.1 Description

The emission sources are calculated and reported in the source category Fugitive emissions from Oil and Gas is described in Table 22 the emission sources, compounds and methodological issues included in the Norwegian GHG Inventory is explained.

Emission sources
The major emissions of GHG from this sector are from source category *1B2a iii Transport* and *1B2c Flaring ii Gas*.

The emissions from the source *1B2a iii Transport* are direct emissions of CH_4 and indirect emissions of CO_2 from oxidised NMVOC during loading, unloading and storage of crude oil on the oil fields off shore and oil terminals on shore.

Flaring gives emissions of CO_2, CH_4 and N_2O. Other major emissions are NO_X emissions. The sector *1B2c Flaring* includes CO_2 emissions from flaring of natural gas off shore, CO_2 from flaring at gas terminals and refineries and CO_2 from well-testing during exploration and extraction/production drilling of oil and gas. The major source in sector 1B2 is flaring of natural gas on oil- and natural gas fields.

The sector *1.B.2.c Venting* includes emissions of CH_4 and NMVOC from exploration and production drilling of gas and oil and reinjection of CO_2 at one oil field. The latter emission source is described in Section 3.11.3 in the NIR. The major source in sector 1B2c Venting is cold vent and leakage of CH_4 and NMVOC from production drilling and hence indirect CO_2 emissions.

In addition to the above described sources this source category also includes emissions of CO_2, CH_4, N_2O and NMVOC, and hence indirect CO_2 emissions, from

- 1.B.2.a iv Refining and storage of oil at refineries
- 1.B.2.a v Distribution of oil products
- 1.B.2.b Other leakage at gas terminals.

Emissions from this source category
Fugitive emissions from oil and natural gas contribute to about 6 per cent of the total GHG emission in Norway in 2002. Due to increased amounts of crude oil loaded and a general growth in the production of oil and gas the emissions have increased by 13 per cent since 1990.

CO_2 from flaring off shore contributed in 2002 to almost 2 per cent of the total GHG emissions in Norway. Despite increased production of oil and gas the CO_2 emissions from flaring is 25 per cent lower in 2002 than it was in 1990. From 2001 to 2002 the emission decreased by 25 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 effect of this can be illustrated with the fluctuation of the amount of flaring at a gas and oil field. In 2000 the CO_2 emissions from flaring were more than 0.2 million tonnes CO_2 while it was reduced to 0.1 million tones in 2001 and 2002. The venting rate is low due to strict security regulations.

CO_2 from flaring is *key source* with respect to the level and total trend due to change in level and trend. CH_4 from cold vent and leakage in oil production is a key source with respect to level and the total trend due to uncertainties in emission factors and change of trend.

CH_4 emissions and indirect emissions of CO_2 from oil loading etcetera are *key sources* both in level and in trend due to uncertain emission factors.

Table 22. Fugitive emissions from oil. 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	NE	NO	E	Tier I/II	CS	PS
v. Distribution of oil products	E	-	NO	E	Tier I	Corinair/ CS	PS/CS
vi. Other	IE	IE	NO				
1.B.2.b Natural gas							
Exploration							
i. Production/Processing	IE	IE	NO				
ii. Transmission	IE	IE	NO				
Distribution							
iii. Other leakage							
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			
ii. Gas	IE	IE	NO	IE			
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 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			

E = Emissions are calculated

3.8.2 Methodological issues

Loading and storage of crude oil on and off shore
The emissions of CH_4 and NMVOC from loading and storage of crude oil on shuttle tankers are calculated by multiplying the amount of crude oil loaded and stored with field specific emission factors. Since year 2000 some tankers have had installed vapour recovery units (VRU). Emissions from loading of crude oil on shuttle tankers with and without VRU are calculated separately for each field. Only the Norwegian part of oil production at fields with oil loading is included.

A similar method is used for calculating emissions from loading of crude oil at the two Norwegian oil terminals onshore and the emissions are reported by the terminals to SFT.

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

Flaring
CO_2 emissions from flaring off shore are calculated by SN on the basis of field specific gas consumption data and country specific emission factor for natural gas.

Activity data

Loading and storage of crude oil on and off shore
The amount of crude oil loaded at shuttle tankers and stored at storage vessel used in the calculation of CH_4 and NMVOC are collect by SN from the Norwegian Petroleum Directorate (OD). The data from each field is each month reported by the field operators to OD on both a mass and a volume basis. The density of the crude oil is also reported. 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 is committed to deliver to SFT and OD.

Venting
The activity data is the amount of gas produced or handled at the platform.

Flaring
The amount of gas flared that SN use in the calculation of the CO_2 emissions from flaring is collected from the statistical office in the Norwegian Petroleum Directorate (OD). OD receives monthly reports with the amount of gas flared. The same data are also included in an annually report to SFT and OD. The two set of data are compared in a quality control of the consumption data.

Emission factors

Loading and storage of crude oil on and off shore
Emission factors used in the calculation of the CH_4 and NMVOC emissions are field specific and is reported to SFT and OD in the same annually report as mentioned before. SFT forwards the emission factors to SN.

The emission factor is considerably lower at one terminal than at the other because the oil is transported by ship to the terminal 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. In 2002, NMVOC emissions at this terminal were estimated to be more than 50 per cent lower than they would have been without VRU. However, VRU technology is not designed to reduce methane and ethane emissions.

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.

Venting
The emission factors used are in Table 23. Their reference is Aker Engineering (1992).

Table 23. 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 [6]	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
In the calculation of CO_2 emissions from flaring off shore we use a country specific emission factor. Plant specific emission factors are available but not yet included in the inventory. This is mainly due to difficulties in preparing a consistent time-series.

[6] The gas source is standard fuel gas.

3.8.3 Uncertainties

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

Due to uncertainties in the CO_2 emission factor flaring is a key source in total trend. It is not likely to expect that the uncertainty in trend will be lower when we include field specific emission factors in the calculation.

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

3.8.4 Source-specific QA/QC and verification

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

The calculated emissions are compared with the emission data the field operators report to SFT and OD. 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.

3.8.5 Recalculations

The emission factors for NMVOC and CH_4 has been increased for oil loading off shore for one oil field for the years 1996-2001. Hence, the indirect CO_2 emissions from this source is reduced for the same years, see Section 3.11.4.

3.8.6 Planned improvements

Norway will consider to used field specific EFs for flaring off shore from next year submission and then recalculate the whole time series for flaring off shore.

3.9 Non-key sources

We will go through the non-key sources in the energy sector in the following.

3.9.1 Stationary Fuel Combustion (1A1, 1A2, 1A4)

1. All Source Categories – Solid Fuels, Biomass, Other Fuels – CO_2

Solid fuels

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

Consumption of coal, coke and petrol coke in manufacturing industries is annually reported from the plants to Statistics Norway. The statistics cover all main consumers and is of high quality. Combustion takes partly place 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 in agriculture is collected from the user.

The CO_2 emission factors used for coal and coke reflect the average carbon content of Norwegian fuels (SFT 1990 and OLF 1994).

Biomass

Use of wood waste and black liquor in manufacturing industries is taken from Statistics Norway's annual survey on energy use in these sectors. Some plants have, however, problems in reporting accurate figures for wood waste. 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 self-harvest. Figures on some minor use in agriculture and construction are derived from earlier surveys for these sectors. Combustion takes place in boilers and, in private households, small ovens.

2. All Source Categories – CH_4, N_2O

Emissions of CH_4 and N_2O in energy industries are negligible. The collation of activity data follows the procedures described in Sections 1.3 for CO_2.

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

3.9.2 Transport (1A3)

3. Civil Aviation – CH_4, N_2O (1A3a)

The methodology used in the calculations and the collation of activity data are described in Section 3.4.

Emission factors for CH_4 and N_2O are listed in Table 18 in Section 3.4.1. A default emission factor for N_2O for all aircrafts is used (IPCC, 2001) and is valid for both LTO and cruise. EEA (2001) and IPCC (2001) suggest using an emission factor for CH_4, given in Oliver (1991), to be 10 per cent of total VOC. This is, however, only valid for LTO since studies indicates that only insignificant amounts of methane is emitted during cruise. No methane is therefore calculated for cruise and all emission is assumed to be VOC (HC).

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

4. Road Transportation – CH_4 (1A3b)

The methodology used in the calculations and the collation of activity data are described in Section 3.5.

The emission factors for CH_4 are presented in Table 20 in Section 3.5.2. They vary from year to year due to changes in the vehicle production.

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

5. Railways – All Components (1A3c)

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

Activity data for auto diesel used in locomotives are collected annually from The Norwegian State Railways.

The emission factors are the same as for diesel machinery in mining and quarrying (see Table 24).

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

In the context of QA/QC, it is possible to compare consumption data from the Norwegian State Railways with sales to railways according to the Petroleum statistics. In such a circumstance care should be taken in handling the latter data since they include some consumption by buses operated by the State Railways.

6. Navigation – CH_4, N_2O (1A3d)

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

Emission factors for CH_4 and N_2O are 0.23 g/kg fuel and 0.08 g/kg fuel, respectively (see Section 3.6) and are taken from IPCC (1996).

The uncertainty in the activity data is assessed to be ±10 per cent of the mean. For CH_4 the uncertainty in the emission factors ranges between -50 and +100 per cent of the mean. For N_2O the uncertainty range is between -66 and +200 per cent of the mean (SN 2001c).

7. Other Transportation – All Components (1A3e)

Pipeline transport

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

The EFs we use for the turbines fired with natural gas are the following:

- CO_2: 2.34 kg/Sm^3
- CH_4: 0.91 g/Sm^3
- N_2O: 0.019 g/Sm^3

Motorized equipment

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

Emissions from motorized equipment are reported under several categories:

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

Only consumption of petrol and auto diesel is considered.

Activity data for petrol and auto diesel are handled differently. Consumption of *petrol* is estimated bottom-up for each type of machinery based on data on number of equipment, usage and specific consumption. The consumption is kept constant for most categories, but the number of snow scooters is updated annually. Consumption of *auto diesel* is based on data from the energy accounts. A certain fraction of the consumption in a number of industries is allocated to motorized equipment, based on surveys or expert judgment.

Table 24. Emission factors of CH_4 and N_2O for boats, snowmobiles, motorised equipment and diesel locomotives. Source: SFT (1993) and IPCC (1997b)

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

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

3.9.3 Other (1A5)

8. Military activities – All Components (1A5ab)

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. Stationary and mobile emissions from the Norwegian military activities for the years 1990 and 1998-2002 are listed in Table 25.

Table 25. Stationary and mobile emissions from military activities Unit: CO_2 in Mtonnes, CH4 and N2O in tonnes

	CO_2	**CH_4**	**N_2O**
1990			
1A5A Military - stationary	62.4	7.9	0.6
1A5B Military - mobile	393.7	15.1	12.5
1998			
1A5A Military - stationary	49.6	6.2	0.5
1A5B Military - mobile	309.9	10.9	112.8
1999			
1A5A Military - stationary	50.3	6.3	0.5
1A5B Military - mobile	341.3	10.6	12.0
2000			
1A5A Military - stationary	40.6	5.1	0.4
1A5B Military - mobile	137.5	7.5	5.3
2001			
1A5A Military - stationary	54.4	6.9	0.5
1A5B Military - mobile	240.6	12.8	8.3
2002			
1A5A Military - stationary	44.1	5.5	0.4
1A5B Military - mobile	409.2	9.8	13.3

3.10 International bunker fuels

Emissions from international aviation and marine bunker fuels are excluded from national totals as required according to the IPCC Guidelines. Emission figures are presented separately for information in Table 26.

In 2002, CO_2 emissions from ships and aircraft in international traffic bunkered in Norway amounted to a total of 2.9 million tonnes, which corresponds to about 7 per cent of the total Norwegian CO_2 emissions. CO_2 emissions from marine and aviation bunkers showed a growth of about 40 per cent during the period 1990 to 2002. This increasing trend was reversed in 1998, and between 2001 and 2002 emissions were reduced by 5 per cent.

Looking at the two categories international marine and aviation bunkers separately, we find the emissions of CO_2 from ships in international traffic increased by 48 per cent from 1990 to 2002, while emissions of CO_2 from aircraft increased by 19 per cent over the same period. The reason for such an increase is primarily growth in traffic. Aircraft engines are more fuel-efficient now than they were some years ago. This means that the increase in international air-traffic has been higher than that of the emissions.

Table 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, 1990-2001. Unit: 1000 tonnes. CO_2 in Mtonnes. Source: SN/SFT

Marine	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
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
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
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
NOx	30.3	25.6	32.1	34.3	37.8	46.2	50.7	61.4	61.8	58.3	57.8	56.0	46.0
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
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
SO_2	9.9	9.7	12.3	13.5	14.0	13.7	15.4	18.8	14.9	12.9	11.5	13.1	8.0
Aviation	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
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
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
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
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
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
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
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

3.10.1 Methodological Issues

Greenhouse gas emissions from international bunkers (marine and aviation) have been estimated and reported separately from national estimates, in accordance with the IPCC Guidelines. The consumption of aviation bunker fuel in Norway is estimated as the difference between total purchases of jet kerosene in Norway for civil aviation (Petroleum Statistics) and reported domestic consumption. A new methodology has been applied to separate domestic from international fuel use for aviation. Figures on total aviation fuel consumption are derived from sales data collected by Statistics Norway (SN) from the Norwegian petroleum company.

These data do not distinguish between national and international uses. Data on domestic fuel purchase and consumption is therefore collected by SN 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 sale for international aviation. The bottom-up approach of Norway is the detailed Tier 2 CORINAIR methodology. The methodology is based on detailed information on types of aircraft and number of LTOs, as well as cruise distances.

We are aware of the differences between the IEA data and the CRF in sectoral data for marine shipping and aviation, which 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.

3.10.2 Precursors

Emissions of NO_x from ships were 48 ktonnes, or about 22 per cent of the total Norwegian NO_x emissions in 2002. During the period from 1990 to 2002, NO_x emissions from international shipping bunkered in Norway increased by 52 per cent. NO_x emissions resulting from international aviation amounted to 2.7 ktonnes in 2002. They increased by 29 cent from 1990 to 2002. As for the other gases in the table, emissions from international aviation and marine bunker fuels are small compared to the total Norwegian emissions of these gases.

3.11 Cross-cutting issues

3.11.1 Sectoral versus reference approach

As shown in the CRF Table 1Ac, comparison of CO_2 emissions from fuel combustion between the Reference and the National Approach (RA and NA respectively) has revealed large deviations in both the energy consumption data (20.4 per cent) and the CO_2 emissions (-8.5 per cent). In the case of CO_2 emissions, the deviation between the two approaches for the years 1990 and 1998-2002 is displayed in Table 27.

Table 27. Comparison between the reference approach and the sectoral approach. 1990, 1998-2001. Gg. Change in per cent. Deviation in per cent. Source: SN/SFT

	1990	**1998**	**1999**	**2000**	**2001**	**90-98**	**90-99**	**90-00**	**90-01**	**90-02**
National Sectorial Approach (Gg)	26.4	31.7	31.9	31.0	32.0	20 %	21 %	17 %	21 %	**20 %**
National Reference Approach (Gg)	25.3	32.0	34.4	33.8	34.3	21 %	30 %	28 %	30 %	**32 %**
Deviation (%)	**-4.27 %**	**0.91 %**	**7.79%**	**8.81 %**	**7.25 %**	**-1 %**	**-9 %**	**-10 %**	**-9 %**	**-9%**

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 Approach (RA) and Sectoral Approach (SA). 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 much CO_2 compared to national total emissions. Norway has a large non-energy use of coal, coke, natural gas and liquefied petroleum gas (LPG), large oil and gas production and exports (domestic supply is the difference between the two large numbers in each case), and relatively large statistical errors, which makes the use of the reference approach inappropriate. End-user statistics from sales by energy commodity, sector and source that are used in the sectoral approach are considered to be more reliable.

The energy balance data used in the CRF are the same data that Statistics Norway has reported to the IEA, but there are differences in the RA estimated by Statistics Norway and the one published by IEA. The main reason for this is that IEA distributes the statistical error between the RA and SA. The IEA estimate is furthermore based on default assumptions about carbon stored, which differs from the actual situation in Norway. IEA and Statistics Norway uses different definitions of domestic and international fuel use with respect to shipping, aviation and offshore gas combustion and flaring (offshore installations are included in the latter while excluded from the former).

3.11.2 Feedstocks and non-energy use of fuels

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

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

3.11.3 CO_2 capture and storage at the oil and gas production field Sleipner West

Description

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

When this North Sea field was planned around 1990 the considerations were influenced by the discussions about strategies to reduce green house gas emissions and a possible national tax on CO_2-emissons (introduced in 1991 and extended in 1996). It was therefore decided that

the removed CO_2 should be injected for permanent storage into a geological reservoir. In their search for a suitable reservoir the companies were looking for a saline aquifer with reasonable high porosity and a capture rock above to prevent leakage. Furthermore the CO_2 should be stored under high pressure - preferably more than 800 meters below the surface. Under these conditions CO_2 is buoyant and less likely to move upwards than CO_2 in gaseous form. The chosen reservoir is the Utsira formation which is a sandstone saline aquifer 1,000 metres beneath the seabed. The field and the injection program have been in operation since 1996. Statoil monitor the injected CO_2 with respect to leakages. Investigations carried out so far show that the injected CO_2 have been kept in place without leaking out.

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. In 2002 this emission amounted to 7567 tonnes CO_2. The figure for the other years is given in Table 28.

Table 28. Emissions of CO_2 from the Sleipner CO_2-injection plant due to inaccessibility of the injection facilities, tonnes. Source: SFT

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

Methodological issues

In order to document what happens with the CO_2 Statoil together with energy companies and research institutes from several countries have started a R&D project called "The saline aquifer carbon dioxide storage (Sacs) project". The core of Sacs 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. One was conducted before injection started, and another took place in the autumn of 1999. The project has confirmed that sound waves reflect differently from carbon dioxide and salt water. Comparing seismic data collected before and after injection started has allowed researchers to show how CO_2 deep inside the Utsira formation migrates. It is held under the layer of shale cap rock, 80 metres thick, which covers the whole formation. This extends for several hundred kilometres in length and about 150 kilometres in width.

Uncertainties

The reported data covers emissions to the atmosphere when the injection system is out of operation. These data are considered most accurate. So far there have not been detected any leakage from the storage. The uncertainty in the emissions has not been estimate. However, we expect to have more reliable information when the monitoring program is put in place according to Statoil's emissions licence – see QA/QC and verification below.

QA/QC and verification

The results are promising and so far it looks that the injected gas remains in place rather than leaking out. However, it remains to see how permanent the storage is. The storage of CO_2 is included in the emission licence for the Sleipner West field. According to the license Statoil should draw up a proposal for a monitoring program of the CO_2-storage within July 1 2003. Furthermore Statoil shall report the amount of CO_2 injected and the results of the monitoring every year to The Norwegian Pollution Control Authority. The monitoring program will give an system for QA. The injected CO_2 is believed to be removed from the atmosphere and

hence it is not reported as in the emission inventory. When the injection have to stop for maintenance etc Statoil have to pay a CO_2-tax for the emissions. These emissions are reported to the Norwegian Petroleum directorate. They are counted for in the emissions inventory.

3.11.4 Indirect CO_2 emissions from CH_4 and NMVOC

According to the reporting guidelines to the Climate Convention it is required to include all emissions of carbon from fossil compounds 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 hence be included. Fossil carbon in fuels *combusted* are automatically included in the emission inventory due to the fact that the guidelines for calculating the emissions takes into account the fossil carbon in the fuel. These indirect CO_2 emissions are included in the Norwegian GHG inventory. However, indirect CO_2 emissions from non-combustion sources originating from the fossil part of CH4 and NMVOC are taken into account separately calculated on the basis of average carbon content.

Fossil carbon in the emissions of CH_4 and NMVOC from the following non-combustion sources are included in the Norwegian GHG emission inventory:

- 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. In methane we have estimated an average of 75 per cent carbon and in NMVOC 82 per cent. This leads to the emission factors 2.75 kg CO_2/kg CH_4 and 3 kg CO_2/kg NMVOC.

Chapter 4. Industrial Processes

4.1 Overview

This chapter provides brief descriptions of the methodologies employed to calculate emissions of greenhouse gases from industrial processes. For further description of the methodologies we refer to section 3.2 of the report SN/SFT 2000. Furthermore, an overview of emissions from industrial processes is presented in Section 2 of this report.

From the key source analysis performed this year we found that PFCs from Aluminium production, CO_2 from ferroalloy production and consumption of halocarbons are key sources in level and/or trend due to high emission level, changing trend and uncertainty.

4.2 PFCs from Aluminium production – 2C3

4.2.1 Description

PFCs from aluminium production accounted for 2.0 per cent of the national total GHG emissions in 2002. This is a decrease from 6.3 per cent in 1990. The reduction has been achieved by improving the efficiency of the production process and by installing point feeders to reduce the numbers and duration of anode effects per cell day (AEF). For Søderberg cells, installation of point feeders has contributed significantly. This has caused a reduction of the PFC emissions per tonne aluminium produced in Norway from 3.79 kg CO_2-equivalent in 1990 to 1.07 kg CO_2-equivalent in 2002. The relative emissions of PFCs in CO_2 equivalents per tonne aluminium produced have increased by 7 per cent from 2001 to 2002. This is due to operational problems such as power failure, unstable amperage and anode problems, which has resulted in increased anode effects. Some plants changed from Søderberg to Prebaked technology during 2002, and they report that the start-up of the new furnaces has resulted in increases in the specific emissions.

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

More than 60 per cent of the aluminium was produced with Prebaked technology in 2002. Almost 30 per cent was produced by old Søderberg and about 10 per cent by new Søderberg technology. The share of aluminium produced by using Prebaked is increasing.

PFCs from aluminium production are a key source both in level and trend due to uncertainty in the emission factors and the reduced share of total emissions from 1990 to 2002.

4.2.2 Methodological issues

Methodology

Perfluorinated hydrocarbons (PFCs), e.g. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), are produced during anode effects (AE) in the Prebake and Søderberg cells, when the voltage of the cells increases from the normal 4-5V to 25-40V. During normal operating

condition, PFCs are not produced. Starting of new electrolytic cells generates additional PFC emissions. The fluorine in the PFCs produced during anode effects originates from cryolite. Molten cryolite is necessary as a solvent for alumina in the production process.

Emissions of PFCs from a pot line (or from smelters) are dependent on the number of anode effects and their intensity and duration. Anode effect characteristics will be different from plant to plant and also depend on the technology used (Prebake or Søderberg).

In 1992, 1996-1997 and 2000-2001, the Norwegian aluminium industry measured emissions of PFCs from the smelters. For Søderberg potrooms, the monitoring also comprised PFCs in ventilation air from the potrooms. The measurements in production cells were carried out using a photoacoustic gas monitor.

The formula currently used in Norway for calculating CF_4 and C_2F_6 emissions from aluminium production is as follows:

$$Q=1.01 \cdot [A \cdot B \cdot C \cdot D \cdot E + (F \cdot G)],$$

where Q is the total yearly emissions of CF_4 and C_2F_6

Variables to be reported each year:

B number of anode effects per cell per day
D average annual amperage in kA
E number of cells in production multiplied by number of production days
G number of "newly started" cells

Constants:

A average measured emissions per anode effect minute per kA per cell
C duration of anode effect in minutes
F average emissions per new start of a cell
1.01 The measured amount of $CF_4 + C_2F_6$ is multiplied by 1.01 in order to compensate for incomplete monitoring of C_2F_6, see explanation below.

Measurements from 1992 showed that the content of C_2F_6 in anode gas was 1 to 10 per cent, and 3 per cent on average. The measured emissions of CF, that is $CF_4 + C_2F_6$, include all CF_4, but only about 70 per cent of the C_2F_6 emissions. This means that 1 per cent of the total emissions of $CF_4 + C_2F_6$ was not measured. The measured total figure for $CF_4 + C_2F_6$ is therefore multiplied by a factor of 1.01 to include non-measured C_2F_6. The total amount of C_2F_6 in the total estimated $CF_4 + C_2F_6$ emissions (Q) is then 4 per cent. These results were confirmed by the measurements made in 1996-97.

The variables of the calculation

Factor B related to the number of anode effects per cell per day, factor D related to the average annual amperage in kA, factor E related to the number of cells in production multiplied by number of production days, and factor G related to the number of newly started cells, are all based on measurements and registrations that are done more or less continuously as part of the regular monitoring of operating results and plant performance. The data are

assumed to be of good quality, and uncertainties in the figures will probably have no significant effect on the calculated emissions.

The constants of the calculation

Factor A
The emissions of CF_4 and C_2F_6 are calculated in kg per year and kg per tonne aluminium produced. These emissions are specified for each plant. For the plants that have both Søderberg and Prebake technology, the emissions are specific for each technology.

Monitoring of emissions followed by calculation of the average emissions of CF_4 per anode effect minute per kA per cell, was carried out in 1992, 1996-97 and 1999-2000. For Prebake-lines, the monitoring campaigns gave some differences in the results for each individual plant, while the average figure for all plants was fairly stable. The same situation applied for the Søderberg-lines.

Estimated uncertainty for both technologies is ± 20 %.

The results from the Prebake-lines are reasonably in line with results from ALCOA and with the IPCC recommendation. Also the average results for Søderberg-lines are in line with the IPCC recommendation, but with smaller margin.

Monitoring of emissions of CF_4 from Søderberg-lines is more difficult than from Prebake-lines, mainly due to the difficulty of getting representative results from fugitive emissions in ventilation air from the potrooms.

The monitoring results of C_2F_6 have significantly bigger uncertainty than for CF_4, and the uncertainty is probably bigger for Søderberg-lines than for Prebake-lines.

Monitoring results from Prebake-lines in 1999/2000 have an estimated uncertainty of 40 %. The values are lower than the IPCC recommendation and lower than some other reported results. The main reason for the deviations is possibly problems to achieve representative monitoring results.

Factor C
The Norwegian calculations of emissions are based on constant duration of anode effects. These constants are specific for each plant and each technology. This is a simplification which contributes to an uncertainty of the calculated result.

At all the plants there are major efforts to reduce the length of the anode effects, and the reported results will therefore be less accurate when the efforts pay off.

In The Aluminium Sector Greenhouse Gas Protocol, International Aluminium Institute, May 2003, the recommended calculation of PFC emissions in accordance with Tier 3 is based on real duration of anode effects. The Norwegian method of calculation will probably be in line with this recommendation when the method has been evaluated in 2004. (See the next section Completeness).

The factor 1,01
The accuracy will depend on the quality of the monitoring results of CF_4 and C_2F_6 and their ratio.

4.2.3 Uncertainties

The uncertainty in the emission estimates of PFCs from aluminium production is mostly determined by the uncertainty in the emission factors. PFCs from aluminium production are among the four source categories in the Norwegian GHG Inventory that is most important to the inventory's level and trend uncertainty (SN, 2000). This is in spite of the efforts that have been done to improve the quality of the emission data.

4.2.4 Source-specific QA/QC and verification

The annual emission figures from the aluminium plants are reported to SFT once per year. As a quality control, it is checked that the reports are complete. Each figure is compared with similar reports from previous years and also related to technical changes and utilisation of production capacity during the year. If errors are found SFT contacts the plant to discuss the reported data and changes are made if necessary.

SFT has regular meetings with the aluminium industry where all plants are present. This forum is used for discussion of uncertainties and improvement possibilities.

SFT's auditing department are regularly auditing the aluminium plants. As part of the audits, their system for monitoring, calculation and reporting of emissions are controlled.

SFT had recently audits at all aluminium plants to check their system for monitoring of emissions of PAH. It will be considered whether similar audits should have climate gases as the main target.

4.2.5 Recalculations

There has been a substantial recalculation of the PFCs emissions from one producer of aluminium. Specifically the emissions in 1990 and 2001 are recalculated and some minor recalculations are made for 1998, 1999 and 2000. The changes are based on an evaluation that has been carried out by the aluminium industry to consider the industries GHGs data in general. Concerning the PFCs from aluminium production the decision was that for 1990 one should use the data from the voluntary agreement between the industry and the government. This resulted in the recalculation of PFCs emissions in 1990, particularly, for one plant. As a consequence of the same plant had to recalculate emission for some other years, too.

Additionally some changes are done for a few other plants but this recalculation is due to small error in the figures.

4.2.6 Planned improvements

With the purpose of monitoring the reduction of emissions from 1990 to 2005, the current method for calculation of climate gases is considered to be acceptable, even if it has some weaknesses.

In the future, the absolute emission values will be more important, and all climate gasses will therefore have to be monitored or calculated more precisely. The method for monitoring of emissions will therefore be evaluated and improved. Discussions on this issue will start in 2004 in cooperation between the aluminium industry and the environmental authorities. The experience from other countries will be utilized.

4.3 SF_6 used in Magnesium foundries – 2C4

4.3.1 Description

SF_6 from magnesium foundries accounted in 2002 for 0.4 per cent of the total GHG emissions in Norway. In 1990 this sector contributed with 4.2 per cent of the national total GHG emissions. The reduction is due to improvements in technology and in process management. The primary magnesium production stopped in 2002 and only secondary production is retained. It is anticipated that this will cut down the consumption of SF_6 by 60-80 per cent.

SF_6 is today used as a cover gas in the magnesium industries to prevent liquid magnesium to oxidise. The covering gas is emitted to air and no SF_6 is expected to react with the metal. Since 1996 SF_6 is no longer used during aluminium production. The gas is assumed to be inert; hence the emissions are set equal to the consumption of SF_6. It is still used in magnesium production.

SF_6 emissions from magnesium foundries are key source in trend due to change in trend.

4.3.2 Methodological issues

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.

4.3.3 Uncertainties

The uncertainty in the emissions is assumed to be ± 5 per cent.

4.3.4 Source-Specific QA/QC and verification

The last years reported emission data from the plant is compared with previous reported data and the emissions are compared with the production.

4.3.5 Recalculations

The emissions have not been recalculated since the NIR 2003.

4.3.6 Planned improvements

There are no plans for improving the data for the time being.

4.4 CO_2 from Ferroalloy production – 2C2

4.4.1 Description

CO_2 emissions from ferroalloy production accounted for 5.2 per cent of the national total GHG emissions in 1990 and have decreased to 4.6 per cent in 2002. The total CO_2 emissions from production of ferroalloy have decreased by 5.3 per cent from 1990 to 2002. The reduction is due to reduced activity in the sector and that plants have been shut down.

CO_2 emissions from production of ferroalloys are key source in level and trend due to uncertainty in emission factors and the large share of total emissions.

4.4.2 Methodological issues

Methodology

The method used in the calculation of CO_2 emissions from production of ferroalloy is in accordance with the method recommended by the IPCC (IPCC 1997b). This methodology is based on consumption of reducing agents and electrodes and national emission factors. Emission data is reported from each plant in an annual report to SFT.

Activity data

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

Emission factors

The emission factors used are country specific based on the actual composition of the raw materials. They are listed in Table 29.

Table 29. Emission factors for CO_2 from production of ferroalloys. Unit: Tonnes CO_2/tonne reducing agent or electrode. Source: SINTEF (1998b, 1998c, 1998d and 1998e) and emission inventory from SN and SFT

	Coal	Coke	Electrodes
Ferro silicon	3.1	3.36	3.36
Silicon metal	3.1	3.36	3.54
Ferro chromium	-	3.22	3.51
Silicon manganese	-	3.24	3.51
Ferro manganese	-	3.24	3.51

4.4.3 Uncertainties

CO_2 from the production of ferroalloy is key source in level due to uncertainty in emission factors. The uncertainties in activity data and emissions factor have been calculated at ± 5 % and ± 7 % respectively.

4.4.4 Source-specific QA/QC and verification

SN makes an annual quality control (QC) of the emission data on the bases of the consumption of reducing agents they collect in an annual survey and average emission factors.

4.4.5 Recalculations

There has been a recalculation for CO_2 for the ferroalloys industry. This is because reported emissions from one plant now are used directly in the inventory instead of using the value calculated by SN. The SN calculated value is now used as a check.

4.4.6 Planned improvements

No specific plans to improve the CO_2 emission data for the production of ferroalloy are prepared before NIR 2005.

4.5 Consumption of halocarbons (HFCs and PFCs) – 2F

4.5.1 Description

HFCs and PFCs are used as substitutes for ozone depleting substances (CFCs and HCFCs) that are being phased out under the Montreal Protocol. They are used in varied applications, including refrigeration and air-conditioning equipment, as well as in foam blowing, fire extinguishing and analyses purposes. There is no production of HFCs and PFCs in Norway. The emissions are calculated on the basis of information on imported bulk and products containing HFCs/PFCs.

In 2002, the total emissions from HFCs and PFCs used as substitutes for ozone depleting substances were 366 ktonnes of CO_2-equivalents. Almost all of this originated from HFCs; the PFC emissions are negligible in comparison. Emissions of PFCs from the production of aluminium are, however, considerable (see Section 4.2). The application categories refrigeration and air-conditioning/heat-pumps contribute by far with the largest part of the HFC and PFC emissions in Norway, thus the other categories contributed only small amounts to the overall emissions. Like in many other Annex I countries, the consumption of these gases has had a strong upward trend since 1990, because of the phasing out of ozone-depleting substances.

Table 30 shows the trend in actual emissions of all HFCs and PFCs used in Norway as substitutes for ozone-depleting substances during the years 1990 through 2002 calculated by the Tier 2 methodology. We have also calculated the potential emissions of HFCs and PFCs during the same period, using the Tier 1b methodology (see CRF Table 2 II, sheet 2).

Table 30. Actual emissions of HFCs and PFCs in Norway (Tier 2) 1990-2002 in tonnes and ktonnes CO_2-equivalents (Excluding Aluminium production). Source: SN/SFT

Compound	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFC 134a	0.00	0.04	0.19	1.78	5.45	10.23	17.24	26.21	38.20	50.21	61.08	71.83	85.82
HFC 125	0.00	0.00	0.00	0.00	0.47	2.38	5.47	9.71	14.73	19.86	25.93	32.93	41.18
HFC 143a	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.15	0.33	0.65	20.28	26.85	34.71
HFC 32	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.15	0.33	0.65	1.04	1.51	2.25
HFC 23	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.07	0.07	0.07	0.07	0.08
HFC 152a	0.13	0.41	0.65	0.79	0.81	0.99	1.47	2.41	4.79	5.99	7.73	10.15	12.39
HFC 227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.11	0.15	0.16	0.16	0.28	0.77
PFC 218	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.06	0.06	0.06	0.06	0.06	0.06
Total (CO2-eq)	**0.02**	**0.11**	**0.34**	**2.43**	**9.23**	**25.97**	**53.15**	**88.82**	**133.02**	**179.84**	**232.49**	**292.07**	**365.51**

4.5.2 Methodology issues

The emissions of HFCs and PFCs are calculated using the Tier 2 methodology and a bottom-up approach. The emissions are calculated on a detailed level, based on yearly consumption figures from bulk importers and emission characteristics related to specific processes and equipment (SFT 1999). Maintenance routines and processes for recovery of chemicals are also taken into account. By accounting for the time lag in emissions from the compounds are introduced into the equipment and until they leak out it gives the actual emissions. Figures on import of products containing HFCs and PFCs were collected through a survey in 1999 (SFT 1999a), and the activity data for the following years were estimated by extrapolating these figures. Figures on imported bulk are collected each year.

We have also calculated the potential emissions employing the Tier 1b methodology, which only considers the import and export of chemicals in bulk and in products. It was found that the ratio between potential and actual emissions was about 4:1 in 2002.

4.5.3 Uncertainties

The uncertainties of the different components of the national greenhouse gas inventory were evaluated in detail in 1999 by Statistics Norway (SFT/SN 1999a). The uncertainty both in relation to the Tier 1a (which only includes bulk chemicals) and the Tier 2 methods were assessed. Concerning the Tier 2 method, both the leakage rate (emission factor) and the stored amount of chemicals (activity data) were considered quite uncertain. The uncertainty of the leakage rate was calculated at ±50 per cent for HFC, while the uncertainty of the stored amount was found to be about ± 25 per cent. The emissions are rather underestimated than overestimated, as some imported bulk/products may not be included. Furthermore, it was found that the uncertainty related to the Tier 2 method appeared to be higher than the uncertainty of Tier 1a. However, these figures are not directly comparable, and it is clear that the Tier 2 method predicts actual annual emissions much better.

4.5.4 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.

4.5.5 Recalculations

There have not been any recalculations in the HFC and PFC data since the previous submission.

4.5.6 Planned improvements

On 1 January 2003 a new tax was imposed on the production and import of HFCs and PFCs in Norway. The tax is differentiated based on the GWPs of the compounds. Preliminary results show that this has resulted in large decreases in import and also lower actual emissions due to better maintenance of equipment etc. A new survey will be carried out in the near future to quantify these changes.

4.6 Non-key sources

4.6.1 Cement Production – 2A1

The production of cement gives rise to both non-combustion and combustion emissions of CO_2. The non-combustion emissions originate mainly from the calcinations of the raw material calcium carbonate. The resulting calcium oxide is heated to form clinker and then crushed to form cement. Emissions factors calculated particularly for the two Norwegian factories are used (0.520 and 0.541 respectively, compared to IPCC default emission factor of 0.5071). These are based on the actual composition of the raw material. The plant reports emissions data, activity data and production data to SFT each year. The emission data is used in the Norwegian Inventory.

The emission data is controlled by SFT. SN makes an annual quality control (QC) of the emission data on the bases of the consumption of reducing agents and production of cement they collect in an annual survey and average emission factors. If errors are found the plants are contacted and changes in the emissions are made when necessary.

4.6.2 Lime Production – 2A2

CO_2 is emitted during the production of lime. Actual production volumes of lime are used as activity data in the emission calculation. These data are reported to SN by the producers. Plant-specific emissions factors for lime and dolomite respectively are used in the calculation of emissions.

4.6.3 Limestone and Dolomite Use – 2A3

In Norway sulphuric acid waste from a specific plant is neutralised with limestone. This produces CO_2 emissions. An emission factor of 0.45 tonnes CO_2 per tonne sulphuric acid is used, calculated from the reaction equation.

4.6.4 Ammonia Production – 2B1

Ammonia is produced as one of the steps during fertiliser production. Hydrogen is needed to produce ammonia, and hydrocarbon gases (LPG) is the basis for the production of hydrogen. The generated CO_2 emissions are calculated by SN from figures on consumed LPG provided by the enterprise. The chemical composition of the gases varies, and we have chosen to use the emission factor recommended by the IPCC (3 tonnes CO_2/tonne LPG). The calculated emission figures agree quite well with emissions figures reported by the enterprises.

A part of the CO_2 which is generated during the production process is captured and sold to other companies in Norway or exported. The amount of CO_2 sold/exported has been taken into account in this submission to the UNFCCC. In 2002, approximately 205,000 tonnes CO_2 were captured and sold. 59,000 tonnes of this were used in Norway, mainly as carbonic acid in carbonated beverages (now reported under Food and Drink 2D2).

4.6.5 Nitric Acid Production – 2B2

Nitric acid production is another step in the manufacturing of fertiliser. There are two plants where nitric acid is produced in Norway. The process generates emissions of nitrous oxide. At one plant the N_2O emissions are measured continuously, while they are calculated from monthly measurements at the other. The production technology has been improved since 1990, which has resulted in a reduction in emissions of about 7 % from 1990 to 2002.

4.6.6 Carbide Production – 2B4

Silicon carbide and calcium carbide are produced in Norway. Petrol coke is used as reducing agent in the production of silicon carbide, and the activity data is consumed petrol coke. A country-specific emissions factor is used (2.51 tonnes CO_2/tonne petrol coke), which deviates somewhat from the IPCC default factor (2.3). The reason for this difference is use of different percentages related to sequestered carbon in produced silicon carbide.

In addition to CO_2, methane may be emitted from petrol coke during parts of the process. The IPCC emission factor is used to calculate these emissions.

The production of calcium carbide also generates CO_2 emissions when limestone is heated and when petrol coke is used as a reducing agent. Emissions estimates are based on the amount of calcium carbide produced each year, and a country-specific emission factor. The emission factor deviates somewhat from the IPCC default factor (1.71 tonnes CO_2/tonne CaC_2 compared to the IPCC factor of 1.8). This is because the IPCC assumes that all the calcium carbonate is calcinated, while the Norwegian factor takes into account that some of the sequestered carbon will be released over time. Production data are reported annually to SN for both silicon- and calcium carbide, which performs the emissions calculations. The production of calcium carbide was closed down in 2002.

4.6.7 Iron and Steel Production – 2C1

The CO_2 emissions from non-combustion processes in iron and steel production are estimated from the use of coal and coke. The annual consumption figures are reported to SN, which performs the emission calculations.

4.6.8 Aluminium Production– CO_2 – 2C3

Emissions of CO_2 from aluminium production are calculated 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. Earlier Statistic Norway (SN) estimated the CO_2-emissions from consumption data provided by the enterprises, but from 2001 the companies calculate and report their emissions to the Norwegian Pollution Control Authority (SFT). New calculations of emissions have been performed for all the years from 1990 based on this change in methodology. For 1990 and 1991 there were no reported data, hence a 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

$$Q = A*C*3.67$$

Where
Q is the total yearly emissions of CO_2
A is the yearly net consumption of anodes
C is % carbon in the anodes
3,67 is the mol-factor CO_2/C

CO_2 from Søderberg Cells

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

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 % Carbon/100
C2 is the fraction of carbon in the peach. Fraction is % Carbon/100

The emissions data is controlled by SFT. SN makes an annual quality control (QC) of the emission data on the bases of the consumption of reducing agents and production data they collect in an annual survey and average emission factors. If errors are found the plants are contacted and changes in the emissions are made when necessary.

4.6.9 Food and Drink – 2D2

As mentioned under Section 4.6.4 Ammonia Production, some CO_2 from this production is used as carbonic acid in carbonated beverages. In 2002, about 59 ktonnes CO_2 were sold for national use, and as mentioned most of this for lemonade production. The whole tonnage is reported under this category, 2D2, although the largest part of the emissions takes place after the bottles are opened and not in the breweries. The figures were previously reported under

2B2 Nitric Acid Production (the part of this is now reported under Ammonia Production 2B1).

4.6.10 Recalculations – non key sources Industrial Processes

2A3 Limestone and Dolomite Use Production

Calcium carbonate has been, and still is used to lime lakes. This is to reduce damages from acidification. The amount of CO_2 emission from liming of lakes is no longer included under the category 2A3, but under section 5E Other emissions from Total Land-Use Change and Forestry, to be consistent with the Good Practice Guidelines.

Chapter 5. Solvent and other product use

5.1 Solvent and other product use

5.1.1 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. Indirect CO_2 emissions from solvents represented approximately 0.2 per cent of the total GHG emissions in 2002.

Solvents and other product use are non-key sources.

5.1.2 Methodological issues

Methodology

The methodology is described in SN/SFT 2000 and in detail in SFT 1995 (only in Norwegian). The methodology is based on a solvent balance approach. 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 the inventory and covers in principle all fugitive sources. For further explanation of the methodology see Section 3.2.18 in SN/SFT 2000.

The equation applied for the solvent balance is:

$$Emissions = (Production + Import - Export - Destruction - Raw\ material\ use) \cdot Solvent\ content \cdot Fraction\ emitted + Emissions\ from\ certain\ industrial\ processes$$

Activity data

Activity data used in the solvent balance is collected by SN in cooperation with authorities like NORSAS, SFT and the Norwegian Product Register. See the report SN/SFT 2000 for more details.

Emission factors

The calculation of indirect CO_2 emissions from NMVOC is based upon the content of carbon in NMVOC. In the Norwegian GHG inventory we assume that the average content is about 82 per cent. The indirect emission factor for CO_2 is then 3 kg CO_2/kg NMVOC (0.82 multiplied with 44/12), see Section 3.13.4.

5.1.3 Uncertainties

An uncertainty analyses was performed for long-range air pollutants by SN (SN 2001c). The analyses conclude that the source category Solvents are one of the highest ranked NMVOC sources with regard to uncertainty.

5.1.4 Source-specific QA/QC and verification

Internal checks of the time-series of calculated emissions data and input activity data is conducted by SN and corrections are made when errors are found.

5.1.5 Recalculations

There has been no recalculation of the indirect CO_2 emissions from solvents since submission of NIR 2002.

5.1.6 Planned improvements

No specific plans to improve the indirect CO_2 emission data for solvents are prepared before NIR 2005.

Chapter 6. Agriculture

6.1 Overview

About 9 per cent of the total Norwegian emissions of greenhouse gases originate from agriculture in 2002. According to the key source analysis, emissions of methane (CH_4) from enteric fermentation and of nitrous oxide (N_2O) from agricultural soils are key sources in level due to high uncertainty in activity data and/or emission factors. These two emission sources are the main contributors to uncertainty in level. A presentation of the two key sources is included in chapter 6.2 and 6.3, followed by a brief overview in chapter 6.4 of the non-key sources in this sector.

Domestic animals are the major source of *CH_4* emissions from agriculture. Both enteric fermentation and manure management contribute to process emissions of CH_4.

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 the use of synthetic fertilisers, animal excreta, 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 small 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 synthetic fertilizer can also generate emissions of ammonia (NH_3). Another source of ammonia is treatment of straw using ammonia as a chemical.

6.2 CH_4 from Enteric Fermentation – 4A

6.2.1 Description

CH_4 is the only pollutant emitted from this source category. NH_3 can be emitted in small amounts, but no separate estimates have been made from NH_3 from manure. Enteric fermentation contributed 80.4 ktonnes of CH_4 emissions in 2002. This constitutes 84 per cent of the overall CH_4 emissions from agriculture. The production of CH_4 by enteric fermentation in animals varies with digestive system and feed intake. Ruminants such as cattle and sheep produce most methane. However, enteric fermentation in pseudo-ruminants (e.g. horses) and monogastric animals (e.g. pigs) is also of significance. Norway has also tame reindeer emitting some CH_4. These emissions are given in Table 4s1 of the CRF-tables.

6.2.2 Methodological issues

The methodology for calculating CH_4 from enteric fermentation is in accordance with IPCC's Good Practice Guidance Tier 1 method (IPCC 1997a,b).The numbers of animals of each kind

and average emission factors for each kind of animals are used to calculate the emissions. At the moment there are no plans to upgrade to Tier 2 methodology to estimate the CH_4 emissions from dairy and non-dairy cattle due to time constraint.

Activity data

Emissions are estimated from the animal population (IPCC Tier 1). The main source of the livestock statistics is the register of production support. The register is a full-scale register (no estimations), and covers 90-100 per cent of the animal populations, except horses and reindeer. The register is used directly, in order to get consistent time series. There is a count twice a year for all animals comprised by the register. The average number of the two counts is used. In addition to the animals included in the register of production support, an estimate of the number of horses that are not used in farming is obtained from the Norwegian Agricultural Economics Research Institute (NILF). The number of reindeer is obtained from the Norwegian Reindeer Husbandry Administration.

For some categories of animals not living a whole year, for instance lambs, lifetime is taken into account to get a yearly average for the number of animals. An expert judgment suggests an average lifetime of 143 days for lambs. The formula for calculating the average figure for lambs will then be:

$$Lambs * \frac{143}{365}$$

The numbers of animals of each kind are given in Annex 3, Table A3-1.

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 SN. Differences include

- Different emphasis on the dates for counting, 31.07 and 31.12
- NILF does not register pigs under 8 weeks, whilst SN does.

Emission factors

The emissions depend on several factors and therefore vary between different individuals of one kind of animal. However, because of a lack of data to perform Tier 2 calculations, the Tier 1 default emission factors from IPCC (1996) for each kind of animal (IPPC 1997a,b) 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 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 carcass 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 31. Emission factors for CH_4 from enteric fermentation and different animal types

Animal	Emission factor (Tonnes/animal/year)
Dairy cattle	0.1
Non-dairy cattle	0.048
Horses	0.018
Sheep, incl. lambs	0.008
Goats	0.005
Pigs	0.0015
Hens	0.00002
Turkeys	0.00002
Reindeer	0.011
Deer	0.053
Ostrich	0.0050
Fur-bearing animals	0.0001

Source: IPCC (1997a,b) and Agricultural Statistics from Statistics Norway

6.2.3 Uncertainties

Activity data

The data are considered to be known within ±5-10%. There is also an uncertainty connected to the fact that some animals are only alive part of the year, and a great uncertainty connected to the number of all types of poultry.

Emission factors

Although the emissions depend on several factors and therefore vary between different individuals of one kind of animal, average emission factors for each kind are used. The standard deviation of the emission factors is considered to be ±25%. The use of IPCC Tier 1 emission factors leads to enhanced uncertainty compared to Tier 2.

Completeness

Major missing emission sources are not likely. There has been a tendency over the last years towards a raise in the body mass for dairy cattle. This constitutes an uncertainty factor that is not reflected in the simple Tier 1 methodology.

6.2.4 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.

6.2.5 Recalculations

New revised figures for the population of different animals have been used for the whole time period 1990-2002. No recalculations are carried out since last year.

6.2.6 Planned improvements

There are currently no planned improvements in the methodology to calculate methane emissions from enteric fermentation.

6.3 N_2O from Agricultural Soils – 4D

6.3.1 Description

Three sources of N_2O from agricultural soils are distinguished in the IPCC methodology, namely:

- Direct emissions from agricultural soils (from the 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 fertilizers, animal excreta nitrogen used as fertiliser and droppings on pastures also gives emissions of NH_3. For these sources the calculated amount of nitrogen that is emitted directly as N_2O has been corrected for the nitrogen emitted as NH_3.

The emissions for the actual year for N_2O are given in CRF Table 4D.

In Norway, the emissions mainly originate from the use of synthetic fertilisers, from crop residues and from the cultivation of soils with a high organic content (histosols) due to enhanced mineralization of old, nitrogen-rich organic matter. Emissions of N_2O also arise from the use of animal manure on agricultural soils, from droppings of grazing animals and from biological nitrogen fixation (the main N-fixing crop in Norway is clover). Nitrogen leaching and run-off is the major source to indirect emissions of N_2O.

The emissions of N_2O in Norway from agricultural soils amounted to 8.9 ktonnes in 2002, or 2.7 Mtonnes calculated in CO_2-equivalents. They accounted for about 47 per cent of the total N_2O emissions in 2002 or about 5 per cent of the total Norwegian greenhouse gas emissions that year.

6.3.2 Methodological issues

Description of method

This chapter presents the methodology used to calculate emissions of nitrous oxide from agricultural soils from different activities/sources

The use of synthetic fertiliser

- *N_2O*

The direct emissions of N_2O from the use of synthetic fertiliser are calculated from data on annual consumption of fertiliser and its nitrogen content, multiplied with the IPCC default

emission factor. The emissions are corrected for ammonia (NH_3) that volatilises during application.

- *NH_3*

Statistics Norway's NH_3-model is used for calculating the emissions of ammonia from the use of synthetic fertiliser. The principle of the model is presented in Figure 25 in chapter 6.4.3. 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.

Manure applied to soils

- *N_2O*

In Norway, all animal excreta that are not deposited during grazing are used as manure. Further, it is assumed that animals do not emit N_2O themselves, but emissions of N_2O from manure management before manure application on fields will be taken into account (see section 6.4.2., N_2O- emissions from manure management). The total amount of nitrogen in manure is estimated from the number of animals and the following nitrogen factors for each kind of animal.

Kg N pr year/animal or kg N pr stalled animal*	
Dairy cattle	81.6
Catle > 1år	35
Catle < 1år	27.5
Horse	47.5
Sheep	8.7
Dairy goat	12.7
Pigs for breeding	22.1
Pigs for slaughter*	4.02
Hens	0.7
Chicks bred for laying hens*	0.147
Chicks for slaughtering*	0.053
Ducks. turkey*	0.34
Mink. females	4.3
Fox. females	10.8

The emissions of N_2O from manure used as fertiliser are 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 application.

- *NH_3*

Statistics Norway's NH_3-model is used for calculating the emissions of NH_3 from spreading of manure on cultivated fields and meadow. The principle of the model is presented in Figure 25 in chapter 6.4.3. A spreading module in the NH_3-model gives the amounts of manure spread as fertiliser, distributed on different spreading methods. Multiplying these with the mission factors for the different spreading methods gives the NH_3 emissions.

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,b). The amount of nitrogen fixed is multiplied with the IPCC default emission factor.

Crop residues
Concerning re-utilisation of nitrogen from crop residues, there is only limited information. Nitrous oxide emissions associated with crop residue decomposition are calculated by estimating the amount of nitrogen entering soils as crop residues, as recommended by the IPCC (1997a,b). The amount of nitrogen in crop residues returned to soils is assumed to be equal to that in the harvest (Aakra and Bleken 1997). The amount has been multiplied with the IPCC default emission factor.

Industrial and urban wastes
No data are available for the amount of N in industrial waste applied as fertilizer 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.

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,b). The emission is 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.

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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 deposited on pastures as droppings is set to 18/78, ca. 23%. The same fraction is used every year. The amount of N deposited during grazing has been multiplied with the IPCC default emission factor. The emissions have been corrected for the amount of ammonia volatilised.

- *NH_3*

Statistics Norway's NH_3-model is used for calculating the emissions of ammonia from pastures. Animal population data, data for pasture times, and factors for the nitrate amount in excreta for different animal categories give the nitrate amounts for the animal categories on pastures. Specific emission factors by animal category are being used.

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, which volatilises during 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.

N_2O from leaching and runoff
A considerable amount of fertiliser N 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,b) proposes a default value of 30 per cent, but in the Norwegian inventory a national factor of 18 per cent (JORDFORSK 1998) is used. This country specific factor has

been estimated from a runoff model by JORDFORSK (Norwegian Centre for Soil and Environmental Research), and is believed to give better results under Norwegian conditions. The amount of nitrogen lost to leaching is multiplied with the IPCC default emission factor to calculate the emission of N_2O.

Activity data

N_2O
The activity data significant for process emissions of N_2O in the agriculture and the sources for the activity data are listed in Annex 3, Table A3-2.

NH_3
-Synthetic fertiliser
The Norwegian Agricultural Inspection Service calculates annually the total amount of synthetic fertilisers, applied in Norway, based on sale figures. To calculate the emissions of NH_3, it is necessary to divide the total amount of synthetic fertilizer on the different types. Due to lack of data from recent years, it is assumed that the different types of fertiliser have the same share of the total as in 1994, see Table 33.

-Animal manure applied to soil and pasture
The main sources for the activity data in the NH_3-model is a manure survey by Statistics Norway 2000 (SN 2001g) and the sample survey of agriculture and forestry 2001 (LU 2001). Some data like the number of animals are updated every year. Other data are used for several years, because of lack of data for every year. Examples are pasture time and the share of animal manure spread to meadow and cultivated fields. The parameters included are shown in Table 32.

Table 32. Parameters included in the estimation of NH_3 emissions from manure

Input	Sources
Number of animals	Statistics Norway
Nitrogen factors for manure	Statistics Norway
Area where manure is spread, split on cultivated field and meadow.	SN 2001g
Area where manure is spread, split on spring and autumn.	Statistics Norway (Sample Surveys of Agriculture), SN 2001g
Cultivation practices concerning water addition to manure, spreading techniques, and usage and time of harrowing and ploughing.	SN 2001g
Pasture times for different animal categories	Tine BA (Dairy cattle, goat), LU 2001 (non-dairy cattle, sheep), expert judgements.

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 two exceptions:

- The emission of N_2O from animals on pastures is calculated by using the IPCC factor of 0.02 kg N_2O-N/kg N

- The emissions that occur as a result of cultivation of organic soils is calculated 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 leaching/runoff is used.

NH_3
-Synthetic fertiliser
Different types of synthetic fertilisers are being used, having different emissions of NH_3. Their share, based on data from 1994, and their NH_3 emission factors are shown in Table 33.

Table 33. Emission factors for different fertilisers and their share of the total use of fertiliser. Source: ECETOC (1994) and Norsk Hydro

Fertiliser	Emission factor (% of applied N)	Used (%)
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

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-Animal manure applied to soil and pasture

Emission factors used for calculating the emissions of NH_3 from spreading of manure on meadow and cultivated fields are shown in Table 34. The emission factors used for the calculation of the NH_3 emissions from grazing animals are shown in Table 35. The same emission factors are used in Germany (Dämmgen, 2003) and Denmark (Hutching *et al.*, 2001).

Table 34. Average NH_3 emission factors for manure on cultivated fields and meadow after time of spreading and region. Source: SN 2001g

	Sør/Østlandet		Hedmark/Oppland		Rogaland		Vestlandet		Trøndelag		Nord-Norge	
	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%

Table 35. Ammonia emission factors from droppings from grazing animals on pasture. Source: Dämmgen (2003), Hutching et al. *(2001).*

	N-loss/N applied
	(%)
Cattle	7,5
Sheep and goat	4,1
Reindeer	4,1
Other animals	7,5

6.3.3 Uncertainties

Activity data

There are several types of activity data entering the calculation scheme:
Sale of nitrogen fertiliser: The data are based on sales figures (The Norwegian Agricultural Inspection Service). Two different methodologies are used for data collection and the results from these agree very well. The uncertainty is within ±5%. Another error, which will be averaged over time, is that sale does not equal consumption in a particular year due to storage.
Amount of nitrogen in manure: The figures are generated by, for each animal type, 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 have been improved over time (the range is considered to be within ±15%). The uncertainty is connected to differences in excreted N 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 feeding practices have changed since the factors were determined. The Norwegian factors are far away from the IPCC default factors (by 40 to several hundred per cent) This wide range can be explained as follows: Three different sets of N-factors are used, one in the calculation of N_2O from manure applied to soils (6.3.2) one for N_2O from manure management (6.4.2) and one in the NH_3 model (6.4.3). In NIR 2005 only the N-factors used in the NH_3 model will be used.

The uncertainty connected to the estimate of the amount of manure is higher than for the amount of synthetic fertiliser used.

Fate of manure: There is significant uncertainty connected to the allocation of manure between what is used as fertiliser, and droppings on pastures.
Nitrogen left after harvest: Norwegian factors have been used. These are 40 % lower than the IPCC default factors. The amount of nitrogen in the harvest is determined within ±10%, but the expansion factor to account for nitrogen left after harvest is very uncertain. Assessed uncertainty range is about ±50%.
Deposition of other agricultural emissions: The data are based on national NH_3 emission figures. These are within ±30%.
Leakage of nitrogen: The upper limit for the leakage is the applied nitrogen. The uncertainty is roughly about ±70%.
Cultivation of organic soils: Data are based on a one-year survey, and are uncertain by more than a factor of three.

Emission factors

N_2O
The uncertainties in the N_2O emission factors are high. In SN (2000) a factor of two was assumed, according to IPCC (1996). In IPCC (2001) these uncertainty intervals have been narrowed somewhat. Aardenne et. al. (1998) have estimated a 95% confidence interval uncertainty (in emissions) of -40%-+70% for this source, but this may not contain all systematic errors.

NH_3
The uncertainty in the estimate of emissions of NH_3 from use of synthetic fertiliser is assessed to be about ±20%. This uncertainty could be lower if better data on fertiliser composition were obtained. The uncertainty is higher for animal manure (±30%). 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) (SN 2001c).

Completeness

All sources described in the IPCC reporting guidelines are included in the estimates. However, the emission factors might not be reflecting national conditions.

6.3.4 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 collected in a report (Petersen and Olesen 2002).

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 done to find more updated activity data.

Statistics Norway has in cooperation with the Agricultural University of Norway (NLH) 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 Agricultural University of Norway (NLH) (SN 2001g), and two surveys from Statistics Norway; a manure survey from 2000 and the sample survey of agriculture and forestry (2001) http://www.ssb.no/english/subjects/10/04/10/lu_en/.

SN's detailed manure survey from 2000 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.

6.3.5 Recalculations

New revised figures for the population of different animals have been used for the whole time period 1990-2002. This has effects on the amount of N_2O from spreading of manure.

Changes in the ammonia model also effect the emissions of N_2O (whole time series)
New activity data for spreading of manure comes from the manure survey from the year 2000, and the sample survey of agriculture and forestry 2001. New loss factors for spreading are also used in the ammonia model.

When it comes to the calculation of emissions from grazing animals, the calculation structure is unchanged, but new time estimates for pasture times are used for the different animal categories. The sample survey of agriculture and forestry 2001, mentioned before is the source of these.

6.3.6 Planned improvements

Three different sets of N-factors are used, one in the calculation of N_2O from manure applied to soils (6.3.2), one for N_2O from manure management (6.4.2) and one in the NH_3 model (6.4.3). In NIR 2005 only the N-factors used in the NH_3 model will be used.

6.4 Non-key sources

6.4.1 CH_4 emissions from manure management – 4Ba

CH_4-emissions due to manure management amounted to 14.6 ktonnes in 2002. 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).

Method

Emissions of methane from manure are estimated using the following equation, in accordance with the IPCC Tier 2 method (IPCC 1997a,b):

$$E_i = \frac{N_i \cdot M_i \cdot VS_i \cdot B_{0_i} \cdot MCF_i}{1000}$$

E: Emissions of methane
N: Population of animals
M: Production of manure (kg/animal/year)
VS: Volatile solids (per cent)[7]
B_0: Maximum methane-producing capacity (m^3/kg-VS)
MCF: Methane conversion factor
$_i$: Species

Table 36. Norwegian factors used to estimate CH_4 from manure management in the IPCC Tier 2 method. Source: Agricultural Statistics from Statistics Norway and Agricultural University of Norway[8]

	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

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 Agricultural University of Norway[8].

[7] Volatile solids (VS) are the degradable organic material in livestock manure (IPCC 1997a,b).
[8] Institute of Chemistry and Biotechnology, Section for Microbiology.

Activity data

Emissions are estimated from the animal population, (Annex 3, Table A3-1). How the animal population is estimated is described in Section 6.2.2. Activity data.

Emission factors

In Table 37 the calculated average emission factors for different animal types are shown.

Table 37. Average CH_4 emission factors for manure management in the Norwegian method. Tier 2. Source: Agricultural Statistics from Statistics Norway

	Emission factor (kg/animal/year)
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
Diary 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

Uncertainties

Activity data

The data for the number of animals are considered to be known within ±5-10%. There is also an uncertainty connected to the fact that some animals are only alive part of the year, and a great uncertainty connected to the number of all types of poultry. Other activity data is the treatment of manure (which will determine the emission factor), which has been assessed by expert judgements. This will contribute to the uncertainty.

Emission factors

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 an uncertainty range of ±25% (SN 2000).

Source specific QA/QC

In a Nordic project in 2002, the results for emissions of both CH_4 and N_2O from manure management in the national emission inventories have been compared with the results using the IPCC default methodology and the IPCC default factors (Petersen and Olesen 2002). . This contributed to discover differences and gaps in the national methodologies.

6.4.2 N_2O emissions from manure management – 4Bb

During storage of manure, some nitrogen is converted to N_2O. The amount released depends on the system and duration of manure management. N_2O-emissions due to manure management amounted to 0.35 ktonnes in 2002. Solid storage and dry lot of manure is the most important source.

Method

In Norway, all animal excreta that are not deposited during grazing are managed as manure. N_2O from manure is estimated in accordance with the IPCC default method (IPCC 1997b), but with Norwegian values for N in excreta from different animals according to Table 38.

Table 38. N in excreta from different animals. Source: Sundstøl and Mroz (1988) and estimations by SN for reindeer, deer and ostrich

	kg/animal/year[2]
Dairy cattle	89.8
Non-dairy cattle > 1year	38.5
Non-dairy cattle < 1year	30.3
Horses	52.3
Sheep	9.6
Dairy goats	14.0
Pigs for breeding	24.3
Pigs for slaughtering[1]	4.0
Hens	0.8
Chicks bred for laying hens[1]	0.16
Chicks for slaughtering[1]	0.058
Ducks, turkey[1]	0.37
Mink, females	4.7
Foxes, females	11.9
Reindeer	9.6
Deer	47.3
Ostrich	14.5

[1] Per stalled animal. Stall we define as the room for one animal. An animal that live one year needs one stall the whole year. While 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 and for slaughter swine is per stalled animal 2.5 slaughter swine per stall (or pen) per year.

[2] Includes pasture.

The emissions of nitrous oxide from manure are estimated using the following equation, in accordance with the IPCC Tier 2 method (IPCC 1997a,b):

$$E = \sum_s \left\{ \left[\sum_i \left(N_i \cdot Nex_i \cdot MS_{i,s} \right) \right] \cdot EF_s \right\}$$

E: Emissions of N_2O-N (kg N_2O-N/yr)
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

Activity data

Emissions are estimated from the animal population, (Annex 3, Table A3-1). How the animal population is estimated is described in Section 6.2.2 Activity data.

Emission factors

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 39. N_2O emission factors for manure management per manure management system Source: IPCC 1997b

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 drylot	0.02
Pasture range and paddock	0.02
Other system	0.005

Uncertainties

Activity data

Emissions are estimated from the animal population. The data are considered to be known within ±5-10%. There is also an uncertainty connected to the fact that some animals are only alive part of the year, and also a great uncertainty connected to the number of all types of poultry.

The nitrogen excretion factors are uncertain. However, due to research on nitrogen leakage problems in parts of Norway the certainty have been improved over time (the range is considered to be within ±15%). The uncertainty is connected to differences in excreted N 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 feeding practices have changed since the factors were determined. The Norwegian factors are far away from the IPCC default factors (by 40 to several hundred per cent) This wide range can be explained as follows; Three different sets of N-factors are used, one in the calculation of N_2O from manure applied to soils(6.3.2) one for N_2O from manure management and one in the NH_3 Model. In 2005 only the N-factors used in the NH_3 model will be used.

The share of the different storage systems for manure is uncertain.

Emission factors
For the emissions of N_2O from different storage systems IPCC default emission factors are used. They have an uncertainty range of -50%/+100% (IPCC 2001) except for the storage category "daily spread" where it not is applicable.

Source specific QA/QC

In a Nordic project in 2002, the results for emissions of both CH_4 and N_2O from manure management in the national emission inventories have been compared with the results using the IPCC default methodology and the IPCC default factors (Petersen and Olesen 2002). . This contributed to discover differences and gaps in the national methodologies

6.4.3 NH_3 emissions from manure management – 4Bb

Method
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 25.

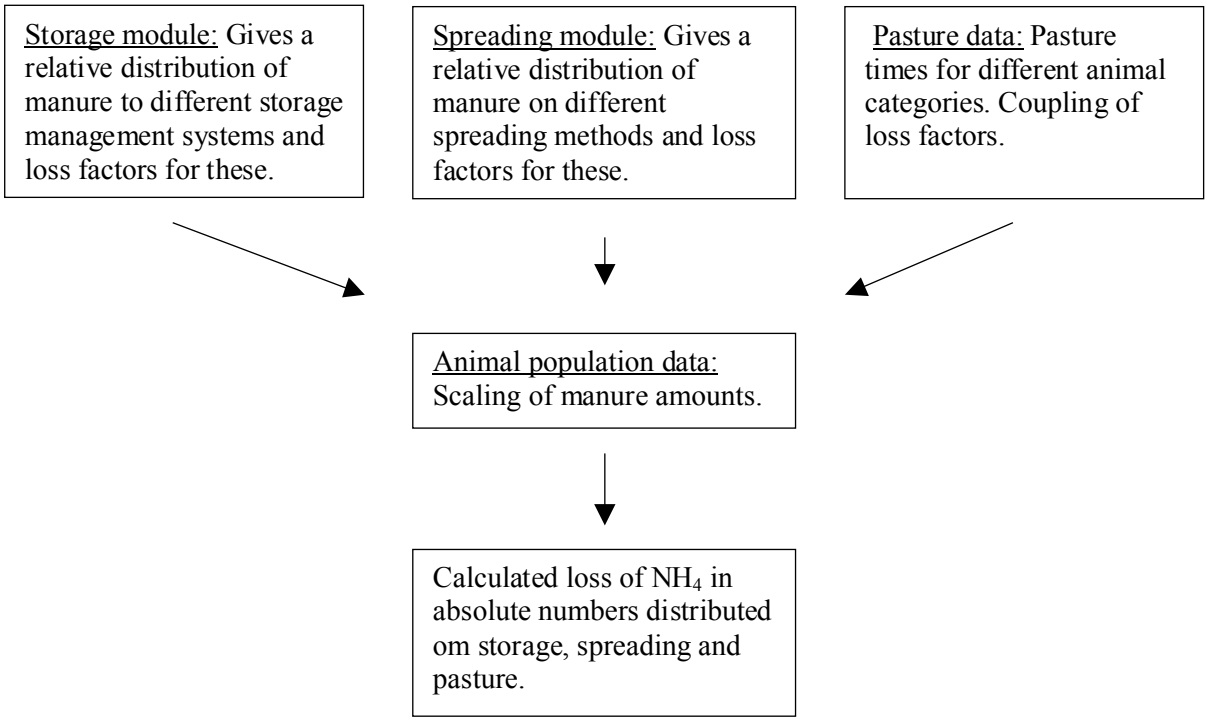


Figure 25. The principle of the NH_3 model

Emissions from the different NH_3 sources are presented in Annex 3, Table A-3.

The total manure from stalled animals is distributed on different manure storage systems. A storage module in the NH_3 model gives a relative distribution of manure to different storage management systems, distributed after occurrence and dimensions of the different storage systems. Different emission factors for the storage systems give the total emission of NH_3 from manure management

Activity data

Emissions are estimated from the animal population, (Annex 3, Table A-1). How the animal population is estimated is described earlier in Section 6.2.2. Activity data.

Nitrogen factors for each kind of animal manure are used to calculate the total amount. The Occurrence and dimensions of different storage systems are given in SN 2001g.

Emission factors

Emission factors for NH_3 emissions from storage of manure and stalled animals are presented in Table 40 as percent of excreted N which evaporates as NH_3.

Table 40. Average emission factors for the manure storage systems used, distributed on type of animal production and region. Source: SN 2001g

	Sør/Østlandet	HedOp	Rogaland	Vestlandet	Trøndelag	Nord-Norge
Cattle	9,6%	8,2%	8,8%	8,1%	7,7%	7,7%
Swine	25,4%	22,3%	20,1%	21,5%	21,0%	21,9%
Sheep and goat	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%

Uncertainties

Activity data

Emissions are estimated from the animal population. The data are considered to be known within ±5-10% (SN 2001c). There is also an uncertainty connected to the fact that some animals are only alive part of the year, and also a great uncertainty connected to the number of all types of poultry. The uncertainty for manure use is considered to be ±20% (SN 2001c).

Emission factors

Ammonia emissions from agriculture are estimated based on national conditions. Uncertainties are still high due to high variability and gaps in data. The uncertainty for animal manure is ±30% (SN 2001c). 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).

6.4.4 Field burning of agricultural residues - 4F

Burning of agricultural residues gives emissions of a large range of standard combustion products, ranging from GHG to heavy metals and POPs. In 2002, the emissions of CH_4, N_2O, NO_X and dioxin from agricultural residual burning were included in the Norwegian inventory. For 2002, this activity gave rise to 430 tonnes of CH_4, 10 tonnes of N_2O, 300 tonnes of NO_x and 8 830 tonnes of CO

Method

CH_4, N_2O and NO_X
The emissions by burning of crop residue are being calculated due to the guidelines in the IPCC reference manual (IPCC 1997b).

(1) $CR = CRB \cdot Fdm \cdot Fo \cdot Fc$

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

(2) $E_i = CR \cdot ER \cdot MW_i \cdot (N/C)$

E:	Emissions (tonnes/yr)
CR:	Carbon released (tonnes C/yr)
ER:	Emission ratio
MW:	Molecular weight conversion factor
N/C:	N/C-ratio
$_i$:	Emission component

Table 41. 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 1997b
N/C	-	0.012	0.012	IPCC 1997b

The amount of carbon released is calculated according to equation (1). In the IPCC manual a default value of 0.9 for the fraction oxidised is given, and water content of 15% for wheat and barley, which are the main cereals that gives straw in Norway. To find the C-fraction in Norwegian straw, the default values given for wheat and barley in the IPCC manual are being used, and scaled according to the per cent distribution between the two cereals in Norway in 1999 due to Food and Agriculture Organization of the United Nations (FAO 2002).

To calculate the emissions of CH_4, the amount of carbon released is multiplied with an emission ratio, equation (2). The emission ratio gives the mass of the actual chemical substance emitted (in C-units) related to the mass of the total carbon emissions by residual burning. To get total amount of emissions of the actual emission component, a molecular weight conversion factor must also be multiplied.

For N_2O and NO_X, the emission ratio gives the ratio of emissions of N_2O relative to the N-content of the crop residuals. This factor also has to be multiplied with the ratio between nitrogen and carbon.

For the emission ratios the IPCC default values are used. As N/C ratio is a value of 0.012 used, which is the IPCC default value for wheat.

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. The value for the actual year is given in Annex 3, TableA3-4.

Table 42. Emission factors for agricultural residue burning. g emitted/tonnes crop residue burned[1]

Components	Emission factors
Greenhouse gases	
CH_4	2 400
N_2O	46.9
Precursors	
NO_X	1 700

[1] The unit of the dioxin emission factor is µg I-TEQ/tonnes crop residue burned.

Uncertainties

Activity data

The uncertainty in the crop residues and other agricultural waste is high. An exact estimate has not been made, but the number can be underestimated due to lack of statistics in this area.

Emission factors

IPCC default factors are used for the fractions of dry matter, carbon and the fraction oxidised. For the N/C-ratio and the emission ratio IPCC default factors are also used. The ranges for the emission ratios are ±40% for CH_4, ±28.6% for N_2O and ±22.3% for NO_X.

The emission factors used for heavy metals are not specific for agricultural residue burning but for wood burning in small stoves in private households. It is expected that use of these emission factors will underestimate the emission of heavy metals from agricultural residue burning considering the two different burning conditions.

Completeness
As mentioned, the estimation may not be entirely complete.

QA/QC

In 2002, the emissions of CH_4, N_2O, NO_X and dioxin from agricultural residual burning were included in the Norwegian inventory and in 2003, the emission of As, Cr and Cu

6.4.5 NH_3 emissions from treatment of straw – 4G

There are three main agricultural sources for NH_3 emissions in Norway:

1. manure and manure management
2. straw treated with NH_3 to be utilised as fodder
3. use of synthetic fertiliser

Emissions for the actual year are presented in Annex 3, Table A3-3. Emissions of NH_3 from treatment of straw amounted to 1021 tonnes in 2002. The emissions depend only on the amount of NH_3 used.).

Method
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.

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 field is given from a sample survey of agriculture and forestry made by Statistics Norway 2003.

Emission factor
The emission factor is estimated by the Department of Animal Science at the Agricultural University of Norway.

Uncertainty
Uncertainty in the estimate of emissions from ammonia treatment of straw is rather low (±5%) (SN 2001c).

6.4.6 Recalculations - non-key sources Agriculture

Statistics Norway has in cooperation with the Agricultural University of Norway (NLH) made improvements in the calculation model for ammonia emissions from the agricultural sector. This gives changes in the figures for all reported years for several emission sources for ammonia but it has also effects on the reported N_2O figures (see Section 9.2.3). Data sources used for the recalculations in the revised NH_3-model are coefficients from the Agricultural University of Norway (NLH) and two surveys from Statistics Norway; a manure survey from 2000 and the sample survey of agriculture and forestry 2001.

4B Manure Management
New revised figures for the population of different animals have been used for the whole time period 1990-2002. This has effects on both CH_4 and N_2O.

Statistics Norway made a detailed manure survey in 2000, which gave more extended activity data that was 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, which are more connected to specific activities. This also has effects on the N_2O figures for the whole time series.

4F Field burning of agricultural residue
New emission figures for CH_4 and N_2O for 1999, 2000 and 2001 caused by improved activity data estimates.

Chapter 7. Land-use change and forestry

7.1 Overview

According to the IPCC, the reporting of emissions and removals from land-use change and forestry should include four activities: changes in forest and other woody biomass stocks (category 5A), forest and grassland conversion (category 5B), abandonment of managed lands (category 5C) and CO_2 emissions and removals from soils (category 5D).

In Norway, it is difficult to separate the contributions from category 5A, 5B and 5C. In principle all forest and grassland conversion (category 5B) are included in our inventory, while abandonment of managed lands (category 5C) are only partially included since the inventory is focused on forest land. However, land use changes (category 5B and 5C) occur at a very small scale in Norway. A study we performed in 2000 as part of a submission to UNFCCC during the negotiation on Article 3.3 and 3.4 under the Kyoto Protocol, showed that deforestation took place on only 2.5 kha/year (0.02 per cent of total forest area), while afforestation took place on 30 kha/year (0.3 percent of total forest area). This study indicates that forest conversion (category 5B) and abandonment of managed lands (category 5C) are likely to have a relatively small impact on the Norwegian LUCF inventory. In addition there are legal restrictions to deforestation which ensures that uncontrolled deforestation does not take place, and that forests are regenerated on harvested lands through replanting or natural re-growth.

The inventory includes net removal of CO_2 from total biomass above and below ground in Norwegian forests. However, uptake of CO_2 in forest and agriculture soil (category 5D) and non-CO_2 gas emissions and removals from forest soils and residues are presently not included in the inventory. However, the inventory includes CO_2 emissions from liming of agricultural soils, reported under category 5D. The inventory also includes CO_2 emissions from liming of lakes to reduce the damages from acidification, reported under category 5E.

Further, the carbon stock change of harvested wood products is not included in the inventory as the IPCC default method is used, where harvested wood is counted as emissions the year the harvest takes places.

Norway has now started the implementation of IPCC's Good Practice Guidance for LULUCF and we will in that regard include a more comprehensive coverage of the different LULUCF categories, probably in NIR 2005.

7.2 Changes in forest and woody biomass stocks - 5A

7.2.1 Description

In principle all forest and grassland conversion (category 5B) are included in our inventory, while abandonment of managed lands (category 5C) are partially included. However, land use changes (category 5B and 5C) occur at a very small scale in Norway.

Forested land in Norway covers about 12 million ha, which is about 37 per cent of Norway's total area of 32.4 million ha, see Figure 26 below. This includes productive forest, other wooded land and forest above the coniferous forest limit. As an average for the years 1994-1998, the total volume under bark for this forest area was almost 680 million m^3, see Figure 27.

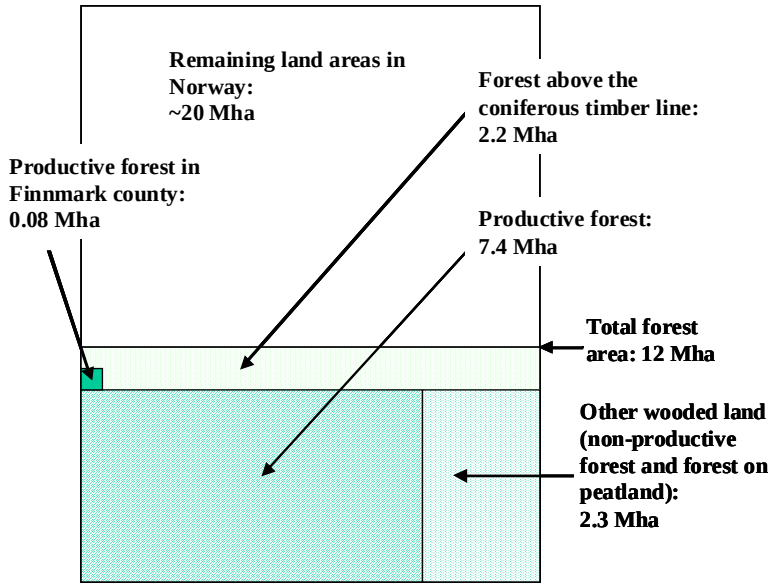


Figure 26. Total forest area in Norway and distribution of categories of forest and other wooded land (average for the period 1994-1998). Source: Norwegian Institute of Land Inventory and SFT

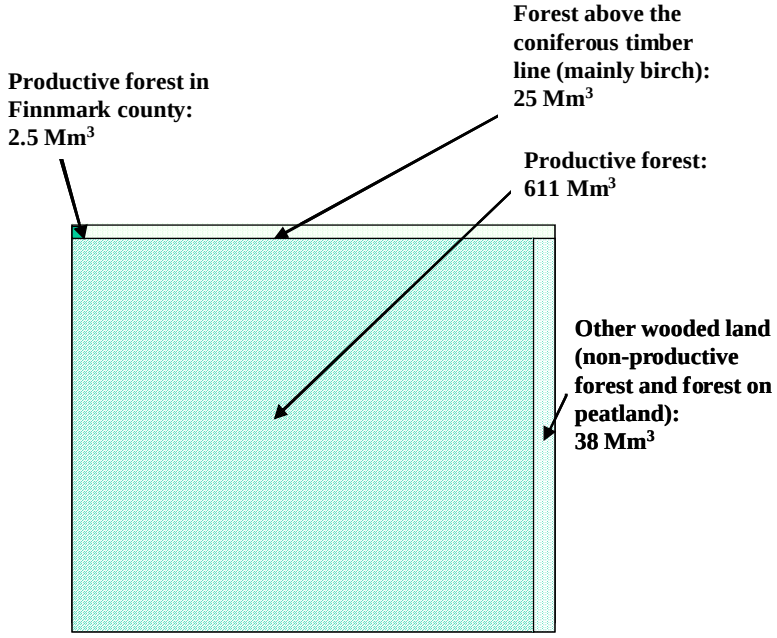


Figure 27. Total forest volume in Norway in million m^3 under bark, as an average for the period 1994-1998). Source: Norwegian Institute of Land Inventory and SFT

A clear distinction between managed and non-managed forest is difficult to establish in Norway, as logging can take place at very long intervals and the forest be left to natural regrowth in intermittent periods. Productive forest is defined as forest with a minimum productivity of 1 m^3 pr ha pr year. However, the CO_2 inventory presented in our submission to UNFCCC excludes carbon stock changes in forest above coniferous forest limit (mountain birch forest and moor land with poorly developed forest), but includes productive forest and other wooded land. Coniferous forest in Finnmark county is also included. Finnmark is the northernmost county in Norway, situated between 68 and 71 degrees north. Finnmark accounts for less than 0.5 per cent of the growing stock of productive forests, and an even smaller fraction of gross increment.

In Norway, removals and emissions from forests and other woody biomass stocks represent to day a large net sink. The reason for this is expansion of forest biomass as a result of planting and natural re-growth at the beginning of the 20th century. The forest area, however, has not increased substantially.

At the end of 2002 the standing volume under bark (growing stock) for productive forest and other wooded land was estimated to be 724 million m^3 (44% spruce, 33% pine and 23% deciduous). The gross increment in Norwegian forests is estimated to be about 24 million m^3 in 2002, corresponding to 36 million tonnes of CO_2 when converted to total biomass above and below ground. A total of 16 million tonnes of CO_2 were harvested or depleted, which resulted in a net removal of 20 million tonnes of CO_2. This corresponds to 36 per cent of the national CO_2 equivalent emissions. More sectoral background data and CO_2 balance are given in Annex 4.

7.2.2 Methodological issues

The inventory of removals and emissions from forestry considers removals due to forest biomass expansion and emissions due to fellings and natural losses. A country specific approach is applied for constructing the national forest balance, using national statistics. The forest balance is created in the following steps:

- A national forest inventory which estimates the growing stock and annual gross increment of forests in m^3/year
- Depletion from fellings, estimated from national statistics on fellings, volume of commercial pulpwood and timber and fuelwood consumption
- Depletion from logging residues and natural losses
- Calculation of biomass and carbon removal from the volume balance obtained above

Hence, we have used following formulae to derive the national forest balance based on the 1996 IPCC guideline:

	Growing stock – January 1
+	Gross increment from January 1 to December 31
÷	Felling, including commercial and private consumption and fuel wood
÷	Logging waste
÷	Natural losses
=	Growing stock – December 31

The Norwegian Institute of Land Inventory (NIJOS) is responsible for the national forest inventory and supplies all data on forest growing stock and increments. Statistics Norway calculates the national forest balance and carbon balance is done by Statistics Norway, who also archives the necessary data.

In the following text we have given a more detailed account of the different steps in the calculation of the forest balance and carbon removal.

Estimation of stock and gross increment

The Norwegian Institute of Land Inventory (NIJOS) performs the national forest inventory every year and supplies all data on forest growing stock and increments. The forest inventory started in 1919 and applies a systematic sampling using permanent sample plots. In the period 1986-1993 permanent sample plots were established in forests in a 3 x 3 km grid. Most of the forest area in Norway is included, except Finnmark county and mountain birch forest. Approximately 10,500 sample plots are located on productive forest and other wooded land, see Figure **X**. On average, each sampled area comprises about 3×10^{-5} of the surveyable area. Measurements are taken of all trees with a dbh $\geq$ 5 cm, with an inventory cycle of 5 years. Measurements are carried out on an area of 250 m^2, and stand parameters are based on a plot size of 0.1 ha. Sample plots are characterized as productive or non-productive. Location coordinates and all collected data on individual sample plots are stored in a database at NIJOS.

The current forest balance use inventory data for the cycle 1994/1998 as input (NIJOS 2000). The growing stock according to the inventory is taken as growing stock at the end of 1996 (31.12.96 = 1.1.97). The gross increment according to the inventory is taken as valid for 1996. Both growing stock and increment data are given as trunk volume under bark. Increment estimation is based on increment boring.

Calculation of the present standing volume is done as a projection of the standing volume computed from inventory data for the cycle 1994/1998 (NIJOS 2000), using field-collected growth data. As there is a five year cycle of the inventory, using the computed standing stock for a five-year period gives the lowest uncertainty. Growth rates are calculated from the inventory data as *gross increment per growing stock*. The growth rates are differentiated by species. Note that the rate uses the growing stock at the end of the year instead of the beginning. The rationale for this method was to improve the correspondence between the forest balance and the inventory in the reference year of 1996. If we had considered the inventory as the growing stock in the beginning of the reference year, then the growth rate would have been more straightforward, but the stock and increment data from the inventory would have appeared in different years in the forest balance result tables. The slightly higher growth resulting from this approach also seemed to correspond better with the change between different inventory cycles.

In order to account for the productive forest in Finnmark county, a separate balance for this county is prepared. This balance uses 1990 as reference year. Stock and gross increment data for Finnmark were obtained from Statistics Norway's Agricultural Census of 1990. The census used a less sophisticated method than the regular forest inventory, being mainly based on information from forest owners. However, note that the productive forest in Finnmark county represent about 2.5 million m^3 or less than 0.4% of the total productive forest in Norway.

Estimation of fellings and fuelwood consumption

Data on fellings are taken from two sources in Statistics Norway: Commercial roundwood removals (published annually) and the Agricultural Census from 1990. Data on total fuelwood consumption are taken from the energy balance. The data are used as shown in Table 43.

Table 43. Data used in the estimation of fellings and fuelwood production in Norway.

Forest balance calculation and result	**Felling type**	**Input data**
Commercial consumption exclusive fuel wood	Commercial pulpwood and timber (as reported to FAO)	Commercial roundwood removals (annual)
Fuelwood consumption	Commercial fuelwood	Energy consumption data (Statistics Norway)
	Non-commercial fuelwood	Agricultural Census 1990 (fixed)
Other private wood consumption	Non-commercial timber etc (use by forest owner)	

Fellings in Finnmark county is treated separately from the other counties. There is currently registered only fuelwood fellings in Finnmark.

Depletion from logging residues and natural losses

Logging residues and natural losses are calculated as fixed percentages of total fellings and gross increment, respectively. The factors were established in cooperation with experts at the National Institute of Land Inventory (Schøning 1992) and are given in Table 44.

Table 44. Factors for logging residues and natural losses, based on Schøning (1992).

Forest type	**Logging residues, percentage of total felling**	**Natural losses, percentage of gross increment**
Spruce	6 %	6 %
Pine	6 %	6 %
Decicuous	10 %	10 %

Calculation of the forest balance and carbon balance

Total biomass is converted to dry mass using national species-specific values given in Table 45, ranging from 0.38-0.50. Conversion to carbon content is done using the IPCC default value of 50 per cent. To convert from carbon to CO_2 we have use IPCC default factor: 3.67. In Annex 4 the results of the calculations are given in detail.

Table 45. Factors for converting from volume to dry matter and carbon content.

Factor	Value	Source
Volume to dry matter - Spruce - Pine - Deciduous	 0.38 t dm/m^3 0.44 t dm/m^3 0.503 t dm/m^3	Lunnan et al. (1991)
Dry matter to carbon content	0.5 t C/t dm	IPCC (1996)

The forest balance is calculated as standing volume under bark. This is expanded to total biomass using the IPCC default ratio of 1.9 for managed forests (IPCC 1996). The factor has been applied to both removal and increment data, as both are given as trunk volume. However, the expansion factor is not applied uniformly to the forest balance. The item *total fellings* and the underlying terms refer to biomass which is removed physically from the forest. These items are converted into carbon or CO_2, but not expanded into total biomass. Instead, the expansion of fellings, which covers branches, stumps and roots etc., is added to the item *logging residues*. This gives the following relation between biomass carbon data and trunk volume data:

Item	To get from trunk volume to total biomass carbon
Gross and net increment	Multiply by dry matter content, carbon content, and biomass expansion factor
Felling	Multiply by dry matter content and carbon content
Logging residues	Multiply by dry matter content, carbon content, and biomass expansion factor *plus* leftover biomass from fellings: *Felling in total* multiplied by dry matter content, carbon content, and (biomass expansion factor - 1)
Natural losses	Multiply by dry matter content, carbon content, and biomass expansion factor

7.2.3 Uncertainties

There are uncertainties related to the national forest survey, the use of expansion factors and in the data sources for constructing the forest balance.

In the calculation of the forest balance, the use of a default biomass expansion factor represents an uncertainty. At present, no national or species-specific biomass expansion factors have been developed. Also, the use of annual stock data for calculating net growth represents an uncertainty particularly for single year results. Inventory data are not annual, and growth and felling estimates do not fully account for change in stock between inventory cycles. Averages over several years are more certain. This is the reason why data for a five-year period are used as the basis for calculating the standing stock. The uncertainty of annual change in forest is, however, far lower than in the biomass stock. The last important uncertainty is with respect to the data on fuelwood consumption. Data on fuelwood consumption are taken for the energy balance, as this gives more correct data, showing higher fuelwood consumption. However, the calculation of net forest increment after felling has not been corrected for this figure for fuelwood consumption. This has not been done yet due to

time constraints. The higher fuelwood consumption gives a smaller standing stock and smaller gross increment. The error in gross increment is estimated to be about 1 per cent.

No national analysis of total uncertainty in the Norwegian forest balance has been undertaken. The forest balance uses a best estimate. A careful estimate of total uncertainty would be in the range of 40 per cent, based *inter alia* on Swedish analyses of their forest balance, which treats forest types similar to the Norwegian.

7.2.4 Source-specificQA/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.

7.2.5 Recalculations

No recalculation has been undertaken for the removals in the forestry sector since last submission.

7.2.6 Planned improvements

Norway has now started the implementation of IPCC's Good Practice Guidance for LULUCF and UNFCCC reporting guideline. It is our plan that NIR 2005 shall be based on these guidelines. Hence, we expect significant improvements in the Norwegian LULUCF inventory in the NIR 2005, both with regard to methodology and completeness.

7.3 CO_2 emissions from liming of agricultural soils – 5D

Process emissions of CO_2 from agriculture derive from liming of calcium carbonate ($CaCO_3$). The total emissions from this source amounted to 116 ktonnes CO_2 in 2002, which represent 0.2 per cent of Norway total GHG emissions. Thus this is regarded as a non-key source in the Norwegian emission inventory.

Wit regard to methodology the amount of limestone applied is given yearly by the Norwegian Agricultural Inspection Service. The emission factor used is 0.44 tonne CO_2 per tonne calcium carbonate applied (SFT 1990). National total emissions have been reported yearly from 1990 and onwards.

7.4 CO_2 emissions from liming of lakes – 5E

For several years many lakes in the southern parts of Norway has been limed to reduce the damages from acidification. The total emissions from this source amounted to 19 ktonnes CO_2 in 2002, 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).

Chapter 8. Waste

8.1 Overview

This sector consists of the sub-sectors Managed waste disposal on land (6.A1), Waste water handling (6.B) (Domestic and Commercial Wastewater and N_2O from human sewage) and Waste incineration (6.C). Sector 6C includes 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.

It is only emissions of methane from solid waste disposal that is key source in the waste sector.

The GHG emissions from the waste sector have increased by 2.5 per cent from 1990 to 2002 while the total emissions of GHG in Norway have increased by 6 per cent. Due to growth in activity the emissions from the sub-sectors (except sector 6.A1), have increased continuously since 1990. It is particularly emissions from flaring of natural gas that have increased. Methane emissions from landfills have been quite stable in the period. Higher volumes of municipal solid waste (MSW) produced have been offset by increased recycling of waste, increased burning of methane from landfills and higher volumes of waste incinerated. The reason for the reduction in specific methane emissions from waste is most likely that a landfill tax for organic waste was introduced in 1999.

In 2002 the waste sector contributed to 7.3 per cent of the total GHG emissions in Norway. This is a decrease from 7.6 per cent in 1990.

8.2 Managed waste disposal on land – 6.1A

8.2.1 Description

Emissions of methane from solid waste disposal on land are a key source in level and trend due to uncertainty in activity data, emission factor and change in trend. The sector's share of the national total GHG emissions was 7.4 in 1990 and 7.1 per cent in 2002.

Norway does not report emissions from unmanaged solid waste disposal (SWDS) sites. The reason for this is that emissions from these sites are minimal and that currently no survey statistics are available.

8.2.2 Methodological issues

Methodology

CH_4 and 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 rise. After a year or so, CH_4 emission reaches its peak, after that the emissions will decrease over some decades.

The Norwegian Pollution Control Authority (SFT) developed in 1999 a new model for calculating methane emissions from landfills (SFT 1999b). The model is based on the IPCC theoretical first order kinetics methodologies (IPCC 1997b) and the method is consistent with the IPCC Good Practice Guidance. The model has given a better estimate of methane emissions from municipal waste and private industrial landfills. The effect of weather conditions is also taken into account.

The amount of methane generated in the year of calculation by waste deposited in year *x* is given by the equation:

$$Q_{T,x} = k \cdot M_x \cdot F \cdot MCF \cdot L_0 \cdot e^{-k(T-x)} \cdot v/1000,$$

Where

$Q_{T, x}$: Amount of methane generated in the year of calculation (T) from the waste volume deposited in year x.
k : Generation rate of methane ($k=\ln(2)/t_{1/2}$)
M_x : Waste volume deposited
F : The fraction of methane in the gas generated
MCF : Methane correction factor
L_0 : Landfill gas potential
T : The year of calculation
x : Base year
v : Density of methane (0.7168 kg/m^3)

The model calculates the amount of methane formed in year x from the amount of waste deposited in year x-1. The amount of methane emitted to the atmosphere in the year of calculation is based on waste deposited in all years from 1945 onwards, and given by the equation:

$$CH_4 \text{ emissions} = (Q_T - R) \cdot (1-Ox)$$

Where

Q_T : Amount of methane generated in the year of calculation (tonnes/year)
R : Amount of methane combusted (tonnes/year)
Ox : Fraction of the methane that is oxidised.

Activity data

Data for total waste and waste to material or energy recovery are reported to SN who compiles these data into national statistics, which are used as input to the methane calculating model. The amount of municipal waste is estimated by annual surveys carried out by SN. Data on commercial waste are taken from surveys conducted every three years, also carried out by SN. In consultation with Norwegian experts, the collection and detail of the activity data have been found to be consistent with the IPCC Good Practice Guidance.

Data from each landfill site with recovery units for methane is sampled by the county governors and reported to SFT. These data are imported into the national model for calculating methane from landfills.

Emission factors

The emissions factors used in the Norwegian model is a mixture of country-specific factors, estimated by a range of officials and Norwegian waste experts, and IPCC defaults values applied where country-specific information was not available. Table 46 shows some of the variables used in the calculations of methane from solid waste disposals.

Table 46. Variables used in the calculations of methane from landfills. Source: SFT (1999a)

Variables	Type of waste		
	Household	Commercial/ Institutional	Manufacturing
$t_{1/2}$ (half life)	9.5 years	11 years	11 years
Landfill gas potential (L_0)	370 Nm^3/tonne	355 Nm^3/tonne	425 Nm^3/tonne
Correction factor (19979) (MCF)	1.00	1.00	0.80
Oxidation effect	10 per cent	10 per cent	10 per cent

8.2.3 Uncertainties

The uncertainty of the calculated methane emissions from landfills is overall ranked in both level and in trend as one of the most uncertain emission estimates in the Norwegian GHG inventory. This is the situation even if this emission source recently has been prioritised for inventory improvement. The importance of the uncertainties in calculations of methane from landfills will decrease with decreased source contribution, but it will most likely still remain among the main uncertainties in the Norwegian GHG inventory.

The methodology we use to calculate methane emissions from landfills is identical for the whole time-series. The quality of the activity data used in the model has been improved the last years and the same is true regarding the data for recovered methane.

8.2.4 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 find an explanation. Corrections are made if there is no plausible explanation of the change.

[9] Different correction factors for different years.

8.2.5 Recalculations

Emissions estimates of methane from SWDS in 1998-2001 have been recalculated since last year's submission of GHG emission data for Norway due to change in the recovery data of methane for some of the landfill sites.

The recalculations have resulted in a change in the emission level of methane from landfills of

- 0.50 per cent in 1998
- 0.32 per cent in 1999
- 0.07 per cent in 2000
- 0.34 per cent in 2001.

8.2.6 Planned improvements

Norway is aware of the fact that the CH_4 emissions per capita from landfills are the highest among all the reporting Parties. This is due to the combined approach of the model and specific conditions in Norway and may also be due to the fact that emissions of methane from organic industrial solid waste are included in the inventory.

However, the methane calculating model is built on waste composition statistics from the early 1990-ies. Composition has obviously changed since then. For the year 2002, Statistics Norway has published the first complete waste statistics for Norway. In these new statistics material groups are reported separately. The current model contains emissions from degradation of plastic sheeting.

Hence, Norway is evaluating the calculation model and will report the result of this evaluation in NIR 2005.

8.3 Non-key sources

8.3.1 Solid waste disposal on land – CO_2 – 6A

The reported estimate of CO_2 emissions from landfills includes both direct emissions and indirect emissions from oxidation of methane in the atmosphere. It is only the fossil carbon in the deposited waste that is included in the CO_2 emission inventory and this is in accordance with the IPCC's Good Practice Guidance.

8.3.2 Waste water handling – N_2O and CH_4 – 6B

Method

CH_4
We report emissions of methane from domestic and commercial wastewater. 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:

$$E_i = N_i * D * B_0 * MCF$$

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
We have reported emissions of nitrous oxides from domestic and commercial wastewater only. The N_2O from sewage sludge applied on fields is reported under Section Agriculture. For N_2O, emissions are calculated from nitrification/denitrification that occurs in the pipelines and the N_2O 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.

Activity data

CH_4
Data for the number of residents in Norway are given from Statistics Norway's population statistics. Activity data for the actual year are given in Annex 5, Table A5-1. 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 given by SN (waste water statistics).

Data for the amount of nitrogen that is removed in the biological step in the actual waste water plants are given by SFT.

Emission factor

CH_4
The IPCC emission factor from the Good Practice Guidance (Ref.) 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 for the fraction that is anaerobic treated is being used. The factor is from SN (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% of the nitrogen removed from plants will form N_2O. This country specific emission is given in (SFT 1992), and the assumption are based on measurements in plants and comparisons with factors used in Sweden.

8.3.3 Waste incineration – CO_2 – 6C

Emissions from waste incineration in district heating plants are reported in sector 1A1a as the energy is utilised. There are 10 waste incineration plants where household waste is incinerated. In addition some incineration plants burn waste other than household waste, mainly wooden waste, and paper, pasteboard and cardboard. This is also reported and described in sector 1A2d. Waste, other than household waste, is also used as energy source in some manufacturing industries. In this chapter the focus will be waste as it is reported in sector 6C. That is emission from flaring, except flaring from energy sectors, and emissions from cremation and hospital waste.

Method

Emissions from flaring are estimated. The amount of gas used in flare is multiplied by appropriate emission factors.

Activity data

The amount of gas flared, is reported by the plant to SN. The amount of hospital waste was reported to SN for the years 1998 and 1999.

The number of cremated bodies is taken from Statistic Yearbook. It is assumed that the average weigh of a body is 60 kilo. Further it is assumed that 40 percent is dry substances. The weight of a coffin is set to 25 kilo.

Emission factors

Table 47. Emission factors for flare, cremation and hospital waste incineration emission/kSm^3 or tonnes

Component	Flare	Cremation	Hospital waste
	Tonnes/kSm^3	Ton/ton	Ton/ton
CO_2	2.34	0	0.3
CH_4	0.00024	0.00024	0.00023
N2O	0.00002	0.0003	

Amount of waste

Incineration of hospital waste is annually report to the SFT. The composition of the waste is changing.

Emission factors

If the composition of the waste is different to the waste the emission factors are based on, the calculated emission will be incorrect. Combustion engineering and processes also influence the emissions. These uncertainties have not been calculated.

There have not been done calculations of uncertainty.

8.3.4 Recalculation – non-key sources Waste

6B Wastewater Handling

There was a double counting that is now corrected. This led to a decrease in the emissions in 2001 from 395 to 356 tonnes of N_2O.

Chapter 9. Recalculations

9.1 Overall description of recalculations

To account for knew knowledge on activity data and emission factors and to correct for some errors in the calculations; the Norwegian emission inventory has been recalculated for the entire time series 1990-2001 for all components. The figures reported in this submission are therefore consistent through the whole time series.

Most of the recalculations have been performed for 2001 because the energy accounts for 2001 that was the basis for last year's submission were "preliminary". Now the "final" figures for the energy accounts are available. This is due to the fact that final energy consumption figures from the manufacturing statistics and some other final energy figures now are included in the energy accounts. These types of revisions caused by the energy balance will not be commented specifically under each IPCC code.

9.2 Specific description of the recalculations

9.2.1 IPCC category 1 Energy

As mentioned above, most of the recalculations for 2001 are caused by revisions in the energy accounts from "preliminary" in last submission to "final" in this submission.

Fuel combustion activities

1A1 Energy Industries
The natural gas consumption for turbines off-shore reported from the Norwegian Petroleum Directorate has been revised for the years 2000 and 2001.

The petroleum refineries report emission figures to the SFT. Figures for some components such as SO_2 and NO_X are already used in the inventory. In this submission the company's own figures for CO_2 are being used for 1990-2002. The reported figures have been quality checked with calculations done by SN. The CO_2 emissions are allocated to 1A1b and 1B2a Refining/Storage. The emissions in the latter sector are from the catalytic cracker at one refinery.

1A2 Manufacturing Industries and Construction
There have been minor revisions in the energy accounts for some sectors.

1A3 Transport
Civil Aviation
There has been an increase in the emissions since the previous calculation as a result of revised activity data for aviation petrol. Activity data have increased for the whole time series since we now use total sale of aviation petrol in our calculations. Previously we used only the amount purchased in the investment group "aviation". We now include all investment groups and therefore total sale.

Road Transportation
Revisions in the energy accounts give revisions in the emission figures for 2001.

There has been a reallocation of autodiesel consumption between light and heavy vehicles.

Navigation
Revisions in the energy accounts give small revisions in the emission figures for 2000-2001.

1A4 Other sectors
Revision in the energy accounts give revision in the emission figures for 2001 mainly due to revised figures for fuel oil.

Fugitive emissions from fuels

1B2 Oil and Natural Gas
The emission factor for NMVOC for oil loading from an offshore installation has increased for the years 1996-2001. This leads to increased emissions also of CO_2 because in the reporting CO_2 from oxidation of NMVOC and CH_4 in the atmosphere is accounted for in the calculations (see Section 3.11.4)

9.2.2 IPCC category 2 Industrial processes

2A Mineral Products
Limestone and Dolomite use.
Calcium carbonate has been, and still is used to lime lakes. This is to reduce damages from acidification. The amount of CO_2 emission from liming of lakes is no longer included under the category 2A3, but under section 5E Other emissions from Total Land-Use Change and Forestry, to be consistent with the Good Practice Guidelines.

2C Metal Production
Ferroallys Production
There has been a recalculation for CO_2 for the whole time series. This is because reported emissions from one plant now are used in the inventory instead of using the value calculated by SN. The SN calculated value is now used as a check.

Non-combustion methane emissions are now included for metal production for the whole time series. These emission figures are based on figures reported from the plants to the SFT.

Aluminium Production
There has been a substantial recalculation of the PFCs emissions from one producer of aluminium. Specifically the emissions in 1990 and 2001 are recalculated and some minor recalculations are made for 1998, 1999 and 2000. The changes are based on an evaluation that has been carried out by the aluminium industry to consider the industries GHGs data in general. Concerning the PFCs from aluminium production the decision was that for 1990 one should use the data from the voluntary agreement between the industry and the government. This resulted in the recalculation of PFCs emissions in 1990, particularly, for one plant. The recalculation was mainly due to change in number and duration of anode effects. As a consequence the same plant had to recalculate emission for some other years, too.

Additionally some changes are done for a few other plants but this recalculation is due to small error in the figures.

9.2.3 IPCC category 4 Agriculture

Statistics Norway has in cooperation with the Agricultural University of Norway (NLH) made improvements in the calculation model for ammonia emissions from the agricultural sector. This gives changes in the figures for all reported years for several emission sources for ammonia but it has also effects on the reported N_2O figures (see below). Data sources used for the recalculations in the revised NH_3-model are coefficients from the Agricultural University of Norway (NLH) and two surveys from Statistics Norway; a manure survey from 2000 and the sample survey of agriculture and forestry 2001.

4B Manure Management
New revised figures for the population of different animals have been used for the whole time period 1990-2002. This has effects on both CH_4 and N_2O.

Statistics Norway made a detailed manure survey in 2000, that gave more extended activity data that was 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, that are more connected to specific activities. This also has effects on the N_2O figures for the whole time series.

4D Agricultural Soils
New revised figures for the population of different animals have been used for the whole time period 1990-2002. This has effects on the amount of N2O from spreading of manure.

Changes in the ammonia model are also effecting the whole time series for N_2O. New activity data for spreading of manure comes from the manure survey from the year 2000, and the sample survey of agriculture and forestry 2001. New loss factors for spreading are also used in the ammonia model.

When it comes to the calculation of emissions from grazing animals, the calculation structure is unchanged, but new time estimates for pasture are used for the different animal categories. The new pasture times come from the sample survey of agriculture and forestry 2001.

Liming of agricultural soils
The emission of CO_2 from liming of agricultural soils is no longer reported under agriculture, but under 5D, due to the IPCC Guidelines.

4F Field burning of agricultural residue
New emission figures for CH_4 and N_2O for 1999, 2000 and 2001 caused by improved activity data.

9.2.4 IPCC category 4 Waste

6A Solid Waste Disposal on Land
Emissions estimates of methane from SWDS in 1998-2001 have been recalculated since last year's submission of GHG emission data for Norway due to change in the recovery data of methane for some of the landfill sites.

The recalculations have resulted in a change in the emission level of methane from landfills of

- 0.50 per cent in 1998
- 0.32 per cent in 1999
- 0.07 per cent in 2000
- 0.34 per cent in 2001.

6B Wastewater Handling
There was a double count which is now corrected for. This led to a decrease in the emissions in 2001 from 395 to 356 tonnes of N_2O.

9.3 Implications of the recalculations

9.3.1 Implications for emissions levels

Table 48 shows the effects of recalculations on the emission figures for the greenhouse gases 1990 – 2001.

Table 48. Recalculations in 2004 submission compared to the 2003 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	34863.0	34690.2	-0.5	6433.1	6448.6	0.2	5499.0	5517.1	0.3
1998	41091.2	40838.3	-0.6	6904.6	6951.9	0.7	5432.7	5448.3	0.3
1999	41559.0	41316.8	-0.6	6863.0	6905.8	0.6	5653.7	5666.6	0.2
2000	41120.0	40856.8	-0.6	6971.7	7007.3	0.5	5546.9	5549.8	0.1
2001	41589.5	42065.5	1.1	6981.7	7002.1	0.3	5570.1	5554.2	-0.3

Table 49. Recalculations in 2004 submission compared to the 2003 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	3 032.03	3 294.40	8.65	2 185.96	2 185.96	0.00
1998	132.64	132.64	0.00	1 267.04	1 267.18	0.01	694.54	694.54	0.00
1999	179.45	179.45	0.00	1 121.76	1 123.01	0.11	840.75	840.75	0.00
2000	232.10	232.10	0.00	899.26	899.24	0.00	890.81	890.81	0.00
2001	291.68	291.68	0.00	1 026.21	1 043.41	1.68	773.35	773.35	0.00

9.3.2 Implications for emission trends

As a result of the different recalculations for 1990-2001 there have been some changes in the trends. The differences are shown in the tables below.

Table 50. Trends in emissions 1990-2001. This submission vs. previous submission. GHG. Per cent change 1990-2001

	Total GHG	CO_2	CH_4	N_2O	PFC's	SF_6	HFC's
This submission	8.81	21.26	8.58	0.67	-68.33	-64.62	1591398.90
Previous submission	8.11	19.29	8.53	1.29	-66.15	-64.62	1591398.90

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Annex 1: Key Sources

This chapter outlines the Tier 2 methodology used to find which sources are key sources in the Norwegian Greenhouse gas emission inventory.

In previous Norwegian National Inventory Report (2003) the key source analysis was based on a work done by Rypdal and Zhang (SN 2000). This report used a tier 2 approach for uncertainty assessment and incorporated Monte Carlo analysis. The current analysis is simplified and uses a tier 1 uncertainty assessment as described in IPCC's Good Practice Guidance (IPCC 2001), equations 7.3-7.4. According to the Good Practice Guidance the key source analysis is a Tier 2 method.

Key sources are identified as the emission sources that add up to 90 per cent of total uncertainty in level and/or trend. This definition of a key source is according to IPCC (2001) which is based on (SN 2001e).

The key source analysis is performed at the level of IPCC source categories and each GHG from each source category is considered separately with respect to total GWP weighted emissions. The advantage in using a Tier 2 rather than the Tier 1 methodology is that uncertainties are taken into account so the ranking shows where uncertainties can be reduced. In addition the Tier 1 method can identify sources that are not actually key according to Tier 2 (SN 2001e).

The steps taken to find key sources with respect to level and trend were the determination of uncertainties in input parameters (AD = activity data and EF = emission factors). Uncertainty data were obtained from SN (2000) with some modifications. The highest uncertainties from SN (2000) could not be used directly, as they would have totally dominated the analysis. These uncertainties were usually associated with emission factors with lognormal probability densities. They were "normalized" by the formula $U^* = ln\,(U + 1)$. The associated emission factors still dominate the analysis more strongly than in SN (2000), but the conclusions with respect to the key sources now seem more robust.

Uncertainties of activity data and emissions factors were combined to source uncertainty by the error propagation rule $U_{source} = \sqrt{U_{AD}^2 + U_{EF}^2}$ (IPCC 2001, equation 6.4).

The next step was the use of sensitivity analysis to identify which parameters in the inventory influence most the total GHG emissions in level and in trend. The current method does not take correlations into account. This has partly been handled by aggregating sources with the same emission factors in stationary combustion, categories 1A1, 1A2, and 1A4. However, correlations due to common activity data for several pollutants have not been taken into account. This may lead to an underestimation of the uncertainty importance for such sources.

Compilations of the uncertainty importance elasticity lead to the estimation of uncertainty importance of each input parameter with respect to total level and trend uncertainty. Out of this we get a ranked list of parameters which add up to 90 per cent of total uncertainty in level and trend.

The background data on emissions and uncertainties are shown in Table A1-1, which also gives the level of aggregation used in the analysis. Emission sources defined as key sources are shown in Tables A1-2 and A1-3, and a summary in Table A1-4.

The key sources identified correspond well with the previous analyses. The major difference is that 2C4 - *SF_6 Used in Aluminium and Magnesium Foundries* is identified as key by the trend analysis. This source has a low uncertainty. However, the major plant using SF_6 were closed in 2002. This leads to an even larger difference between total trend and source trend than in SN (2000).

N_2O from agriculture figure more prominently than in SN (2000). This is probably due to a different treatment of the very large uncertainty in this source. The source would be identified as key by all reasonable treatments. However, the choice of treatment influences which sources are included by the 90% threshold. The next sources in the trend analysis were both identified as key in the level analysis. The next sources in the level analysis were 2B2 *Nitric acid production* and 1A3e *Other motorized equipment*.

The other differences between the current analysis and SN (2000) have no bearings on the conclusions on key sources. There are some differences in ranking and in whether the sources are identified by the level, trend or both analyses.

CH_4 from coal mining - 1B1a - has been designated key in the previous National Inventory Reports. This source is not identified by the quantitative method. It is included because the national emission factor we use is in an order of magnitude less than IPCC's default factors (not shown in the tables).

No formal analysis of the separate effects of AD and EF uncertainty has been performed. An informal analysis, using the equation for U_{source} given above, gives the same conclusion as SN(2000): The uncertainty importance of activity data is generally lower than the emission factors. Except for N_2O from agriculture, uncertainty importance of emission factors seems to be more widely distributed among sources than the uncertainty importance of activity data. This corresponds with the results in SN (2000) that more emissions factors than activity data are identified as key parameters (data not shown).

The analyses have been performed for 1990 and 2002 GHG emission data. The main conclusion is that there are few differences in the result for 1990 compared with 2002.

Table A1-1 Background data for key source analysis

IPCC	Source category	Emissions, 1000 t CO_2-eq.						Uncertainties			
								Acti-	Emission factors		
Part 1	CO_2, CH_4, and N_2O	CO_2		CH_4		N_2O		vity	CO_2	CH_4	N_2O
		1990	2002	1990	2002	1990	2002				
1A1, 1A2, 1A4	Stationary Fuel Combustion, Coal/coke	558	607	2	1	1	1	0.05	0.07	0.69	1.10
do.	Stationary Fuel Combustion, Gas	7 196	11 830	46	78	19	29	0.04	0.07	0.69	1.10
do.	Stationary Fuel Combustion, Oil	6 406	5 651	10	8	81	66	0.03	0.03	0.69	1.10
do.	Stationary Fuel Combustion, Wood etc	.	.	119	145	40	52	0.30	.	0.69	1.10
do.	Stationary Fuel Combustion, Waste	100	146	2	3	4	9	0.05	0.30	0.69	1.10
1A3a	Civil Aviation	679	913	0	1	7	9	0.20	0.03	0.69	1.10
1A3b	Road Transportation	7 850	9 468	59	44	92	660	0.20	0.03	0.69	1.10
1A3c	Railways	96	43	0	0	11	5	0.10	0.03	0.69	1.10
1A3d	Navigation	1 929	2 240	4	6	14	16	0.10	0.03	0.69	1.10
1A3e	Other (snow scooters, boats, motorized equipment)	544	661	6	7	40	54	0.20	0.03	0.69	1.10
1A5a	Military - Stationary	62	44	0	0	0	0	0.05	0.05	0.69	1.10
1A5b	Military - Mobile	394	409	0	0	4	4	0.05	0.05	0.69	1.10
1B1a	Coal Mining	0	3	3	21	.	.	0.03	0.69	0.69	.
1B2a	Oil (incl. oil refineries, gasoline distribution)	1 105	1 369	125	346	.	.	0.03	0.34	0.34	.
1B2b	Natural Gas	6	15	16	36	.	.	0.03	0.69	0.69	.
1B2c	Venting and Flaring	1 514	1 289	148	253	4	4	0.04	0.10	0.69	1.10
2A1	Cement Production	653	860	.	.	.	.	0.03	0.07	.	.
2A2	Lime Production	25	32	.	.	.	.	0.03	0.07	.	.
2A3	Limestone and Dolomite Use	20	21	.	.	.	.	0.03	0.07	.	.
2B1	Ammonia Production	579	372	.	.	.	.	0.03	0.07	.	.
2B2	Nitric Acid Production	.	.	.	.	2 062	1 912	0.00	.	.	0.07
2B4	Carbide Production	447	335	21	16	.	.	0.03	0.10	0.69	.
2B5	Other	3	1	1	3	.	.	0.10	0.10	0.69	.
2C1	Iron and Steel Production	201	296	.	.	.	.	0.03	0.07	.	.
2C2	Ferroalloys Production	2 498	2 261	16	13	.	.	0.03	0.07	0.69	.
2C3	Aluminium Production	1 431	1 726	.	.	.	.	0.03	0.07	.	.
2C5	Other	190	98	.	.	.	.	0.10	0.10	.	.
2D2	Food and Drink	20	59	.	.	.	.	0.10	0.10	.	.
3A	Paint Application	37	24	.	.	.	.	0.15	0.20	.	.
3B	Degreasing and Dry Cleaning	8	1	.	.	.	.	0.15	0.20	.	.
3C	Chemical Products, Manufacture and Processing	8	15	.	.	.	.	0.15	0.20	.	.
3D	Other	92	87	.	.	36	37	0.15	0.20	.	1.10
4A1	Cattle	.	.	1 360	1 296	.	.	0.10	.	0.25	.
4A3	Sheep	.	.	260	300	.	.	0.10	.	0.25	.
4A4	Goats	.	.	9	7	.	.	0.10	.	0.25	.
4A6	Horses	.	.	12	19	.	.	0.10	.	0.25	.
4A8	Swine	.	.	17	19	.	.	0.10	.	0.25	.
4A9	Poultry	.	.	1	1	.	.	0.10	.	0.25	.
4B1	Cattle	.	.	215	208	.	.	0.10	.	0.25	.
4B3	Sheep	.	.	24	27	.	.	0.10	.	0.25	.
4B4	Goats	.	.	2	1	.	.	0.10	.	0.25	.
4B6	Horses	.	.	11	18	.	.	0.10	.	0.25	.
4B8	Swine	.	.	23	26	.	.	0.10	.	0.25	.
4B9	Poultry	.	.	19	23	.	.	0.10	.	0.25	.
4B11	Liquid Systems	.	.	.	.	14	14	0.10	.	.	1.10
4B12	Solid Storage and Dry Lot	.	.	.	.	79	77	0.10	.	.	1.10
4B13	Other	.	.	4	4	16	17	0.10	.	0.25	1.10

IPCC	Source category	Emissions, 1000 t CO_2-eq.						Uncertainties			
								Acti-	Emission factors		
Part 1	CO_2, CH_4, and N_2O	CO_2		CH_4		N_2O		vity	CO_2	CH_4	N_2O
		1990	2002	1990	2002	1990	2002				
4D1	Direct soil emissions	.	.	.	.	2 241	2 072	0.20	.	.	4.62
4D2	Animal production	.	.	.	.	172	169	0.20	.	.	4.62
4D3	Indirect emissions	.	.	.	.	483	504	0.41	.	.	4.62
4F1	Cereals	.	.	24	9	7	3	0.10	.	0.69	1.10
4A10	Other	.	.	54	46	.	.	0.10	.	0.25	.
6A	Solid Waste Disposal on Land	37	39	3 816	3 868	.	.	0.20	0.30	0.30	.
6B	Wastewater Handling	.	.	20	21	91	103	0.41	.	0.53	1.10
6C	Waste Incineration	0	30	0	0	0	0	0.30	0.30	0.69	1.10
Part 2	HFCs, PFCs, and SF_6	HFC		PFC		SF_6			HFC	PFC	SF_6
		1990	2002	1990	2002	1990	2002				
2C3	Aluminium Production	.	.	3 294	1 120	.	.	0.03	.	0.41	.
2C4	SF6 Used in Aluminium and Magnesium Foundries	.	.	.	.	2 144	150	0	.	.	0.05
2F	Consumption of Halocarbons and Sulphur Hexafluoride	0	365	.	0	43	82	0	0.41	0.41	0.47

Table A1-2. Uncertainty importance of source categories with respect to total level uncertainty. 1990 and 2002. Sources with assesement in bold types are identified as key sources.

IPCC	Source category	Gas	Source category level assessment, with uncertainty (fraction of total)		Cumulative total
			1990	2000	2000
4D1	Direct soil emissions	N_2O	**47.00 %**	**43.05 %**	43.05 %
4D3	Indirect emissions	N_2O	**10.16 %**	**10.49 %**	53.55 %
1A3b	Road Transportation	CO_2	**7.21 %**	**8.61 %**	62.16 %
6A	Solid Waste Disposal on Land	CH_4	**6.25 %**	**6.27 %**	68.43 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO_2	**2.63 %**	**4.29 %**	72.72 %
4D2	Animal production	N_2O	**3.62 %**	**3.52 %**	76.24 %
1A3b	Road Transportation	N_2O	0.47 %	**3.31 %**	79.55 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO_2	**1.70 %**	**2.08 %**	81.63 %
2C3	Aluminium Production	PFC	**6.08 %**	**2.05 %**	83.68 %
4A1	Cattle	CH_4	**1.66 %**	**1.57 %**	85.25 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO_2	**1.23 %**	**1.08 %**	86.33 %
1A3d	Navigation	CO_2	**0.91 %**	**1.05 %**	87.38 %
1A3a	Civil Aviation	CO_2	0.62 %	**0.83 %**	88.21 %
1B2c	Venting and Flaring	CH_4	0.47 %	**0.79 %**	89.00 %
2C2	Ferroalloys Production	CO_2	**0.86 %**	**0.77 %**	89.78 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC	0.00 %	**0.67 %**	90.44 %
1B2c	Venting and Flaring	CO_2	**0.74 %**	0.62 %	91.07 %

Table A1-3. Uncertainty importance of source categories with respect to total trend uncertainty. 1990 - 2002. All sources in the table are identified as key sources.

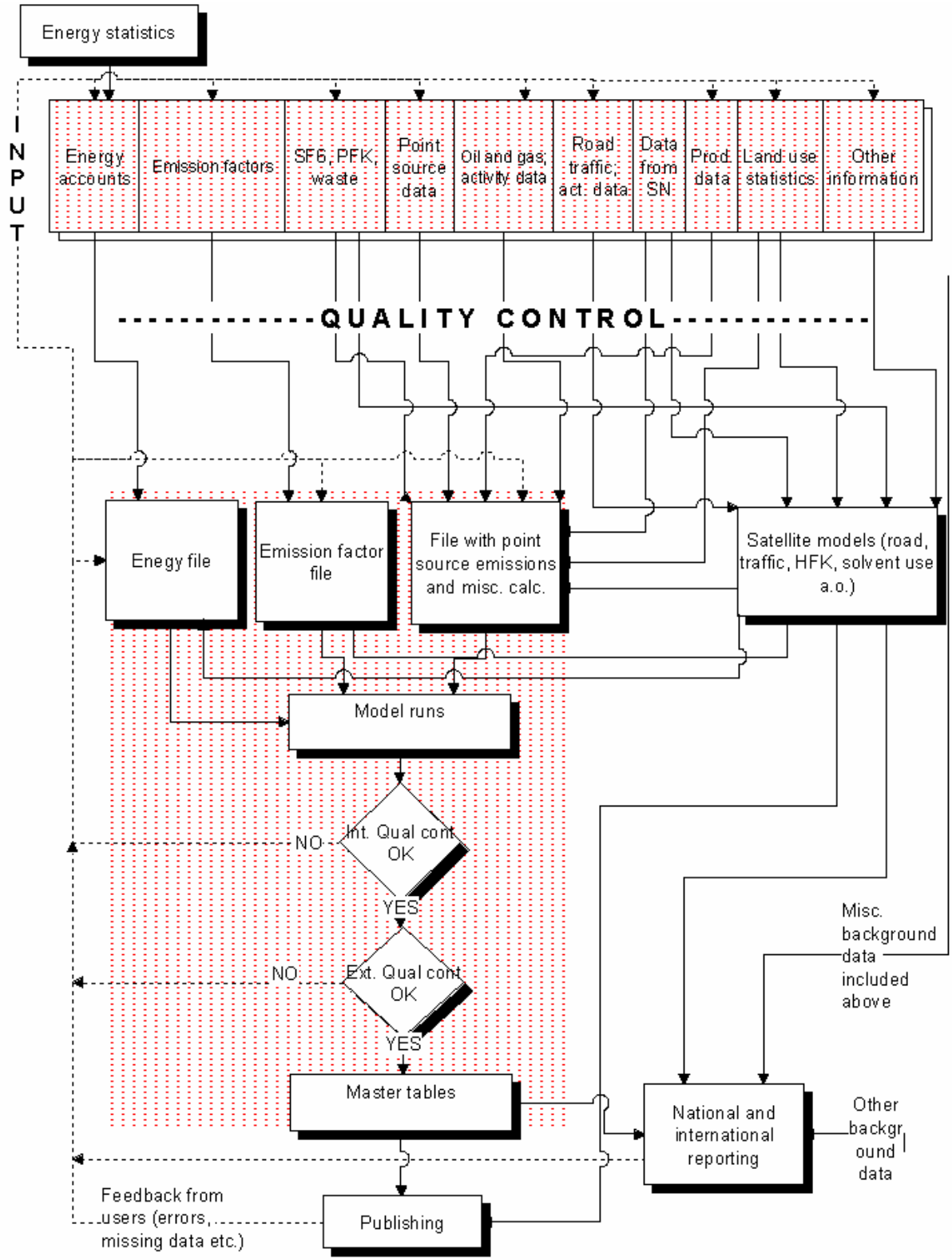
IPCC	Source category	Gas	Source category trend assessment, with uncertainty (fraction of total) 1990-2002	Cumulative total 1990-2002
4D1	Direct soil emissions	N_2O	29.33 %	29.33 %
2C3	Aluminium Production	PFC	20.03 %	49.36 %
1A3b	Road Transportation	N_2O	13.01 %	62.37 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO_2	7.00 %	69.37 %
1A3b	Road Transportation	CO_2	4.75 %	74.12 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC	3.07 %	77.19 %
2C4	SF6 Used in Aluminium and Magnesium Foundries	SF_6	2.20 %	79.39 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CH_4	1.49 %	80.88 %
1B2c	Venting and Flaring	CH_4	1.38 %	82.26 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO_2	1.37 %	83.63 %
6A	Solid Waste Disposal on Land	CH_4	1.37 %	84.99 %
4D2	Animal production	N_2O	1.31 %	86.30 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO_2	1.01 %	87.31 %
4D3	Indirect emissions	N_2O	0.88 %	88.19 %
4A1	Cattle	CH4	0.82 %	89.01 %
1A3a	Civil Aviation	CO2	0.80 %	89.82 %
1B2c	Venting and Flaring	CO_2	0.71 %	90.53 %

Table A1-4. Summary of identified key sources.

IPCC	Source category	Gas	Level assessment 1990	Level assessment 2000	Trend assessment 2000
1A1, 1A2, 1A4	Stationary Fuel Combustion, Gas	CO_2	2.63 %	4.29 %	7.00 %
1A1, 1A2, 1A4	Stationary Fuel Combustion, Oil	CO_2	1.23 %	1.08 %	1.01 %
1A3a	Civil Aviation	CO2		0.83 %	0.80 %
1A3b	Road Transportation	CO_2	7.21 %	8.61 %	4.75 %
1A3b	Road Transportation	N_2O		3.31 %	13.01 %
1A3d	Navigation	CO_2	0.91 %	1.05 %	
1B2a	Oil (incl. oil refineries, gasoline distribution)	CH_4	1.70 %	2.08 %	1.49 %
1B2a	Oil (incl. oil refineries, gasoline distribution)	CO_2			1.37 %
1B2c	Venting and Flaring	CH_4		0.79 %	1.38 %
1B2c	Venting and Flaring	CO_2	0.74 %		0.71 %
2C2	Ferroalloys Production	CO_2	0.86 %	0.77 %	
2C3	Aluminium Production	PFC	6.08 %	2.05 %	20.03 %
2C4	SF6 Used in Aluminium and Magnesium Foundries	SF_6			2.20 %
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFC		0.67 %	3.07 %
4A1	Cattle	CH4	1.66 %	1.57 %	0.82 %
4D1	Direct soil emissions	N_2O	29.33 %	47.00 %	43.05 %
4D2	Animal production	N_2O	1.31 %	3.62 %	3.52 %
4D3	Indirect emissions	N_2O	0.88 %	10.16 %	10.49 %
6A	Solid Waste Disposal on Land	CH_4	1.37 %	6.25 %	6.27 %

Annex 2: Quality Assurance/Quality Control

The figure below shows the flow of information in the national inventory system, primarily. (Source: Haakonsen (2001))



Annex 3: Agriculture

Activity data tables

Agriculture

Table A3-1. Numbers of animals. 2002

	No. of animals
Dairy cattle	323141
Bulls > 1 year	108901
Heifers > 1 year	178826
Non-dairy cattle < 1 year	324994
Horses	49799
Sheep > 1 year	1132358
Sheep < 1 year	651139
Diary goats	45871
Other goats	22369
Pigs for breeding	86925
Pigs for slaughter	529669
Hens	3011630
Chicks bred for laying hens	1841569
Chicks for slaughter	6398932
Ducks for breeding	8490
Ducks for slaughter	29297
Turkey and goose for breeding	48107
Turkey and goose for slaughter	252246
Mink, males	8504
Mink, females	59531
Fox, males	12137
Fox, females	60687
Reindeer	184925
Deer	2719
Ostrich	537

Source: Agricultural Statistics from Statistics Norway.

Table A3-2. Activity data for process emissions of N_2O in the agriculture. 2002

	Value	Source
Synthetic fertilizer	101 258 tonnes N	Norwegian Agricultural Inspection Service
Manure (fertilizer)	49 751 tonnes N	Statistics Norway and Sundstøl and Mroz (1988)
Biological N-fixation	8 000 tonnes N	Aakra and Bleken (1997)
Crop residues	78 000 tonnes N	Aakra and Bleken (1997)
Amount of sewage sludge	103 000 tonnes dry weight	Statistics Norway, water statistics
Fraction sewage sludge applied on fields	42 %	Statistics Norway, water statistics
N-content in the sludge	2.82%	Statistics Norway, water statistics
Cultivation of organic soils	175 000 tonnes N	Aakra and Bleken (1997)
N deposited during grazing	18 099 tonnes N	Statistics Norway, manure balance
N leaching	35 000 tonnes N	JORDFORSK (1998)

Table A3-3. Emission data from Statistics Norway's ammonia model. 2002

Emission sources	Emission (tonnes NH_3)
Manure in storage	5 685
Manure during and after spreading	10 992
Droppings on pastures	864
Emissions from reindeer	33
Synthetic fertiliser	1 131
Treatment of straw	1 021

Table A3-4. Activity data for stationary emissions from burning of agricultural residues. 2002

	Amount (tonnes)	Source
Crop residue burned	177 705	Statistics Norway and the Norwegian Crop Research Institute.

Annex 4: Land Use Change and Forestry

The CO_2 balance for changes in forest and woody biomass stocks and the sectoral background data for the calculation for 2002 are given in Table A4-1 below.

Table A4-1. Sectoral background data for land use change and forestry, changes in forest and woody biomass stocks in 2002

	In total	Spruce	Pine	Deciduous
		1000 m^3		
Growing Stock per 1.1.02	**710 447**	**313 176**	**237 997**	**159 273**
Total Gross Depletion	11 124	7 092	2 325	1 707
Felling in total	8 864	5 998	1 826	1 041
Commercial consumption exclusive fuel wood	7 685	7 263	5 515	1 693
Fuel wood consumption	1 399	323	93	983
Other private wood consumption	202	160	39	3
Other depletion in total	2 259	1 094	499	667
Logging and sivilcultural waste	573	360	110	104
Natural losses	1 686	734	390	562
Gross Increment	**24 348**	**12 230**	**6 493**	**5 625**
Net Growth	**13 225**	**5 139**	**4 168**	**3 918**
Growing Stock per 31.12.02	**723 672**	**318 315**	**242 166**	**163 191**
Converting factors				
Tonnes dry matter per m3		0,38	0,44	0,503
Carbon fraction	0,5			
Expansion ratio (to include branches, roots etc.)	1,9			
CO_2 ratio	3,67			
		1000 tonnes CO_2		
Total Gross CO_2 Emissions	**15 957**	**9 395**	**3 567**	**2 995**
Felling in total	6 617	4 184	1 475	962
Commercial consumption exclusive fuel wood	5 560	5 263	3 846	1 369
Fuel wood consumption	1 207	224	73	906
Other private wood consumption	147	110	33	4
Other depletion in total	9 340	5 211	2 092	2 033
Logging and sivilcultural waste	6 782	4 243	1 494	1 046
Natural losses	2 558	973	598	987
Gross CO_2 removals	**36 028**	**16 203**	**9 960**	**9 865**
Net CO_2 removals	**20 071**	**6 808**	**6 393**	**6 870**

Annex 5: Waste

Activity data tables

Table A5-1. Activity data for emissions of CH_4 for waste water. 2002

	Persons	Source
Population in Norway	4524066	Statistics Norway

Table A5-2. Activity data for emissions of N_2O for waste water. 2002

	tonnes N	Source
N supplied to pipelines	15413	Statistics Norway

Table A5-3. Amount of nitrogen removed in in biological nitrogen-removal plants. 2002

Plant, Concern number	tonnes N
21401	35
22001	1743
23501	79
30109	761
50101	158
90401	38
Total	2814

Source: The Norwegian Pollution Control Authority

Annex 6: Uncertainty Estimates for Single Sources

Table A6-1. Summary of standard deviation and probability density of activity data.

IPCC source category	Pollutant source	Standard deviation (2σ). %	Density shape	Source/Comment
1A1, 1A2	Gas combustion	± 4	Normal	Directorate of oil and gas
1A1, 1A2, 1A3, 1A4	Oil combustion (total)	± 3	Normal	Spread in data.
1A1	Waste combustion - Energy industries	± 5	Normal	Expert judgement
1A2, 1A4	Waste combustion - Other sectors	± 30	Lognormal	Expert judgement
1A1, 1A2, 1A4	Wood combustion - All sectors	± 30	Lognormal	Expert judgement
1A2	Coal and coke combustion- Industry	± 5	Normal	Spread in data
1A3b, 1A3e	Oil, road/off-road/catalytic/non-catalytic	± 20	Normal	Comparisons of data
1A3a	Oil combustion - Aviation	± 20	Normal	Expert judgement
1A3d	Oil combustion - Shipping	± 10	Normal	Comparisons of data
1A4b	Coal and coke combustion - Residential	± 20	Normal	Expert judgement
1B1a	Mining of coal	± 3	Normal	Expert judgement
1B2a and b	Extraction of oil and gas	± 3	Normal	Expert judgement
1B2a	Loading of crude oil	± 3	Normal	Expert judgement
1B2c	Flaring of natural gas	± 4	Normal	As combustion of gas
2A1	Cement production	± 3	Normal	Expert judgement
2B1	Ammonia production	± 3	Normal	Expert judgement
2B2	Nitric acid production	-	-	Measured value
2B4	Carbide production	± 3	Normal	Expert judgement
2C1, 2C2, 2C3	Metal production	± 5	Normal	Expert judgement
2F	HFCs in products	-	-	See emission factor
2F	SF_6 in products	-	-	See emission factor
4A, 4B	Animal population	± 5-10	Normal	Expert judgement
4D	Agricultural soils - Fertiliser use	± 5	Normal	Agriculture authorities
4D	Agricultural soils - Manure use	± 20	Normal	Expert judgement
4D	Agricultural soils - Other activities	± 50	Lognormal	Expert judgement
6A	Solid waste disposal	± 20	Normal	Expert judgement
6B	Waste water treatment	± 25	Normal	Expert judgement

Table A6-2. Summary of standard deviation and probability density of emission factors.

IPCC source category	Pollutant source	Standard deviation (2σ). %	Density shape	Source/Comment
1A1, 1A2	CO_2 - Gas combustion	± 7	Normal	The Norwegian Petroleum Directorate
1A1, 1A2, 1A3, 1A4	CO_2 - Oil combustion	± 3	Normal	Spread in data
1A1, 1A2, 1A4	CO_2 - Coal combustion	± 7	Normal	Spread in data
1A1, 1A2, 1A4	CO_2 - Coke combustion	± 7	Normal	Spread in data
1A1, 1A2, 1A4	CO_2 - Waste combustion	± 30	Normal	Spread in data
1A1, 1A2, 1A4	CH_4 - Wood, coal, waste combustion	-50 - +100	Lognormal	Spread in data
1A3	CH_4 - Oil combustion. Road traffic	-50 - +100	Lognormal	Spread in data. Expert judgement
1A1, 1A2, 1A4	CH_4 - Oil combustion. Other	-50 - +100	Truncated N	Spread in data
1A3	N_2O - Oil combustion. Road traffic	-66 - +200	Beta	Spread in data. Expert judgement
1A1, 1A2, 1A4	N_2O - Oil combustion. Other	-66 - +200	Beta	Spread in data. Expert judgement. IPCC (1997)
1B2c	CO_2 - Flaring	± 10	Normal	As combustion of gas
1B1a	CH_4 - Coal mining	-50 - +100	Lognormal	Expert judgement. IPCC (1997)
1B2a, 1B2b	CH_4 - Oil & gas extraction, refineries	-50 - +100	Lognormal	Expert judgement
1B2a	CH_4 - Oil loading	± 40	Lognormal	Oil company
1B2c	CH_4 - Flaring	-50 - +100	Lognormal	As combustion of gas
1B2c	N_2O - Flaring	-66 - +200	Beta	As combustion of gas
2A1	CO_2 - Cement production	± 7	Normal	Spread in data. IPCC (1997)
2B1	CO_2 - Ammonia production	± 7	Normal	Expert judgement
2B2	N_2O - Nitric acid production	± 7	Normal	Plants' estimate. Continuos measurements
2B4	CO_2 - Carbide production	± 10	Normal	Spread in data
2C1, 2C2, 2C3	CO_2 - Metal production	± 7	Normal	Spread in data
2C4	SF_6 - Metal production	± 5	Normal	Expert judgement. Consumption of chemical
2C3	PFCs - Metal production	-30 - +50	Lognormal	Plants estimate
2F	HFCs from product use	± 50	Lognormal	Expert judgement
2F	SF_6 from product use	± 60	Lognormal	Expert judgement
4A	CH_4 - Enteric fermentation	± 25	Normal	IPCC (1997)
4B	CH_4 - Animal waste	± 25	Normal	IPCC (1997)
4D	N_2O - Agricultural soils	2 orders of magnitude	Lognormal	Expert judgement
6A	CH_4, CO_2 - Landfilled solid waste	± 30	Lognormal	SFT (1999)
6B	CH_4 - Waste water treatment	± 70	Lognormal	Expert judgement

Table A6-3. Uncertainties in emission level. Each gas and total GWP weighted emissions.

1990	μ (mean)	Fraction of total emissions	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)
Total	52 mill. tonnes	1	0.103	21
CO_2	35 mill. tonnes	0.67	0.017	3
CH_4	317 ktonnes	0.12	0.111	22
N_2O	18 ktonnes	0.11	0.960	200
HFC	0.13 tonnes	0.00	0.251	50
PFC	390 tonnes	0.05	0.203	40
SF_6	95 tonnes	0.04	0.026	5

*2010**	μ (mean)	Fraction of total emissions	Relative standard deviation	Uncertainty 2σ (% of mean)
Total	63 mill. tonnes	1	0.084	17
CO_2	48 mill. tonnes	0.76	0.018	4
CH_4	286 ktonnes	0.10	0.098	20
N_2O	19 ktonnes	0.09	0.852	170
HFC	580 tonnes	0.02	0.255	50
PFC	185 tonnes	0.02	0.202	40
SF_6	21 tonnes	0.01	0.043	9

* Projected data with uncertainties as if they were historical.

Table A6-4. Uncertainty of emission trend. 1990-2010*

	% change $((\mu_{2010}-\mu_{1990})*100/\mu_{1990})$	Relative standard deviation $(\sigma/(\mu_{2010}-\mu_{1990}))$	Uncertainty 2σ (%-point of change)
Total	21	0.107	4
CO_2	36	0.066	5
CH_4	-10	-0.785	16
N_2O	10	0.652	13
HFC	-	0.250	-
PFC	-51	-0.193	20
SF_6	-77	-0.024	4

* Projected values with uncertainties as if they were historical.

Annex 7: National Energy Balance Tables, 1990-2002

Table A7-1 Energy balance sheet 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	5 146	9	.	42	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)	952	21	23	42	521	-204	92	514	-57	-
8	Energy converted	1 093	1	1	1	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	0	-	-	-	-	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	1 037	.	6	.	.	542	45	.	439	5
9	Consumption by energy sector	156	-	-	-	-	4	145	-	7	-
10	Consumption for non-energy purposes	47	.	.	.	.	47	-	-	-	-
11	Losses in transport and distribution	28	..	..	.	..	..	0	-	26	2
12	Statistical differences (7-8+1.2-9-10-11-13)	-43	-1	2	-0	-18	0	-24	-	-2	0
13	Net domestic consumption	706	21	26	41	-	251	15	-	349	3
13.1	Manufacturing, mining and quarrying	276	21	26	21	-	30	15	-	163	1
13.2	Transport	161	-	-	-	-	158	-	-	2	-
13.3	Other sectors	269	0	0	20	-	62	0	-	183	2
14	Calculated energy consumption3)	540	17	21	27	-	109	14	-	349	3
14.1	Manufacturing, mining and quarrying	254	17	21	13	-	26	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)	167	4	5	14	-	142	1	-	-	-
15.1	Manufacturing, mining and quarrying	22	4	5	7	-	4	1	-	-	-
15.2	Transport	119	-	-	-	-	119	-	-	-	-
15.3	Other sectors	26	0	0	7	-	19	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 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.

Table A7-2. Energy balance sheet 1991. PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy 2)	Electricity	District heating
1.1	Production of primary energy bearers	5 607	9	.	40	3 899	49	1 142	468	.	.
2	Imports	251	17	26	0	69	128	-	-	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)	995	19	23	40	518	-168	106	468	-10	-
8	Energy converted	1 019	1	2	1	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	0	-	-	-	-	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	153	-	-	-	-	4	141	-	8	-
10	Consumption for non-energy purposes	32	.	.	.	.	32	-	-	-	-
11	Losses in transport and distribution	31	..	..	.	..	..	1	-	29	2
12	Statistical differences (7-8+1.2-9-10-11-13)	45	0	2	-	8	48	-9	-	-4	-0
13	Net domestic consumption	696	18	24	38	-	240	15	-	356	4
13.1	Manufacturing, mining and quarrying	267	18	24	20	-	28	15	-	161	1
13.2	Transport	158	-	-	-	-	156	-	-	2	-
13.3	Other sectors	271	0	0	18	-	56	0	-	193	3
14	Calculated energy consumption3)	535	15	19	25	-	102	14	-	356	4
14.1	Manufacturing, mining and quarrying	246	14	19	13	-	24	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)	161	4	5	13	-	138	1	-	-	-
15.1	Manufacturing, mining and quarrying	20	4	5	7	-	4	1	-	-	-
15.2	Transport	117	-	-	-	-	117	-	-	-	-
15.3	Other sectors	24	0	0	6	-	17	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 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.

Table A7-3. Energy balance sheet 1992. PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy 2)	Electricity	District heating
1.1	Production of primary energy bearers	6 246	10	.	42	4 473	53	1 172	496	.	.
2	Imports	215	17	25	0	47	121	-	-	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)	982	18	21	42	580	-265	122	496	-31	-
8	Energy converted	1 118	1	1	4	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	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	496	-	-	-	-	-	-	496	-	-
1.2	Production of derived energy bearers	1 066	.	6	.	.	584	48	.	423	6
9	Consumption by energy sector	164	-	-	-	-	4	152	-	8	-
10	Consumption for non-energy purposes	31	.	.	.	.	31	-	-	-	-
11	Losses in transport and distribution	32	..	..	.	..	..	1	-	30	2
12	Statistical differences (7-8+1.2-9-10-11-13)	7	-1	1	-	8	0	3	-	-5	-0
13	Net domestic consumption	697	18	24	38	-	240	14	-	358	4
13.1	Manufacturing, mining and quarrying	263	18	24	20	-	26	14	-	160	1
13.2	Transport	163	-	-	-	-	161	-	-	2	-
13.3	Other sectors	270	0	0	18	-	53	0	-	196	3
14	Calculated energy consumption3)	534	15	19	25	-	100	14	-	358	4
14.1	Manufacturing, mining and quarrying	243	15	19	13	-	23	13	-	160	1
14.2	Transport	43	-	-	-	-	41	-	-	2	-
14.3	Other sectors	248	0	0	12	-	37	0	-	196	3
15	Energy losses in final consumption (13-14)	162	4	5	13	-	140	1	-	-	-
15.1	Manufacturing, mining and quarrying	20	4	5	7	-	4	1	-	-	-
15.2	Transport	120	-	-	-	-	120	-	-	-	-
15.3	Other sectors	22	0	0	6	-	16	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 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.

Table A7-4. Energy balance sheet 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	6 533	8	.	45	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)	1 007	23	20	45	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	1 081	.	7	.	.	585	50	.	432	6
9	Consumption by energy sector	173	-	-	-	-	5	160	-	8	-
10	Consumption for non-energy purposes	37	.	.	.	.	37	-	-	-	-
11	Losses in transport and distribution	31	..	..	.	..	..	1	-	29	2
12	Statistical differences (7-8+1.2-9-10-11-13)	3	2	1	-	-9	2	4	-	3	-0
13	Net domestic consumption	716	21	25	40	-	248	16	-	363	4
13.1	Manufacturing, mining and quarrying	273	21	25	20	-	28	15	-	164	1
13.2	Transport	171	-	-	-	-	169	-	-	2	-
13.3	Other sectors	272	0	0	21	-	51	0	-	197	3
14	Calculated energy consumption3)	547	17	20	26	-	103	15	-	363	4
14.1	Manufacturing, mining and quarrying	252	16	20	13	-	24	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)	169	4	5	14	-	145	1	-	-	-
15.1	Manufacturing, mining and quarrying	21	4	5	7	-	4	1	-	-	-
15.2	Transport	125	-	-	-	-	125	-	-	-	-
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.

Table A7-5. Energy balance sheet 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	7 234	8	.	48	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)	1 040	26	23	48	575	-230	122	477	-0	-
8	Energy converted	1 119	1	2	5	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	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	477	-	-	-	-	-	-	477	-	-
1.2	Production of derived energy bearers	1 080	.	7	.	.	611	48	.	408	6
9	Consumption by energy sector	188	-	-	-	-	6	171	-	11	-
10	Consumption for non-energy purposes	37	.	.	.	.	37	-	-	-	-
11	Losses in transport and distribution	31	..	..	.	..	..	1	-	28	2
12	Statistical differences (7-8+1.2-9-10-11-13)	9	1	1	-	-18	41	-16	-	0	0
13	Net domestic consumption	736	24	27	44	-	257	14	-	366	4
13.1	Manufacturing, mining and quarrying	287	24	27	22	-	35	14	-	164	1
13.2	Transport	170	-	-	-	-	168	-	-	2	-
13.3	Other sectors	278	0	0	22	-	54	0	-	200	3
14	Calculated energy consumption3)	564	19	22	28	-	111	13	-	366	4
14.1	Manufacturing, mining and quarrying	264	19	22	14	-	30	13	-	164	1
14.2	Transport	46	-	-	-	-	43	-	-	2	-
14.3	Other sectors	255	0	0	14	-	38	0	-	200	3
15	Energy losses in final consumption (13-14)	172	5	5	15	-	146	1	-	-	-
15.1	Manufacturing, mining and quarrying	23	5	5	8	-	5	1	-	-	-
15.2	Transport	124	-	-	-	-	124	-	-	-	-
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.

Table A7-6. Energy balance sheet 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	7 753	8	.	49	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)	1 098	29	25	49	531	-179	149	519	-24	-
8	Energy converted	1 111	1	2	5	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	0	-	-	-	-	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	1 054	.	6	.	.	559	41	.	443	6
9	Consumption by energy sector	185	-	-	-	-	6	170	-	10	-
10	Consumption for non-energy purposes	38	.	.	.	.	38	-	-	-	-
11	Losses in transport and distribution	29	..	..	.	..	..	1	-	26	2
12	Statistical differences (7-8+1.2-9-10-11-13)	43	1	0	-	-11	37	7	-	8	0
13	Net domestic consumption	746	27	28	44	-	257	12	-	374	4
13.1	Manufacturing, mining and quarrying	292	26	28	22	-	32	12	-	170	1
13.2	Transport	174	-	-	-	-	172	-	-	2	-
13.3	Other sectors	280	0	0	22	-	54	0	-	201	3
14	Calculated energy consumption3)	571	21	23	28	-	110	11	-	374	4
14.1	Manufacturing, mining and quarrying	268	21	23	14	-	27	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)	175	5	6	15	-	148	1	-	-	-
15.1	Manufacturing, mining and quarrying	24	5	6	8	-	4	1	-	-	-
15.2	Transport	127	-	-	-	-	127	-	-	-	-
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.
ource: Statistics Norway.

Table A7-7. Energy balance sheet 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	8 793	6	.	50	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)	1 044	26	23	50	565	-226	132	441	32	-
8	Energy converted	1 099	1	1	5	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	0	-	-	-	-	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	1 063	.	7	.	.	626	46	.	377	6
9	Consumption by energy sector	197	-	-	-	-	6	185	-	7	-
10	Consumption for non-energy purposes	39	.	.	.	.	39	-	-	-	-
11	Losses in transport and distribution	30	..	..	.	..	..	1	-	28	1
12	Statistical differences (7-8+1.2-9-10-11-13)	-28	-1	1	-	-36	24	-20	-	3	-0
13	Net domestic consumption	771	26	28	45	-	282	13	-	371	5
13.1	Manufacturing, mining and quarrying	288	26	28	22	-	39	13	-	158	1
13.2	Transport	182	-	-	-	-	179	0	-	2	-
13.3	Other sectors	302	0	0	23	-	64	0	-	211	4
14	Calculated energy consumption3)	587	21	23	29	-	125	12	-	371	5
14.1	Manufacturing, mining and quarrying	263	21	23	14	-	33	12	-	158	1
14.2	Transport	49	-	-	-	-	47	0	-	2	-
14.3	Other sectors	275	0	0	15	-	45	0	-	211	4
15	Energy losses in final consumption (13-14)	185	5	6	16	-	157	1	-	-	-
15.1	Manufacturing, mining and quarrying	25	5	6	8	-	6	1	-	-	-
15.2	Transport	133	-	-	-	-	133	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.

Table A7-8. Energy balance sheet 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	9 093	11	.	52	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)	1 122	28	24	52	591	-238	181	470	14	-
8	Energy converted	1 134	1	2	5	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	0	-	-	-	-	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	1 089	.	7	.	.	626	49	.	401	6
9	Consumption by energy sector	206	-	-	-	-	7	188	-	11	-
10	Consumption for non-energy purposes	49	.	.	.	.	40	9	-	-	-
11	Losses in transport and distribution	32	..	..	.	..	..	1	-	29	2
12	Statistical differences (7-8+1.2-9-10-11-13)	14	1	1	-	-6	5	13	-	0	0
13	Net domestic consumption	776	26	28	47	-	277	19	-	374	5
13.1	Manufacturing, mining and quarrying	295	26	28	23	-	35	19	-	163	1
13.2	Transport	185	-	-	-	-	183	0	-	2	-
13.3	Other sectors	296	0	0	24	-	59	0	-	209	4
14	Calculated energy consumption3)	590	21	23	31	-	120	18	-	374	5
14.1	Manufacturing, mining and quarrying	270	21	23	15	-	30	18	-	163	1
14.2	Transport	50	-	-	-	-	48	-	-	2	-
14.3	Other sectors	270	0	0	16	-	41	0	-	209	4
15	Energy losses in final consumption (13-14)	185	5	6	17	-	157	1	-	-	-
15.1	Manufacturing, mining and quarrying	25	5	6	8	-	5	1	-	-	-
15.2	Transport	135	-	-	-	-	135	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.

Table A7-9. Energy balance sheet 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	8 854	9	.	53	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)	1 210	29	26	53	605	-217	209	492	13	-
8	Energy converted	1 144	1	2	5	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	0	-	-	-	-	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	1 081	.	7	.	.	599	48	.	421	7
9	Consumption by energy sector	196	-	-	-	-	8	180	-	8	-
10	Consumption for non-energy purposes	54	.	.	.	.	37	17	-	-	-
11	Losses in transport and distribution	36	..	..	.	..	..	2	-	32	2
12	Statistical differences (7-8+1.2-9-10-11-13)	57	-1	3	0	6	11	37	-	-1	-
13	Net domestic consumption	805	29	27	48	-	283	20	-	394	5
13.1	Manufacturing, mining and quarrying	313	28	27	25	-	37	19	-	175	1
13.2	Transport	190	-	-	-	-	187	0	-	2	-
13.3	Other sectors	302	0	0	23	-	59	0	-	216	4
14	Calculated energy consumption3)	616	23	22	31	-	123	19	-	394	5
14.1	Manufacturing, mining and quarrying	287	23	22	16	-	32	18	-	175	1
14.2	Transport	52	-	-	-	-	49	-	-	2	-
14.3	Other sectors	277	0	0	15	-	41	0	-	216	4
15	Energy losses in final consumption (13-14)	189	6	5	17	-	161	1	-	-	-
15.1	Manufacturing, mining and quarrying	26	6	5	9	-	5	1	-	-	-
15.2	Transport	138	-	-	-	-	138	0	-	-	-
15.3	Other sectors	26	0	0	8	-	17	0	-	-	-

1) The energy balance is derived from the energy sources balance sheet.
2) Electricity is treated as derived energy. Waterfall energy is the primary energy source for the electricity produced in hydropower plants. It is estimated that in average 15 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.

Table A7-10. Energy balance sheet 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	9 014	11	.	55	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)	1 281	29	27	55	678	-226	207	516	-7	-
8	Energy converted	1 184	1	2	5	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	0	-	-	-	-	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	1 133	.	7	.	.	628	48	.	442	7
9	Consumption by energy sector	197	-	-	-	-	8	180	-	9	0
10	Consumption for non-energy purposes	51	.	.	.	.	32	19	-	-	-
11	Losses in transport and distribution	34	..	..	.	..	..	2	-	30	2
12	Statistical differences (7-8+1.2-9-10-11-13)	131	1	6	0	72	16	34	-	2	-0
13	Net domestic consumption	817	27	27	50	-	293	20	-	393	6
13.1	Manufacturing, mining and quarrying	313	27	27	27	-	36	20	-	176	1
13.2	Transport	200	-	-	-	-	198	0	-	2	-
13.3	Other sectors	303	0	0	23	-	60	0	-	215	5
14	Calculated energy consumption3)	619	22	21	32	-	125	19	-	393	6
14.1	Manufacturing, mining and quarrying	287	22	21	17	-	31	19	-	176	1
14.2	Transport	55	-	-	-	-	52	-	-	2	-
14.3	Other sectors	277	0	0	15	-	42	0	-	215	5
15	Energy losses in final consumption (13-14)	198	5	5	17	-	168	1	-	-	-
15.1	Manufacturing, mining and quarrying	26	5	5	9	-	5	1	-	-	-
15.2	Transport	146	-	-	-	-	146	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.

Table A7-11. Energy balance sheet 2000. PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy 2)	Elect-ricity	District heating
1.1	Production of primary energy bearers	9 664	18	.	55	6 505	302	2 182	603	.	.
2	Imports	235	26	29	0	43	132	-	-	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)	1 398	28	29	56	690	-161	222	603	-69	-
8	Energy converted	1 268	1	2	5	604	51	0	603	2	-
8.1	In blast furnaces	2	-	2	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	655	-	-	-	604	51	-	-	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	0	-	-	-	-
8.5	In district heating plants	5	-	-	3	-	1	0	-	2	-
8.6	In hydropower plants	603	-	-	-	-	-	-	603	-	-
1.2	Production of derived energy bearers	1 193	.	7	.	.	616	48	.	515	7
9	Consumption by energy sector	218	-	-	-	-	9	201	-	8	0
10	Consumption for non-energy purposes	53	.	.	.	.	33	19	-	-	-
11	Losses in transport and distribution	46	..	..	.	..	..	3	-	41	1
12	Statistical differences (7-8+1.2-9-10-11-13)	216	0	8	0	86	95	26	-	1	-0
13	Net domestic consumption	792	27	27	50	-	268	21	-	394	5
13.1	Manufacturing, mining and quarrying	319	27	27	26	-	35	20	-	184	1
13.2	Transport	184	-	-	-	-	182	0	-	3	-
13.3	Other sectors	288	0	0	24	-	51	0	-	208	5
14	Calculated energy consumption3)	608	22	21	32	-	114	20	-	394	5
14.1	Manufacturing, mining and quarrying	293	22	21	17	-	30	19	-	184	1
14.2	Transport	50	-	-	-	-	48	-	-	3	-
14.3	Other sectors	265	0	0	16	-	36	0	-	208	5
15	Energy losses in final consumption (13-14)	183	5	5	17	-	154	1	-	-	-
15.1	Manufacturing, mining and quarrying	26	5	5	9	-	5	1	-	-	-
15.2	Transport	134	-	-	-	-	134	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.

Table A7-12. Energy balance sheet 2001. PJ

		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water-fall energy 2)	Elect-ricity	District heating
1.1	Production of primary energy bearers	9 865	50	.	60	6 485	415	2 341	513	.	.
2	Imports	262	23	27	1	41	131	-	-	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)	95	-6	1	..	87	12	.	.	.	.
7	Net domestic supply (1.1+2-3-4+5)	1 398	26	28	61	608	-159	310	513	13	-
8	Energy converted	1 139	1	1	6	560	56	0	513	2	0
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	615	-	-	-	560	55	-	-	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	7	-	-	4	-	1	0	-	2	0
8.6	In hydropower plants	513	-	-	-	-	-	-	513	-	-
1.2	Production of derived energy bearers	1 071	.	7	.	.	577	40	.	439	8
9	Consumption by energy sector	215	-	-	-	-	8	198	-	9	0
10	Consumption for non-energy purposes	73	.	.	.	.	50	23	-	-	-
11	Losses in transport and distribution	42	..	..	.	..	..	3	-	38	1
12	Statistical differences (7-8+1.2-9-10-11-13)	188	1	9	1	48	26	104	-	-1	0
13	Net domestic consumption	813	24	25	55	-	278	22	-	404	7
13.1	Manufacturing, mining and quarrying	310	24	25	29	-	36	21	-	175	1
13.2	Transport	189	-	-	-	-	186	0	-	3	-
13.3	Other sectors	314	0	0	25	-	56	1	-	227	6
14	Calculated energy consumption3)	624	19	20	35	-	119	20	-	404	7
14.1	Manufacturing, mining and quarrying	284	19	20	19	-	31	20	-	175	1
14.2	Transport	51	-	-	-	-	49	-	-	3	-
14.3	Other sectors	289	0	0	16	-	39	1	-	227	6
15	Energy losses in final consumption (13-14)	189	5	5	19	-	159	1	-	-	-
15.1	Manufacturing, mining and quarrying	26	5	5	10	-	5	1	-	-	-
15.2	Transport	137	-	-	-	-	137	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.

Table A7-13. Energy balance sheet 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	10 157	60	.	57	6 213	485	2 792	549	.	.
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	28	-	-	-	-	28	-	-	-	-
5	Changes in stocks (+ net decrease, - net increase)	1	2	0	..	-3	2	.	.	.	.
7	Net domestic supply (1.1+2-3-4+5)	1 233	23	25	58	504	-107	216	549	-35	-
8	Energy converted	1 139	1	1	6	530	50	0	549	2	0
8.1	In blast furnaces	1	-	1	-	-	-	-	-	-	-
8.2	In crude petroleum refineries	578	-	-	-	530	48	-	-	-	-
8.3	In thermal power plants	0	-	-	-	-	0	-	-	-	-
8.4	In combined heat and power plants	3	1	-	2	-	-	-	-	-	-
8.5	In district heating plants	7	-	-	4	-	1	0	-	2	0
8.6	In hydropower plants	549	-	-	-	-	-	-	549	-	-
1.2	Production of derived energy bearers	1 073	.	7	.	.	551	36	.	470	9
9	Consumption by energy sector	210	-	-	-	-	7	193	-	9	0
10	Consumption for non-energy purposes	66	.	.	.	.	49	17	-	-	-
11	Losses in transport and distribution	40	..	..	.	..	..	4	-	34	2
12	Statistical differences (7-8+1.2-9-10-11-13)	62	2	8	-	-26	61	19	-	0	0
13	Net domestic consumption	789	20	23	51	-	278	19	-	390	7
13.1	Manufacturing, mining and quarrying	287	20	23	26	-	33	19	-	165	1
13.2	Transport	191	-	-	-	-	189	0	-	3	-
13.3	Other sectors	311	0	0	25	-	57	1	-	222	6
14	Calculated energy consumption3)	607	16	19	33	-	124	18	-	390	7
14.1	Manufacturing, mining and quarrying	266	16	19	17	-	30	18	-	165	1
14.2	Transport	52	-	-	-	-	49	-	-	3	-
14.3	Other sectors	290	0	0	16	-	45	1	-	222	6
15	Energy losses in final consumption (13-14)	182	4	5	18	-	154	1	-	-	-
15.1	Manufacturing, mining and quarrying	22	4	5	9	-	3	1	-	-	-
15.2	Transport	139	-	-	-	-	139	0	-	-	-
15.3	Other sectors	21	0	0	9	-	12	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.

Annex 8: Common Reporting Format Tables 1990, 2002

This annex contains Summary II-tables for the whole period 1990-2002. The full CRF tables for 1990 and 1998-2002 are enclosed in a zip-file.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1990
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**25 151,84**	**6 448,59**	**5 517,14**	**0,02**	**3 294,40**	**2 185,96**	**42 597,94**
1. Energy	**28 442,10**	**541,28**	**316,31**				**29 299,69**
A. Fuel Combustion (Sectoral Approach)	25 816,17	249,32	312,42				26 377,91
1. Energy Industries	6 633,52	46,77	22,20				6 702,49
2. Manufacturing Industries and Construction	3 496,59	10,33	38,46				3 545,37
3. Transport	11 099,18	70,02	163,40				11 332,59
4. Other Sectors	4 130,70	121,72	84,30				4 336,72
5. Other	456,19	0,48	4,06				460,74
B. Fugitive Emissions from Fuels	2 625,93	291,96	3,89				2 921,78
1. Solid Fuels	0,44	3,41	0,00				3,85
2. Oil and Natural Gas	2 625,48	288,55	3,89				2 917,93
2. Industrial Processes	**6 066,27**	**37,54**	**2 061,50**	**0,02**	**3 294,40**	**2 185,96**	**13 645,68**
A. Mineral Products	697,29	0,00	0,00				697,29
B. Chemical Industry	1 029,13	22,04	2 061,50				3 112,67
C. Metal Production	4 319,85	15,50	0,00		3 294,40	2 136,66	9 766,41
D. Other Production	20,00						20,00
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				0,02		39,99	40,01
G. Other						9,31	9,31
3. Solvent and Other Product Use	**144,49**		**35,53**				**180,02**
4. Agriculture	**0,00**	**2 034,53**	**3 012,66**				**5 047,19**
A. Enteric Fermentation		1 712,60					1 712,60
B. Manure Management		298,09	109,82				407,90
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 895,97				2 895,97
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		23,85	6,88				30,72
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-9 538,39**	**0,00**	**0,00**				**-9 538,39**
6. Waste	**37,38**	**3 835,24**	**91,13**				3 963,75
A. Solid Waste Disposal on Land	36,91	3 815,72					3 852,63
B. Wastewater Handling		19,51	91,07				110,58
C. Waste Incineration	0,46	0,01	0,06				0,54
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 097,52**	**2,30**	**17,61**				**2 117,43**
Aviation	619,47	0,06	6,10				625,63
Marine	1 478,05	2,24	11,51				1 491,80
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 717,37**						**4 717,37**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	19 726,69	-29 491,86	-9 765,17			-9 765,17
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	216,66		216,66			216,66
E. Other	10,12		10,12			10,12
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	19 953,47	-29 491,86	-9 538,39	0,00	0,00	-9 538,39

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	52 136,33
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	42 597,94

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1991
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**21 807,67**	**6 540,92**	**5 362,34**	**0,11**	**2 523,63**	**2 065,89**	**38 300,57**
1. Energy	**27 874,98**	**563,54**	**323,26**				**28 761,78**
A. Fuel Combustion (Sectoral Approach)	25 302,74	236,84	320,65				25 860,23
1. Energy Industries	6 943,01	49,12	25,65				7 017,78
2. Manufacturing Industries and Construction	3 230,51	9,95	36,59				3 277,05
3. Transport	11 016,13	67,87	174,77				11 258,76
4. Other Sectors	3 707,34	109,47	79,97				3 896,79
5. Other	405,75	0,43	3,67				409,85
B. Fugitive Emissions from Fuels	2 572,24	326,70	2,61				2 901,55
1. Solid Fuels	0,48	3,71	0,00				4,20
2. Oil and Natural Gas	2 571,75	322,98	2,61				2 897,35
2. Industrial Processes	**5 520,46**	**29,84**	**1 891,00**	**0,11**	**2 523,63**	**2 065,89**	**12 030,94**
A. Mineral Products	640,13	0,00	0,00				640,13
B. Chemical Industry	860,03	17,13	1 891,00				2 768,17
C. Metal Production	3 989,91	12,71	0,00		2 523,63	2 007,60	8 533,86
D. Other Production	30,38						30,38
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				0,11		43,94	44,05
G. Other						14,35	14,35
3. Solvent and Other Product Use	125,23		35,30				**160,53**
4. Agriculture	**0,00**	**2 061,43**	**3 021,64**				**5 083,07**
A. Enteric Fermentation		1 736,57					1 736,57
B. Manure Management		306,11	112,64				418,76
C. Rice Cultivation							0,00
D. Agricultural Soils[(2)]		0,00	2 903,59				2 903,59
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		18,74	5,41				24,15
G. Other							0,00
5. Land-Use Change and Forestry[(1)]	**-11 751,43**	**0,00**	**0,00**				**-11 751,43**
6. Waste	**38,43**	**3 886,11**	**91,13**				4 015,67
A. Solid Waste Disposal on Land	37,32	3 866,48					3 903,80
B. Wastewater Handling		19,60	91,07				110,67
C. Waste Incineration	1,11	0,03	0,06				1,20
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**1 811,80**	**1,95**	**15,25**				**1 829,01**
Aviation	559,65	0,06	5,51				565,21
Marine	1 252,15	1,90	9,75				1 263,79
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 407,64**						**4 407,64**

[(1)] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[(2)] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	18 192,81	-30 141,43	-11 948,62			-11 948,62
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	185,31		185,31			185,31
E. Other	11,88		11,88			11,88
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	18 390,00	-30 141,43	-11 751,43	0,00	0,00	-11 751,43

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [(a)]	50 051,99
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [(a)]	38 300,57

[(a)] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 1992
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	**20 705,18**	**6 626,96**	**4 684,00**	**0,34**	**2 016,46**	**687,63**	**34 720,57**
1. Energy	**28 161,34**	**655,00**	**339,23**				**29 155,58**
A. Fuel Combustion (Sectoral Approach)	25 786,24	237,91	336,83				26 360,98
1. Energy Industries	7 536,76	52,68	28,44				7 617,88
2. Manufacturing Industries and Construction	3 139,94	9,76	35,96				3 185,66
3. Transport	11 231,78	68,39	190,74				11 490,91
4. Other Sectors	3 390,84	106,56	77,19				3 574,59
5. Other	486,91	0,53	4,49				491,93
B. Fugitive Emissions from Fuels	2 375,11	417,09	2,40				2 794,60
1. Solid Fuels	0,53	4,04	0,00				4,57
2. Oil and Natural Gas	2 374,58	413,05	2,40				2 790,04
2. Industrial Processes	**5 600,42**	**30,96**	**1 291,15**	**0,34**	**2 016,46**	**687,63**	**9 626,96**
A. Mineral Products	698,61	0,00	0,00				698,61
B. Chemical Industry	870,02	18,02	1 291,15				2 179,19
C. Metal Production	4 001,68	12,94	0,00		2 016,46	619,61	6 650,69
D. Other Production	30,10						30,10
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				0,34		46,71	47,05
G. Other						21,31	21,31
3. Solvent and Other Product Use	**129,62**		**35,21**				**164,83**
4. Agriculture	**0,00**	**2 057,60**	**2 927,27**				**4 984,88**
A. Enteric Fermentation		1 740,10					1 740,10
B. Manure Management		307,25	112,51				419,76
C. Rice Cultivation							0,00
D. Agricultural Soils[2]		0,00	2 811,80				2 811,80
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		10,26	2,96				13,22
G. Other							0,00
5. Land-Use Change and Forestry[1]	**-13 225,46**	**0,00**	**0,00**				**-13 225,46**
6. Waste	**39,25**	**3 883,39**	**91,14**				**4 013,78**
A. Solid Waste Disposal on Land	37,20	3 863,62					3 900,82
B. Wastewater Handling		19,71	91,07				110,78
C. Waste Incineration	2,05	0,06	0,07				2,18
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 169,53**	**2,43**	**18,12**				**2 190,09**
Aviation	602,87	0,06	5,93				608,86
Marine	1 566,66	2,37	12,19				1 581,23
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 335,87**						**4 335,87**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	17 413,94	-30 802,04	-13 388,10			-13 388,10
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	150,76		150,76			150,76
E. Other	11,88		11,88			11,88
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	17 576,58	-30 802,04	-13 225,46	0,00	0,00	-13 225,46

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	47 946,03
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	34 720,57

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1993
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**22 094,90**	**6 757,36**	**5 046,87**	**2,43**	**1 980,37**	**718,87**	**36 600,79**
1. Energy	**29 230,51**	**741,38**	**370,61**				**30 342,51**
A. Fuel Combustion (Sectoral Approach)	26 745,52	254,42	367,62				27 367,55
1. Energy Industries	7 853,87	55,45	27,83				7 937,15
2. Manufacturing Industries and Construction	3 346,72	9,85	36,01				3 392,58
3. Transport	11 845,66	68,34	222,98				12 136,98
4. Other Sectors	3 332,48	120,36	77,54				3 530,38
5. Other	366,79	0,40	3,26				370,46
B. Fugitive Emissions from Fuels	2 484,99	486,97	2,99				2 974,96
1. Solid Fuels	0,39	3,01	0,00				3,41
2. Oil and Natural Gas	2 484,60	483,95	2,99				2 971,55
2. Industrial Processes	**6 165,13**	**33,62**	**1 560,54**	**2,43**	**1 980,37**	**718,87**	**10 460,96**
A. Mineral Products	885,31	0,00	0,00				885,31
B. Chemical Industry	1 008,22	19,54	1 560,54				2 588,30
C. Metal Production	4 239,29	14,09	0,00		1 980,37	659,64	6 893,38
D. Other Production	32,31						32,31
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				2,43		52,72	55,14
G. Other						6,51	6,51
3. Solvent and Other Product Use	**129,28**		**35,51**				**164,80**
4. Agriculture	**0,00**	**2 040,73**	**2 985,78**				**5 026,51**
A. Enteric Fermentation		1 721,12					1 721,12
B. Manure Management		305,51	111,36				416,87
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 870,35				2 870,35
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		14,10	4,07				18,16
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-13 470,12**	**0,00**	**0,00**				**-13 470,12**
6. Waste	**40,08**	**3 941,63**	**94,42**				4 076,13
A. Solid Waste Disposal on Land	37,90	3 921,74					3 959,64
B. Wastewater Handling		19,83	94,35				114,19
C. Waste Incineration	2,18	0,06	0,07				2,31
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 312,09**	**2,68**	**19,30**				**2 334,06**
Aviation	635,14	0,13	6,25				641,53
Marine	1 676,94	2,54	13,05				1 692,53
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 606,74**						**4 606,74**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	17 775,67	-31 436,36	-13 660,69			-13 660,69
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	178,70		178,70			178,70
E. Other	11,88		11,88			11,88
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	17 966,25	-31 436,36	-13 470,12	0,00	0,00	-13 470,12

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	50 070,91
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 600,79

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1994
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 697,21**	**6 844,20**	**5 144,26**	**9,23**	**1 710,38**	**854,45**	**36 259,72**
1. Energy	**30 752,49**	**781,91**	**415,64**				**31 950,04**
A. Fuel Combustion (Sectoral Approach)	28 136,82	265,63	412,54				28 814,99
1. Energy Industries	8 464,77	59,30	29,57				8 553,65
2. Manufacturing Industries and Construction	4 015,02	10,99	40,48				4 066,49
3. Transport	11 675,08	66,70	264,37				12 006,16
4. Other Sectors	3 474,29	128,21	73,38				3 675,89
5. Other	507,65	0,43	4,74				512,81
B. Fugitive Emissions from Fuels	2 615,67	516,27	3,11				3 135,05
1. Solid Fuels	0,44	3,39	0,00				3,83
2. Oil and Natural Gas	2 615,22	512,88	3,11				3 131,21
2. Industrial Processes	**6 363,96**	**37,70**	**1 663,15**	**9,23**	**1 710,38**	**854,45**	**10 638,86**
A. Mineral Products	896,63	0,00	0,00				896,63
B. Chemical Industry	946,56	21,72	1 663,15				2 631,43
C. Metal Production	4 489,28	15,98	0,00		1 710,38	783,92	6 999,56
D. Other Production	31,48						31,48
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				9,23		55,24	64,48
G. Other						15,28	15,28
3. Solvent and Other Product Use	**138,88**		**35,56**				**174,44**
4. Agriculture	**0,00**	**2 059,65**	**2 929,79**				**4 989,44**
A. Enteric Fermentation		1 740,76					1 740,76
B. Manure Management		308,77	111,73				420,51
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 815,14				2 815,14
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		10,12	2,92				13,04
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-15 598,90**	**0,00**	**0,00**				**-15 598,90**
6. Waste	**40,78**	**3 964,94**	**100,11**				4 105,84
A. Solid Waste Disposal on Land	38,27	3 944,92					3 983,20
B. Wastewater Handling		19,94	100,05				119,99
C. Waste Incineration	2,51	0,07	0,07				2,65
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 462,27**	**2,93**	**20,43**				**2 485,62**
Aviation	616,57	0,13	6,07				622,77
Marine	1 845,70	2,80	14,36				1 862,86
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**4 973,04**						**4 973,04**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 267,19	-32 036,49	-15 769,30			-15 769,30
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	155,06		155,06			155,06
E. Other	15,34		15,34			15,34
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 437,60	-32 036,49	-15 598,90	0,00	0,00	-15 598,90

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	51 858,62
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 259,72

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1995
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 887,06**	**6 902,54**	**5 225,83**	**25,88**	**1 561,93**	**577,97**	**36 181,21**
1. Energy	**30 562,47**	**781,10**	**462,69**				**31 806,26**
A. Fuel Combustion (Sectoral Approach)	28 012,35	261,61	459,27				28 733,23
1. Energy Industries	8 353,75	59,67	29,36				8 442,77
2. Manufacturing Industries and Construction	3 662,03	10,88	40,89				3 713,80
3. Transport	12 074,72	65,56	313,55				12 453,82
4. Other Sectors	3 467,67	125,14	71,10				3 663,91
5. Other	454,19	0,37	4,38				458,93
B. Fugitive Emissions from Fuels	2 550,13	519,49	3,42				3 073,03
1. Solid Fuels	0,43	3,29	0,00				3,72
2. Oil and Natural Gas	2 549,70	516,20	3,42				3 069,31
2. Industrial Processes	**6 650,94**	**38,37**	**1 638,35**	**25,88**	**1 561,93**	**577,97**	**10 493,44**
A. Mineral Products	940,49	0,00	0,00				940,49
B. Chemical Industry	1 156,04	21,88	1 638,35				2 816,28
C. Metal Production	4 520,44	16,49	0,00		1 561,83	501,90	6 600,66
D. Other Production	33,97						33,97
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				25,88	0,09	57,85	83,83
G. Other						18,22	18,22
3. Solvent and Other Product Use	**135,22**		**36,01**				**171,23**
4. Agriculture	**0,00**	**2 087,61**	**2 985,19**				**5 072,81**
A. Enteric Fermentation		1 760,92					1 760,92
B. Manure Management		314,15	112,97				427,12
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 868,61				2 868,61
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		12,54	3,62				16,16
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-15 502,81**	**0,00**	**0,00**				**-15 502,81**
6. Waste	**41,23**	**3 995,46**	**103,59**				4 140,28
A. Solid Waste Disposal on Land	38,83	3 975,34					4 014,17
B. Wastewater Handling		20,05	103,52				123,57
C. Waste Incineration	2,40	0,07	0,07				2,54
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 841,18**	**3,54**	**23,32**				**2 868,05**
Aviation	585,57	0,12	5,76				591,45
Marine	2 255,62	3,42	17,56				2 276,59
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 021,54**						**5 021,54**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	17 628,85	-33 321,35	-15 692,50			-15 692,50
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	170,88		170,88			170,88
E. Other	18,80		18,80			18,80
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	17 818,54	-33 321,35	-15 502,81	0,00	0,00	-15 502,81

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	51 684,02
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 181,21

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1996
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 175,84**	**6 980,88**	**5 225,04**	**52,87**	**1 439,84**	**543,14**	**37 417,60**
1. Energy	**33 570,88**	**795,72**	**523,00**				**34 889,61**
A. Fuel Combustion (Sectoral Approach)	30 652,47	275,21	519,21				31 446,90
1. Energy Industries	9 170,74	63,76	31,56				9 266,06
2. Manufacturing Industries and Construction	4 165,87	11,03	41,65				4 218,55
3. Transport	12 716,81	65,80	369,22				13 151,82
4. Other Sectors	4 192,45	134,23	73,23				4 399,91
5. Other	406,60	0,39	3,56				410,55
B. Fugitive Emissions from Fuels	2 918,41	520,51	3,79				3 442,71
1. Solid Fuels	0,34	2,58	0,00				2,92
2. Oil and Natural Gas	2 918,07	517,93	3,79				3 439,79
2. Industrial Processes	**6 851,09**	**37,53**	**1 619,75**	**52,87**	**1 439,84**	**543,14**	**10 544,22**
A. Mineral Products	937,03	0,00	0,00				937,03
B. Chemical Industry	1 090,74	21,45	1 619,75				2 731,93
C. Metal Production	4 788,81	16,09	0,00		1 439,55	465,33	6 709,78
D. Other Production	34,52						34,52
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				52,87	0,29	59,29	112,44
G. Other						18,52	18,52
3. Solvent and Other Product Use	**142,70**		**36,57**				**179,27**
4. Agriculture	**0,00**	**2 108,87**	**2 935,46**				**5 044,33**
A. Enteric Fermentation		1 775,25					1 775,25
B. Manure Management		319,94	114,29				434,23
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 817,22				2 817,22
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		13,68	3,95				17,63
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-17 430,92**	**0,00**	**0,00**				**-17 430,92**
6. Waste	**42,08**	**4 038,76**	**110,25**				4 191,09
A. Solid Waste Disposal on Land	39,37	4 018,53					4 057,90
B. Wastewater Handling		20,15	110,18				130,33
C. Waste Incineration	2,71	0,08	0,07				2,86
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 171,59**	**3,91**	**26,11**				**3 201,61**
Aviation	691,44	0,15	6,80				698,39
Marine	2 480,16	3,76	19,30				2 503,22
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 122,07**						**5 122,07**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 378,33	-32 985,30	-17 606,98			-17 606,98
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	151,53		151,53			151,53
E. Other	24,53		24,53			24,53
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	15 554,39	-32 985,30	-17 430,92	0,00	0,00	-17 430,92

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	54 848,52
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	37 417,60

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1997
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**24 247,16**	**7 033,02**	**5 163,81**	**88,43**	**1 376,67**	**548,01**	**38 457,11**
1. Energy	**33 601,49**	**870,12**	**578,35**				**35 049,96**
A. Fuel Combustion (Sectoral Approach)	30 853,01	281,15	574,80				31 708,96
1. Energy Industries	9 449,97	66,95	32,02				9 548,94
2. Manufacturing Industries and Construction	4 264,91	11,62	43,32				4 319,85
3. Transport	12 962,84	63,95	424,28				13 451,06
4. Other Sectors	3 750,73	138,22	71,35				3 960,30
5. Other	424,57	0,41	3,82				428,80
B. Fugitive Emissions from Fuels	2 748,48	588,98	3,55				3 341,00
1. Solid Fuels	0,57	4,35	0,00				4,92
2. Oil and Natural Gas	2 747,91	584,63	3,55				3 336,09
2. Industrial Processes	**6 771,14**	**37,93**	**1 481,18**	**88,43**	**1 376,67**	**548,01**	**10 303,37**
A. Mineral Products	999,43	0,00	0,00				999,43
B. Chemical Industry	1 007,08	21,07	1 481,18				2 509,33
C. Metal Production	4 725,69	16,86	0,00		1 376,29	430,20	6 549,04
D. Other Production	38,94						38,94
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				88,43	0,39	60,74	149,56
G. Other						57,06	57,06
3. Solvent and Other Product Use	**137,17**		**36,51**				**173,67**
4. Agriculture	**0,00**	**2 109,76**	**2 948,88**				**5 058,64**
A. Enteric Fermentation		1 779,31					1 779,31
B. Manure Management		320,61	113,81				434,41
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 832,24				2 832,24
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,85	2,84				12,69
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-16 322,30**	**0,00**	**0,00**				**-16 322,30**
6. Waste	**59,66**	**4 015,21**	**118,90**				4 193,76
A. Solid Waste Disposal on Land	39,35	3 994,81					4 034,16
B. Wastewater Handling		20,26	118,78				139,04
C. Waste Incineration	20,30	0,14	0,11				20,55
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 771,31**	**4,71**	**30,95**				**3 806,98**
Aviation	770,89	0,16	7,59				778,64
Marine	3 000,43	4,55	23,36				3 028,34
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 368,06**						**5 368,06**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 403,78	-32 902,41	-16 498,63			-16 498,63
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	149,12		149,12			149,12
E. Other	27,22		27,22			27,22
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 580,11	-32 902,41	-16 322,30	0,00	0,00	-16 322,30

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	54 779,40
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	38 457,11

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1998
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 407,48**	**6 951,94**	**5 448,33**	**132,64**	**1 267,18**	**694,54**	**37 902,10**
1. Energy	**33 668,60**	**819,27**	**642,34**				**35 130,21**
A. Fuel Combustion (Sectoral Approach)	30 988,28	271,23	638,63				31 898,14
1. Energy Industries	9 151,62	64,08	30,88				9 246,58
2. Manufacturing Industries and Construction	4 443,29	12,26	45,51				4 501,06
3. Transport	13 305,42	62,59	486,04				13 854,05
4. Other Sectors	3 728,39	131,93	72,56				3 932,88
5. Other	359,57	0,36	3,64				363,57
B. Fugitive Emissions from Fuels	2 680,32	548,05	3,71				3 232,07
1. Solid Fuels	0,48	3,69	0,00				4,18
2. Oil and Natural Gas	2 679,84	544,35	3,71				3 227,90
2. Industrial Processes	**6 937,43**	**40,44**	**1 689,28**	**132,64**	**1 267,18**	**694,54**	**10 761,51**
A. Mineral Products	945,26	0,00	0,00				945,26
B. Chemical Industry	791,16	22,36	1 689,28				2 502,80
C. Metal Production	5 175,32	18,08	0,00		**1266,79**	573,60	7 033,79
D. Other Production	25,68						25,68
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				132,64	0,39	62,07	195,09
G. Other						58,87	58,87
3. Solvent and Other Product Use	**136,54**		**36,58**				**173,12**
4. Agriculture	**0,00**	**2 130,47**	**2 960,91**				**5 091,38**
A. Enteric Fermentation		1 795,42					1 795,42
B. Manure Management		324,71	114,89				439,60
C. Rice Cultivation							0,00
D. Agricultural Soils[2]		0,00	2 843,04				2 843,04
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		10,34	2,98				13,32
G. Other							0,00
5. Land-Use Change and Forestry[1]	**-17 430,80**	**0,00**	**0,00**				**-17 430,80**
6. Waste	**95,71**	**3 961,76**	**119,22**				4 176,69
A. Solid Waste Disposal on Land	39,01	3 941,14					3 980,14
B. Wastewater Handling		20,38	119,02				139,40
C. Waste Incineration	56,70	0,24	0,21				57,15
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 720,80**	**4,60**	**30,67**				**3 756,07**
Aviation	821,39	0,21	8,08				829,68
Marine	2 899,41	4,40	22,58				2 926,39
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 389,34**						**5 389,34**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 898,68	-33 486,49	-17 587,82			-17 587,82
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	133,78		133,78			133,78
E. Other	23,23		23,23			23,23
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 055,69	-33 486,49	-17 430,80	0,00	0,00	-17 430,80

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	55 332,91
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	37 902,10

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 1999
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 704,98**	**6 905,79**	**5 666,64**	**179,45**	**1 123,01**	**840,75**	**38 420,61**
1. Energy	**34 330,02**	**793,35**	**712,90**				**35 836,26**
A. Fuel Combustion (Sectoral Approach)	30 968,47	269,01	708,02				31 945,50
1. Energy Industries	8 582,90	60,09	30,93				8 673,92
2. Manufacturing Industries and Construction	4 282,87	12,76	47,14				4 342,76
3. Transport	13 902,31	61,05	554,26				14 517,62
4. Other Sectors	3 808,82	134,76	71,82				4 015,40
5. Other	391,56	0,36	3,87				395,79
B. Fugitive Emissions from Fuels	3 361,55	524,34	4,88				3 890,77
1. Solid Fuels	0,59	4,55	0,00				5,14
2. Oil and Natural Gas	3 360,96	519,79	4,88				3 885,63
2. Industrial Processes	**6 765,16**	**35,68**	**1 878,60**	**179,45**	**1 123,01**	**840,75**	**10 822,64**
A. Mineral Products	933,42	0,00	0,00				933,42
B. Chemical Industry	512,55	17,68	1 878,60				2 408,83
C. Metal Production	5 299,86	18,00	0,00		1 122,62	717,00	7 157,48
D. Other Production	19,33						19,33
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				179,45	0,39	63,39	243,23
G. Other						60,36	60,36
3. Solvent and Other Product Use	**133,66**		**37,26**				**170,92**
4. Agriculture	**0,00**	**2 115,78**	**2 917,36**				**5 033,14**
A. Enteric Fermentation		1 784,72					1 784,72
B. Manure Management		321,69	114,39				436,09
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 800,27				2 800,27
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,37	2,70				12,07
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-17 611,86**	**0,00**	**0,00**				**-17 611,86**
6. Waste	**88,00**	**3 960,99**	**120,51**				4 169,50
A. Solid Waste Disposal on Land	39,17	3 940,23					3 979,40
B. Wastewater Handling		20,52	120,32				140,84
C. Waste Incineration	48,83	0,24	0,19				49,26
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 674,83**	**4,38**	**30,56**				**3 709,77**
Aviation	941,67	0,24	9,27				951,18
Marine	2 733,16	4,15	21,29				2 758,60
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 610,82**						**5 610,82**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 306,29	-34 073,62	-17 767,33			-17 767,33
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	129,43		129,43			129,43
E. Other	26,04		26,04			26,04
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 461,76	-34 073,62	-17 611,86	0,00	0,00	-17 611,86

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	56 032,47
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	38 420,61

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 2000
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**22 247,99**	**7 007,32**	**5 549,79**	**232,10**	**899,24**	**890,81**	**36 827,25**
1. Energy	**33 573,24**	**901,01**	**749,88**				**35 224,13**
A. Fuel Combustion (Sectoral Approach)	30 007,02	279,30	744,86				31 031,18
1. Energy Industries	9 451,58	69,54	34,46				9 555,58
2. Manufacturing Industries and Construction	4 143,47	12,61	46,47				4 202,55
3. Transport	13 027,83	59,94	593,65				13 681,42
4. Other Sectors	3 205,98	136,94	68,52				3 411,44
5. Other	178,16	0,27	1,77				180,19
B. Fugitive Emissions from Fuels	3 566,22	621,71	5,02				4 192,95
1. Solid Fuels	0,93	7,11	0,00				8,04
2. Oil and Natural Gas	3 565,30	614,59	5,02				4 184,91
2. Industrial Processes	**7 026,45**	**36,24**	**1 733,14**	**232,10**	**899,24**	**890,81**	**10 817,98**
A. Mineral Products	940,73	0,00	0,00				940,73
B. Chemical Industry	733,11	17,99	1 733,14				2 484,24
C. Metal Production	5 302,61	18,25	0,00		898,85	764,80	6 984,51
D. Other Production	50,00						50,00
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				232,10	0,39	64,74	297,23
G. Other						61,27	61,27
3. Solvent and Other Product Use	**126,82**		**37,11**				**163,92**
4. Agriculture	**0,00**	**2 082,66**	**2 921,50**				**5 004,16**
A. Enteric Fermentation		1 754,04					1 754,04
B. Manure Management		318,72	112,66				431,38
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 805,99				2 805,99
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,90	2,85				12,75
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-18 608,79**	**0,00**	**0,00**				**-18 608,79**
6. Waste	**130,27**	**3 987,42**	**108,16**				**4 225,85**
A. Solid Waste Disposal on Land	39,73	3 966,51					4 006,25
B. Wastewater Handling		20,60	107,88				128,47
C. Waste Incineration	90,54	0,31	0,29				91,13
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 624,42**	**4,34**	**30,11**				**3 658,87**
Aviation	912,88	0,23	8,98				922,09
Marine	2 711,55	4,11	21,12				2 736,78
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 651,48**						**5 651,48**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 952,55	-34 695,96	-18 743,41			-18 743,41
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	108,19		108,19			108,19
E. Other	26,43		26,43			26,43
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 087,17	-34 695,96	-18 608,79	0,00	0,00	-18 608,79

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	55 436,04
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	36 827,25

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Party NORWAY
Year 2001
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**23 234,74**	**7 002,07**	**5 554,21**	**291,68**	**1 043,41**	**773,35**	**37 899,45**
1. Energy	**35 052,57**	**1 027,50**	**853,80**				**36 933,87**
A. Fuel Combustion (Sectoral Approach)	31 854,74	293,17	849,46				32 997,37
1. Energy Industries	10 625,30	76,71	37,05				10 739,07
2. Manufacturing Industries and Construction	4 111,32	13,96	51,55				4 176,83
3. Transport	13 335,63	59,06	682,89				14 077,58
4. Other Sectors	3 487,57	143,02	75,23				3 705,82
5. Other	294,91	0,41	2,74				298,07
B. Fugitive Emissions from Fuels	3 197,83	734,33	4,34				3 936,50
1. Solid Fuels	2,63	20,13	0,00				22,75
2. Oil and Natural Gas	3 195,20	714,20	4,34				3 913,75
2. Industrial Processes	**6 810,79**	**32,48**	**1 693,84**	**291,68**	**1 043,41**	**773,35**	**10 645,56**
A. Mineral Products	898,10	0,00	0,00				898,10
B. Chemical Industry	716,02	17,36	1 693,84				2 427,22
C. Metal Production	5 143,67	15,12	0,00		1 043,03	645,30	6 847,12
D. Other Production	53,00						53,00
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				291,68	0,39	66,09	358,16
G. Other						61,96	61,96
3. Solvent and Other Product Use	**126,82**		**37,11**				**163,92**
4. Agriculture	**0,00**	**2 026,84**	**2 858,90**				**4 885,74**
A. Enteric Fermentation		1 706,95					1 706,95
B. Manure Management		310,55	109,01				419,56
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 747,19				2 747,19
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		9,35	2,70				12,05
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-18 830,76**	**0,00**	**0,00**				**-18 830,76**
6. Waste	**75,32**	**3 915,24**	**110,56**				4 101,12
A. Solid Waste Disposal on Land	39,28	3 894,36					3 933,64
B. Wastewater Handling		20,71	110,42				131,13
C. Waste Incineration	36,04	0,17	0,14				36,35
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**3 459,41**	**4,19**	**28,66**				**3 492,26**
Aviation	835,42	0,21	8,22				843,85
Marine	2 623,99	3,98	20,44				2 648,41
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**6 326,13**						**6 326,13**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 358,54	-35 326,50	-18 967,96			-18 967,96
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	113,39		113,39			113,39
E. Other	23,81		23,81			23,81
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 495,74	-35 326,50	-18 830,76	0,00	0,00	-18 830,76

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	56 730,211
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	37 899,45

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Party NORWAY
Year 2002
Submission 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**21 024,78**	**6 875,08**	**5 814,88**	**365,12**	**1 120**	**230,72**	**35 430,54**
1. Energy	**34 689,19**	**949,49**	**907,64**				**36 546,32**
A. Fuel Combustion (Sectoral Approach)	32 013,28	293,93	904,07				33 211,29
1. Energy Industries	10 881,65	79,77	38,78				11 000,20
2. Manufacturing Industries and Construction	3 735,41	12,50	45,02				3 792,93
3. Transport	13 325,69	57,29	743,89				14 126,87
4. Other Sectors	3 617,30	144,05	72,13				3 833,48
5. Other	453,23	0,32	4,26				457,81
B. Fugitive Emissions from Fuels	2 675,91	655,56	3,57				3 335,04
1. Solid Fuels	2,73	20,90	0,00				23,63
2. Oil and Natural Gas	2 673,18	634,66	3,57				3 311,41
2. Industrial Processes	**6 059,99**	**31,59**	**1 912,08**	**365,12**	**1 119,95**	**230,72**	**9 719,45**
A. Mineral Products	913,55	0,00	0,00				913,55
B. Chemical Industry	707,75	18,40	1 912,08				2 638,23
C. Metal Production	4 379,69	13,19	0,00		1 119,57	141,73	5 654,17
D. Other Production	59,00						59,00
E. Production of Halocarbons and SF_6							0,00
F. Consumption of Halocarbons and SF_6				365,12	0,39	67,44	432,95
G. Other						21,55	21,55
3. Solvent and Other Product Use	**126,82**		**37,17**				**163,98**
4. Agriculture	**0,00**	**2 004,81**	**2 855,36**				**4 860,18**
A. Enteric Fermentation		1 688,72					1 688,72
B. Manure Management		307,13	107,55				414,69
C. Rice Cultivation							0,00
D. Agricultural Soils [2]		0,00	2 745,23				2 745,23
E. Prescribed Burning of Savannas							0,00
F. Field Burning of Agricultural Residues		8,96	2,58				11,54
G. Other							0,00
5. Land-Use Change and Forestry [1]	**-19 920,37**	**0,00**	**0,00**				**-19 920,37**
6. Waste	**69,16**	**3 889,19**	**102,63**				4 060,97
A. Solid Waste Disposal on Land	39,27	3 868,23					3 907,50
B. Wastewater Handling		20,81	102,50				123,31
C. Waste Incineration	29,88	0,16	0,12				30,16
D. Other							0,00
7. Other *(please specify)*							**0,00**
							0,00
Memo Items:							
International Bunkers	**2 933,28**	**3,51**	**24,38**				**2 961,17**
Aviation	739,74	0,18	7,28				747,20
Marine	2 193,54	3,33	17,10				2 213,97
Multilateral Operations							**0,00**
CO_2 Emissions from Biomass	**5 941,72**						**5 941,72**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	15 941,29	-35 996,12	-20 054,83			-20 054,83
B. Forest and Grassland Conversion			0,00			0,00
C. Abandonment of Managed Lands			0,00			0,00
D. CO_2 Emissions and Removals from Soil	115,94		115,94			115,94
E. Other	18,52		18,52			18,52
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 075,75	-35 996,12	-19 920,37	0,00	0,00	-19 920,37

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	55 350,91
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	35 430,54

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table 10s5 if Parties report non-CO2 emissions from LUCF.