

National Inventory Report 2002

Norway

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Preface

The United Nations Framework Convention on Climate Change (UNFCCC) entered into force in 1994. It requires parties to report emissions from sources and removals by sinks of greenhouse gases annually.

This report has been prepared in accordance with the UNFCCC Reporting Guidelines on Annual Inventories adopted in November 1999 by decision 3/CP.5. The methodology used in the calculation of emissions is according to the revised IPCC Guidelines for emission inventories approved by the UNFCCC.

The Norwegian Pollution Control Authority is responsible for the report. Statistics Norway has contributed to the report.

SFT, Oslo, April 2002

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National Inventory Report

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Executive Summary

This report presents an inventory of greenhouse gas (GHG) emissions and removals in Norway from 1990 to 2000. Emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), tetrafluoromethane (CF₄), hexafluoroethane (C₂F₆), sulphur hexafluoride (SF₆) and HFCs (HFC-134a, HFC-125, HFC-143a, HFC-23, HFC-32, HFC-152a and HCF227ea) are described with regard to source categories.

The National Inventory Report (NIR) has been prepared and Common Reporting Format (CRF) tables are filled in in accordance with the UNFCCC Reporting Guidelines on Annual Inventories. This is the same format that was used in last year's submission, but the text in the NIR provides more detail compared to previous years' submissions. Methodology used to calculate emissions are in accordance with the Guidelines for National Greenhouse Gas Inventories and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories published by the Intergovernmental Panel on Climate Change (IPCC). According to these guidelines country specific methods have been used where appropriate and give more accurate emission data. The methodology is described in detail in the report The Norwegian Emission Inventory (SN/SFT 2000), and changes in methodology and/or revised estimates give relatively small effects compared to previous submissions.

Emissions by gases

The **total emissions of greenhouse gases**, measured as CO₂-equivalents, were about 55.3 million tonnes in 2000 (see Table 1). Preliminary figures show 56.4 million tonnes in 2001. From 1990 to 2000 the emissions have increased by 6.3 per cent. From 1999 to 2000 the emissions have decreased by 1 per cent. The emissions increased by 5.5 per cent from 1990 to 1996, but from 1996 to 2000 they have increased by less than 1 per cent. The growth in emissions from 1990-2000 is mainly explained by higher CO₂-emissions due to increased emissions from oil and gas extraction and from the transport sector. The growth in total GHG emissions in 2001 accounts to 8 per cent since 1990 and is due to increased CO₂ emissions from electricity production in the oil and gas extraction sector, road vehicles, shipping and oil combustion.

Table 1. Emissions of greenhouse gases for the years 1990-2000.

Mill tonnes CO₂-equivalents.

Actual emissions of HFCs, PFCs and SF₆ are given (Tier 2).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001 ¹	90-00
CO ₂	35.2	33.5	34.3	35.8	37.7	37.8	40.9	41.2	41.3	41.7	41.3	42.4	17 %
CH ₄	6.5	6.5	6.6	6.7	6.8	6.9	7.0	7.0	6.9	6.8	6.8	6.8	6 %
N ₂ O	5.1	5.0	4.3	4.7	4.8	4.8	4.8	4.8	5.0	5.3	5.2	5.2	0 %
PFC	3.0	2.5	2.0	2.0	1.7	1.6	1.4	1.4	1.3	1.1	0.9	1.0	-70 %
SF ₆	2.2	2.1	0.7	0.7	0.9	0.6	0.6	0.5	0.7	0.8	0.9	0.8	-59 %
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 %
Total	52.0	49.5	47.9	49.9	51.8	51.6	54.8	55.0	55.3	56.0	55.3	56.4	6 %

Source: SN/SFT

The **emissions of CO₂** in 2000 were 41.3 million tonnes. This is approximately 1 per cent higher than in 1999 and 17 per cent above 1990 emission level. The increase from 1990 to 2000 is mainly a result of growth in oil- and gas production, including transport of natural gas in pipelines, and higher emissions from the transport sector. CO₂ accounted for 75 per cent of

¹ Preliminary data.

total GHG emissions in Norway in 2000. Preliminary calculations of CO₂-emissions in 2001 amounted to 42.4 million tonnes, which indicates an increase of more than 20 per cent since 1990 and 3 per cent since 2000. The increased emissions are explained by growth in the consumption of natural gas and in the production of electricity in the oil and gas extraction sector by 11 per cent from 2000. Emissions from road vehicles have increased by 6 per cent and by 3 per cent from domestic shipping. There has been a decrease in emissions from metal production by 3 per cent and from flaring in the oil and gas extraction sector by 19 per cent from 2000 to 2001.

The **emissions of CH₄** have been stable during most of the 1990s, and in 2000 they were 334 ktonnes. The emissions were 6 per cent higher in 2000 than in 1990. From 1997 the trend has been reversed due to a small decrease in emissions from several sources. In 2000 as much as 21.2 ktonnes CH₄ were recovered from landfills. CH₄ contributed to 12 per cent of the total Norwegian GHG emissions in 2000.

Anthropogenic **emissions of N₂O** in 2000 were estimated to be 16.3 ktonnes and are now at the same level as in 1990. This trend is mainly influenced by variations in activity in the fertiliser industry, and steadily rising emissions from road traffic due to increased use of catalytic converters. N₂O's overall contribution to the total GHG emissions was 9 per cent in 2000.

The **emissions of PFCs** (CF₄ and C₂F₆) from Norwegian aluminium plants in 2000 were calculated to be approximately 0.9 Mtonnes CO₂-equivalents. From 1999 to 2000 there was a decrease by 20 per cent in the emissions of PFC-gases. From 1990 to 2000 the emissions of PFC-gases were reduced by as much as 70 per cent. This is due to improved technology and process control. The emissions of PFCs measured as CO₂-equivalents have increased by 11 per cent since 2000 due to increased production of aluminium.

The **emissions of SF₆** in 2000 were estimated at approximately 0.9 Mtonnes CO₂-equivalents. In the period 1990-1997, the emissions were reduced by 75 per cent as a result of reduced production levels for magnesium in addition to improved production routines. From 1997 to 2000 emissions have increased by 62 per cent, due to increased production. The use of SF₆ as a cover gas in magnesium production accounted for 86 per cent of the total SF₆ emissions in 2000.

The actual **emissions of HFCs** in Norway were about 0.232 Mtonnes of CO₂-equivalents in 2000, and they increased by 30 per cent from 1999. The emissions in 1990 were insignificant. As the phasing out of CFCs, HCFCs and halons continues, a further strong growth in the consumption of HFCs is expected in the years to come.

Emissions by source categories

Energy use accounts for around 2/3 of 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 the energy related emissions have been increasing, mainly due to higher activity in the offshore- and transport sector.

Production of raw materials is also the main source of process-related industrial emissions of both CO₂ and other greenhouse gases such as N₂O (fertiliser production), SF₆ (magnesium foundries) and PFCs (aluminium production). Industrial processes account for 20 per cent of national emissions of greenhouse gases. From 1992 and onwards these emissions have been

relatively stable, with a trend of lower emissions of PFCs, being counterbalanced by rising emissions of CO₂.

In 2000, CO₂ emissions from ships and aircraft in international traffic bunkered in Norway amounted to 3.6 Mtonnes. From 1990 to 2000, CO₂ emissions from ships in international traffic bunkered in Norway increased by 83 per cent. For aviation the increase in CO₂ emissions was 47 per cent over the same period.

Land-use change and forestry

The gross increment of carbon in Norwegian forests was estimated at 34.7 million tonnes of CO₂ in 2000. A total of 16 million tonnes of CO₂ was harvested or depleted, which resulted in a net removal of 18.7 million tonnes of CO₂. The sequestration of CO₂ in forest soil and harvested wood products is not included in this figure. The net sink increased by 1 million tonne from 1999 to 2000. The net removal of CO₂ in 2000 may be compared with the total emissions of greenhouse gases; as much as about 34 per cent of the emissions are offset by CO₂ uptake due to forest regrowth. This considerable accumulation is due to a large increment in the standing volume of forests.

Chapter 1. Introduction and general methodology approach

1.1 Institutional arrangement

The emission figures for CO₂, CH₄, N₂O, HFCs, PFCs, SF₆ and for the precursors CO, NO_x, NMVOC and SO₂ are estimated in collaboration between Statistics Norway (SN) and the Norwegian Pollution Control Authority (SFT). SFT contributes with emission factors from all sources and measured emission data from large industrial plants. SN is responsible for activity data (e.g. on energy use), emission models and calculations.

1.2 Brief description of the process for inventory preparation

The emission estimates are based mainly on internationally recommended methodologies. The Intergovernmental Panel on Climate Change (IPCC) and Corinair²/ EEA³/EMEP⁴ (IPCC 1997a,b, EEA 2001) have developed guidelines for emission estimation for all main emission sources. These manuals are updated regularly. However, in some cases methodologies have been adjusted to take account of Norwegian conditions. In addition, more detailed studies have been undertaken in certain cases:

- Activity data are mostly taken from official statistical sources and other material available at SN. Where activity data are not available, research reports are used or extrapolations are made from expert judgements.
- Emissions of the main pollutants from large industrial plants are based on the figures reported to the SFT by the plants (based on measurements or calculations at the plants).
- Emission factors for the main emission sources are taken from reports on Norwegian conditions. International default data are used in cases where the emission factors are highly uncertain (e.g. N₂O from agriculture, and CH₄ and N₂O from stationary combustion) or when the source is insignificant in relation to other sources. For smaller emission sources, or when national data are difficult to obtain, international data are used. The use of recommended international default data is considered to reduce the uncertainty of the national inventory in these cases.
- Activity data, emission factors and calculation data for all years are recorded at SN.

1.3 General methodology for the Norwegian emission inventory

The methods of estimation of all gases are harmonised with 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 Good Practice Guidance. The methodology, emission factors, activity data and measurements used in the Norwegian inventory model are described in the report The Norwegian Emission Inventory (SN/SFT 2000). Since that report was printed methodologies and data to estimate emissions from shipping and aviation have been further elaborated. See documentation for shipping in

² The Core Inventory of Air Emissions in Europe

³ European Environment Agency

⁴ Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe

the report *Utslipp til luft fra innenriks sjøfart, fiske og annen sjøtrafikk mellom norske havner* (Emissions to air from shipping in Norway) (SN 2001a) and for aviation in *Utslipp til luft fra norsk luftfart* (Emissions to air from aviation in Norway) (SN 2002). In addition, smaller refinements have been made also for other sources.

In the Norwegian emission inventory model all emissions are calculated in 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 CO₂, CH₄ and N₂O and in addition the precursors NO_x, SO₂, NMVOC, CO and some other gases like heavy metals and particles. Thus, emissions can be listed by a multitude of combinations of fuels, sources and sectors. The combustion emissions are calculated by combining the fuel consumption distributed on emission sources and economic sectors with fuel-, source-, sector- and pollutant specific emission factors. If measured emission estimates are available, these are used instead of the calculated emissions. Aggregated emission factors are input to the main emission model. The non-combustion emissions are estimated by combining activity data with emission factors, by more complicated calculations. The emission factors are either estimated from measurements or taken from special investigations. The non-combustion emissions are 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 SF₆ from products are calculated in side-models to the main model.

The calculation of greenhouse gas emissions measured as CO₂ equivalents is based on data for global warming potential (GWP), calculated for a time horizon of 100 years, from IPCC's Second Assessment Report in 1995.

The emissions estimation methodologies are being developed continuously. SN and the SFT have initiated several studies of emissions, e.g. emissions from road, sea, and air transport, emissions from landfills as well as emissions of HFCs and SF₆. Usually, such studies are connected to an evaluation of emission reduction measures. SN is also working 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.

SN is in 2002 developing the emission model further. The main goal is to better facilitate QA/QC and international reporting. The main features of the model will be kept. But, there will be changes in the parameter structure and the amount of data (especially activity data) entering the model will be increased.

1.4 Information on the QA/QC plan including verification

Norway has not yet implemented a formally written verification or QA/QC procedure plan for the national inventory. Several checks are, however, formalised. The emissions figures are compared to last year figures and outliers are detected for extended QA/QC. The first inventory is produced 2-3 months after the end of the year based on preliminary and aggregated data. These figures are updated one year later based on final and preliminary data and two years later based on final data. This process, with several updates based on partly different datasets, is also used as QA/QC as all differences in data are recorded and need to be explained before publishing.

Methods for most key sources (Chapter 4) are reviewed regularly including a comparison of different emission factors and if possible also comparisons of top-down and bottom up estimates of emission factors. Most often these projects involve collaboration between source

experts and SN. The goal is to get a detailed technology assessment and at the same time secure consistency with estimates for other sources and that guidelines and good practice is followed.

As mentioned above, the development of a new model will facilitate better QA/QC as it will be more easy to compare input data and to detect outliers, not just emission figures as today.

The inventory team participated in an internal TQM (Total Quality Management) project in 2001 using an external pilot. Through this project the data flows and routines were evaluated from data collection to publishing. The main conclusion was that the flows and processes in general are efficient with respect to quality. But also that they can be improved through the building of a new emission model as described below.

SN and SFT verify emissions data reported to SFT by companies. First SFT makes a check of the data they receive from the plants and the plants have the opportunity to submit new data when errors are discovered. SN, where possible, then makes comparable emission calculations based on activity data sampled in official statistics and deviations are explained through contact with the plants. Internal checks of timeseries for all emission sources are made every year when an emission calculation for a new year is done. Changes in timeseries have to be explained with either change in data or in methodology.

Norway has also conducted a verification of national GHG emissions data in the report Verification of the Norwegian Emission Inventory (SFT/SN 2000). The main goals of that work was to suggest possible statistical data to use 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 we compared Norwegian emission data with national data for Canada, Sweden and New Zealand. The report concluded that no large errors in the Norwegian emission inventory were detected. The process of verification did, however, revealed several smaller reporting errors, emissions that have been reported in other categories than they should have been. These are errors that have been corrected in later reports to the UNFCCC. Finally, it is important to realise that this method of verification only considers consistency compared to what other countries report. It is not a verification of the scientific value of the inventory data themselves.

Source specific QA/QC for key sources is briefly described in chapter 4.

1.5 General assessment of the completeness

The Norwegian GHG emission inventory includes calculations of emissions from all relevant sources that we are aware of, though with a few minor exceptions. These exceptions are

- N₂O from aerosol propellant use in spray box
- CH₄ from agricultural waste
- sinks/emissions of CO₂ from Norwegian agricultural soils
- N₂O from manure handling
- N₂O from application of industrial and urban wastes on fields
- from Norwegian forests we report emissions/removals of no other greenhouse gas than CO₂
- CO₂ removals from forest soil sector are not reported.

Emissions from the use of feedstock are according to good practice in general accounted for in the industrial processes sector in the Norwegian inventory. By-products from processes like CO gas that is sold and combusted are accounted for and reported under the energy sector.

1.6 Uncertainties in the Norwegian greenhouse gas emission inventory

Uncertainty in the Norwegian emission inventory has been systematic investigated in the following two reports: the SN/SFT-report Evaluation of uncertainty in the Norwegian emission inventory (SFT/SN 1999a) and the SN-report Uncertainties in the Norwegian greenhouse gas emission inventory (SN 2000).

In (SN 2000) the uncertainty in level of the total Norwegian GHG emissions in 1990 was estimated to 21 per cent. An uncertainty of 3 per cent was estimated for CO₂, while estimations of other gases have much higher uncertainties. Calculations of emissions of N₂O were most uncertain; the level was estimated at more than 150 per cent. The uncertainty in trend is estimated to 4 per cent in (SN 2000) for the period 1990 to 2000. The uncertainty in level in (SFT/SN 1999a) was estimated to be 11-17 per cent but we then used a simpler method of analysis (Good Practice Tier 1).

In (SFT/SN 1999a) a qualitatively evaluation of the uncertainty in the Norwegian greenhouse gas inventory of each gas was made concerning emissions factors, activity data and direct measured emissions. Emissions of CH₄ from landfills, N₂O from agriculture and PFCs from production of aluminium are found to have highest uncertainty. This result is in accordance with what was found in (SN 2000) where uncertainties in level and trend were estimated using models based on simulations (Good Practice Tier 2).

1.7 Actions undertaken in response to issues raised in previous reviews

Several minor errors have been corrected, but most of the remarks presented in the Synthesis Assessment (SA) report were explained in the Norwegian answer to the secretariat or are of minor importance. Recalculations done as a consequence of the SA report are explained in Chapter 3 Recalculations.

1.8 Future improvement of the inventory

As mentioned above improvements in key sources are made regularly. Though there are some sectors that in the years to come will be prioritised for further elaboration of methods, activity data and emission factors i.e. emissions from road vehicles, solvents, methane from animals and LUFC.

As mentioned above, a new emission model is developed and this can also lead to some methodological refinements.

Chapter 2. Trends in total greenhouse gas emissions

Norway is under the Kyoto protocol committed to increase the 1990 emissions of greenhouse gases by 1 per cent i.e. to 52.5 million CO₂ equivalents in 2010-2012. In 2000 the total emissions of GHG in Norway were 5.2 per cent above the emission level we are committed to according to the protocol.

Table 2. Total emissions of greenhouse gases in Norway 1990-2000.

Gas	Unit	Year											Change	
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	90-00	99-00
CO ₂	Mtonnes	35.2	33.5	34.3	35.8	37.7	37.8	40.9	41.2	41.3	41.7	41.3	17 %	-1 %
CH ₄	ktonnes	307	309	314	320	326	328	332	334	329	326	324	6 %	-1 %
N ₂ O	ktonnes	16.5	16.0	13.8	15.0	15.3	15.6	15.6	15.4	16.2	17.0	16.6	0 %	-2 %
CF ₄	tonnes	441	369	294	290	251	229	214	201	185	164	131	-70 %	-20 %
C ₂ F ₆	tonnes	18	14	11	10	9	8	5	8	7	6	5	-72 %	-18 %
SF ₆	tonnes	92	86	29	30	36	24	24	23	29	35	37	-59 %	7 %
HFC 134a	tonnes			0.2	1.8	5.4	10.2	17.2	26.2	38.2	50.2	61.4		22 %
HFC 152a	tonnes	0.1	0.4	0.7	0.8	0.8	1.0	1.5	2.4	4.8	6.0	6.4		6 %
HFC 125	tonnes					0.5	2.4	5.5	9.7	14.7	19.9	24.7		24 %
HFC 143a	tonnes					0.2	1.5	3.9	6.8	10.4	14.7	17.6		19 %
HFC 23	tonnes									0.1	0.1	0.2		143 %
HFC 32	tonnes								0.2	0.3	0.6	0.8		24 %
HFC 227ea	tonnes								0.1	0.1	0.2	0.3		82 %
Total	Mt CO₂-eq.	52.0	49.5	47.9	49.9	51.8	51.6	54.8	55.0	55.3	56.0	55.2	6 %	-1 %

Source: SN/SFT

2.1 Emission trends by sources

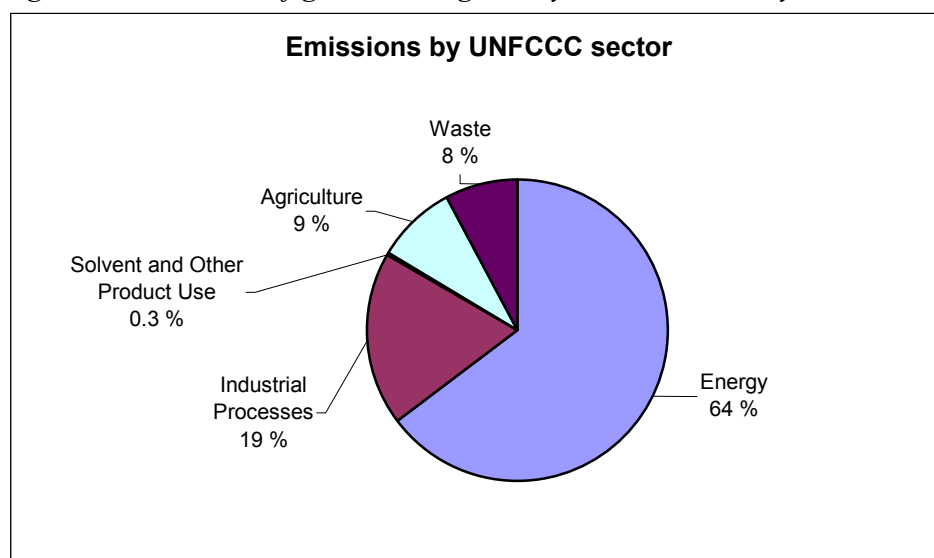
The Energy sector accounts for around 2/3 of Norwegian GHG emissions. Road traffic and offshore gas turbines (electricity generation and pumping of natural gas in pipelines) are the sector's largest single contributors, while coastal navigation and energy used for the production of raw materials are other major contributors. During most of the 1990s the energy related emissions have been increasing, mainly due to higher activity in the oil and gas extraction sector and in transport sector. From 1999 to 2000 emissions from Energy sector has decreased by approximately 2 per cent. The reduction was caused by reduced emissions from fuel used for heating purposes due to that year 2000 had a mild winter, reduced emissions from navigation, road vehicles and civil aviation, see later in this chapter for further explanation. This reduction was achieved in despite of that CO₂ emissions from oil and gas extraction increased by 12 per cent from 1999 to 2000.

Production of raw materials is also the main source of process-related industrial emissions of both CO₂ and other greenhouse gases such as N₂O (fertiliser production), SF₆ (magnesium foundries) and PFCs (aluminium production). The industrial process sector accounts for 20 per cent of national emissions of greenhouse gases. From 1992 and onwards these emissions have been relatively stable, with a trend of lower emissions of PFCs, being counterbalanced by rising emissions of CO₂.

Emissions from waste and agriculture were relatively stable during the 1990s, with emission levels of around 4, respectively 5 Mtonnes CO₂-equivalents.

During the 1990s the net uptake of CO₂ from land-use change and forestry activities has almost doubled. The net removal of CO₂ in 2000 represents 34 per cent of the total greenhouse gas emissions that year. The uptake of CO₂ in forest soil and harvested wood products is not included in these figures.

Figure 1. Emissions of greenhouse gases by sector in Norway in 2000.



Sources: SFT/SN

Table 3. Emissions of greenhouse gases by sources and CO₂ removals in Norway. Mtonnes CO₂-equivalents. 1990-2000.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	29.4	28.3	29.2	30.4	32.0	31.9	34.9	35.4	35.3	36.0	35.2
Industrial Processes	13.5	12.2	9.8	10.5	10.8	10.6	10.7	10.5	10.9	10.9	10.1
Solvent and Other Product Use	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Agriculture	4.9	4.8	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.7
Waste	4.0	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.1	4.1	4.2
Land-Use Change and Forestry	-9.6	-11.7	-13.3	-13.5	-15.7	-13.6	-17.6	-16.5	-17.6	-17.8	-18.7

Sources: SN/SFT

2.1.1 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.

In recent decades offshore oil- and gas extraction has played an important role in the national economy. 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 dominate the Norwegian emissions from the UNFCCC sector "Manufacturing

of Solid Fuels and Other Energy Industries”. In 2000 the emissions from oil and gas extraction off shore contributed to almost 20 per cent of the total GHG emissions in Norway. This is an increase from 14 per cent in 1990 and the growth can be explained by increased production of oil and gas. From 1990 to 2000 there was a 46 per cent increase in the total greenhouse gas emissions from offshore energy production. Oil refineries and gas terminals constitute the major onshore energy industries emissions.

Public generation of electricity and heat is completely dominated by hydroelectric generation, the only important exception being waste incineration plants and a small coal combustion plant (6 MW) on the island of Spitsbergen.

Industrial emissions related to fuel combustion⁵ originate to a large extent from the production of raw materials and semi-manufactured goods, e.g. alloys, petrochemicals, paper and minerals. From 1990 to 2000 the combined increase in emissions from manufacturing and construction were 24 per cent, with the most pronounced increase being in the petrochemical (opening of a new methanol production plant) and in the pulp and paper industry.

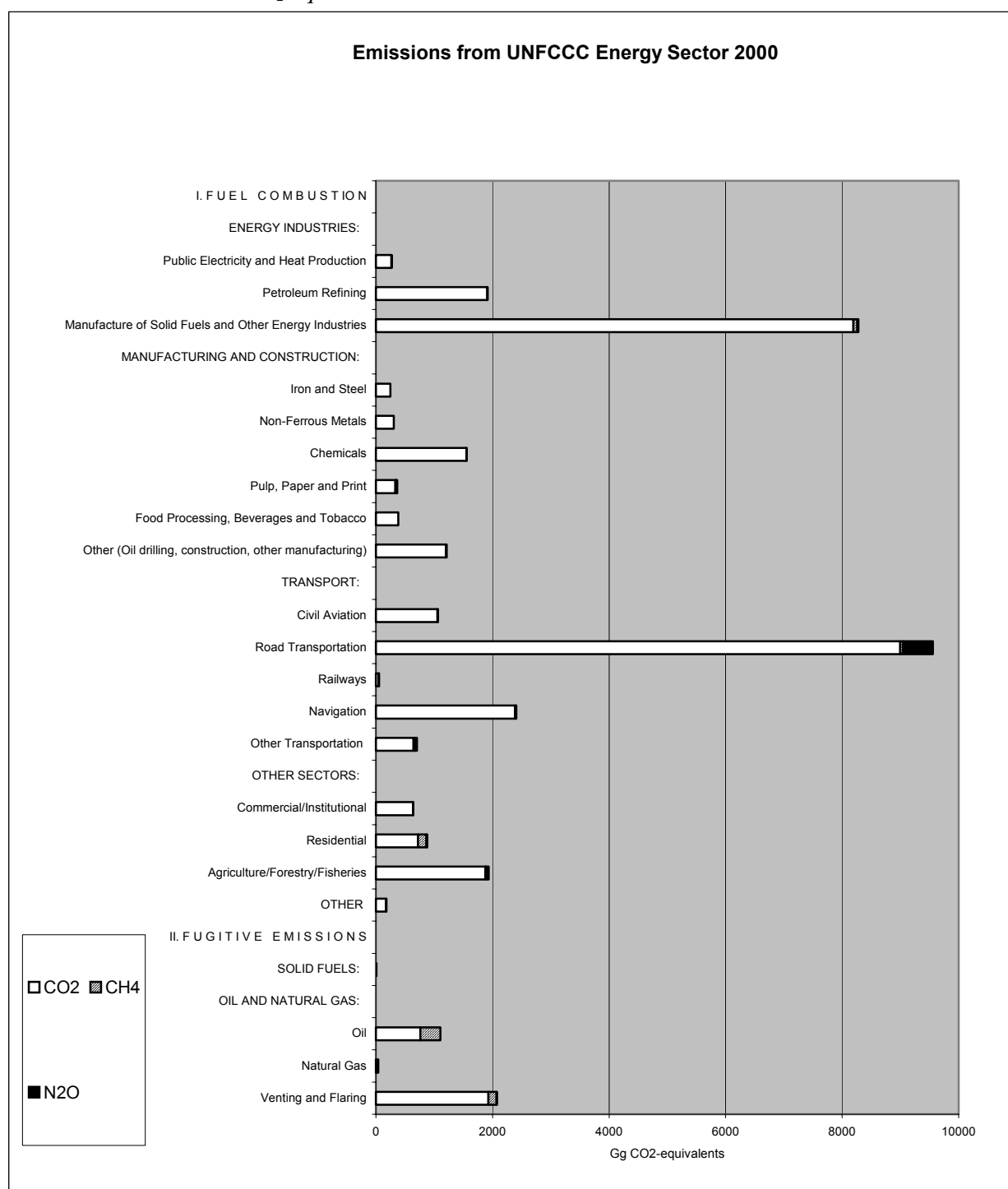
Emissions from transport showed an overall increase of 19 per cent from 1990 to 2000, while there was a decrease of 3 per cent from 1999 to 2000. Transport's share of the total GHG emissions was 25 per cent in 2000 and 22 per cent in 1990. Road traffic accounts for more than 2/3 of the total mobile emissions and these emissions have increased by 19 per cent since 1990. Emissions from road vehicles decreased by almost 3 per cent from 1999 to 2000. Preliminary emission figures for 2001 indicate that the reduction from 1999 to 2000 is temporary because of changes in fuel taxes from 1 January 2000 which led to change stock-in-trade for fuels. Emissions from navigation increased by 24 per cent from 1990 to 2000, mainly because of increased activity related to the oil- and gas extraction sector. But from 1999 to 2000 the emission from navigation decreased by 14 per cent. Emission from civil aviation has increased by 55 per cent since 1990 while there was a reduction of 9 per cent from 1999 to 2000. Domestic civil aviation contributed to the total national GHG emissions by almost 2 per cent in 2000. Due to the fact that most railways are electrified in Norway, emissions of GHG from this source are insignificant.

Due to electrification of heating infrastructure, residential emissions have decreased by almost 50 per cent since 1990. New technologies and occasional electricity shortages have, however, temporarily during the 90ies reversed this trend. The winter in 2000 was extraordinarily mild and the consumption of fuel oils was therefore all time low.

Emissions from the sector Fugitive emissions from fuels are from oil and gas activities and originate from flaring of natural gas, leakages and venting of methane and indirect CO₂ emissions of NMVOC from loading and unloading of oil tankers. Technical measures and CO₂ tax have been implemented to minimise emissions from this sector, however due to large increases in production, emissions have increased by almost 40 per cent from 1990 to 2000 and 7 per cent from 1999 to 2000.

⁵ 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.

Figure 2. Emissions of greenhouse gases from energy sector in Norway in 2000.
1000 tonnes CO₂ equivalents



Sources: SFT/SN

2.1.2 Industrial processes

During the first half of the 19-century there was a large-scale industrialisation in Norway. Particularly in the western parts, many industrial communities based around the large hydroelectric resources appeared. Typical products were raw materials and semi manufactured goods, such as aluminium and ferroalloys. The main energy source was, and is, hydroelectric. Fossil fuels are, however, used as reducing agents or raw materials, and other greenhouse gases are emitted as process related gases.

Norway is a major producer of ferroalloys, with 15 plants in operation. CO₂ is emitted from these plants due to the use of coal and coke of coal as reducing agents. These emissions have increased by 22 per cent from 1990 to 2000 due to growth in production. 5.4 per cent of national total GHG emissions in 2000 were CO₂ from ferroalloys production.

Norway is, with 7 plants, one of the worlds leading producer of primary aluminium. Both the prebaked anode and the Söderberg (old and new) production technology are in use. The main energy source is electricity, but CO₂ is emitted from the use of petrol coke, coke of coal and from coal electrodes. In addition, production of aluminium causes emissions of PFCs (perfluorocarbons). From 1990 to 1992 the emissions of PFCs were reduced by as much as 33 per cent. Since then there has been a stable reduction until 2000 when the PFC emissions were 70 per cent lower then in 1990. The total emissions of GHG from aluminium production decreased by 41 per cent from 1990 to 2000. PFCs reduction is caused by improved technology and process control, which has caused a reduction of the PFC emissions per tonne aluminium produced from 3.49 to 0.87 tonnes CO₂ equivalents in the years 1990 to 2000. In 1997 the aluminium producers and the Ministry of Environment signed an agreement to reduce emissions of greenhouse gases from production. Emissions measured as CO₂-equivalents per tonne primary aluminium produced are according to the agreement to be reduced by 50 per cent in 2000 and 55 per cent in 2005. In 2000 the emissions of the greenhouse gases CO₂ and PFC were reduced by almost 50 per cent since 1990 and accounted to 2.65 tonnes per tonne aluminium produced.

The major iron producing plant was closed down in 1988, but a minor plant still exists. Other metals produced in Norway today are nickel, zinc and magnesium, one plant of each.

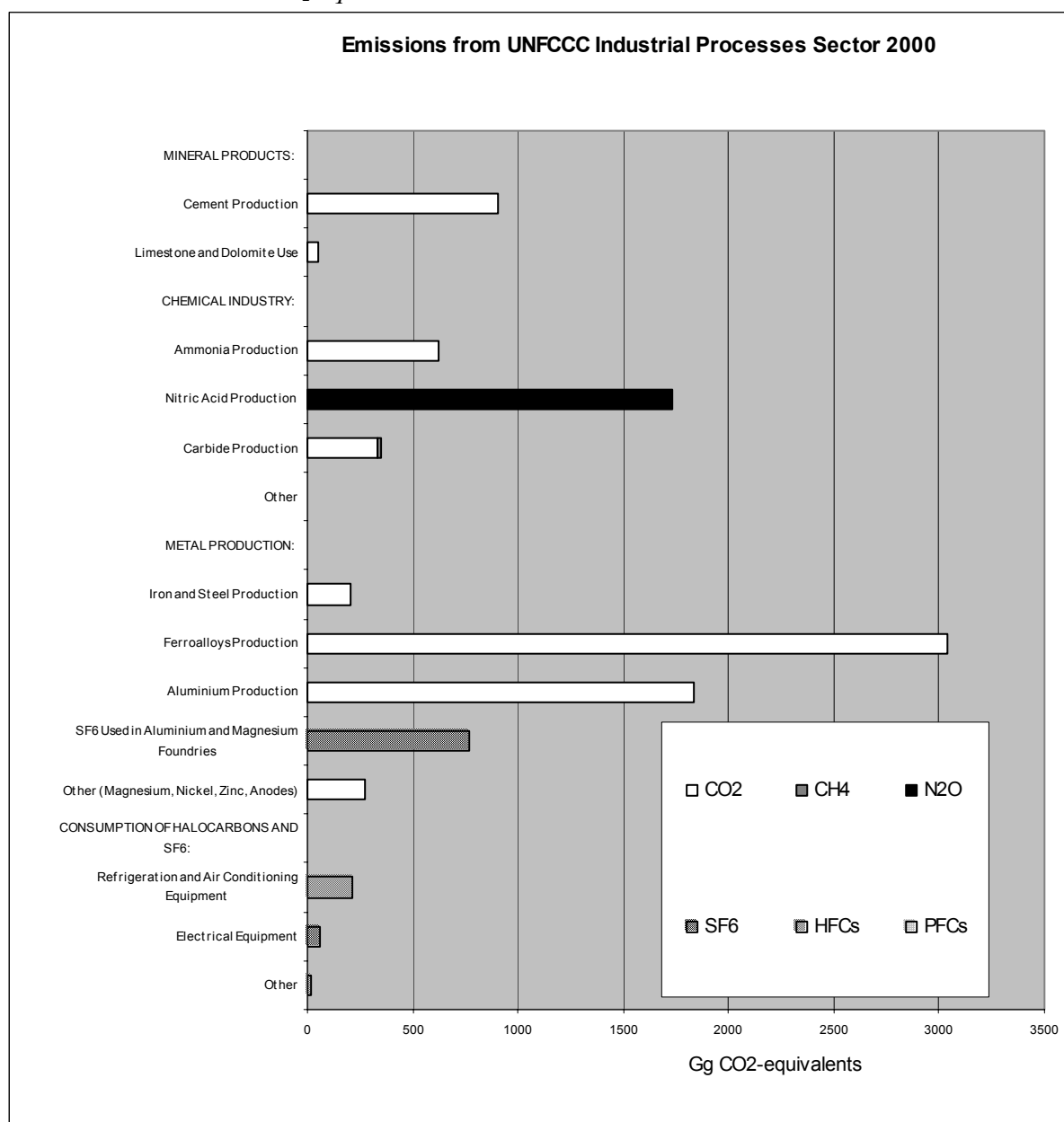
Cement is today produced in two plants in Norway. The GHG emissions from cement production is CO₂ that originates from coal and waste used in direct fired furnaces, and from carbon in limestone - the latter is reported as process related emissions according to the 1996 Revised IPCC Guideline. Due to growth in production CO₂ emissions from the cement production increased by 33 per cent from 1990 to 2000 and accounted in 2000 for 1.6 per cent of total GHG emissions.

Chemical industry in Norway primarily includes production of fertilisers and silicon carbide. The largest emission sources are N₂O from nitric acid production and CO₂ from production of ammonia and carbides. Nitric acids and ammonia are formed as steps during fertiliser production. This production gives emissions of N₂O and CO₂ which accounted for 4.3 per cent of the total GHG emissions in Norway in 2000, which is a reduction from 4.9 per cent in 1990. The reduction is due to improved technology in the nitric acid production. This improvement in technology has to some extent been counteracted by higher production.

The major source of SF₆ emissions is magnesium production, where the gas is used to cover the surface of liquid magnesium to prevent oxidising. These emissions have been reduced through the 1990s due to improvements in technology and process-management. The emissions in 2000 were 66 per cent lower than in 1990. However, there has been a significant increase in SF₆ emissions from 1998 due to growth in production of magnesium and due to increased production and higher shares of primary production versus recycled metal. The consumption of SF₆ per tonne primary magnesium produced is higher than for recycled magnesium. The company has this year decided to shut down the production of primary magnesium, and only retain the production of secondary magnesium. Hence the emission will be reduced to one third of the 2000-level from 2003.

Refrigeration and air conditioning equipment are the largest source of halocarbon (HFC) emissions. Increased application of air-conditioning systems in new cars amplifies the rapid growth in these emissions. Electrical switchgears and the use of SF₆ as trace gas are the most important source of non-process emissions of SF₆. Norway does not manufacture halocarbons or SF₆.

Figure 3. Greenhouse gas emissions from industrial processes sector in Norway in 2000.
1000 tonnes CO₂ equivalents



Sources: SFT/SN

2.1.3 Solvent and other product use

Use of solvents and products containing solvent leads to emissions of NMVOC, which oxidise in the atmosphere to CO₂. This emission source represents a share of 0.2 per cent of the national totals of GHGs. The share has been more or less unchanged since 1990.

2.1.4 Agriculture

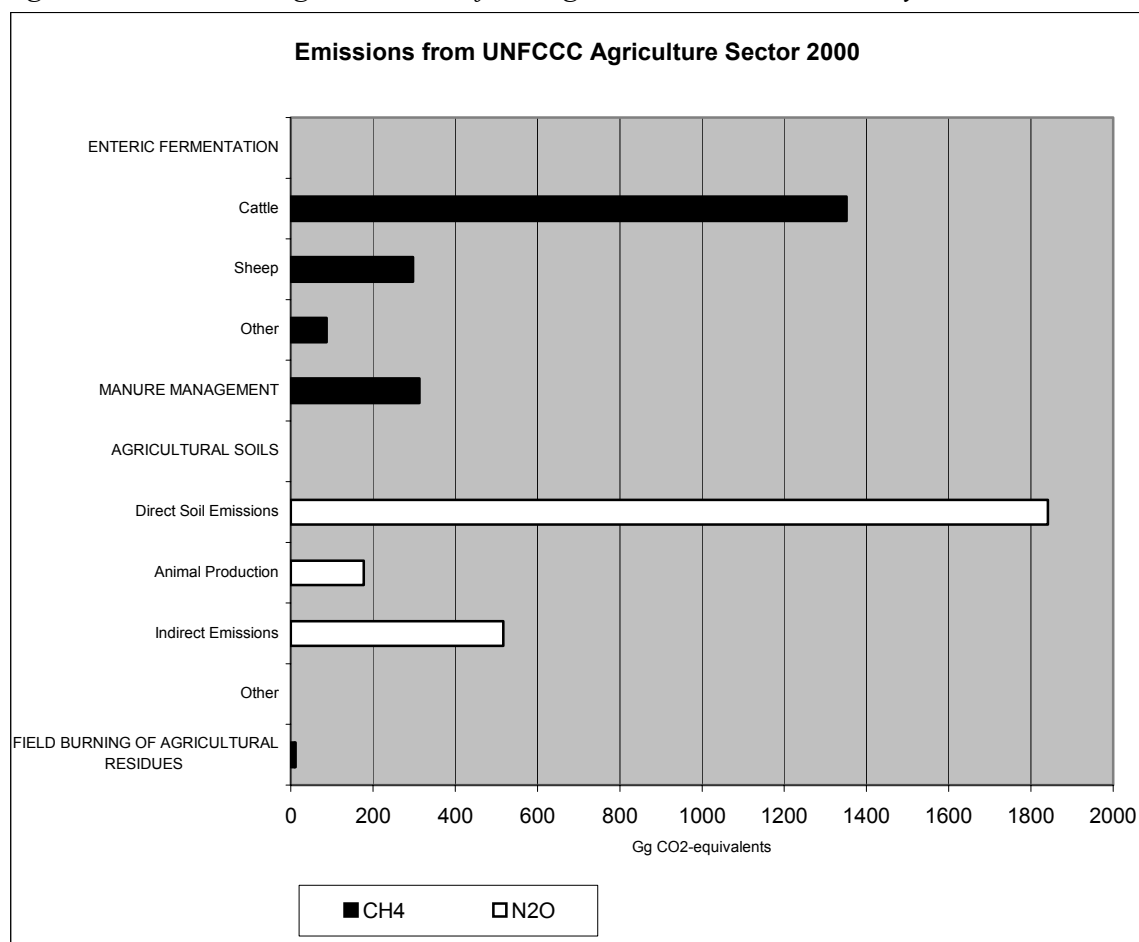
GHG emissions from agriculture are direct emissions of methane and nitrous oxide and oxidised emissions of CO₂. The agricultural sector contributed to almost 4.7 Mtonnes of CO₂-equivalents in 2000, which is a reduction of 4 per cent since 1990. The reduction is due to reduced N₂O emissions. The GHG emissions from this sector contributed to almost 9 per cent of the overall Norwegian GHG emissions in 2000.

The largest sources for agricultural GHG emissions are N₂O from soil processes and CH₄ from enteric fermentation from cattle and sheep et cetera. Each of these source categories contributes to almost 40 per cent of the total GHG emissions from the agricultural sector. The remaining emissions in this sector originate from indirect emissions of N₂O (N losses by volatilisation, leaching and runoff and sewage production), animal production outdoors (N₂O) and CH₄ from manure management.

Over the period 1990-2000 the nitrous oxide emissions from agriculture decreased by about 3.5 per cent because of reduction in direct soil emissions due to that the amount of N in harvested products has been reduced which decreases the N₂O emissions from crop residues. Methane emissions have been unchanged in the same period.

These figures might reflect the stability of the production in the agricultural sector and the absence of improvements in technology resulting in lower emissions of GHGs.

Figure 4. Greenhouse gas emissions from agriculture sector in Norway in 2000.



Sources: SFT/SN

2.1.5 Land Use Change and Forestry

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 has almost doubled from 1925 to 2000, while the harvest has been about the same (10 mill m³ per year). 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. The standing volume yields a carbon reservoir of 250 million tonnes (1995), including bark, stumps, branches and roots.

The gross increment of carbon in Norwegian forests is estimated to 34.7 million tonnes of CO₂ in 2000. A total of 16 million tonnes of CO₂ were harvested or depleted, which resulted in a net removal of 18.7 million tonnes of CO₂. The net sink increased by 1 million tonne from 1999 to 2000. The net removal may be compared with the total emissions of greenhouse gases; as much as about 34 per cent of the emissions are offset by CO₂ uptake due to forest regrowth. The net changes in CO₂ emissions and removals from forest soils have not been estimated.

The total biomass consumption from stocks resulted in emissions of 6.7 million tonnes of CO₂. This figure is the sum of contributions from total biomass removed in commercial harvest (5.4 million tonnes CO₂), traditional fuel wood consumed (1.1 million tonnes CO₂) and total other wood use (0.2 million tonnes CO₂). Other changes in carbon stocks gave

emissions of 9.3 million tonnes, which signifies emissions from logging and sivilcultural waste and natural losses. We have calculated felled wood as emissions the year of harvest, as recommended in the IPCC Guidelines.

Carbon in products and waste

As mentioned in Chapter 4.6, the stock of carbon in products and waste was estimated in 1996 using a national estimation method (SFT 1996), and updated in 2001 (SFT 2001). The storage sources included are paper and paper products, furniture, buildings, and wood and paper disposed of in landfills. This stock is not included in the tables on land-use change and forestry. According to the latest study, the total stock of carbon in wood products was estimated at 16.8 million tonnes of carbon (or 61.5 million tonnes of CO₂) in 1998. The stock has increased by about 10 per cent since 1990. The main part of the stock was stored in buildings and waste; these two categories constituted respectively 50 per cent and 43 per cent of the harvested wood stock in 1998. The change in the reservoir from 1997 to 1998 has been estimated at 0.2 million tonnes of carbon (or 0.7 million tonnes of CO₂).

2.1.6 Waste

Emissions of GHG from waste, mainly methane from landfills, accounted for 7.5 per cent of the total GHG emissions in Norway in 2000, see Table 4.

Emissions of methane have slightly decreased since 1996 due to reduction of the amount of waste disposed at disposal sites, see Table 4 and Figure 5. The effects of several measures introduced in the waste sector explain this reduction. With a few exemptions, at all landfills in Norway it is prohibited to dispose easy degradable organic waste. In 1999 a tax was introduced on waste delivered to final disposal sites. This tax is today equal to 320 Nkr per tonne waste disposed at landfill sites. In addition, landfills receiving biodegradable waste (waste containing degradable organic carbon (DOC)) is required to collect and treat landfill gas. Today 53 landfills have installed a landfill gas extraction system, and approximately 21 ktonnes of methane were recovered in 2000. In addition, the amounts of waste recycled have increased significantly since 1990.

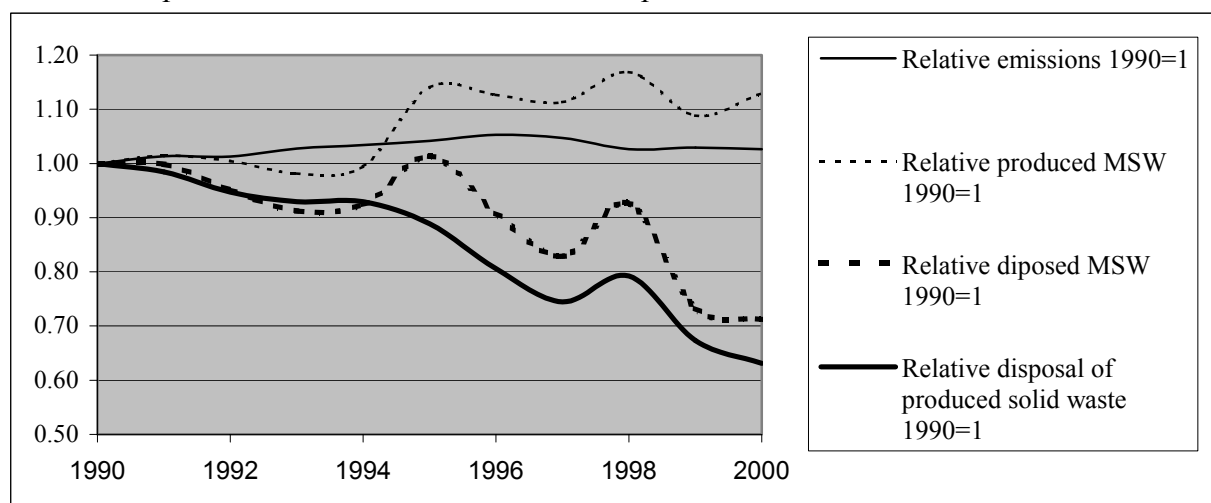
Figure 5 shows relative to 1990-level change in trends for emissions of CH₄, disposed MSW at landfills, total production of MSW and ratio between produced and disposed waste.

Table 4. Emissions of greenhouse gases from waste. (ktonnes CO₂- equivalents)

	1990	1998	1999	2000
Landfills	3 853	3 956	3 966	3 956
Wastewater handling	99	180	173	203
Totals	3 952	4 136	4 139	4 159
% of national totals	7.6	7.5	7.4	7.5

Sources: SFT/SN

Figure 5. Emissions of methane from landfills and produced waste. Index of total emissions, total produced waste, disposed MSW at landfills and ratio between produced and disposed waste. 1990=1. MSW=Municipal Solid Waste⁶.



Sources: SFT/SN

⁶ MSW includes household waste, yard/garden waste, commercial/market waste, and organic industrial solid waste.

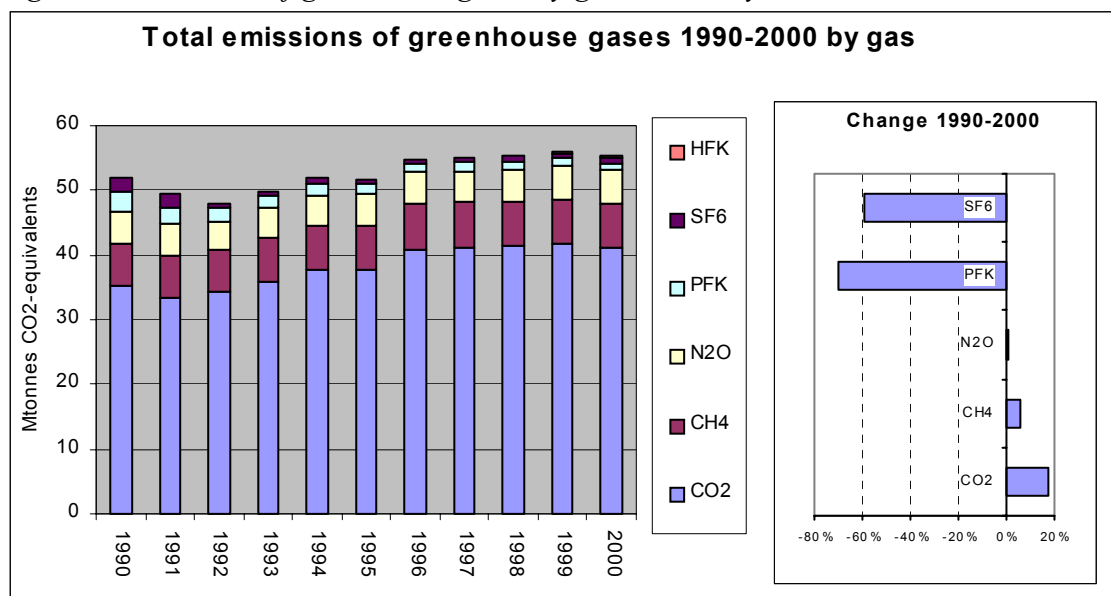
2.2 Emission trends by gas

In 2000 the total emissions of greenhouse gases, measured as CO₂-equivalents, were about 55.3 million tonnes. Since 1990 the total emissions of greenhouse gases have increased by 6.3 per cent. Since 1997 the emissions of GHG gases in Norway have been quite stable.

The relative contribution to the national totals from the different gases were in 2000; CO₂ 75 per cent, CH₄ 12 per cent, N₂O 9 per cent, PFCs and SF₆ 2 per cent each and HFCs less than 1 per cent.

The increase in emissions from 1990 is mainly due to economic growth in general, which has resulted in higher CO₂-emissions from most sources, but in particular from gas and oil extraction and the transport sector and to less extent from production of metals. This trend has to some degree been counteracted by decreased emissions of PFCs and SF₆ from aluminium- and magnesium plants. Emissions of CH₄ and N₂O as a total have been relatively stable over the same period. There has been a strong rise in emissions of N₂O from road vehicles as an effect of the introduction of the catalytic converter.

Figure 6. Emissions of greenhouse gases by gas in Norway. 1990-2000.



Sources: SFT/SN

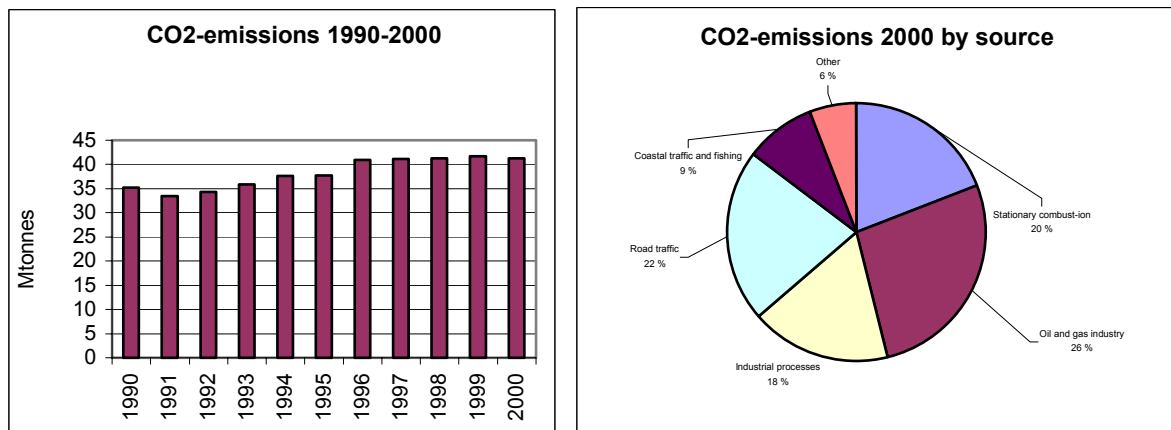
2.2.1 Carbon dioxide (CO₂)

The Norwegian CO₂-emissions are characterised by industrial sources related to oil and gas extraction and the production of metals. 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.

From 1990 to 2000 the total CO₂-emissions have increased by 17 per cent. Most major sectors have contributed to this increase, but the increases from the oil- and gas extraction industry have been the most pronounced.

In 2000 the total Norwegian emissions of CO₂ were 41.3 Mtonnes – a decrease of 1 per cent from last year. The decrease is caused by a mild winter season and changes in taxes on petrol and diesel that led to a temporary reduction in stock-in-trade of those products. In addition there were reduction in emissions from civil aviation and coastal navigation. The decrease in emissions from these sources was counteracted by higher emissions of 12 per cent from oil and gas extraction.

Figure 7. CO₂-emissions 1990-2000 and CO₂-emissions by sources 2000.



Sources: SFT/SN

The increased CO₂-emissions of 45 per cent from the oil- and gas industry in the 1990s are a result of large increases in production volume of oil and gas and the export of natural gas in pipelines. Because of technical and administrative improvements, induced by a CO₂-taxation regime, the emissions per unit produced oil/gas have been decreasing. Due to technical factors related to a shift to older and more marginal oil-and gas fields, this trend has however been reversed in the last few years.

For road transportation the increase in CO₂ emissions of 15 per cent from 1990 to 2000 is particularly due to increased traffic by diesel powered vehicles by 67 per cent. The decrease in CO₂ emissions of 10 per cent from gasoline powered vehicles between 1990 and 2000 has been compensated for by a significant shift from gasoline- to diesel-powered vehicles. The decreases in emissions from 1999 to 2000 are temporary due to changes in fuel taxes from January 2000 as explained earlier in the report.

Emissions of CO₂ from domestic civil aviation increased by 64 per cent from 1990 to 2000, due to an increase in the number of civil flights. There was a decrease in emission of 9 per cent from 1999 to 2000. The reason was an overcapacity in domestic air transport in the late nineties. In 2000 and 2001 the activity level has decreased as one company left the market.

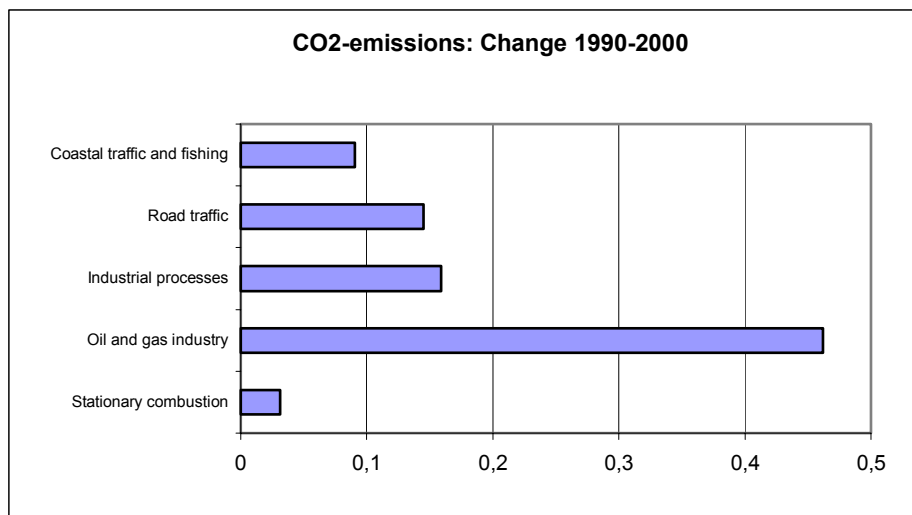
Emissions of CO₂ from navigation have increased by 24 per cent from 1990 to 2000, mainly due to increased activity in the petroleum sector.

Chemical production (fertilisers, carbides and petro chemicals) has had an increase in CO₂ emissions by almost 60 per cent from 1990 to 2000. This growth in emissions is due to that a new plant that produce methanol was established in 1997.

From the heating sector (commercial, institutional and residential) there has been a reduction in CO₂ emissions by 63 per cent from 1990 to 2000 and 17 per cent from 1999 to 2000. This

is the only sector with a significant decrease in emissions. Last year reduction is due to an extraordinarily mild winter. The long-term trend is mainly caused by an increase in the use of electricity rather than oil.

Figure 8. *CO₂-emissions; change in emissions from important sources. 1990-2000.*



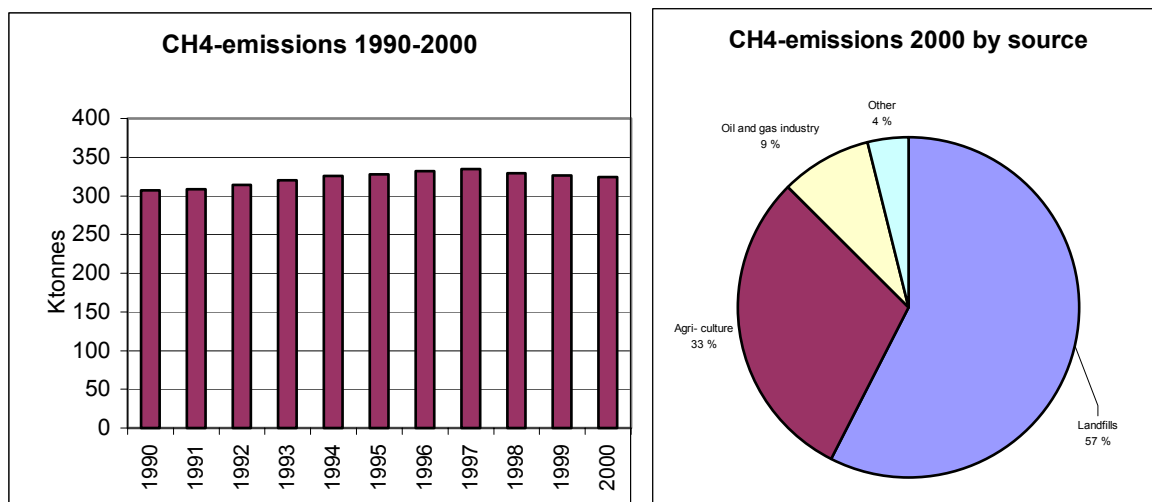
Sources: SFT/SN

2.2.2 Methane (CH₄)

About 88 per cent of the emissions of methane in 2000 originated from waste treatment and agriculture. These sources are relatively stable from year to year, and are little affected by short-term economic cycles. However, emissions from agriculture (in particular from enteric fermentation) have decreased by 3 per cent from 1999 to 2000 due to reduced population of cattle which has led to decreased emissions from enteric fermentation. Combustion and evaporation/leakage in the oil- and gas industry accounted for 8 per cent of the total emissions, while minor sources include emissions from petrol cars, domestic heating and coal mining.

Emissions have now stabilised after a moderate increase in the first half of the 1990s. This trend is mainly caused by fluctuations in emissions from the oil- and gas industry, caused by changes in production volumes. Emissions from waste treatment were relatively stable throughout the 1990s, as higher waste volumes were offset by increased recycling of waste and increased burning of methane from landfills.

Figure 9. Methane emissions 1990-2000 and methane emissions by sources in 2000.

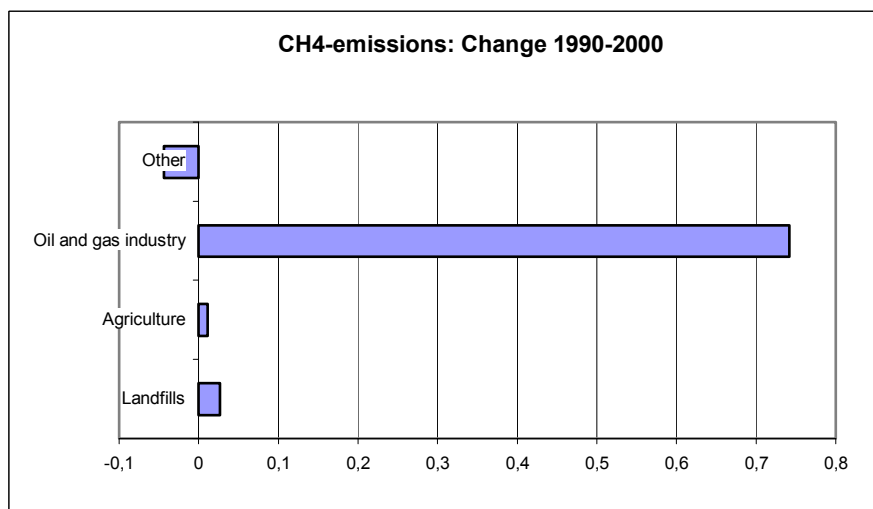


Sources: SFT/SN

From 1990 to 2000 the total CH₄-emissions increased by 6 per cent due to increased emissions from oil- and gas industry and from landfills.

The emissions from agriculture are mainly from animal manure.

Emissions from oil- and gas extraction industry are largely caused by landing and loading of crude oil, and the rises in these emissions are influenced by increased production.

Figure 10. CH₄-emissions; change in emissions from important sources. 1990-2000.

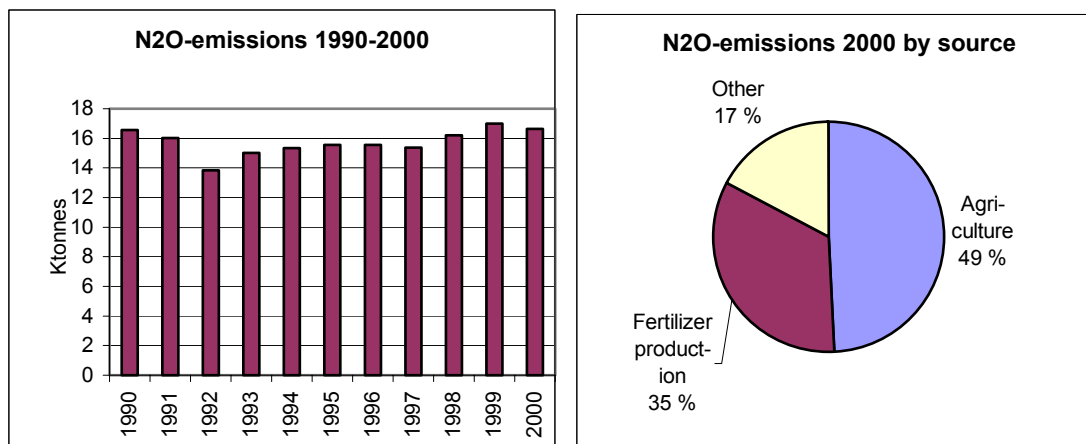
Sources: SFT/SN

2.2.3 Nitrous oxide (N₂O)

The emissions from agriculture (manure and nitrogenous fertiliser) account for almost half of the Norwegian emissions of N₂O. These emissions have been rather stable through the 1990s. The other major source is the two plants manufacturing nitrogenous fertiliser. N₂O emissions from nitric acid production constitute to around 1/3 of the national N₂O emissions. Changes in production processes led to decreased emissions in the beginning of the 1990s, while there was a moderate increase in emission in the following years due to increased production volumes. From 1999 to 2000 there was an 8 per cent decrease in these emissions.

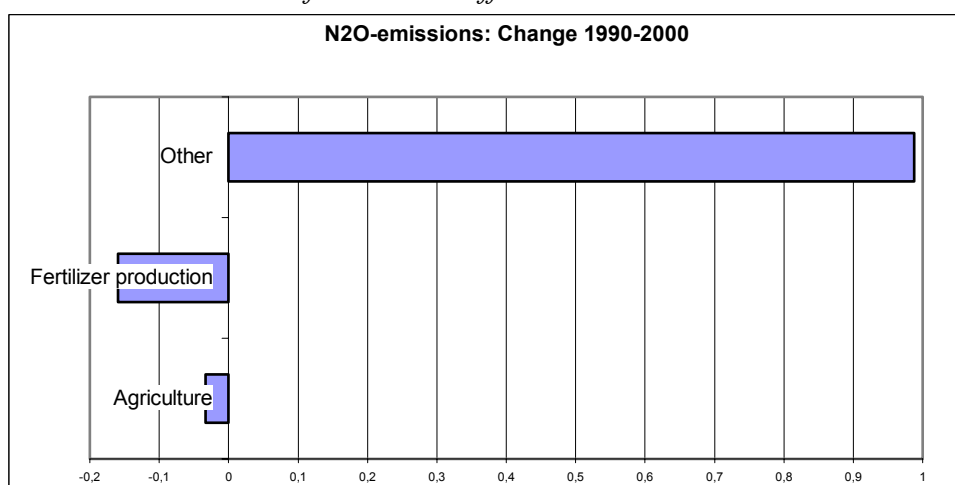
Emissions from mobile sources are increasing considerably because of the introduction of catalytic converters, and accounted for 10 per cent of the total N₂O-emissions in 2000.

Figure 11. Emissions of N₂O 1990-2000 and emissions of N₂O by sources in 2000.



Sources: SFT/SN

Figure 12. N₂O emissions; change in emissions from important sources. 1990-2000. Change in source "other" is mainly due to large increases in emissions from road traffic (6x from 1990 to 2000). In 2000 ½ of emissions from source category "other" were from road traffic.



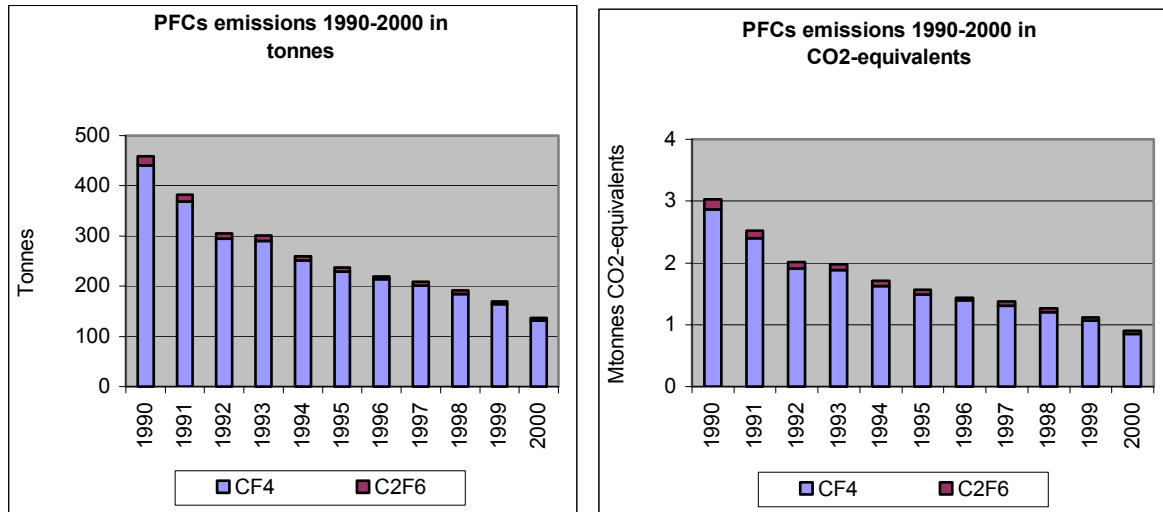
Sources: SFT/SN

2.2.4 Perfluorocarbons (PFCs)

The emissions of the perfluorocarbons tetrafluoromethane (CF₄) and hexafluoroethane (C₂F₆) from Norwegian aluminium plants in 2000 were reported by the companies to 131 and 5 tonnes respectively, corresponding to a total of 0.9 million tonnes of CO₂-equivalents. For more information about PFCs from production of aluminium, see 2.1.2 Industrial processes.

PFCs may be used as substitutes for ozone-depleting substances. In Norway, only one compound is used for this purpose, namely C₃F₈ (PFC-218). The actual emissions of C₃F₈ have been calculated at 55 kg in 2000, corresponding to almost 390 tonnes of CO₂-equivalents.

Figure 13. Emissions of PFC gases (CF_4 and C_2F_6) in tonnes and Mtonnes CO_2 -equivalents. 1990-2000.

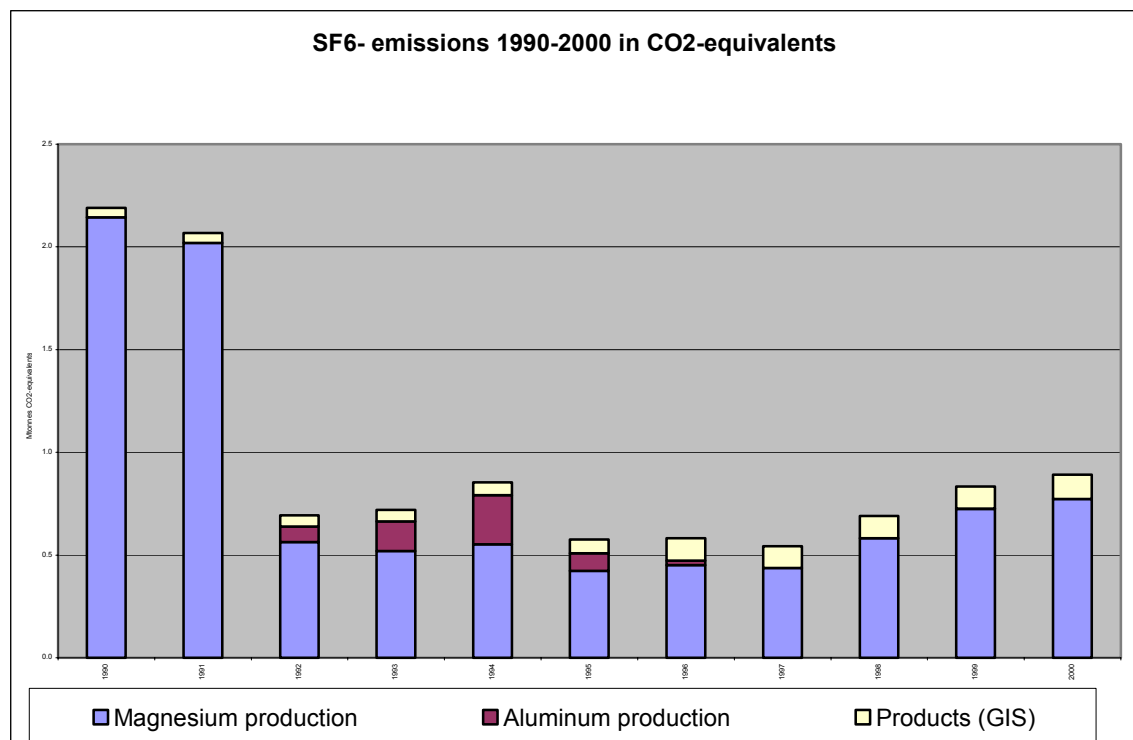


Sources: SFT/SN

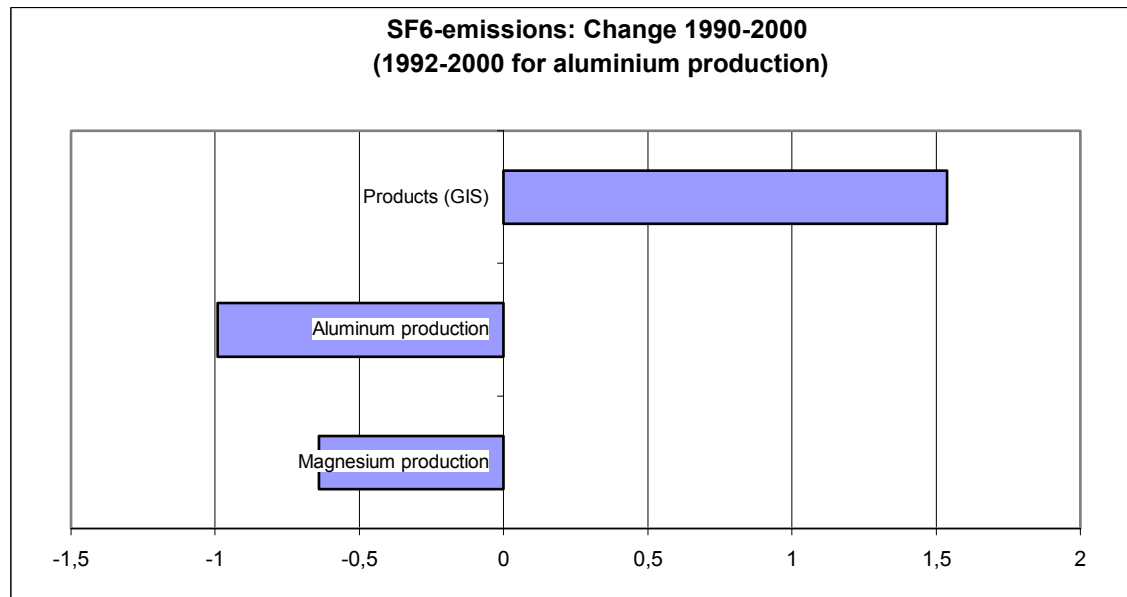
2.2.5 Sulphur hexafluoride (SF_6)

The largest emission source 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. Emissions have been reduced through the 1990s due to improvements in technology and process-management. In the period 1990-1997, the emissions were reduced by 75 per cent. From 1997 to 2000 emissions have increased by 67 per cent due to increased production and higher shares of production of primary magnesium versus recycled metal. There is one company in Norway that produces primary magnesium. The company has decided to shut down this production and only retain the secondary production. Hence the emission will be reduced to one third of the 2000-level from 2003.

Similar use of SF_6 in the aluminium industry has been phased out because of changes in process (from Soederberg to Prebaked).

Figure 14. Emissions of sulphur hexafluoride (SF_6) by source. 1990-2000.

Sources: SFT/SN

Figure 15. SF_6 - emissions; change in emissions from important sources. 1990-2000.

Sources: SFT/SN

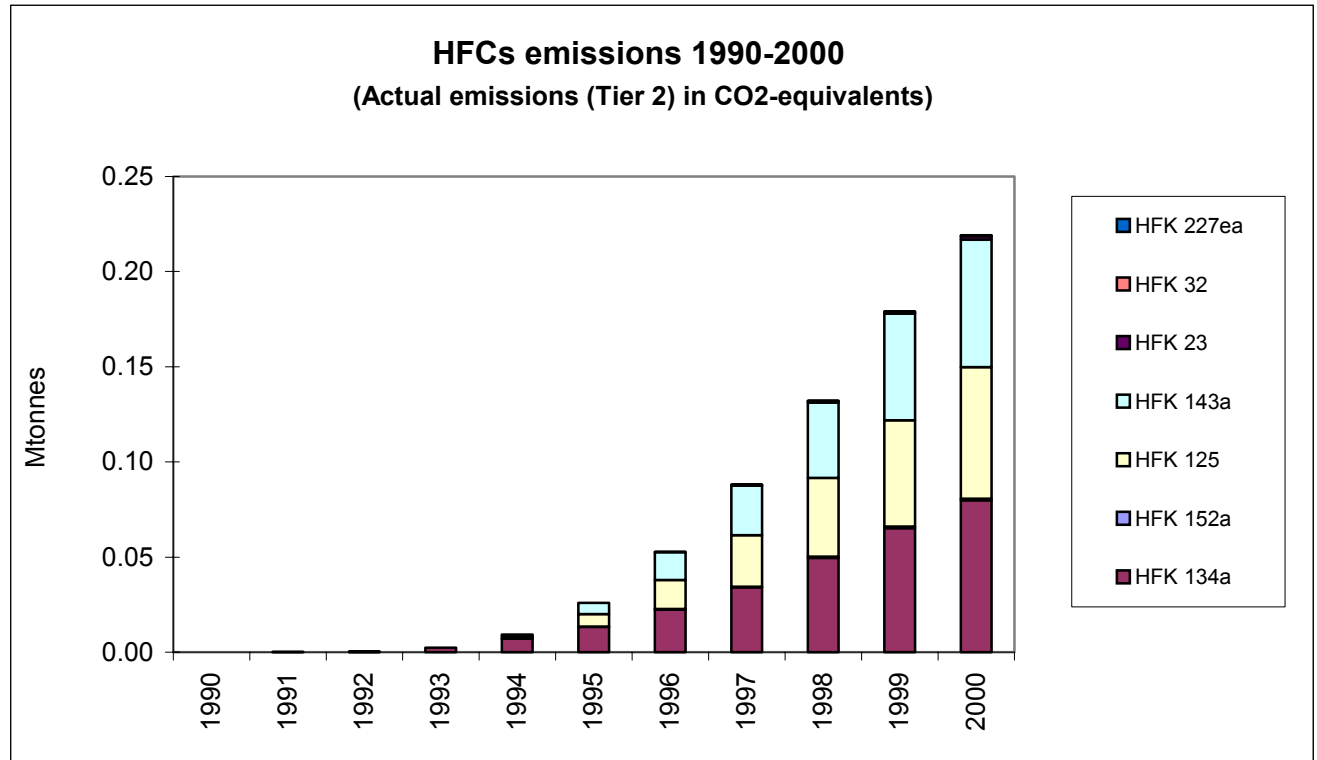
2.2.6 Substitutes for ozone depleting substances (HFCs and PFCs)

The total actual emissions from HFCs and PFCs used as substitutes for ozone depleting substances amounted to 0.22 Mtonnes of CO₂-equivalents in 2000. Compared to the emissions in 1999, this represents an increase of about 22 per cent. The application category refrigeration and air conditioning contributed by far with the largest part of the HFC and PFC

emissions in 2000. The other categories foam and foam blowing, fire extinguishing products and solvents and aerosol propellants contributed small amounts to the overall emissions.

We have also calculated the potential emissions employing the Tier 1a methodology, which includes the import and export of chemicals in bulk and in products. The ratio between potential and actual emissions in 2000 was about four.

Figure 16. Emissions of HFC-gases by gas. 1990-2000.



Sources: SN/SFT

Table 5. Actual and potential emissions of HFCs and PFCs in Norway. 1990-2000. tonnes.

Halocarbons Emissions in tonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual emissions (Tier 2)											
HFK-134a	0.00	0.04	0.19	1.78	5.45	10.23	17.24	26.21	38.20	50.21	61.08
HFK-125	0.00	0.00	0.00	0.00	0.47	2.38	5.47	9.71	14.73	19.86	25.93
HFK-143a	0.00	0.00	0.00	0.00	0.18	1.52	3.86	6.84	10.43	14.75	20.28
HFK-32	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.15	0.33	0.65	1.04
HFK-23	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.07	0.07	0.07
HFK-152a	0.13	0.41	0.65	0.79	0.81	0.99	1.47	2.41	4.79	5.99	7.73
HFK-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.11	0.15	0.16	0.16
PFC-218	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.06	0.06	0.06	0.06
Potential emissions (Tier 1a)											
HFC-134a	0	1.0	2.2	12.37	22.34	128.07	142.20	226.68	259.59	247.60	274.42
HFC-125	0	0	0	0	0.41	31.63	39.16	64.42	62.57	79.11	92.72
HFC-143a	0	0	0	0	0.41	25.73	26.80	48.71	43.59	70.50	75.87
HFC-32	0	0	0	0	0	0.1	0.44	2.72	1.65	6.5	3.22
HFC-23	0	0	0	0	0	0	0.12	0.51	0.07	0.07	0.07
HFC-152a	3.0	3.0	3.0	1.0	1.1	4.5	3.4	6.8	49.78	48.24	55.52
HFC-227ea	0	0	0	0	0	0	1.56	1.26	0.58	0.2	0.4
PFC-218	0	0	0	0	0	0.3	0.3	0	0.06	0.06	0.06

Sources SN/SFT

2.3 Emission trends for precursors (CO, NO_x and NMVOC) and SO₂

Precursors are gases, e.g. NO_x, CO and NMVOC, which have an indirect effect on the climate through their influence on greenhouse gases, especially ozone. SO₂ has a climate effect by increasing the level of aerosols, which have a cooling effect on the atmosphere.

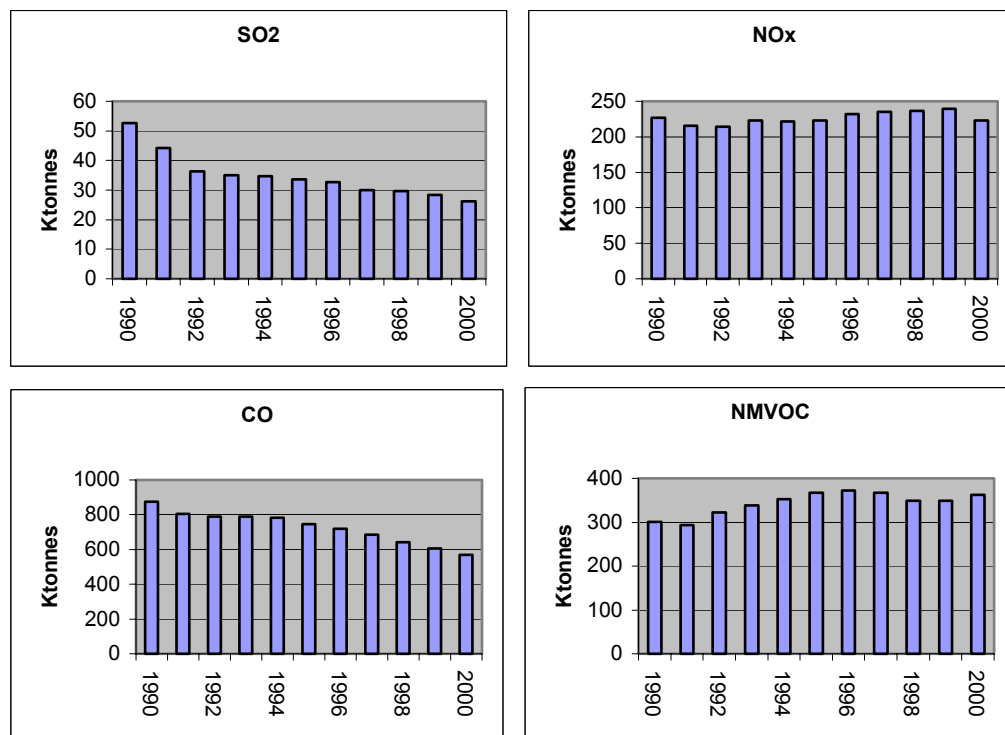
Emissions of NO_x have decreased by 1 per cent from 1990 to 2000. Reduced emissions from road traffic due to the introduction of stricter emission regulations have been counteracted by increased emissions from oil and gas production and navigation.

Emissions of NMVOCs increased by 21 per cent from 1990 to 2000 due to a growth in oil production, and in spite of reduced emissions from road traffic. From 1996 and onwards there has been a reversed trend in emissions, due to installation of a vapour recovery unit at one of the oil terminals onshore.

From 1990 to 2000 the emissions of CO have decreased by 35 per cent, mainly because of new emission standards for motor vehicles.

Emissions of SO₂ were reduced by 50 per cent from 1990 to 2000. Industrial processes are with 65 per cent of total emissions in 2000 the most important contributors to the Norwegian SO₂ emissions. The reduction is mainly explained by a reduction in the sulphur content of all oil products and lower process emissions from ferroalloy and aluminium production and refineries.

Figure 17. Emissions of NO_x , CO, NMVOC and SO_2 . 1990-2000.



Sources: SFT/SN

Chapter 3. Recalculations

In this chapter recalculations in the Norwegian emission inventory since the 2001 submission (SFT 2001a) are described. The recalculations are done because of better knowledge (for instance new emission factors or activity data) or to correct previous errors or misunderstandings.

According to the 2001 submission for Norway (SFT 2001a), the emission trend for CO₂, CH₄ and N₂O were an increase of 15.5 per cent from 1990 to 1999. After the recalculations done for the 2002 submission the increase were calculated to 15.2 per cent in the same period. The single recalculation that has had most influence on the emission trend is the use of new figures for animal population. In addition there have been several other recalculation, but in sum they do not contribute to a change in trend.

3.1 Energy

3.1.1 A. Fuel Combustion Activities

2. Manufacturing Industries and Construction Pulp, Paper and Print

Better knowledge on the data for use of wood, wood waste and black liquor in the pulp and paper manufacturing industries has lead to a reduction in the figures for consumption of this energy commodity and in the emissions of CH₄ and N₂O, compared to last years submission (SFT 2001a). Based on a misunderstanding, we then used a fuel efficiency that already had been incorporated, because some of the enterprises reported energy supplied instead of utilised energy.

3. Transport Road Transportation

The N₂O emissions from heavy-duty diesel vehicles have increased because an error in the basic emission factor has been corrected. The old emission factor we used was only 20% of the correct value.

The fuel consumption data for 1999 have been marginally revised. In addition, *vehicle mileage data has been revised for some vehicle classes*. This has lead to some differences between new and old emission figures for road traffic.

Civil Aviation

The emission figures for national air traffic are recalculated due to new emission factors for CH₄ based on (EEA 2001). The project is documented in a report that was published in April this year (SN 2002).

4. Other Sectors Residential

The emissions from small-scale fuel wood combustion are recalculated based on new knowledge of emission factors for CH₄, N₂O and precursors. SN has collected new national and international emission factor data, compared them and recommended new factors for Norwegian stoves and fireplaces.

In addition to the factor changes we have also corrected the fuel wood consumption figures for approximate moisture content of 18 per cent.

The changes are documented in a report [Utslipp til luft fra vedfyring i Norge. Utslippsfaktorer, ildstedsbestand og fyringsvaner](#) (Emissions to air from combustion of wood in Norway) (SN 2001).

3.2 Industrial Processes

A. Mineral Products: Cement Production

A small plant was not previously included with non-combustion emissions in the inventory. This error is now corrected for the whole period 1990-2000. This correction has led to a 24,500 tonnes increase in the total emissions of CO₂ in 1990 and 39,600 tonnes in 1999.

B. Chemical Industry: Ammonia Production

There is one plant in Norway producing ammonia. In 1999 this plant started to use some LPG directly as fuel. Emissions of CO₂ from this plant were last year erroneously reported as non-combustion emissions. This error is now corrected.

C. Metal Production: Ferroalloys Production

Previously we supposed that all coke used in ferroalloys production were used for non-combustion purposes (used as a reducing agent). One plant, however, uses some coke as fuel. This error is now corrected.

Earlier, all emissions from the reducing agent were reported on metal production, even though we knew that this was somewhat wrong. Two plants in Norway sell some CO gas to neighbouring plants where the gas is burnt. This has now been taken into account in the emission inventory, and leads to higher emissions reported under *Energy* but less emissions for *Industrial processes*. The correction of this error has led to recalculations of the emissions of CO₂ for all years.

3.3 Solvent and Other Product Use

Previous submission (SFT 2001a) did not include updated NMVOC and indirect CO₂ emissions from solvent use for 1999. The figures reported for 1999 were the same as those reported for 1998. In this report our solvent use model is updated. This has led to a reduction in the figures for 1999 and 2000 compared to 1998.

3.4 Agriculture

New figures for population of animals

SN has used new consistent figures for the populations of different animals used in the calculation model. The figures for lambs have been reduced, taking into account that they have lifetimes less than a year. In order to get a better estimate, the figures for some of the populations are an average of two animal counts per year. By mistake, humans were previously included in the calculations. This error is now corrected. The combined effect of these errors/revisions is lower emission figures for CH₄ and N₂O for the years 1990-2000.

Field burning of agricultural wastes-Cereals

This source was earlier not included in the emission inventory for Norway for other components than PAH. Norway therefore now also reports data for CH₄ and N₂O from this source for the period 1990-2000.

Chapter 4. Methodologies for key sources

In this chapter we present the Tier 2 methodology we have used to find which sources are key sources in the Norwegian Greenhouse gas emission inventory. Then we summarise methodology, activity data and emission factors for the key sources. Methodologies for the non-key sources are described in SN/SFT (2000).

4.1 Methodology to identify key sources

Key sources in the Norwegian Emission Inventory are identified as described in SN's report Uncertainties in the Norwegian greenhouse Gas Emission Inventory (SN 2000). This report gives conclusions on both uncertainties in the total emissions and trends and on the sensitivity of the conclusions of possible errors of each input parameter. According to IPCC's Good Practice Guidance (IPCC 2001) the methodology we have used 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 (Rypdal and Flugsrud 2001).

Here in this chapter we will give a short description of the method used to identify key sources and results given. For further details we refer to the report (SN 2000).

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. Correlations are taken into account in the analysis. 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. Furthermore, emission factors and activity data can be assessed separately. In addition the Tier 1 method can identify sources that are not actually key according to Tier 2 (Rypdal and Flugsrud 2001).

Steps to be taken to find key sources to level and trend is to decide uncertainties in input parameters (AD and EF) and to make use of sensitivity analysis to identify which parameters in the inventory that influence most to total GHG emissions in level and in trend.

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. Emission sources defined as key sources are shown in Table 6 and Table 7. These key sources are described in detail later in Chapter 4.

The values of level uncertainty importance of activity data are generally lower than the emission factors. This is because the uncertainty in activity data usually is lower than in the emission factors. The amount of solid waste disposed of and the amount of oil used for domestic shipping are the main activity data influencing the uncertainty importance in level. The emission factors for N₂O from agricultural soils is dominating the uncertainty importance. CH₄ from landfills and PFC from aluminium production are the next contributors to level uncertainty importance.

The trend uncertainty importance identifies HFC from product use, N₂O from road traffic and PFC from aluminium production as the main sources contributing to the trend uncertainty.

The analyses have been performed for 1990 GHG emission data and projected emissions for 2010. The main conclusion is that there are few differences in the result for 1990 compared with 2010.

Table 6. Uncertainty importance of input parameters with respect to total level uncertainty. 1990 and 2010.

Activity data. Ranking of the main important parameters (uncertainty importance ≥ 0.002).

1990			2010		
IPCC category	Source	Unc_imp	IPCC category	Source	Unc_imp
6A	Solid waste disposal	0.007	6A	Solid waste disposal	0.005
1A3d	Oil - shipping	0.004	1A3d	Oil - shipping	0.004
1A1c	Gas - oil and gas extraction	0.002	1A1c	Gas - oil and gas extraction	0.003
1A3a	Oil - aviation	0.002	1A3a	Oil - aviation	0.002
1A4a	Oil - services	0.002	1A4a	Oil - services	0.002
			1A4b	Oil - households	0.002

Emission factors. Ranking of the main important parameters (uncertainty importance ≥ 0.002).

1990			2010		
IPCC category	Source	Unc_imp	IPCC category	Source	Unc_imp
4D	N ₂ O from agricultural soils (other)	0.11	4D	N ₂ O from agricultural soils (other)	0.09
4D	N ₂ O from agricultural soils (fertiliser)	0.04	4D	N ₂ O from agricultural soils (fertiliser)	0.03
4D	N ₂ O from agricultural soils (manure)	0.03	4D	N ₂ O from agricultural soils (manure)	0.02
6A	CH ₄ from landfilled waste	0.01	6A	CH ₄ from landfilled waste	0.007
2C3	PFC from aluminium	0.01	1A1-1A4	CO ₂ from oil combustion	0.006
1A1-1A4	CO ₂ from oil combustion	0.005	1A1c	CO ₂ from gas - oil and gas extraction	0.006
1A1c	CO ₂ from gas - oil and gas extraction	0.004	3F	HFC used in products	0.005
4A	CH ₄ from cattle	0.003	1A3b	N ₂ O from road traffic	0.005
2C2	CO ₂ from ferroalloy production	0.002	2C3	PFC from aluminium	0.004
1B2a-b	CO ₂ + CH ₄ from oil loading	0.002	1B2a-b	CO ₂ + CH ₄ from oil loading	0.003
			4A	CH ₄ from cattle	0.003

Source: SN 2000

Table 7. Uncertainty importance of input parameters with respect to total trend uncertainty. 1990 and 2010.

Activity data. Ranking of the main important parameters (uncertainty importance elasticity ≥ 0.01 or < -0.01).

IPCC category	Source	Unc imp
1A1c	Gas - oil and gas extraction	+0.01
6A	Solid waste disposal	- 0.01
1A3d	Oil - shipping	+0.01

Emission factors. Ranking of the main important parameters (uncertainty importance elasticity ≥ 0.01 or < -0.01).

IPCC category	Source	Unc imp
2F	HFC consumption	+0.02
1A3b	N ₂ O from road traffic	+0.02
2C3	PFC from aluminium production	-0.02
1A1c	CO ₂ from natural gas combustion	+0.01
1A	CO ₂ from oil combustion	+0.01
1B2a	CH ₄ from oil loading	+0.01
1B2a	CO ₂ from oil loading	+0.01
6a	CH ₄ from landfilled waste	-0.01
1B2c	CH ₄ from venting	-0.00
1B2c	CO ₂ from venting	-0.00
1B2c	CO ₂ from flaring	+0.00

Source: SN 2000

4.2 Energy

4.2.1 Key sources

The source categories in the energy sector which are found to be *key sources* on the basis of their contribution to the total level and/or trend uncertainty are:

- Fuel combustion activities - A1-A4
- Manufacture of Solid Fuels and Other Energy Industries (oil and gas extraction) - 1A1c
- Civil aviation - 1A3a
- N₂O from road traffic – 1A3b
- Navigation - 1A3d
- Commercial/Institutional - 1A4a
- Venting and Flaring - 1B2c (CO₂ from venting, CO₂ from flaring, CH₄ from venting)
- Loading of crude oil offshore and onshore – 1B2a.

A description of the above key sources is presented in the following.

4.2.1.1 *Fuel combustion activities - A1-A4*

The parameter, which renders fuel combustion activities a key source, is the CO₂ emissions from oil combustion in energy and manufacturing industries, in construction, in transport and in other sectors. This parameter is a key source both in level and in trend due to the high emission level.

Emissions of CO₂ from fuel combustion activities in Norway increased by 17 per cent in the period 1990-2000. In 2000 they constituted about 80 per cent of the national CO₂ total.

The general methodology for the estimation of CO₂ emissions from oil combustion has been described in SN/SFT (2000). The energy data are determined through surveys (annual for industry, occasional for other sources) and the total energy balance. The total oil consumption used in the energy balance is based on the monthly and annual sale statistics of oil products, which has almost full coverage. CO₂ emission factors are based on the average carbon content of fuels used in Norway.

4.2.1.2 *CO₂ from Manufacture of Solid Fuels and Other Energy Industries (i.e. oil and gas extraction) - 1A1c*

Emissions from this sector refer almost exclusively to CO₂ and originate predominately from the combustion of natural gas in offshore oil and gas extraction installations (93 per cent of the sectoral total in 2000). Electricity and pumping power are principally produced by gas turbines and, to a lesser extend diesel engines.

In recent decades offshore oil- and gas extraction has played an important role in the national economy. In 2000, oil and gas extraction accounted for 17 per cent of the national total and 52 per cent of the stationary CO₂ emissions. Emissions of CO₂ in 2000 were 45 per cent above the 1990 level and accounted for 18 per cent of the Norwegian total GHG emissions.

Oil and gas extraction is a key source in level and in trend due to uncertainties in both activity data and emission factors.

Methodology

The calculation methodology applied is described in (SN/SFT 2000). According to the IPCC Good Practice Guidance (IPCC 2001) the methodology used is Tier 2.

Activity data

With regard to gaseous fuels 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, included the Norwegian economic part of platforms shared with the UK. The data are of high quality due to the system of CO₂ taxes.

Emission factors

The emission factor for CO₂ from combustion of natural gas in gas turbines is from a study by the Norwegian Oil Industry Association (OLF 1994) reflecting the average carbon content of the natural gas.

Uncertainties

The uncertainty in the activity data is ± 4 per cent and in the CO₂ emissions factor ± 7 per cent. The uncertainty in emission factor is relatively high as the gas composition can vary according to field.

4.2.1.3 Civil aviation - 1A3a

Emissions of CO₂ from civil aviation accounted for about 3 per cent of total Norwegian CO₂ emissions in 2000. Aviation is a minor source of emissions of methane and nitrous oxide in Norway (less than 0.5 per cent of the total in both cases).

National emissions of CO₂ from civil aviation have increased by 55 per cent from 1990 to 2000.

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

Methodology

The calculation methodology applied is described in (SN 2002). According to the IPCC Good Practice guidelines 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.

Activity data

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.

Emission factors

The Norwegian Petroleum Industry Association (SN/SFT 2000) provides emission factors for CO₂ from the combustion of jet fuel and gasoline. The emission factors for N₂O and CH₄ are uncertain. Default emission factors from the IPCC (IPCC 1997a,b) are used for jet fuel, while

factors for CH₄ for gasoline are derived from VOC data. The NO_x, CO and VOC emission factors are aircraft specific as given in EEA (2001).

Uncertainty

The uncertainty in the emissions from aircraft is about 20 per cent of the mean due to the difficulty in separating domestic emissions from bunkers. In the new study on emissions from aircraft, 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.

4.2.1.4 N₂O from road traffic – 1A3b

Emissions of N₂O from road traffic constituted 10 per cent of the N₂O total and 1 per cent of the national GHG emissions in 2000. Since 1989 they have been increasing rapidly due to the introduction of catalytic converters.

This source category is a key source with respect to total level uncertainty due to uncertainties in the emission factors and trend also due the rapid increase.

Methodology

Emissions from road traffic are estimated through a model developed by SN in (SFT 1993) and revised in (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

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.

Emission factors

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 (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 Copert and Sérié & Joumard (1996), taking into account detailed driving patterns and regional temperature data. Changes in emissions factors due to ageing of vehicles has been taken into account by introducing ageing factors per 10,000 km.

Uncertainty

All sources of N₂O have an assessed uncertainty of more than 100 per cent (SN 2000).

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 N₂O 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 N₂O 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.

Top down and bottom up data on fuel consumption are annually compared for gasoline and diesel vehicles. For gasoline the difference is small (maximum a few percent), for diesel it is far higher (about 30-40 per cent). The reason is probably that diesel is used for other applications than road transport, higher uncertainty in consumption factors and that the driving mode data are uncertain.

4.2.1.5 Navigation - 1A3d

Emissions of CO₂ from Norwegian navigation increased by almost 24 per cent in the period 1990-2000 due to general growth in economy activity, primarily in the oil and gas extraction sector. In 2000 they accounted for 4.3 per cent of the total GHG emissions in Norway. The contribution of CH₄ and N₂O to the total emission in this sector is insignificant.

Navigation is a key source both in level and trend due to uncertainties in activity data and the high emission level.

Methodology

The levels and the spatial distribution of emissions from national sea traffic are estimated by an updated and improved methodology presented in (SN 2001). This methodology is based on the work by Flugsrud and Rypdal (1996) and Flugsrud and Haakonsen (1998). 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). According to the IPCC Good Practice Guidance the methodology used is Tier 2. Emissions from international marine bunkers are excluded from the national totals and are reported separately.

Activity data

Information on fuel use in different vessel types is drawn from available statistics and/or obtained through calculations. Information on fuel used in freighters is gathered from surveys performed by SN. In cases where information on oil related vessels are lacking, data are collected directly. Data on fuel consumed in 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 companies. The consumption figures in other types of ships and boats are mainly taken from Flugsrud and Rypdal (1996).

Emission factors

Emission factors for CO₂ from ships are country specific. For CH₄ and N₂O the IPCC/CORINAIR default values are used.

Uncertainties

The uncertainty in the CO₂ emissions from shipping is estimated to be about 20 per cent of the mean, primarily due to the difficulty in separating domestic emissions from bunkers (SN 2000). In (SN 2001) bottom-up (from surveys) and top down data (from sales) on fuel consumption was compared (source specific QA/QC). The sale is 15 per cent higher than the reported consumption. The sales figures are used in the calculation as they are assumed to be more complete and are annually available. A survey will be performed in 2002 to get a better estimate of fuel consumption in the fishing fleet.

4.2.1.6 Commercial/Institutional – 1A4a

Emissions from the commercial/institutional sector decreased by half during the period 1990-2000. In 2000 they accounted for 1 per cent of the total GHG emissions in Norway.

This sector is a key source with respect to total level uncertainty due to uncertain activity data and change in trend.

Methodology

The emission calculation is based on a Tier 2 methodology that is described in (SN/SFT 2000).

Activity data

The sales statistics for petroleum products, derived from reports on sales figures from the oil companies, constitute the basis for annual figures on the use of different oil products in Norway. These are the basis for the calculation of Norwegian emission figures by economic sectors.

While for some sectors (i.e. 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 total fuel consumption (based on sales figures) is accounted for.

Emission factors

For liquid fuels, coal and coke the CO₂ emission factors used reflect the average carbon content of Norwegian fuels (SFT 1990 and Norwegian Petroleum Industry Association).

Information on emission factors for CH₄ and N₂O is very limited, because, unlike those for CO₂, 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.

Uncertainties

Emission factors for CH₄ have an uncertainty of 50-100 per cent of the mean, while those of N₂O exceed 100 per cent (SN 2000). The CO₂ emission factors are well known, within ± 3 per cent.

4.2.1.7 Fugitive emissions from oil loading, venting and flaring - 1B2a,c

Fugitive emissions in the Norwegian energy sector originate primarily from the extraction and handling of crude oil. This includes leakage of CH₄ and indirect emissions of CO₂ during drilling and extraction, as well as emissions of NMVOCs from loading and unloading of oil tankers. The major source in sector 1B2 is flaring on oil- and natural gas fields and venting of CH₄ and NMVOC. Due to increased activity total GHG emissions from the sector 1 B2 have increased by 40 per cent from 1990 to 2000 and by 5 per cent from 1999 to 2000.

- *Loading of crude oil offshore and onshore – 1B2a*

Uncertainties in the emissions of CO₂ and CH₄ from oil loading result in making this source category a key source both in level and in trend due to uncertain emission factors.

The emissions of CH₄ and NMVOC from loading of crude oil are calculated on the basis of the amount of crude oil loaded on to shuttle tankers (Norwegian Petroleum Directorate) and on field specific emission factors. Only the Norwegian part of oil production at fields with oil loading is included. 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 CH₄ content of VOC evaporated is also measured so that total emissions of VOC are split between CH₄ and NMVOC.

A similar method is used for calculating emissions from loading of crude oil at the two Norwegian oil terminals onshore. 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. This terminal has installed vapour recovery units (VRU), which may reduce NMVOC emissions from loading of ships at the terminal by about 90 per cent. In 2000, NMVOC emissions at this terminal were 51 per cent lower than they would have been without VRU. However, VRU technology is not designed to reduce methane and ethane emissions.

The uncertainty in the emissions of methane from oil loading is estimated to be 40 per cent (SN 2000).

- **Venting and Flaring – 1B2c (CO₂ from venting, CO₂ from flaring, CH₄ from venting)**

Venting and flaring is a key source with respect to total trend due to uncertainties in emission factors.

Carbon emitted in compounds other than CO₂, e.g. as CO, CH₄ and NMVOC, is included in the CO₂ emission estimates. This intentional double counting of carbon is in accordance with the IPCC guidelines (IPCC 1997b). Technical measures have been implemented to minimise emissions from venting and flaring, however due to the large increases in production, emissions have increased by 21 per cent from 1990 to 2000 and by only 1 per cent from 1999 to 2000.

Figures for cold venting and diffuse emissions are based on information collected from the field operators.

4.2.1.8 Coal mining – 1B1a

Emissions of CH₄ from coal mining was in 2000 339 tonnes and in 2001 it is estimated to more than 900 tonnes. The growth in emissions is due to increased production of coal.

Coal mining is 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.

Norway produces coal on the Arctic island of Spitsbergen. Emissions of methane from coal mining have till today been based on a Tier 1 methodology due to lack of relevant national data. In the calculation of methane emissions from underground mining Norway has used a default emission factor value of 14 kg CH₄ per tonne extracted (Tier 1). Based on measurements the methodology has been improved and we have changed the factor to 0.54 kg methane per tonne coal (Tier 2). The result is that Norwegian figure for fugitive emissions from coal mining and handling has decreased with 96 per cent measured as CO₂-equivalents.

Emission factors

In year 2000 emissions of methane from coal mining has been measured in two ways. Firstly coal has been sampled and methane content has been analysed by (IMC Technical Services Limited 2000). Samples yielded an estimate of seam gas content of 0.535-1.325 m³ methane per tonne coal derived from an average content of 0.79 m³ per tonne. This factor includes the total possible methane emissions from coal mining, loading and transport on shore and on sea. This factor also includes the possible emission from handling and crushing at the coal power plant. The sampling process started after a long period (a week) of continuo production. Small samples of coal were removed directly from the coalface as soon as possible after a cut has been taken This was to minimise degassing losses in the samples if the face or heading has been standing for a long time.

Secondly the methane content in ventilation air from the underground coalmines at Spitsbergen has been measured. From the Norwegian mines it was measured to 0.1-0.4 m³ methane per tonne coal (Bergfald & Co 2000). 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 therefor methane has been aired through many years. Bergfald & Co has also measured methane in ventilation air from an underground mine at Spitsbergen that is located 500-700 meter *below* sea level. This Russian operated mine is not included in the Norwegian emission inventory. Methane was measured to 10 m³ methane per tonne coal. The high emissions of methane compared with the Norwegian mines are explained with that the mountain covering the coal is deeper and more solid and methane has not been ventilated as much as in the Norwegian mines.

According to IPCC's Good Practice Guideline the Norwegian mines at Spitsbergen are to be defined as underground mines but due to other characteristics they have emissions that is more like those from surface mines. Considering the above mentioned measurements we therefor conclude to use the 0.54 kg methane per tonne coal as emission factor when calculating methane emission from coal mining in Norway.

4.2.2 Comparison with CO₂ reference approach

The synthesis and assessment of the Norwegian submissions in 2000 and 2001 have identified large deviations between the Reference Approach (RA) and Sectorial Approach (SA), and the RA estimated by Norway and the one estimated by IEA (International Energy Agency). In order to reduce these differences and to better explain them, all input data to RA were reviewed in a special study (Rypdal 2001). This study also considered the appropriate level of comparison between the approaches.

There are several reasons for the problems using the RA for Norway:

- Large crude oil and natural gas production and export
- Crude oil carbon content not known
- Large amounts of fossil energy used as feedstock and reducing agents.

In Rypdal (2001) several changes in RA were proposed

- Consequent use of production, export and import data as reported by SN to IEA
- A large refinery was contacted to provide a best estimate of average crude oil carbon content
- Use of the same feedstock data as used in the SA, rather than using IPCC (1996) default assumptions.

Data for 1990, 1998, 1999 and 2000 are given in Table 8. The table clearly shows that large systematic deviations from the national sectorial approach, especially for the last two years. 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 CO₂ compared to national total emissions. This is also reflected in a large statistical error in the energy balance. The estimate also deviates from the one made 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 can differ from the actual situation in Norway.

We will stress that the large deviations not indicate the uncertainty of the CO₂ estimates made by Norway, as the statistics of *end use* of energy is generally accurate.

Table 8. *Comparison between RA and SA. 1990, 1998-2000. Gg. Change in per cent. Deviation in per cent.*

	1990	1998	1999	2000	90-98	90-99	90-00
National Sectorial Approach	26.5	31.8	32.0	31.0	20	21	17
National Reference Approach	25.7	31.9	34.1	33.7	22	32	31
Deviation (%)	-3	+0.2	+6.8	+8.9	-2 pp	-11 pp	14 pp

Source: SN

4.2.3 Bunker fuels

In accordance with the IPCC Guidelines, emissions from international aviation and marine bunker fuels are excluded from national totals. They are presented separately for information, see Table 9.

In 2000, CO₂ emissions from ships and aircraft in international traffic bunkered in Norway amounted to a total of 3.6 million tonnes, which corresponds to about 9 per cent of the total Norwegian CO₂ emissions. CO₂-emissions from marine and aviation bunkers remained almost constant from 1999 to 2000.

The emissions of CO₂ from ships in international traffic have increased by as much as 83 per cent from 1990 to 2000, while emissions of CO₂ from aircraft increased by 47 per cent in this period. The reason for these increases is primarily growth in traffic. We know that the aircraft engines are more fuel-efficient now than they were some years ago, which means that the growth in international air-traffic has been even higher than the growth in emissions.

Consumption of aviation bunker fuel in Norway, which is reported to the UNFCCC, is estimated as the difference between total purchases of jet kerosene in Norway for civil aviation (Petroleum Statistics) and reported domestic consumption. The quantities of fuel bought abroad by Norwegian airlines are reported directly to SN by the airlines.

The Petroleum statistics gives figures for international bunker fuel.

Table 9. Emissions of CO₂, CH₄, N₂O, NO_x, CO, NMVOC and SO₂ from ships and aircraft in international traffic bunkered in Norway. 1990-2000. 1000 tonnes. CO₂ in Mtonnes

Marine	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO ₂	1.5	1.3	1.6	1.7	1.8	2.3	2.5	3.0	2.9	2.7	2.7
CH ₄	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
N ₂ O	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
NO _x	30.3	25.6	32.1	34.3	37.8	46.2	50.7	61.4	61.8	58.3	57.8
CO	1.4	1.2	1.5	1.6	1.8	2.2	2.4	2.9	2.6	2.5	2.5
NMVOC	1.1	0.9	1.2	1.3	1.4	1.7	1.9	2.3	2.2	2.1	2.0
SO ₂	9.9	9.7	12.3	13.5	14.0	13.7	15.4	19.0	14.9	12.9	11.5

Aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO ₂	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.9	0.9
CH ₄	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N ₂ O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO _x	2.0	1.8	2.0	2.4	2.3	2.2	2.6	2.9	3.0	3.4	3.3
CO	1.3	1.1	1.2	1.4	1.3	1.3	1.5	1.7	0.8	1.0	0.9
NMVOC	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.8	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

Sources: SFT/SN

Emissions of NO_x from ships were 57.8 ktonnes, or about 26 per cent of the total Norwegian NO_x emissions in 2000. During the period from 1990 to 2000, NO_x emissions from international shipping bunkered in Norway increased by more than 90 per cent. NO_x-emissions resulting from international aviation accounted for more than 3 ktonnes increased by 64 per cent from 1990 to 2000. 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.

4.2.4 Military or any other country-specific issue

Emissions of CO₂ from military issues are primarily from aviation but there are also considerable CO₂ emissions from military vessels, see Table 10. Total CO₂ emissions from the military sector accounted in 1990 to about 1 per cent of the Norwegian CO₂ emissions that year. The sectors share of the national total GHG emissions in 2000 was decreased to less than 0.5 per cent. The reduction is due to change in stock-of-trade and reduced activity level. Emissions of CH₄ and N₂O are insignificant.

Table 10. Emissions of CO₂ from military in 1990 and 1998-2000. 1000 tonnes.

	1990	1998	1999	2000
Stationary	62.4	49.6	50.3	40.6
Mobile	394.4	309.9	341.3	137.5
Total	456.8	359.6	391.6	178.2

Source: SN

4.3 Industrial Processes

Methodology used to calculate emissions of GHG from industrial processes are described in detail in chapter 3.2 in (SN/SFT 2000). An overview of emissions from industrial processes is presented in chapter 2 in this report.

4.3.1 Key sources

PFCs from Aluminium production, CO₂ from ferroalloy production and consumption of halocarbons are key sources in level and/or trend due to high emission level, changing trend and uncertainty.

4.3.1.1 PFCs from Aluminium production – 2C3

PFCs from aluminium production accounted for 1.6 per cent of the national total GHG emissions in 2000. This is a decrease from 5.8 per cent in 1990. The reduction has been achieved by improving the efficiency of the production process and by installing point feeders which reduce the numbers of anode effects per cell day (AEF). This has caused a reduction of the PFC emissions per tonne aluminium produced in Norway from 3.49 to 0.87 kg CO₂-equivalent from 1990 to 2000.

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 2000.

Methodology

Calculation methodology for CF₄ and C₂F₆ from aluminium production is described in (SN/SFT 2000). According to IPCC's Good Practice Guidelines we use a Tier 3b methodology in the calculation of PFC emissions. Each plant annually reports production data and emissions by technology to SFT.

Activity data

Activity data included in the calculation of PFC is number of AED, average annual amperage in kA, number of cells in production, number of production days and number of "newly started" cells.

Emission factors

We use country specific emission factors based on measurements done at two plants in 1992, at two plants in 1997 and at all plants in 1999/2000. Measurements show that the content of C₂F₆ in anode gas is 1 to 10 per cent, and 3 per cent on average. The measured emissions of CF, that is CF₄ + C₂F₆, include all CF₄, but only about 70 per cent of the C₂F₆ emissions. This means that 1 per cent of the total emissions of CF₄ + C₂F₆ were not measured. The total figure for CF₄ + C₂F₆ is therefore multiplied by a factor of 1.01 to include non-measured C₂F₆. The total amount of C₂F₆ in the total estimated CF₄ + C₂F₆ emissions is then 4 per cent. These results are confirmed by the measurements made in 1997 and in 1999/2000. Experience gained from measurement shows that anode effects duration in minutes (AED) has greater variation than expected and this has to be reflected in the calculation. Duration of anode effects is today a constant in the calculation of the emission.

4.3.1.2 CO₂ from Ferroalloy production – 2C2

CO₂ emissions from ferroalloy production accounted for 4.8 per cent of national total GHG emissions in 1990 and have increased to 5.5 per cent in 2000. This is due to growth in production.

CO₂ emissions from production of ferroalloy is key source in level and trend due to uncertainty in emission factors and the large share of total emissions.

Methodology

Method used in the calculation of CO₂ emissions from production of ferroalloy is in accordance with method recommended by (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. 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.

Activity data

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

Emission factors

We use country specific emission factors based on actual compositions of the raw materials, see Table 11.

Table 11. Emission factors for CO₂ from production of ferroalloys. Tonnes CO₂/tonne reducing agent or electrode.

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

Source: SINTEF (1998b, 1998c, 1998d and 1998e) and emission inventory from SN and SFT.

4.3.1.3 Consumption of halocarbons – 2F

In 1990 the consumption of HFCs in Norway were negligible and accounted for 0.2 per cent of national total GHG emissions. Since then there has been a huge increase in the consumption of HFCs because HFCs have replaced CFCs and in some extent HCFCs as refrigerants and in some other application area. HFCs contributed with 0.4 per cent of Norway's total GHG emissions 2000.

Emissions from consumption of HFCs are key source in trend due to uncertainty in emission factors and the large increase in emissions since 1990.

Methodology

Norway use a Tier 2 methodology in the calculation of emissions of HFCs from consumption of HFC. Emissions are calculated on the basis of HFCs consumption and leakage rates related to processes and equipment. SN has prepared a model where annual emissions of HFCs are estimated. In Norway there is no production of HFCs or PFCs, and production of equipment containing these chemicals does only occur to a small extent. The report/methodology therefore focuses on import of chemicals in bulk and import and export of products containing HFC/PFC. Further details about the methodology and the model is described in (SN/SFT 2000) and the report *Calculations of emissions of HFCs and PFCs in Norway. Tier 2 method* (SFT 1999a).

Activity data

Activity data in the calculation model is import/export data in bulk and in products. Import/export data for HFCs in bulk have since 1990 been collected by SFT. Importers of chemicals in bulk are each year obliged to report types, amounts and application categories of chemicals they import. Chemical imported in products were estimated in (SFT 1999a) using a “bottom-up approach”, which means that we counted the imported units and multiplied them by the amount of chemical per unit. Routines for servicing equipment and for recovering the chemicals are also taken into account in the model.

Emission factors

Emission characteristics and emission factors for the different categories of equipment and products are defined by expert judgement (SFT 1999a).

4.4 Solvent use

Methodology et cetera is described in (SN/SFT 2000).

4.5 Agriculture**4.5.1 Key sources**

Emissions of N₂O and CH₄ from Agriculture are key sources in level due to high uncertainty in activity data and/or emission factors (SN 2000). These two emission sources are main contributors to uncertainty in level.

4.5.1.1 N₂O from agricultural soils- 4D

Emissions of N₂O from agriculture have been quite stable in the years 1990-2000. In 2000 the emissions of N₂O from agriculture accounted for 4.6 per cent of national total GHG emission which is a decrease from 5.0 per cent in 1990. The reduction can mainly be explained by reduction in direct soil emissions due to that the amount of N in harvest has been reduced, which decreases the N₂O emissions from crop residues.

Emission of N₂O from agriculture is key source in level because of uncertainty in emission factors.

Methodology

The methodologies used to calculate N₂O emissions from agriculture are described in (SN/SFT 2000) and are in accordance with (IPCC 1997a,b). Default emission factors are used, but other estimation factors are national (for example excretion rates, ammonia evaporation and leakage) where they are available and where they are evaluated to give better results under Norwegian conditions than the default factors from the (IPCC 1997a,b).

In the Norwegian inventory it has been assumed that animals do not emit N₂O themselves, and emissions of N₂O before manure application on fields has not been taken into account (Aakra and Bleken 1997). In next years submission of national emission data this source will be included in the inventory in line with the IPCC methodology.

Activity data

The Norwegian Agricultural Inspection Service calculates consumption of synthetic fertilisers in Norway.

The amount of manure used to calculate the N₂O emissions is estimated from the number of animals (Agricultural Statistics) and national excretion factors for each kind of animal, see chapter 3.35 in (SN/SFT 2000). There is significant uncertainty connected to the allocation of manure between what is used as fertiliser and droppings on pastures. The split was estimated in 1994 (Aakra and Bleken 1997), and the same fractions are used every year.

Aakra and Bleken (1997) have estimated the amount of biological N-fixation and the area of cultivated organic soil in Norway. The amount of nitrogen leaching has been estimated from a runoff model by Centre for Soil and Environmental Research at the Agricultural University of Norway.

Values for ammonia volatilisation are given from SN's ammonia model. These data will also be updated in 2002 based on a national survey performed in 2001.

Emission factors

We use IPCC default emission factors for calculating N₂O from agriculture.

4.5.1.2 CH₄ from Enteric fermentation – 4A

CH₄ emissions from the agricultural sector accounted in year 2000 for 3.7 per cent of the total GHG emissions and in the base year 1990 for 3.9 per cent. CH₄ emissions from enteric fermentation stand alone for 85 per cent of the total CH₄ emissions from agriculture in the year 2000.

An emission of CH₄ from cattle (enteric fermentation) is key source in level because of uncertainty in emission factors.

Methodology

The methodology we use for calculating CH₄ from enteric fermentation is in accordance with IPCC's Good Practice Guidelines Tier 1 method.

Activity data

The numbers of the different animals included in the calculation model are taken from SN's livestock statistics. These are based on the register of production holders applying for governmental grants. Almost 100 per cent of all livestock are registered here.

Emission factors

We use IPCC's Tier 1 default emission factors for each kind of animal (IPPC 1997a,b). Furthermore is the emission from reindeer, deer and ostrich included in the Norwegian calculations. The emission factor used for reindeer is 11 kg/animal/year, 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/year has been estimated by scaling the emission factor for dairy cattle, and the emission factor 4.97 kg/animal/year for ostrich by scaling the emission factor for horses.

4.6 LUCF

As mentioned earlier, this chapter describes the calculation methodology for different key sources. Land-use change and forestry is not included in the analysis of key sources. A methodology for that will be developed by IPCC in 2002/2003. However, due to the large net sink in Norway it is clearly a key source and we will describe the methodology for calculating emissions and removals from this sector in the following. The rationale for this is that the methodology for this sector is not included in the enclosed report where our inventory methodology is outlined.

According to the IPCC Guidelines, the reporting of emissions and uptake from land-use change and forestry should focus on four activities, namely changes in forest and other woody biomass stocks, forest and grassland conversion, abandonment of managed lands and CO₂ emissions and removals from soils. In Norway it is difficult to separate the contributions from the first three different categories, hence we have reported the uptake and emissions under changes in forest and other woody biomass stocks. This can be found in Table 5 and 5.A of the reporting tables. We calculate the emissions employing the IPCC default method, where harvested wood is counted as emissions the year the harvest takes place. This means that uptake in harvested wood products is not included. Concerning the latter category, emissions and removals from soils, we have not reported any figure here. The uptake of carbon in forest soils has not been estimated, whereas the calculated removal of carbon in agricultural soils is reported under Agriculture (since this is optional as mentioned in footnote 4 of summary table 1A).

The Norwegian Institute of Land Inventory (NIJOS) performs a national forest inventory every year. Field observations are then collected from all counties in Norway. These observations are the basis for the calculations of the annual growth increment. Permanent observation fields have been established and all plots are visited within the course of a five-year cycle. From this survey, and from annual figures of felling and other depletion, the figures for uptake and emission of CO₂ are calculated. The figures include above and below ground biomass, which signify tops and branches, bark, stumps and coarse roots. As mentioned earlier, the carbon content in forest soils is not included in the estimates.

The National Forest Inventory is carried out as a sample survey. In the period 1986-1993 permanent sample plots were established in forests in a 3 x 3 km grid. This includes most of the forest area in Norway, except the county of Finnmark and the mountain birch forests. Totally, approximately 10,500 permanent sample plots are located on productive forest and other wooded land below the coniferous forest limit. On the average, each sampled area comprises about 3×10^{-5} of the surveyable area. The plots are re-measured every 5th year. Measurements on trees are carried out on an area of 250 m². Stand parameters are based on a plot size of 0,1 ha.

An extensive number of attributes concerning forest conditions are being recorded at the plots. Some of these describe the area. Parameters which characterise the level of development and species composition of the vegetation, certain aspects on biodiversity, utilisation and yield capacity of the land, forest treatment, relations concerning forest operations etc., are being measured or estimated.

To include total above and below ground biomass (tops, branches, stumps, coarse roots and bark) the roundwood cut volume is multiplied with a factor of 1.9. Trees lower than 1.3 meters are not taken into account.

Norway follows the FAO definition where forestland is defined as an area with a minimum of 10 per cent crown coverage. The trees should be able to reach a minimum height of 5 meters at maturity. The area can be temporarily without crown coverage due to harvesting without following land use change. In Norway the category “Other wooded lands” defines areas with a minimum of 5 per cent crown coverage and tree heights over 5 meters at maturity, or a crown coverage of more than 10 per cent and tree heights under 5 meters at maturity, which is the FAO definition.

Carbon in products and waste

The stock of carbon in products and waste has been estimated by Gjesdal et al, SN, and the storage sources included are paper and paper products, furniture, buildings, and wood and paper disposed of in landfills (SFT 1996). This stock is not included in the tables on land-use change and forestry. A national estimation method has been used, which is based on the stock change approach (defined in Brown *et al* (1998)).

The study from 1996 has been updated by SN (SFT 2001), and it also includes a comparison between different approaches for allocating carbon storage and CO₂ emissions from wood products to countries. According to the study, the total stock of carbon in wood products was estimated at 16.8 million tonnes of carbon (or 61.5 million tonnes of CO₂) in 1998. The stock has increased by about 10 per cent since 1990. The main part of the stock was stored in buildings and waste; these two categories constituted respectively 50 per cent and 43 per cent of the harvested wood stock in 1998. The change in the reservoir from 1997 to 1998 has been estimated at 0.2 million tonnes of carbon (or 0.7 million tonnes of CO₂).

In the national method, carbon stored in paper is calculated from consumption of paper, lifetimes and carbon content in the paper products. Production data is obtained from SN's annual industry survey, while the annual External trade statistics gives data on import and export. The amount of wood in buildings and furniture is calculated from *inter alia* the number of dwellings, the average utility of floor space, the fraction of dwellings built with wood, the amount of wood per m² in wood buildings and the C-content. The calculations of carbon stored in waste are based on background data used in estimation of methane emissions from landfills. Three categories of waste are considered: household and industrial waste included in municipal waste, and industrial waste treated outside the municipal refuse disposal service. The waste products included in this analysis are paper and wood.

4.7 Waste

4.7.1 Key sources

4.7.1.1 Solid waste disposal – 6A

Emission from this source category is described in Chapter 2.1.6.

Emissions of methane from solid waste disposal is a key source in level and trend due to uncertainty in activity data, emission factor and change in trend.

Methodology

Although development of better methodology for calculation of emissions of CH₄ from landfills have been prioritised in the inventory system the last years, there is still considerable uncertainty connected to the emissions of CH₄ from solid waste disposal.

With respect to methane emissions from landfills SFT has developed a new calculation model (SFT 1999b). This model, which is based on the IPCC theoretical first order kinetics methodologies (IPCC 1997b), takes into account the fact that methane is emitted from a waste deposit for several years. Improved waste statistics have become available in the last few years, giving better data on waste volumes and waste composition (SN 1998). The model therefore now gives a better estimate of methane emissions from municipal waste and private industrial landfills. The effect of weather conditions is also taken into account. See further description of the model in (SFT 1999b) and (SN/SFT 2000).

Activity data

SN prepares in an annual survey waste statistics for waste from households, yard/garden and commercial/market. Organic industrial solid waste is collected less frequently. The waste statistics give details for waste produced and the amount of waste disposed at landfills.

Emission factors

Table 12 shows some of the variables used in the calculations of methane from solid waste disposals.

Table 12. Variables used in the calculations.

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 (1997 ⁷) (MCF)	1.00	0.80	0.80
Oxidation effect	10 per cent	10 per cent	10 per cent

Source: SFT (1999a).

⁷ Different correction factors for different years.

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Annex 1. National Energy Balance 1990

Energy balance sheet ⁸ . 1990. PJ											
		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water fall energy ⁹	Electricity	District heating
1.1	Production of primary energy bearers	5147	9	0	43	3412	50	1119	514	0	0
2	Imports	258	20	28	0	69	140	0		1	0
3	Exports	4368	7	4	0	2897	373	1028		58	0
4	Bunker oil	19	0	0	0	0	19	0		0	0
5	Changes in stocks (+ net decrease, - net increase)	-64	0	-1	0	-62	-1	0		0	0
7	Net domestic supply (1.1+2-3+4+5)	953	21	23	43	521	-204	92	514	-57	0
8	Energy converted	1092	1	0	1	539	36	0	514	1	0
8.1	In blast furnaces	0	0	0	0	0	0	0		0	0
8.2	In crude petroleum refineries	575	0	0	0	539	36	0		0	0
8.3	In thermal power plants	0	0	0	0	0	0	0		0	0
8.4	In combined heat and power plants	1	1	0	1	0	0	0		0	0
8.5	In district heating plants	2	0	0	1	0	0	0		1	0
8.6	In hydropower plants	514							514		
1.2	Production of derived energy bearers	1036	0	6	0	0	542	44	0	439	5
9	Consumption by energy sector	123	0	0	0	0	4	112		7	0
10	Consumption for non-energy purposes	47	0	0	0	0	47	0		0	0
11	Losses in transport and distribution	28	0	0	0	0	0	0		26	2
12	Statistical differences (7-8+1.2-9-10-11-13)	-11	-1	0	0	-18	0	9		-2	0
		-11	-1	0	0	-18	0	9		-2	0
13	Net domestic consumption	709	21	28	42		251	15		349	3
13.1	Manufacturing, mining and quarrying	278	21	28	21		30	15		163	1
13.2	Transport	161	0	0	0		158	0		2	0
13.3	Other sectors	270	0	0	22		63	0		183	2
14	Calculated energy consumption ¹⁰	542	17	23	28		109	14		349	3
14.1	Manufacturing, mining and quarrying	256	17	23	13		26	14		163	1
14.2	Transport	42					40			2	0
14.3	Other sectors	244	0	0	14		44	0		183	2
15	Energy losses in final consumption (13-14)	167	4	6	15		142	1		0	0
15.1	Manufacturing, mining and quarrying	22	4	6	7		4	1		0	0
15.2	Transport	119	0	0	0		119	0		0	0
15.3	Other sectors	27	0	0	8		19	0		0	0

Source: SN

⁸ The energy balance is derived from the energy sources balance sheet.

⁹ 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.

¹⁰ Line 14, "calculated energy consumption" shows the amount of energy actually utilised. The numbers are estimated by multiplying the values in line 13 by thermal efficiency coefficients.

Annex 2. National Energy Balance 2000

Energy balance sheet. 2000 ⁷ . PJ Preliminary data.											
		Total	Coal	Coke	Fuel wood, black liquor, waste	Crude oil	Petroleum products	Natural gas and other gases	Water fall energy ⁸	Electricity	District heating
1.1	Production of primary energy bearers	795	27	32	49	-	267	20		395	5
2	Imports	318	27	32	25	-	34	20		181	1
3	Exports	186	-	-	-	-	183	0		3	-
4	Bunker oil	291	0	0	24	-	50	0		212	5
5	Changes in stocks (+ net decrease, - net increase)	-29	2	-1	..	-35	5	.	.	.	.
7	Net domestic supply (1.1+2-34+5)	1 391	29	27	54	721	-195	221	602	-69	-
8	Energy converted	1 266	1	1	5	579	76	0	602	2	-
8.1	In blast furnaces	0	0	0	0	0	0	0		0	0
8.2	In crude petroleum refineries	575	0	0	0	539	36	0		0	0
8.3	In thermal power plants	0	0	0	0	0	0	0		0	0
8.4	In combined heat and power plants	1	1	0	1	0	0	0		0	0
8.5	In district heating plants	2	0	0	1	0	0	0		1	0
8.6	In hydropower plants	514							514		
1.2	Production of derived energy bearers	1 192	.	7	.	.	616	47	.	515	7
9	Consumption by energy sector	217	-	-	-	-	9	198		11	-
10	Consumption for non-energy purposes	53	.	.	.	.	33	19		-	-
11	Losses in transport and distribution	40	..	..	.	..	..	2		36	1
12	Statistical differences (7-8+1.2-9-10-11-13)	213	1	2	-	142	36	28		3	0
13	Net domestic consumption	795	27	32	49	-	267	20		395	5
13.1	Manufacturing, mining and quarrying	318	27	32	25	-	34	20		181	1
13.2	Transport	186	-	-	-	-	183	0		3	-
13.3	Other sectors	291	0	0	24	-	50	0		212	5
14	Calculated energy consumption ⁹	611	22	25	32	-	113	19	-	395	5
14.1	Manufacturing, mining and quarrying	292	22	25	16	-	29	19		181	1
14.2	Transport	51	-	-	-	-	48	0		3	0
14.3	Other sectors	268	0	0	16	-	35	0		212	5
15	Energy losses in final consumption (13-14)	184	5	6	17	-	155	1		-	-
15.1	Manufacturing, mining and quarrying	26	5	6	9	-	5	1		-	-
15.2	Transport	135	-	-	-	-	135	0		-	-
15.3	Other sectors	24	0	0	9	-	15	0		-	-

Annex 3. Common Reporting Format tables 1990

http://www.sft.no/publikasjoner/luft/1886/ta1886_annex3_1990.xls

Annex 4. Common Reporting Format tables 2000

http://www.sft.no/publikasjoner/luft/1886/ta1886_annex4_2000.xls



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Title Greenhouse Gas Emissions in Norway 1990-2000. Reporting according to the UNFCCC guidelines.
Summary The report presents an inventory of greenhouse gas emissions and sinks in Norway from 1990 to 2000. Trends in total greenhouse gas emissions by UNFCCC's sources and gases are described for carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), tetrafluoromethane (CF ₄), hexafluoroethane (C ₂ F ₆), sulphur hexafluoride (SF ₆) and HFCs. Methodology used in the calculation of emissions from key sources in the Norwegian Emission Inventory are presented. Emissions are reported according to UNFCCC/IPCC common reporting format (CRF).

Subject words Climate convention Greenhouse gases Emission inventory Carbon dioxide Key sources	Klimakonvensjonen Drivhusgasser Utslippskartlegging Karbondioksid Viktigste utslippskilder
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