Norway's second national communication under the Framework Convention on Climate Change - April 1997

Annex

Introduction

The United Nations Framework Convention on Climate Change entered into force on 21 March 1994. This report is Norway's second national communication according to our commitments under Article 12 of the Convention, which concerns communication of information related to implementation. Norway's first national communication was submitted on 21 September 1994. This second report has been prepared in accordance with the Guidelines for Communication determined by the Conference of the Parties (COP) and the Subsidiary Body for Scientific and Technological Advice (SBSTA) in 1996. The Norwegian greenhouse gas inventory presented in the report generally follows the Draft Guidelines for national greenhouse gas inventories published by the Intergovernmental Panel on Climate Change (IPCC). However, where appropriate other estimation methods have been used to achieve better, more complete figures for our greenhouse gas emissions. The methodology for all estimations is well documented in the attached report «Greenhouse gas emissions in Norway 1990-1995» published by the Norwegian Pollution Control Authority (SFT report 1997:02).

In addition to the description of our current domestic activities, the report gives a brief overview of Norway's most important international actitivities in the field of climate change.

The following ministries and institutions have contributed to the report:
Ministry of Finance
Ministry of Foreign Affairs
Ministry of Environment
Ministry of Petroleum and Energy (formerly Ministry of Industry and Energy)
Ministry of Trade and Industry
Ministry of Transport and Communications
Ministry of Agriculture
Directorate for Nature Management (DN)
Norwegian Pollution Control Authority (SFT)
Research Council of Norway
Statistics Norway (SN)
Center for International Climate and Environmental Research (CICERO)
Fridtjof Nansen Institute (FNI)
ECON Centre for Economic Analysis
The Foundation for Research in Economics and Business Administration (SNF)

Oslo, 15 April 1997
MINISTRY OF ENVIRONMENT

1. Executive summary

This report is the second national communication presenting Norwegian climate policy according to the commitments under the Framework Convention on Climate Change. The first communication was submitted on 21 September 1994. In addition, a report on Greenhouse gas emissions in Norway 1990-94 (SFT 96:06) was submitted in 1996.

National circumstances

Several aspects of international efforts to mitigate adverse effects of climate change may have consequences for Norway. The Norwegian economy is small and open and exports and imports constitute a relatively high share of GDP, approximately 50%. International action to reduce or limit emissions of greenhouse gases may in this respect alter the external framework for the Norwegian economy and result in changes in the prices of important commodities.

Norwegian CO_2 taxes have been in force since 1991 and cover about 60% of the CO_2 emissions. The development of Norwegian CO_2 taxes illustrates the challenges a small open economy faces in being at the forefront of efforts to introduce efficient instruments designed at limiting global environmental problems. A lack of international implementation and coordination of such instruments may lead to leakage effects, and this in turn may mean that a country like Norway incurs substantial costs in achieving a given reduction in national emissions. However, due to the careful design of the CO_2 tax system, the competitive position of the Norwegian industries has not been significantly affected so far.

The sectoral composition of total Norwegian CO_2 emissions differs from that of most other countries. There are several reasons for this:

The petroleum sector (production and transport of petroleum) accounted for about 23% of total CO_2 emissions in 1995. Pipeline transport of natural gas to the European continent is energy demanding and therefore causes CO_2 emissions. Such exports may, however, contribute to a regional reduction of CO_2 emissions. If exported gas replaces coal in the importing countries, the sum of CO_2 emissions from the exporting and importing countries will be reduced. In relation to the climate change issue, it is therefore important to consider the emissions of CO_2 from Norwegian production and transport of natural gas in relation to the emission reductions achieved from the use of this gas in the receiving countries.

Electricity production in mainland Norway is based almost entirely on hydropower, which does not cause CO_2 emissions. Norway therefore has no opportunity to reduce CO_2 emissions from electricity production, for example by using gas instead of coal. There is limited potential for further development of hydropower production. During the period 1990-1995, Norway was on average a net exporter of electricity (7 TWh per year). Generation of this quantity of electricity in a coal-fired plant of average energy efficiency would cause CO_2 emissions in the order of 5.7 million tonnes (or about 15% of total Norwegian CO_2 emissions in 1995).

The Norwegian electricity market was deregulated with the entry into force of the Energy Act in 1991. Because of growing competition and variation in hydropower production and available water supplies, emissions from electricity production in the Nordic countries vary from year to year. Electricity trade between these countries is likely to increase in the years ahead. It is therefore hard to predict the implications this might have on national greenhouse gas emissions.

The way in which electricity trade affects greenhouse gas emissions is also dependent on national taxation schemes. To reduce greenhouse gas emissions in a deregulated market, it is important to combine the market with the use of CO_2 taxes so that the polluter-pays-principle can be applied. A coordination of such a system among countries would lower emissions because the competitiveness of clean electricity production would be improved. Without such coordination of taxation, the competitiveness of energy-related industry in each country could be seriously affected.

Norway has a desentralized settlement pattern and a relatively high demand for transport. The decentralized settlement pattern makes public transport systems costly to develop. Though taxes are considered the most cost-effective measure to limit CO_2 emissions from the transport sector, the demand for transport oils is relatively insensitive to price changes. In addition, some transport oils are already heavily taxed.

Inventories of anthropogenic greenhouse gas emissions and removals

The following greenhouse gases are included in the inventories: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs i.e. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6)), sulphur hexafluoride (SF_6) and HFCs (HFC-134a, HFC-125, HFC-143 and HFC-152a). Emission data for precursors (NO_x, CO and NMVOC) and SO_2 are also given. Emissions figures for 1990-1995 are reported.

The Norwegian greenhouse gas inventories presented in the report generally follows the Draft Guidelines for national greenhouse gas inventories published by the Intergovernmental Panel on Climate Change (IPCC). However, where appropriate other estimation methods have been used to achieve better, more complete figures for our greenhouse gas emissions. The report «Greenhouse gas emissions in Norway 1990-1995» published by the Norwegian Pollution Control Authority (SFT report 1997:02) presents a more detailed inventory of greenhouse gas emissions in Norway. This report contains «Minimum data Tables» where both activity data, emission estimates and aggregated emissions factors are given, as recommended by the IPCC.

The greenhouse gas emission inventory for the period 1990-1995 is summarized in Table 1.

Table 1 Total emissions of the greenhouse gases CO_2 , CH_4 , N_2O, CF_4 , C_2F_6 , SF_6 , HFC-134a, HFC-152a, HFC-125 and HFC-143a in Norway in the period 1989 to 1995 and percentage changes from 1990 to 1995.

	CO_2 MTONNES	CH_4 KTONNES	N_2O KTONNES	CF_4 TONNES	C_2F_6 TONNES	SF_6 TONNES	HFC-134a TONNES	HFC-152a TONNES	HFC-125 TONNES	HFC-143a TONNES	CO_2-EQU. MTONNES
1989	35.3	429	15	360	16	107	0	3			54.1
1990	35.5	432	15	369	16	92	0	3			54.1
1991	33.9	432	15	313	14	86	1	3			51.7
1992	34.4	438	13	242	11	29	2	3			50.0
1993	35.9	448	14	254	11	30	31	1			52.1
1994	37.8	467	14	231	11	35	40	1	11	4	54.5
1995	37.9	469	14	209	9	24	47	5	31	25	54.4
1990-95	7 %	9 %	-8 %	-43 %	-44 %	-74 %	..	50 %	..	..	1 %

CO_2 is by far the most important greenhouse gas in Norway, accounting for 70% of total greenhouse gas emissions in 1995. Methane accounted for 18% and nitrous oxide for 8%, while PFCs and SF_6 together contributed about 4%.

The industry and energy sector is the most important emission source and contributed about 45% of total greenhouse gas emissions in 1995. Mobile sources accounted for about 25%.

The largest CO_2 emissions in 1995 were from stationary combustion, including the offshore industry (40%) and mobile sources (39%). Gas turbines offshore accounted for 16%. Road traffic contributed about 22%, while coastal traffic and fishing accounted for 9%. Industrial processes, i.e. production of metals, carbides, cement etc., constituted 21% of total CO_2 emissions.

The method of calculating CH_4 emissions from landfills has been changed. In the previous report we included only landfills for municipal waste, whereas this report includes emissions from both municipal waste and landfills for industrial waste.

The net anthropogenic sink of CO_2 in the Norwegian forests was in 1995 estimated to 13.6 million tonnes, equivalent to about one third of total emissions of CO_2. The yearly increase in net sink of CO_2 increased by about 4.2 million tonnes in the period 1990-1995. This means that when the increase in yearly forest sink is included, Norway's total atmospheric emission of greenhouse gases was lower in 1995 than in 1990.

Policies and measures

Norway's climate policy is founded on the objective of the Climate Convention and the scientific understanding of the greenhouse effect set out in the reports from the UN Intergovernmental Panel on Climate Change (IPCC). An important principle of the Norwegian climate policy is that all policies and measures, at both national and international level, should be based on a comprehensive approach and be as cost-effective as possible. Coordinated international efforts and the development of international economic measures are essential in dealing with the greenhouse effect.

Norway ratified the Climate Convention on 9 July 1993. As the Convention is further developed, Norway will continue to advocate the need for new and more binding commitments, as well as flexible mechanisms for their implementation. There should be a special focus on the period beyond year 2000 to ensure the development of policies in accordance with the objective of the Convention to stabilize the greenhouse gas concentrations in the atmosphere «at a level that would prevent dangerous anthropogenic interference with the climate system».

On 2 June 1995, the Government submitted Report to the Storting No. 41 (1994-95) on «Norwegian policy to mitigate climate change and reduce emissions of nitrogen oxides (NOx)». This report contains a complete account of Norway's climate policy, addressing all relevant greenhouse gases and economic sectors in accordance with the guiding principles of the Convention. Relevant economic and administrative measures consistent with the Government's overall economic strategy were considered with the aim of finding cost-effective ways of limiting the net emissions of greenhouse gases in all sectors. Taxes are still the most important means of limiting CO_2 emissions. The authorities will try to find new means of limiting emissions of greenhouse gases, including agreements with various branches of industry. Talks with the industrial sector have begun with the aim of reducing emissions that are exempt from the CO_2 tax. On the basis of practical experience of this process, the Government will evaluate whether other instruments should be applied, e.g. direct regulation or taxation.

Norway appointed a Green Tax Commission in 1992 as part of its efforts to follow up the report of the World Commission on Environment and Development. On the Storting's recommendation, a second Green Tax Commission was appointed in 1994. The Commission published its recommendations in NOU 1996:9 «Policies for a Better Environment and High Employment». A key question for the Commission was how to achieve a long-term path of development that results in a more efficient economy, a better environment and a higher employment. The follow up of the Commission's report will be presented to the Storting later this year in the annual bill on tax rates for 1998.

The Government's Long-term Programme for 1998-2001 gives high priority to climate and environmental policies. It is recognized as an aim to limit the expected growth in national energy use. Furthermore, the Long-term Programme establishes the aim that domestic use of electricity in a normal year shall be based on renewable energy sources. This implies enhanced efforts in the field of energy efficiency and in energy production in order to increase energy conservation and the share of new renewable energy sources such as bioenergy in the Norwegian energy supply system. In spring 1997, the Government will submit a Report to the Storting on environmental policies for a sustainable development that will give a more comprehensive overview of future action in the field of climate and energy as a follow up of the Long-term Programme.

The Norwegian CO_2 tax scheme

Norway has for a number of years been at the forefront in introducing economic instruments to enhance the efficiency of environmental policies, with an emphasis on curbing emissions to air. Norway is one of the few countries who have so far introduced CO_2 taxes, and the overall tax level on fossil fuels is considerably higher than in most other countries. The Norwegian environmental tax system consists primarily of product taxes. Experience of the use of CO_2 taxes in Norway is positive, but closer coordination between countries will be necessary to enhance the effect and extend the application of such schemes.

Table 2 shows tax rates for petroleum products, gas, coal and coke as of 1 January 1997. Table 3 shows how the CO_2 tax rates on petroleum products, gas, coal and coke have been increased during the last years.

Table 2: Tax rates for petroleum products (NOK/1), gas (NOK/Sm^3) and coal and coke (NOK/kg)

	Basic Tax	CO_2 Tax	SO_2 Tax	Total	CO_2 tax per tonne CO_2 emitted
Unleaded petrol	4.02	0.87		4.89	376
Leaded petrol content below 0,05g/l	4.26	0.87		5.13	376
Leaded petrol content above 0,05g/l	4.76	0.87		5.63	376
Autodiesel	3.35	0.435		3.785	164
Light mineral oil	0	0.435	0-0.07[1]	0.435-0.505	164
Heavy mineral oil	0	0.435	0.14-0.70[1]	0.575-1.135	140
Diesel, North Sea	0	0.87		0.87	328
Gas, North Sea	0	0.87		0.87	373
Coal	0	0.435		0.435	179
Coke	0	0.435		0.435	136

Table 3: CO_2 taxes on petroleum products from 1991-1997 (NOK/1), gas (NOK/Sm^3)

	From 1.1.91	From 1.1.92	From 1.7.92	From 1.1.93	From 1.1.94[2]	From 1.1.95	From 1.1.96	From 1.1.97
Petrol	0.60	0.80			0.82	0.83	0.85	0.87
Mineral oil[3]	0.30			0.40	0.41	0.415	0.425	0.435
Gas, North Sea	0.60	0.80			0.82	0.83	0.85	0.87
Oil, North Sea	0.60	0.80			0.82	0.83	0.85	0.87
Coal and coke			0.30	0.40	0.41	0.415	0.425	0.435

CO_2 emissions in Norway dropped by about 5 % from 1989 to 1991, and subsequently increased again, reaching the 1989 level in 1993. From 1993 to 1995 the emissions further increased by 5%. Although this partly reflects cyclical developments in the Norwegian economy and variations in weather conditions, the underlying trend is significantly different from the steady increase that was expected to continue into the 1990s. In addition to the CO_2 tax which was implemented with effect from 1991, the ample supply of hydropower and low economic activity have contributed to this development. The main increase since 1991 has been in emissions from the petroleum industry as production and export of oil and natural gas increased. In addition, emissions from diesel vehicles and coastal traffic rose. The preliminary emission figure for emissions of CO_2 in 1996 is about 41 million tonnes, which is 7,5% higher than in 1995. This increase is explained by a considerable increase in consumption of fuel oil stimulated by an increase in electricity prices through 1996, a further increase in oil and gas production and a further increase in emissions from diesel vehicles and coastal traffic.

From 1990 to 1995 there was a steady decrease in national petrol consumption and the consumption in 1996 was about the same as in 1995. The introduction of the CO_2 tax has been one contributory factor, but it is difficult to precisely estimate the exact effect of the tax. During the same period the consumption of autodiesel, which is taxed at a lower rate, has risen.

[1] *The tax rate is 0.07 NOK per 0,25% sulphur content*

[2] *From 1.1.94 the only changes has been adjustments for inflation.*

[3] *From 1.1.91 the CO_2 tax was levied in addition to an already established fiscal duty of 0.32 NOK/litre. The fiscal duty was reduced to 0.17 NOK from 1.7.92 and to zero from 1.1.93.*

Energy policy and energy efficiency

The new Energy Act that entered into force on 1 January 1991 establishes general terms and conditions designed to ensure more efficient utilisation of hydropower. It has brought about deregulation and keener competition in the power sector, and the power market has changed substantially since its introduction. From 1991 to 1996, growing competition led to a reduction in the price of power for several categories of customers. However, in 1996 the extremely low degree of filling of the reservoirs led to steep price increases in the spot market. This increased the price for end users significantly.

In 1993 Norway introduced a change in the energy efficiency policy based on Report to the Storting No. 41 (1992-93). The main activities in the field of energy efficiency are information, education and introduction of energy-efficient technology. Regional energy efficiency centres have now been established in almost every county in Norway. Information campaigns have increased the awareness of energy efficiency. The Industrial Energy Efficiency Network has continued to grow and its members now represents 80% of the total energy use in the Norwegian domestic industry. The fiscal budget for 1997 includes an additional allocation to projects involving the use of bioenergy in order to stimulate increased use. The Government's goal is to put bioenergy at a level playing field with other energy sources such as oil and electricity.

Energy production

Almost all electricity generated in Norway is hydropower and nearly all emissions of CO_2 from electricity production are generated by the offshore petroleum production. A Norwegian company is, however, in the process of licencing two 350 MW gas-fired power plants.

In 1995, the Ministry of Industry and Energy appointed a committee (MILJØSOK) with the objective to ensure that extraction, transport and processing of oil and gas in the Norwegian petroleum sector meet the highest possible environmental standards. The committee included members from the industry, the authorities as well as research and conservation groups. In a report submitted to the Ministry of Petroleum and Energy in December 1996, the committee established the goal of reducing CO_2 emissions per kWh produced from the petroleum sector by 30-40 % within 15 years, provided that certain assumptions are fulfilled.

The CO_2 tax is believed to have contributed to the development of more energy-efficient production and transport of oil and gas. Development of more efficient gas turbines is the single most important means of reducing emissions of CO_2. One example of the progress made in this respect is the Ekofisk field, where new gas turbines and infrastructure are expected to reduce CO_2 emissions by about 40%. Another recent development is the installation of equipment on the Sleipner field to separate CO_2 from the well stream and re-inject it under the sea bed. This solution is expected to reduce emissions with 0.8 million tonnes CO_2 yearly.

Transport

Norwegian taxes on transport oils are among the highest in the world, currently 4,89 NOK/l petrol and 3,785 NOK/l diesel (VAT not included). Petrol taxes are more than 70% higher in 1997 than in 1990. Consumption of petrol dropped by more than 8% between 1990 and 1995 in the transport sector.

The purchase tax on cars is among the highest in the world, and has from 1996 been differentiated according to weight, engine output and engine volume. The purchase tax scheme is to a certain degree designed to act as an incentive to buy more energy-efficient cars. Preparations are currently in progress for tests on the use of natural gas in ferries.

The Government's policy on road pricing will be presented to the Parliament in spring 1997. Further, a special programme has been established to support the country's four largest towns in building infrastructure for public transport. In addition, the EURO-vehicle inspection system will be fully implemented from 1998.

Industry

In recent years, CO_2 emissions from energy use in industry have decreased considerably as a result of improved energy efficiency and changes in the energy mix. In 1996, however, the CO_2 emissions rose since high electricity prices led to more use of heating oil. Between 1990 and 1995 emissions of perfluorocarbons (PFCs) from aluminium producers have been reduced by about 43%. Ongoing discussions about an agreement with this industry are expected to lead to further reductions in emissions. The sulphur hexafluoride (SF_6) amount used in magnesium production has been reduced from about 90 tonnes in 1990 to about 17 tonnes in 1995 as a result of improved routines and maintenance in the plant as well as reduced production levels.

CO_2 sinks

One of the main objectives of Norwegian forestry policy has been to maintain and enhance forestry resources, mainly because this permits continued utilisation of the natural resource base for forestry purposes. Enhancing national forestry resources may also have a significant impact on emissions of greenhouse gases, and help to limit their accumulation in the atmosphere. The Government is currently studying the possibilities for further enhancement of forest sinks by means of concrete action. The study is expected to be finalized in 1997.

Landfills

It is estimated that emissions of methane from municipal and industrial landfills in 1995 totalled about 322 000 tonnes. In 1996 15 plants for using methane for energy purposes or burning of flares were in operation. The number of plants is expected to be doubled the next 2-3 years. The total quantity of waste generated for the country as a whole will continue to increase, whereas the share of waste landfilled can be reduced substantially in the period up to 2010-2015 by means of separation, recycling and composting. Emissions of methane from waste deposited in industrial landfills and other landfills outside the municipal disposal system in 1995 are estimated at about 100 000 tonnes. Existing or new policy instruments is expected to be an incentive to find other solutions than landfilling, such as incineration with energy recovery.

The Norwegian Government is evaluating the introduction of a tax on final waste disposal, including the consequences it would have for various actors. Such a tax is expected to stimulate and intensify the introduction of the measures described above.

Projections

Projections of CO_2 emissions

The projections of CO_2 emissions are based on macroeconomic model projections supplemented with sectoral studies (e.g. transport and petroleum production).

Table 4 shows estimated CO_2 emissions during the period 1995-2020 based on current policies, i.e. including the present CO_2 taxes. CO_2 emissions are expected to rise by about 26% from 1995 to 2010. This relatively large increase is explained by rises in emissions from petroleum extraction and transport, electricity generation, manufacturing and domestic transport. Emissions are expected to be reduced somewhat from 2010 to 2020. The main reason for this reduction is that petroleum extraction is expected to reach a peak around the turn of the century and then gradually fall, resulting in lower emissions.

A Norwegian company is in the process of licencing two gas-fired plants. These plants will eventually be phased in around 2000 and will increase CO_2 emissions by about 2.1 million tonnes yearly. These emissions are included in the projections.

Table 4 Gross emissions of CO_2 in Norway by sector. (Million tonnes)

	1989	1990	1993	1995	2000	2005	2010	2020
Petroleum sector	7	8	9	9	12	12	12	8
Domestic transport[1)]	4	4	5	5	6	6	7	8
Manufacturing	11	12	10	12	13	14	14	15
Households[2)]	6	6	5	5	5	5	6	7
Electricity generation	0	0	0	0	2	2	2	2
Other sectors	7	6	7	7	6	7	7	7
Total emissions[3)]	35	36	36	38	44	47	48	46

1) Excl. transport on own account in industries and households.
2) Incl. transport by private car.
3) Numbers may not add because of rounding errors.

Projections of emissions of other greenhouse gases

Table 5 shows emissions and projected emissions of methane, nitrous oxide, perfluorocarbons, sulphur hexafluoride and HFCs. Emissions of greenhouse gases other than CO_2.are expected to decrease by approximately 16% from 1990 to 2010. The main reason for this is that emissions of methane is expected to be reduced by almost 23% from 1990 to 2010. The projections in methane emissions from landfills are based on Scenario 1 which assumes that implementation of existing or new policy instruments will reduce the methane emissions from landfills by about 33% by 2010 compared to 1990. There are, however, uncertainties associated with this prognosis. Scenario 0 includes only effects of measures that already have been implemented, without new policy instruments or measures. The emissions from landfills in this scenario is expected to increase by about 15% by 2010.

Table 5 Emissions of the various greenhouse gases in 1989, 1990, 1995 and projections for 2000, 2005, 2010 and 2020. (The figures are given in million tonnes CO_2 equivalents)

	1989	1990	1995	2000	2005	2010	2020	Changes 1990-2010
Σ other greenhouse gases	18.8	18.6	16.5	16.1	16	15.6	16.1	-16%
Methane*)	9.0	9.1	9.9	8.7	7.9	7.0	6.8	-23%
Nitrous oxide	4.7	4.8	4.4	4.8	5.1	5.2	5.5	10 %
PFCs	2.5	2.5	1.4	1.3	1.2	1.2	1.2	-52 %
Sulphur hexafluoride	2.6	2.2	0.6	0.5	0.5	0.6	0.7	-75 %
HFCs	0.0	0.0	0.2	0.8	1.3	1.6	1.9	..

*) The projections on methane from landfills are based on scenario 1 in section 4.4.1, which assumes that implementation of existing or new policy instruments will reduce the methane emissions from landfills by 33% by 2010.

Projections of precursors

Table 6 shows projections of emissions of ozone precursors and SO_2. These are based on the same assumptions as for CO_2, as described in section 5.1.

Table 6 Summary of projections of anthropogenic emissions of precursors and SO_2. (1000 tonnes)

	1990	1995	2000	2005	2010	2020
CO	961	829	657	621	614	622
NO_X	227	222	208	220	225	226
NMVOCs	299	378	337	261	236	215
SO_2	53	35	32	34	35	36

Projections of CO_2 sinks

Table 7 shows the projections of CO_2 sinks in the period 1990-2020. Important factors in such projections are the levels of harvesting and natural losses. The actual level of harvest is difficult to estimate as it will depend strongly in the world market price for timber. The maximum path assumes that the harvest will remain at a relatively low level as in 1990-1994. The minimum path illustrates the effect of a considerable increase in the natural losses. This is plausible, since the forest will age. The rate of natural losses rises to 12% in the year 2010 and 16% in 2020 in the minimum estimate.

Table 7 Net CO_2 removals in Norwegian forests in the period 1990-2020. (Million tonnes)

	1990	2000	2005	2010	2015	2020
Maximum	9.4	12.1	13.9	15.6	16.2	16.8
Best estimate	9.4	11.0	12.9	14.8	15.3	15.7
Minimum	9.4	11.0	12.2	13.4	13.1	12.8
Best estimate compared with 1990	-	1.6	3.5	5.4	5.9	6.3

Expected impacts of climate change, vulnerability assessment and adaptation measures

Most attention has until now been focused on effects on ecosystems and their vulnerability to climate change. Because of its geography and long coastline, Norway may, however, be more vulnerable to changes in the frequency of weather patterns and extreme events like storms, flood and spring tides than to climate change caused by increases in mean temperature.

Financial resources and transfer of technology

The Norwegian Government considers the financial mechanism and transfer of climate-friendly technology to be essential to the implementation of the Convention.

The Government of Norway has officially notified the World Bank as Trustee of the interim operating entity of the financial mechanism of the Convention of its participation in the Global Environment Facility Trust Fund (GEF). The annual contribution to the facility based on IDA10 basic shares for the years 1994-1997 has been in the order of NOK 54 million. In addition to this assessed contribution, the Government of Norway each year has been providing an extra grant, levelling the total annual contribution for 1994, 1995 and 1996 at the amount of NOK 55 million (the equivalent of approximately USD 8.5 million). This level corresponds to the level contributed to the GEF during the GEF pilot phase. The Norwegian contributions to the GEF are over and above the United Nations' agreed 0.7% target of development assistance in relation to GNP.

The official development assistance (ODA) provided by the Government of Norway for the years 1994, 1995 and 1996 corresponded to about 1% of GNP. The ODA is poverty oriented and not geared towards producing global environmental benefits. At the same time, transfer of technology and know-how in order to promote development and energy availability/efficiency constitute a significant element of Norwegian ODA, which may have significant environmental side-effects consistent with promoting the Convention. Because such effects are not the primary purpose of development assistance they have been rather scarcely recorded and assessed. Work is now under way to address such recording and assessment, and the outcome will be fully reflected in future reports to the Convention. ODA funds that have been designed specifically with a view to disburse technology and ensure private sector participation include a programme for countries in Asia.

In addition, Norway is currently participating in projects under the Activities Implemented Jointly Pilot Phase with Burkina Faso, Costa Rica, Mexico and Poland.

Research and systematic observation

In Norway, research related to climate change involves a range of disciplines in various programmes and projects. The bulk of public and governmental funding goes into technical R&D, but there are substantial contributions to the basic natural sciences, economics and social sciences. The Norwegian Climate and Ozone Research Programme was established in 1989 and is run under the auspices of the Research Council of Norway. The programme was evaluated by an international expert group in 1996. The group reached the conclusion that the Norwegian scientists had provided valuable input to international research and policy-making both in Norway and internationally.

Norway has felt a special responsibility to develop regional climate change models for Scandinavia and the North Atlantic Ocean with the aim of reducing uncertainties in predictions of future climate change. A major research project on regional climate modelling and prediction was launched in 1997 to meet these challenges. In addition, the Research Council of Norway established in 1996 the research programme Constraints, Measures and Possibilities in Norwegian Energy and Environmental Policy.

In 1997, a programme was started under the auspices of the Research Council of Norway with the objective of encouraging increased use of technologies to reduce emissions of greenhouse gases. The programme is targeted towards the petroleum and process industries and the transport sector.

Education, training and public awareness

In 1990, the Government established CICERO, the Center for International Climate and Environmental Research. Active involvement in the public debate on climate issues is of special importance for CICERO. It publishes the newsletter «CICERONE» and it translated the IPCC Second Assessment Report to Norwegian. CICERO also arranges the Climate Forum, which brings together representatives of industry and business as well as government and researchers.

Information campaigns in media with nationwide coverage helped to raise the awareness of energy efficiency issues in private households and among other energy users. Energy efficiency centres have been established in almost every county in Norway, and in 1996, regulations relating to energy labelling of refrigerators, freezers and their combinations, tumble dryers and washing machines were introduced in Norway.

The Research Council of Norway produced in 1996 an overview of the state of the art regarding climate change and ozone layer depletion. Norway is also arranging an international workshop in 1997 with the overall goal of increasing the understanding of the relationship between nitrogen dissipation from society and atmospheric N_2O.

2. National circumstances

Several aspects of international efforts to mitigate adverse effects of climate change may have consequences for Norway. The Norwegian economy is small and open and exports and imports constitute a relatively high share of GDP, approximately 50%. International action to reduce or limit emissions of greenhouse gases may in this respect alter the external framework for the Norwegian economy and result in changes in the prices of important commodities.

Norwegian CO_2 taxes have been in force since 1991 and cover about 60% of the CO_2 emissions. The development of Norwegian CO_2 taxes illustrates the challenges a small open economy faces in being at the forefront of efforts to introduce efficient instruments designed at limiting global environmental problems. A lack of international implementation and coordination of such instruments may lead to leakage effects, and this in turn may mean that a country like Norway incurs substantial costs in achieving a given reduction in national emissions. However, due to the careful design of the CO_2 tax system, the competitive position of the Norwegian industries has not been significantly affected so far.

The sectoral composition of Norwegian CO_2 emissions differs from that of most other countries. There are several reasons for this:

The petroleum sector (production and transport of petroleum) accounted for about 23% of total CO_2 emissions in 1995. Pipeline transport of natural gas to the European continent is energy demanding and therefore generates CO_2 emissions. Such exports may, however, contribute to a regional reduction in CO_2 emissions. If exported gas replaces coal in the importing countries, the sum of CO_2 emissions from the exporting and importing countries will be reduced. In relation to the climate change issue, it is therefore important to consider the emissions of CO_2 from Norwegian production and transport of natural gas in relation to the emission reductions achieved from the use of this gas in the receiving countries.

Electricity production in mainland Norway is based almost entirely on hydropower, which does not cause CO_2 emissions. Norway therefore has no opportunity to reduce CO_2 emissions from electricity production, for example by using gas instead of coal. There is limited potential for further development of hydropower production. During the period 1990-1995, Norway was on average a net exporter of electricity (7 TWh per year). Generation of this quantity of electricity in a coal-fired plant of average energy efficiency would cause CO_2 emissions of the order of 5.7 million tonnes (or about 15% of total Norwegian CO_2 emissions in 1995).

The Norwegian electricity market was deregulated with the entry into force of the Energy Act in 1991. Because of growing competition and variation in hydropower production and available water supplies, emissions from electricity production in the Nordic countries vary from year to year. Electricity trade between these countries is likely to increase in the years ahead. It is therefore hard to predict the effects this might have on national greenhouse gas emissions. A study (Nordic Council of Ministers 1995:539) indicates that the total costs of emission reductions in the Nordic countries would be significantly lower if these countries had common goals for emission reductions than if each country were to act alone.

The way in which electricity trade affects greenhouse gas emissions is also dependent on national taxation schemes. To reduce greenhouse gas emissions in a deregulated market, it is important to combine the market with the use of CO_2 taxes so that the polluter-pays-principle can be applied. The coordination of such a system among countries would lower emissions because the competitiveness of clean electricity production would be improved. Without such coordination of taxation, the competitiveness of energy-related industry in each country could be seriously affected.

Norway has a decentralized settlement pattern and a relatively high demand for transport. The decentralized settlement pattern makes public transport systems costly to develop. Though taxes are considered the most cost-effective measure to limit CO_2 emissions from the transport sector, the demand for transport oils is relatively insensitive to price changes. In addition, some transport oils are already heavily taxed.

3. Inventories of anthropogenic greenhouse gas emissions and removals

3.1 Introduction

This section gives an outline of national emissions of greenhouse gases and biotic CO_2 sinks in Norway. The following greenhouse gases are included: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), PFCs (tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6)), sulphur hexafluoride (SF_6) and HFCs (HFC-134a, HFC-125, HFC-143 and HFC-152a). Emission data for precursors (NO_x, CO and NMVOCs) and SO_2 are also given.

The emission figures for 1990-1995 are reported according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines for reporting national greenhouse gas emissions.

3.1.1 Methods of estimation

Statistics Norway (SN) and the Norwegian Pollution Control Authority (SFT) cooperate to provide emission inventories for several air pollutants in Norway. SFT contributes emission factors for all sources and measured emission data from large industrial plants. SN has prepared various emission models based on information from SFT and other industrial and energy statistics. The emission figures for CO_2, CH_4 and N_2O, as well as for NO_x, CO, NMVOCs and SO_2, have been prepared in this way. The methodology is described in two reports: Statistics Norway (1993) and Statistics Norway (1995). Figures for emissions of PFCs, SF_6 and HFCs have been provided by SFT and the methodology is described in SFT (1997). The figures for HFCs are reported as potential emissions equal to the amount of HFCs imported in bulk.

As a general rule, the estimation methods follow the IPCC Guidelines. However, other methods have been used where necessary (SFT, 1997). Greenhouse gas emissions are reported in «Minimum Data Tables» in SFT (1997) where both activity data, emission estimates and aggregated emission factors are given, as recommended by the IPCC.

All CO_2 emissions from gas, coal, coke and petrol coke used as feedstock in industrial sectors such as iron and steel, non-ferrous metals and chemical and petro-chemical industry are included in Industrial Processes (SFT, 1997). It is assumed that all carbon in feedstock used in the production of primary plastic is absorbed in the product. Therefore no CO_2 emissions from this production other than indirect CO_2 from oxidised VOCs are reported.

The carbon in the products will be released if the plastic products are incinerated or oxidised in landfills.

The method of calculating CH_4 emissions from landfills has been changed. In the previous report we included only landfills for municipal waste landfills, whereas this report includes emissions from both municipal waste and landfills for industrial waste. In 1995 the estimated methane emissions from these two types of landfills were approximately 322 000 tonnes.

Calculations of CH_4 emissions are based on several assumptions made by Berdal Strømme (1990) and Det Norske Veritas (DNV 1996). Based upon the composition of solid waste in Norway and a theoretical maximum for production of gas from waste, we have estimated emissions of methane from landfills containing municipal waste at 130 kg/tonne of waste (DNV, 1996) and emissions from industrial waste at 100 kg/tonne. The emission factor for municipal waste is increased since the previous report. A lower emission factor is used for industrial waste because these landfills are smaller and a larger proportion of the waste will therefore undergo aerobic fermentation.

Direct and indirect emissions of CO_2 from landfills are estimated at approximately 15 ktonnes in 1995. Based on DNV (1996) we have assumed that only 1% of the fossil carbon in municipal solid waste is emitted. This is because only a very small part of the fossil carbon is available for oxidation. In addition, the methane emitted is a source of indirect emissions of CO_2, since it is oxidised in the atmosphere. Further, we assume that industrial solid waste in landfills consists of organic waste only.

In accordance with the IPCC Guidelines, emissions from international aviation and marine bunker fuels are not included in the overall Norwegian greenhouse gas inventory. However, the inventory includes emissions from Norwegian-owned coastal traffic, the fishing fleet and offshore oil and gas production activities. In section 3.8 we also present some separate emission data based upon fuel sold to ships in international traffic bunkered in Norwegian harbours and to foreign aeroplanes in international traffic bunkered at Norwegian airports.

Figures for biotic CO_2 sinks have also been provided by SFT (1997). These data include both emissions from fuelwood, wood waste etc. and annual CO_2 accumulation in Norwegian forests. However, in accordance with the IPCC Guidelines, these emissions are not included in the overall Norwegian greenhouse gas inventory.

3.1.2. GWP values used in the Norwegian calculations

The various gases have different capacities for absorbing long-wave radiation and therefore different effects on climate. To make it possible to compare the climatic effects of the various gases, we have presented emissions of greenhouse gases measured as CO_2 equivalents based on data for global warming potential (GWP) from the IPCC Second Assessment Report in 1995.

Table 3.1 Global warming potential (GWP) calculated for a time horizon of 100 years. (Direct GWP for all gases and indirect GWP for methane)

Gas	CO_2	CF_4	C_2F_6	SF_6	HFC-125	HFC-134a	HFC-143a	HFC-152a	CH_4	N_2O
GWP	1	6500	9200	23900	2800	1300	3800	140	21	310

3.2. Total emissions of greenhouse gases.

This section presents an overview of greenhouse gas emissions in Norway from 1990 to 1995. In sections 3.3 to 3.5, more details are presented for each pollutant separately.

Data on emissions of greenhouse gases in Norway in 1990-1995 are given as recommended by the IPCC Guidelines in tables 3.2-3.9. Table 3.2 shows total emission figures for each greenhouse gas and for each year in the period 1989-95 in CO_2 equivalents, using the GWP values quoted in section 3.1.2. Tables 3.3-3.8 summarize national greenhouse gas inventories for 1990-1995. They show emissions of CO_2, CH_4, N_2O, NO_x, CO, NMVOCs and SO_2 by source, based on the «Minimum Data Tables» presented in SFT (1997). Emissions of PFCs, SF_6 and HFCs in 1990-1995 are shown in table 3.9.

The tables show that CO_2 is by far the most important greenhouse gas in Norway, accounting for 70% of total greenhouse gas emissions in 1995. Methane accounted for 18% and nitrous oxide for 8%, while PFCs and SF_6 together contributed about 4%. Consumption of HFCs is so far a minor source in the context of climate change, but as mentioned in section 3.4 their use is expected to increase significantly.

The industry and energy sector is the most important emission source and contributed about 45% of total greenhouse gas emissions. Mobile sources accounted for about 25% of total emissions in 1995.

Table 3.2 Total emissions of the greenhouse gases CO_2, CH_4, N_2O, CF_4, C2F6, SF6, HFC-134a, HFC-152a, HFC-125 and HFC-143a in Norway in the period 1989 to 1995 and percentage changes from 1990 to 1995.

	CO_2 MTONNES	CH_4 KTONNES	N_2O 13 KTONNES	CF_4 TONNES	C_2F_6 TONNES	SF_6 TONNES	HFC-134a TONNES	HFC-152a TONNES	HFC-125 TONNES	HFC-143a TONNES	CO_2-EQU. MTONNES
1989	35.3	429	15	360	16	107	0	3			54.1
1990	35.5	432	15	369	16	92	0	3			54.1
1991	33.9	432	15	313	14	86	1	3			51.7
1992	34.4	438	13	242	11	29	2	3			50.0
1993	35.9	448	14	254	11	30	31	1			52.1
1994	37.8	467	14	231	11	35	40	1	11	4	54.5
1995	37.9	469	14	209	9	24	47	5	31	25	54.4
1990-95	7 %	9 %	-8 %	-43 %	-44 %	-74 %	..	50 %	..	..	1 %

Table 3.3 Summary Report for National Greenhouse Gas Inventories in 1990
Sources according to IPCC draft reporting instructions. 1000 tonnes

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emission	35544	432	15	227	961	299	53
I All Energy (Fuel Combustion + Fugitive)	28698	37	2	217	901	249	27
A Fuel Combustion	26938	16	2	211	900	115	23
1 Energy & Transformation Industries	7444	2	0	21	5	2	1
2 Industry (ISIC)	3023	0	1	7	6	1	7
3 Transport	13885	2	1	179	762	103	11
4 Commercial/Institutional	940	0	0	1	1	0	1
5 Residential	1416	11	0	2	126	9	2
6 Agriculture/Forestry	150	0	0	0	0	0	0
7 Other	80	0	0	0	0	0	0
8 Biomass Burned for Energy							
B Fugitive Fuel Emission	1760	21	0	7	1	134	4
1 Oil and Natural Gas Systems	1722	15	0	7	1	127	4
2 Coal Mining	15	5	0	0	0	NE	NE
3 Distribution of oil products	22	0	0	0	0	7	0
2 Industrial Processes	6514	1	7	10	60	3	27
A Iron and Steel	3019	0	0	7	0	1	12
B Non-Ferrous Metals	1699	0	0	1	20	0	5
C Inorganic Chemicals	1083	1	7	2	40	0	6
D Organic Chemicals	2	0	0	0	0	1	0
E Non-Metallic Mineral products	690	0	0	0	0	0	1
F Other	20	0	0	0	0	1	2
3 Solvent Use	139	0	0	0	0	46	0
A Paint Application	37	-	-	-	-	12	-
B Degreasing and Dry Cleaning	1	-	-	-	-	0	-
C Chemical Products Manufacture/Processing	8	-	-	-	-	3	-
D Other	93	-	-	-	-	31	-
4 Agriculture	180	91	6	0	0	0	0
A Enteric Fermentation	0	76	0	0	0	0	0
B Animal Wastes	0	15	0	0	0	0	0
C Rice Cultivation	NO	NO	NO	NO	NO	NO	NO
D Agricultural Soils	180	NE	6	0	0	0	0
E Agricultural Waste Burning	NE	NE	NE	NE	NE	NE	NE
F Savannah Burning	NO	NO	NO	NO	NO	NO	NO
5 Land Use Change & Forestry							
A Forest Clearing & On-Site Burning of Cleared Forest							
B Grassland Conversion							
C Abandonment of Managed Lands							
D Managed Forests							
6 Waste	14	302	0	0	0	0	0
A Landfills	14	302	0	0	0	NE	NE
B Wastewater	0	0	0	0	0	NE	NE
C Other							

NO = not occurring
NE = not estimated

Table 3.4 Summary Report for National Greenhouse Gas Inventories in 1991
Sources according to IPCC draft reporting instructions. 1000 tonnes

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emission	33870	432	15	225	901	298	45
I All Energy (Fuel Combustion + Fugitive)	27523	37	2	217	853	252	22
A Fuel Combustion	26198	15	2	213	852	110	19
1 Energy & Transformation Industries	7603	2	0	21	5	2	1
2 Industry (ISIC)	2787	0	1	8	6	1	6
3 Transport	13603	2	1	181	728	100	10
4 Commercial/Institutional	838	0	0	1	1	0	1
5 Residential	1164	10	0	2	112	8	1
6 Agriculture/Forestry	130	0	0	0	0	0	0
7 Other	73	0	0	0	0	0	0
8 Biomass Burned for Energy							
B Fugitive Fuel Emission	1325	22	0	4	1	142	2
1 Oil and Natural Gas Systems	1281	16	0,007	4	1	135	2
2 Coal Mining	16	6	0	0	0	NE	NE
3 Distribution of oil products	27	0	0	0	0	7	0
2 Industrial Processes	6024	1	6	8	49	3	23
A Iron and Steel	2716	0	0	6	0	1	10
B Non-Ferrous Metals	1677	0	0	1	18	0	5
C Inorganic Chemicals	961	1	6	2	31	0	5
D Organic Chemicals	3	0	0	0	0	1	0
E Non-Metallic Mineral products	646	0	0	0	0	0	1
F Other	20	0	0	0	0	1	2
3 Solvent Use	128	0	0	0	0	43	0
A Paint Application	31	-	-	-	-	10	-
B Degreasing and Dry Cleaning	1	-	-	-	-	0	-
C Chemical Products Manufacture/Processing	10	-	-	-	-	3	-
D Other	85	-	-	-	-	28	-
4 Agriculture	182	93	6	0	0	0	0
A Enteric Fermentation	0	77	0	0	0	0	0
B Animal Wastes	0	16	0	0	0	0	0
C Rice Cultivation	NO	NO	NO	NO	NO	NO	NO
D Agricultural Soils	182	NE	6	0	0	0	0
E Agricultural Waste Burning	NE	NE	NE	NE	NE	NE	NE
F Savannah Burning	NO	NO	NO	NO	NO	NO	NO
5 Land Use Change & Forestry							
A Forest Clearing & On-Site Burning of Cleared Forest							
B Grassland Conversion							
C Abandonment of Managed Lands							
D Managed Forests							
6 Waste	14	301	0	0	0	0	0
A Landfills	14	301	0	0	0	NE	NE
B Wastewater	0	0	0	0	0	NE	NE
C Other							

NO = not occurring
NE = not estimated

Table 3.5 Summary Report for National Greenhouse Gas Inventories in 1992
Sources according to IPCC draft reporting instructions. 1000 tonnes

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emission	34420	438	13	216	870	323	37
I All Energy (Fuel Combustion + Fugitive)	28225	42	2	209	823	277	19
A Fuel Combustion	26924	15	2	205	823	108	16
1 Energy & Transformation Industries	8432	3	0	24	5	2	1
2 Industry (ISIC)	2625	0	1	7	6	1	5
3 Transport	13812	2	1	172	702	97	8
4 Commercial/Institutional	803	0	0	1	1	0	1
5 Residential	981	10	0	2	109	8	1
6 Agriculture/Forestry	115	0	0	0	0	0	0
7 Other	157	0	0	0	0	0	0
8 Biomass Burned for Energy							
B Fugitive Fuel Emission	1301	27	0	4	0	169	2
1 Oil and Natural Gas Systems	1262	20	0	4	0	162	2
2 Coal Mining	18	6	0	0	0	NE	NE
3 Distribution of oil products	21	0	0	0	0	7	0
2 Industrial Processes	5870	1	4	7	46	3	18
A Iron and Steel	2592	0	0	5	0	1	7
B Non-Ferrous Metals	1667	0	0	1	14	0	4
C Inorganic Chemicals	969	1	4	1	32	0	5
D Organic Chemicals	3	0	0	0	0	1	0
E Non-Metallic Mineral products	621	0	0	0	0	0	0
F Other	18	0	0	0	0	1	1
3 Solvent Use	129	0	0	0	0	43	0
A Paint Application	31	-	-	-	-	10	-
B Degreasing and Dry Cleaning	1	-	-	-	-	0	-
C Chemical Products Manufacture/Processing	9	-	-	-	-	3	-
D Other	88	-	-	-	-	29	-
4 Agriculture	183	95	6	0	0	0	0
A Enteric Fermentation	0	79	0	0	0	0	0
B Animal Wastes	0	16	0	0	0	0	0
C Rice Cultivation	NO	NO	NO	NO	NO	NO	NO
D Agricultural Soils	183	NE	6	0	0	0	0
E Agricultural Waste Burning	NE	NE	NE	NE	NE	NE	NE
F Savannah Burning	NO	NO	NO	NO	NO	NO	NO
5 Land Use Change & Forestry							
A Forest Clearing & On-Site Burning of Cleared Forest							
B Grassland Conversion							
C Abandonment of Managed Lands							
D Managed Forests							
6 Waste	14	301	0	0	0	0	0
A Landfills	14	301	0	0	0	NE	NE
B Wastewater	0	0	0	0	0	NE	NE
C Other							

NO = not occurring
NE = not estimated

Table 3.6 Summary Report for National Greenhouse Gas Inventories in 1993
Sources according to IPCC draft reporting instructions. 1000 tonnes

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emission	35889	448	14	225	853	351	35
I All Energy (Fuel Combustion + Fugitive)	29427	46	2	217	809	306	16
A Fuel Combustion	27964	17	2	213	808	108	14
1 Energy & Transformation Industries	8838	3	0	25	6	2	1
2 Industry (ISIC)	2870	0	1	8	7	1	4
3 Transport	14307	2	1	177	662	95	7
4 Commercial/Institutional	796	0	0	1	1	0	1
5 Residential	940	12	0	2	134	9	1
6 Agriculture/Forestry	111	0	0	0	0	0	0
7 Other	101	0	0	0	0	0	0
8 Biomass Burned for Energy							
B Fugitive Fuel Emission	1463	29	0	4	1	198	2
1 Oil and Natural Gas Systems	1430	24	0	4	1	191	2
2 Coal Mining	13	5	0	0	0	NE	NE
3 Distribution of oil products	20	0	0	0	0	7	0
2 Industrial Processes	6138	1	5	8	44	3	19
A Iron and Steel	2637	0	0	6	0	1	10
B Non-Ferrous Metals	1537	0	0	1	9	0	2
C Inorganic Chemicals	1111	1	5	1	35	0	5
D Organic Chemicals	3	0	0	0	0	1	0
E Non-Metallic Mineral products	832	0	0	0	0	0	1
F Other	18	0	0	0	0	1	1
3 Solvent Use	126	0	0	0	0	42	0
A Paint Application	31	-	-	-	-	10	-
B Degreasing and Dry Cleaning	0	-	-	-	-	0	-
C Chemical Products Manufacture/Processing	22	-	-	-	-	7	-
D Other	73	-	-	-	-	24	-
4 Agriculture	183	93	6	0	0	0	0
A Enteric Fermentation	0	78	0	0	0	0	0
B Animal Wastes	0	16	0	0	0	0	0
C Rice Cultivation	NO	NO	NO	NO	NO	NO	NO
D Agricultural Soils	183	NE	6	0	0	0	0
E Agricultural Waste Burning	NE	NE	NE	NE	NE	NE	NE
F Savannah Burning	NO	NO	NO	NO	NO	NO	NO
5 Land Use Change & Forestry							
A Forest Clearing & On-Site Burning of Cleared Forest							
B Grassland Conversion							
C Abandonment of Managed Lands							
D Managed Forests							
6 Waste	14	308	0	0	0	0	0
A Landfills	14	308	0	0	0	NE	NE
B Wastewater	0	0	0	0	0	NE	NE
C Other							

NO = not occurring
NE = not estimated

Table 3.7 Summary Report for National Greenhouse Gas Inventories in 1994
Sources according to IPCC draft reporting instructions. 1000 tonnes

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emission	37785	467	14	222	864	365	34
I All Energy (Fuel Combustion + Fugitive)	30835	50	3	213	816	315	15
A Fuel Combustion	29275	20	3	209	816	107	13
1 Energy & Transformation Industries	9359	3	0	27	6	2	1
2 Industry (ISIC)	3523	0	1	9	6	1	5
3 Transport	14255	2	1	169	644	92	5
4 Commercial/Institutional	930	0	0	1	1	0	1
5 Residential	922	14	0	2	159	11	1
6 Agriculture/Forestry	137	0	0	0	0	0	0
7 Other	148	0	0	0	0	0	0
8 Biomass Burned for Energy							
B Fugitive Fuel Emission	1559	30	0	4	1	208	2
1 Oil and Natural Gas Systems	1525	24	0	4	1	202	2
2 Coal Mining	15	5	0	0	0	NE	NE
3 Distribution of oil products	20	0	0	0	0	7	0
2 Industrial Processes	6615	1	5	9	48	3	20
A Iron and Steel	3053	0	0	6	0	2	10
B Non-Ferrous Metals	1632	0	0	1	9	0	2
C Inorganic Chemicals	1045	1	5	2	39	0	5
D Organic Chemicals	2	0	0	0	0	1	0
E Non-Metallic Mineral products	865	0	0	0	0	0	1
F Other	18	0	0	0	0	1	1
3 Solvent Use	140	0	0	0	0	47	0
A Paint Application	36	-	-	-	-	12	-
B Degreasing and Dry Cleaning	IE	-	-	-	-	IE	-
C Chemical Products Manufacture/Processing	20	-	-	-	-	7	-
D Other	83	-	-	-	-	28	-
4 Agriculture	183	97	6	0	0	0	0
A Enteric Fermentation	0	81	0	0	0	0	0
B Animal Wastes	0	16	0	0	0	0	0
C Rice Cultivation	NO	NO	NO	NO	NO	NO	NO
D Agricultural Soils	183	NE	6	0	0	0	0
E Agricultural Waste Burning	NE	NE	NE	NE	NE	NE	NE
F Savannah Burning	NO	NO	NO	NO	NO	NO	NO
5 Land Use Change & Forestry							
A Forest Clearing & On-Site Burning of Cleared Forest							
B Grassland Conversion							
C Abandonment of Managed Lands							
D Managed Forests							
6 Waste	12	319	0	0	0	0	0
A Landfills	12	318	0	0	0	NE	NE
B Wastewater	0	0	0	0	0	NE	NE
C Other							

NO = not occurring
NE = not estimated

Table 3.8 Summary Report for National Greenhouse Gas Inventories in 1995
Sources according to IPCC draft reporting instructions. 1000 tonnes

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emission	37880	469	14	222	829	378	35
I All Energy (Fuel Combustion + Fugitive)	30578	50	2	214	779	330	14
A Fuel Combustion	28854	20	2	209	779	102	12
1 Energy & Transformation Industries	9059	3	0	27	6	2	1
2 Industry (ISIC)	3220	0	1	9	6	1	4
3 Transport	14578	2	1	171	607	88	5
4 Commercial/Institutional	877	0	0	1	1	0	0
5 Residential	872	14	0	2	159	11	1
6 Agriculture/Forestry	142	0	0	0	0	0	0
7 Other Oil test drilling off-shore	107	0	0	0	0	0	0
8 Biomass Burned for Energy							
B Fugitive Fuel Emission	1724	30	0	5	1	227	2
1 Oil and Natural Gas Systems	1690	25	0	5	1	221	2
2 Coal Mining	14	5	0	0	0	NE	NE
3 Distribution of oil products	19	0	0	0	0	6	0
2 Industrial Processes	6969	1	5	8	50	3	20
A Iron and Steel	3247	0	0	6	0	2	10
B Non-Ferrous Metals	1598	0	0	1	10	0	2
C Inorganic Chemicals	1263	1	5	1	40	0	6
D Organic Chemicals	2	0	0	0	0	1	0
E Non-Metallic Mineral products	841	0	0	0	0	0	1
F Other	18	0	0	0	0	1	1
3 Solvent Use	134	0	0	0	0	45	0
A Paint Application	36	-	-	-	-	12	-
B Degreasing and Dry Cleaning	IE	-	-	-	-	IE	-
C Chemical Products Manufacture/Processing	26	-	-	-	-	9	-
D Other	72	-	-	-	-	24	-
4 Agriculture	183	96	6	0	0	0	0
A Enteric Fermentation	0	80	0	0	0	0	0
B Animal Wastes	0	16	0	0	0	0	0
C Rice Cultivation	NO	NO	NO	NO	NO	NO	NO
D Agricultural Soils	183	NE	6	0	0	0	0
E Agricultural Waste Burning	NE	NE	NE	NE	NE	NE	NE
F Savannah Burning	NO	NO	NO	NO	NO	NO	NO
5 Land Use Change & Forestry							
A Forest Clearing & On-Site Burning of Cleared Forest							
B Grassland Conversion							
C Abandonment of Managed Lands							
D Managed Forests							
6 Waste	15	322	0	0	0	0	0
A Landfills	15	322	0	0	0	NE	NE
B Wastewater	0	0	0	0	0	NE	NE
C Other							

NO = not occurring
NE = not estimated

Table 3.9 Emissions of PFCs, SF_6 and HFCs in Norway by source categories. 1990-1995. Tonnes.

	1990	1991	1992	1993	1994	1995
Aluminium production						
- CF_4	369	313	242	254.3	230.5	208.5
- C_2F_6	16	14	10.7	11.2	10.5	8.9
- SF_6	NE	NE	3.1	6	10	3.6
Magnesium production						
- SF_6	89.4	84	22.8	21.6	22.8	17.4
Other emission sources						
- SF_6 from secondary smelters	0.3	0.5	0.8	0.2	0.2	0.2
- SF_6 from GIS 145-420 kV	1.6	1.6	1.9	2.0	2.0	2.0
- SF_6 from GIS 12-24 kV	0.2	0.3	0.3	0.4	0.4	0.4
Use of HFCs [1]						
- HFC-134a	0	1	2.2	31.2	39.7	46.9
- HFC-143a	0	0	0	0	4	25.2
- HFC-152a	3	3	3	1	1.1	4.5
- HFC-125	0	0	0	0	10.6	31.1
- HFC-23	0	0	0	0	0.1	0.03

[1] Chemicals imported in bulk (potential emissions).
NE = not estimated
GIS = gas-insulated switchgear

3.3 Emissions of CO_2, CH_4 and N_2O

3.3.1 Emissions of CO_2

In 1995, Norwegian emissions of CO_2 totalled about 37.9 million tonnes. This corresponds to 8.9 tonnes CO_2 per capita. In 1995, the largest CO_2 emissions were from stationary combustion, including the offshore industry (40%) and mobile sources (39%). Gas turbines offshore accounted for 16% of Norwegian emissions of CO_2. Road traffic contributed about 22%, while coastal traffic and fishing accounted for 9%. Industrial processes, i.e. production of metals, carbides, cement etc., constituted 21% of total CO_2 emissions.

From 1990 to 1991, CO_2 emissions were reduced by about 5%, primarily because of a reduction in the consumption of petrol and fuel oils and reduced production of metals. In addition to the CO_2 tax, which was implemented with effect from 1991, the ample supply of hydroelectric power and low economic activity contributed to this trend. From 1991 to 1995, CO_2 emissions increased by 12%. This is mainly explained by increased oil and gas production and transport in addition to higher emissions from diesel vehicles and coastal traffic. The preliminary figure for emissions of CO_2 in 1996 is about 41 million tonnes which is 7.5% higher than in 1995. This increase is explained by a considerable increase in the consumption of fuel oil stimulated by an increase in electricity prices through 1996, a further increase in oil and gas production and a further increase in emissions from diesel vehicles and coastal traffic.

3.3.2 Emissions of methane

In 1995, Norwegian methane emissions were about 470 000 tonnes. The dominant sources of methane emissions are landfills (69%) and domestic animals (21%). Methane emissions from oil and gas production are relatively small in Norway compared to other countries which produce large amounts of oil and gas, and account for only 6% of the total. The main reason for this is low levels of venting.

Total methane emissions probably more than doubled during the period 1950-90. From 1990 to 1995, emissions of CH_4 increased by about 9%.

3.3.3 Emissions of nitrous oxide

Norwegian anthropogenic emissions of nitrous oxide in 1995 have been estimated at about 14 000 tonnes. There is a large degree of uncertainty in this estimate, especially as regards emissions from soil. The calculations indicate that emissions from the use of nitrogenous fertiliser and manure account for almost 45% of the total and the production of nitric acid for about 37%.

From 1990 to 1995, emissions of N_2O were reduced by 8% mainly because of improved production processes and lower production of nitric acid.

3.4 Emissions of other greenhouse gases (PFCs, SF_6 and HFCs)

3.4.1 Emissions of PFCs

Perfluorocarbons (PFCs), e.g. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), are greenhouse gases with a very high global warming potential in addition to an exceptionally long atmospheric lifetime. Perfluorocarbons are primarily formed during aluminium production, and since Norway is a major aluminium producer it seemed likely that PFC emissions would also be high. However, the emissions per tonne of aluminium from Norwegian production plants occur to be much smaller than those reported from other countries.

On the basis of photoacoustic measurements carried out in 1992 by aluminium producers, emissions of PFCs (CF_4 + C_2F_6) in 1995 have been calculated to about 218 tonnes. Around 4% of the PFC emissions is estimated to be hexafluoroethane (C_2F_6), and the remainder is tetrafluoromethane (CF_4). From 1990 to 1995, emissions were reduced by 43%. This is explained by a reduction in emissions per produced unit from about 0.6 to 0.3 kg PFCs per tonne aluminium during the past 7-10 years. This is a result of improved process control and thereby reduced frequency of anode effects. PFCs are mainly produced from anode effects.

3.4.2 Emissions of sulphur hexafluoride (SF_6)

Sulphur hexafluoride is another very potent greenhouse gas with a very high global warming potential. The use of SF_6 as a cover gas in magnesium production accounts for a large proportion of consumption. Emissions in 1995 are estimated at 24 tonnes, and emissions were reduced by 74% from 1990 to 1995. The reduction in consumption of SF_6, and in the corresponding emissions, has been caused by changes in types of products manufactured and in production procedures.

Emissions of SF_6 were considerably reduced from 1987 to 1995, and emissions in 1986-87 were 10 times higher than in 1992.

3.4.3 Emissions of HFCs

HFCs are halogenized carbon compounds that do not contain bromine or chlorine. HFCs are used in cooling installations and are very much in focus as substitute materials for CFCs, HCFCs and halons. Consumption is modest at present, but is expected to increase as CFCs and HCFCs are phased out. Consumption increased from approximately 3 tonnes in 1990 to 108 tonnes in 1995 and these quantities correspond to 0.45% of total emissions of CO_2 equivalents in Norway in 1995. The most important HFCs are HFC-134a, HFC-125 and HFC-143a.

3.5 Emissions of precursors (CO, NO_x and NMVOCs) and SO_2

Precursors are gases, e.g. NO_x, CO and NMVOCs, which have an indirect effect on the climate through their influence on other greenhouse gases, especially ozone. Emissions of NO_x, CO and NMVOCs from 1990 to 1995 are shown in tables 3.3-3.8, according to the source categories defined in the IPCC Guidelines.

Mobile sources make the most important contribution to emissions of all these pollutants, especially as regards CO and NO_x. Oil and gas production, particularly loading crude oil to ships, is an important source of NMVOCs in Norway. From 1990 to 1995 emissions of NO_x and CO decreased by approximately 2% and 14% respectively, mainly because of new emission standards for motor vehicles. Emissions of NMVOCs increased by 27% from 1990 to 1995 in spite of reduced emissions from road traffic as a result of the introduction of private cars with three-way catalytic converters. The increase in the total NMVOC emissions is explained by a rise in oil production.

Emissions of SO_2 were reduced by 35% in the period 1990-1995. This is mainly explained by a reduction in the sulphur content of all oil products and lower process emissions from ferro-alloy and aluminium production and refineries.

3.6 Emissions of CO_2 equivalents

Total emissions of greenhouse gases given as CO_2 equivalents, using the GWP values quoted in section 3.1.2, were in 1995 about 54 million tonnes, (see table 3.2). In 1990-1992 emissions were about 8% lower, mainly because of a reduction in SF_6 and CF_4 emissions and a temporary reduction in CO_2 emissions. From 1992 to 1995 total emissions returned to the same level as in 1990 as a result of higher CO_2 emissions. Thus, in CO_2 equivalents the total emissions of greenhouse gases in 1995 were at the same level as in 1990, (see table 3.2).

3.7 CO_2 sinks

The net anthropogenic sink of CO_2 in the forest in Norway in 1995 is estimated at 13.6 million tonnes (see table 3.10), equivalent to about one third of total emissions of CO_2 in Norway in 1995. The yearly net sink of CO_2 increased by about 4.2 million tonnes in the period 1990-1995. This means that when the increase in yearly forest sink is included, Norway's total atmospheric emission of greenhouse gases was lower in 1995 than in 1990.

This annual accumulation occurs mainly because the annual increments in the standing volume in Norwegian forests is larger than the sum of CO_2 emissions from wood harvested for industrial use and fuel. The net uptake of CO_2 in forest soil and sedimentation of carbon in fresh water and estuaries are not included. The methods of calculation are described in SFT (1997).

Harvesting the forest has a long tradition in Norway, and up to the beginning of this century the annual harvest was larger than the gross increments. Since then there has been an increase in the standing volume of Norwegian forests. The estimate of the standing volume (i.e. trunk volume without bark) is based on annual surveys of main forest areas and estimates for marginal forest made by the Norwegian Forest Research Institute (NISK). These show that roots, stumps, branches and bark contain only about half as much carbon as tree trunks (NISK 1991). Most of the branches and tops, stumps and roots are left in the forest and decay at varying rates. Part of the trunks and bark used pulp and paper industry is burned for energy, and the carbon is released during the same year, while the carbon in sawmill products may be confined for many years.

This difference in lifetime are not taken into account when estimating emissions for one year. All carbon is assumed to be emitted in the year when the biomass is harvested. The error introduced by this assumption is small within one year but may be significant when summed over decades. Export and import of wood have not been taken into account.

Table 3.10 Managed Forests 1995. Increments and harvest)

Source and sink categories	Emissions/ Removals estimates
Increments	Carbon dioxide emissions (1000 tonnes CO_2)
Annual gross increments of roundcut wood	-31 267
Harvest commercial timber	11 007
Fuelwood	4 261
Other: Natural decay	2 361
Net CO_2 emissions	-13 637

3.8 International aviation and marine bunker fuels

In accordance with the IPCC Guidelines, emissions from international aviation and marine bunker fuels are not included in the overall Norwegian greenhouse gas inventory, but are presented separately.

In 1995, CO_2 emissions from ships and aircraft in international traffic and bunkered in Norway amounted to 2.3 million tonnes, corresponding to about 6% of total Norwegian CO_2 emissions, (see table 3.11). Emissions of NO_x were 42 400 tonnes or 19% of all Norwegian NO_x emissions. From 1990 to 1995, CO_2 emissions from ships in international traffic and bunkered in Norway rose by 33% and NO_x emissions by about 40%, whereas emissions from international aviation have been more or less stable in this period.

Emissions of N_2O, CH_4 and NMVOCs from international aviation and marine bunker fuels are small compared to total Norwegian emissions of these gases.

Table 3.11 Emissions of CO_2, N_2O, CH_4, NMVOCs, NO_X and CO from ships and aircraft in international traffic bunkered in Norway. 1990-1995. (1000 tonnes unless otherwise specified). Source: SN and SFT.

	CO_2 1)	N_2O	CH_4	NMVOC	NO_X	CO
1990	**1.8**	**0.0**	**0.1**	**1.2**	**30.6**	**2.0**
International shipping	1.5	0.0	0.1	1.1	29.9	1.4
International aviation	0.3	0.0	0.0	0.1	0.7	0.6
1991	**1.4**	**0.0**	**0.1**	**1.0**	**26.3**	**1.8**
International shipping	1.2	0.0	0.1	0.9	25.6	1.2
International aviation	0.2	0.0	0.0	0.1	0.7	0.6
1992	**1.9**	**0.0**	**0.1**	**1.3**	**32.7**	**2.1**
International shipping	1.6	0.0	0.1	1.2	32.0	1.5
International aviation	0.3	0.0	0.0	0.1	0.7	0.6
1993	**2.0**	**0.0**	**0.1**	**1.4**	**35.1**	**2.3**
International shipping	1.7	0.0	0.1	1.3	34.3	1.6
International aviation	0.3	0.0	0.0	0.1	0.8	0.7
1994	**2.1**	**0.0**	**0.1**	**1.5**	**38.3**	**2.5**
International shipping	1.8	0.0	0.1	1.4	37.5	1.8
International aviation	0.3	0.0	0.0	0.1	0.8	0.7
1995	**2.3**	**0.1**	**0.1**	**1.6**	**42.4**	**2.7**
International shipping	2.0	0.1	0.1	1.5	41.6	2.0
International aviation	0.3	0.0	0.0	0.1	0.8	0.7

1) Million tonnes.

4. Policies and measures

4.1 Overall policy context

Norway's climate policy is founded on the objective of the Climate Convention and the scientific understanding of the greenhouse effect set out in the reports from the UN Intergovernmental Panel on Climate Change (IPCC). An important principle of the Norwegian climate policy is that all policies and measures, at both national and international level, should be based on a comprehensive approach and be as cost-effective as possible. Coordinated international efforts and the development of international economic measures are essential in dealing with the greenhouse effect.

Norway ratified the Climate Convention on 9 July 1993. As the Convention is further developed, Norway will continue to advocate the need for new and more binding commitments, as well as flexible mechanisms for their implementation. There should be a special focus on the period beyond year 2000 to ensure the development of policies in accordance with the objective of the Convention to stabilize the greenhouse gas concentrations in the atmosphere «at a level that would prevent dangerous anthropogenic interference with the climate system».

On 2 June 1995, the Government submitted Report to the Storting No. 41 (1994-95) on «Norwegian policy to mitigate climate change and reduce emissions of nitrogen oxides (NO_x)». This report contains a complete account of Norway's climate policy, addressing all relevant greenhouse gases and economic sectors in accordance with the guiding principles of the Convention. Relevant economic and administrative measures consistent with the Government's overall economic strategy were considered with the aim of finding cost-effective ways of limiting the emissions of greenhouse gases in all sectors. Taxes are still the most important means of limiting CO_2 emissions. The authorities will try to find new means of limiting emissions of greenhouse gases, including agreements with various branches of industry. Talks with the industrial sector have begun with the aim of reducing emissions that are exempt from the CO_2 tax. On the basis of practical experience of this process, the Government will evaluate whether other instruments should be applied, e.g. direct regulation or taxation.

Norway appointed a Green Tax Commission in 1992 as part of its efforts to follow up the report of the World Commission on Environment and Development. On the Storting's recommendation, a second Green Tax Commission was appointed in 1994. The Commission published its recommendations in NOU 1996:9 «Policies for a Better Environment and High Employment». The key question for the Commission was how to achieve a long-term path of development that results in a more efficient economy, a better environment and a higher employment. The follow up of the Commission's report will be presented to the Storting later this year in the annual bill on tax rates for 1998.

The Government's Long-term Programme for 1998-2001 gives high priority to climate and environmental policies. It is recognized as an aim to limit the expected growth in national energy use. Furthermore, the Long-term Programme establishes the aim that domestic use of electricity in a normal year shall be based on renewable energy sources. This implies enhanced efforts in the field of energy efficiency and in energy production in order to increase energy conservation and the share of new renewable energy sources such as bioenergy in the Norwegian energy supply system. In spring 1997, the Government will submit a Report to the Storting on environmental policies for a sustainable development that will give a more comprehensive overview of future action in the field of climate and energy as a follow up of the Long-term Programme.

4.2 CO_2 emissions

4.2.1 Cross sectoral

The Norwegian CO_2 tax scheme

Norway has for a number of years been at the forefront in introducing economic instruments to enhance the efficiency of environmental policies, with an emphasis on curbing emissions to air. Norway is one of the few countries who have so far introduced CO_2 taxes, and the overall tax level on fossil fuels is considerably higher than in most other countries. Experience of the use of CO_2 taxes in Norway is positive, but closer coordination between countries will be necessary to enhance the effect and extend the application of such schemes.

The Norwegian environmental tax system consists primarily of product taxes, which in many instances may be a suitable approximation to emission taxes, e.g. for emissions of CO_2, SO_2 and lead. These emission components are already included in the current Norwegian product-tax system for fossil fuels.

Both the petrol and the mineral oil tax contain a CO_2 element. It should be emphasised that Norwegian retail prices for petrol and mineral oil are among the highest in the world, as a result of the high tax levels, (see table 4.1). A CO_2 tax has also been introduced for gas and diesel combustion on the continental shelf and for certain uses of coal and coke. About 60% of national CO_2 emissions are currently subject to such taxes.

Table 4.1: Tax rates for petroleum products (NOK/1), gas (NOK/Sm^3) and coal and coke (NOK/kg)

	Basic Tax	CO_2 Tax	SO_2 Tax	Total	CO_2 tax per tonne CO_2 emitted
Unleaded petrol	4.02	0.87		4.89	376
Leaded petrol (< 0,05g/l lead)	4.26	0.87		5.13	376
Leaded petrol (> 0,05g/l lead)	4.76	0.87		5.63	376
Auto diesel	3.35	0.435		3.785	164
Light mineral oil	0	0.435	0-0.07[4]	0.435-0.505	164
Heavy mineral oil	0	0.435	0.14-0.70[4]	0.575-1.135	140
Diesel, North Sea	0	0.87		0.87	328
Gas, North Sea	0	0.87		0.87	373
Coal	0	0.435		0.435	179
Coke	0	0.435		0.435	136

Table 4.2: CO_2 taxes on petroleum products from 1991-1997 (NOK/1), gas (NOK/Sm^3)

	From	From	From	From	From	From 1.1.95	From	From

[4] *The tax rate is 0.07 NOK per 0.25% sulphur content.*

	1.1.91	1.1.92	1.7.92	1.1.93	1.1.94[5]		1.1.96	1.1.97
Petrol	0,60	0,80			0,82	0,83	0,85	0,87
Mineral oil[6]	0,30			0,40	0,41	0,415	0,425	0,435
Gas, North Sea	0,60	0,80			0,82	0,83	0,85	0,87
Oil, North Sea	0,60	0,80			0,82	0,83	0,85	0,87
Coal and coke			0,30	0,40	0,41	0,415	0,425	0,435

Table 4.1 shows tax rates for petroleum products, gas, coal and coke as of 1 January 1997. Table 4.2 shows how CO_2 tax rates on petroleum products, gas, coal and coke have been increased during the last years.

Exemptions from the CO_2 tax

Petrol: The petrol tax (basic tax and CO_2 tax) is levied on practically all domestic petrol use.

Mineral oil: Certain sectors exposed to international competition are exempted from the CO_2 tax and the SO_2 tax. The most important exemptions concern the consumption of mineral oil products in air transport, ships engaged in foreign trade, the supply fleet in the North Sea and fishing in distant waters. Through reimbursement schemes fuel consumption in coastal fishing and in coastal goods transport is virtually untaxed. Fuel consumption in coastal passenger transport is taxed at the full rate. Moreover, the pulp and paper industry and the herring meal industry pay a reduced CO_2 tax of 0.2175 NOK/l.

Onshore use of natural gas: Not taxed.

Coal and coke: The CO_2 tax is not levied on coal and coke used as a reducing agent or as raw material in industrial processes. These processes account for nearly 90% of all CO_2 emissions from coal and coke in Norway. In addition coal and coke used for energy purposes in the production of cement and LECA lightweight concrete are exempted.

Norwegian experience of carbon taxes

CO_2 emissions in Norway dropped by about 5% from 1989 to 1991 (mainly as a result of reductions in petrol consumption and metal production during an economic recession), and subsequently increased again, reaching the 1989 level in 1993. From 1993 to 1995 the emissions further increased by 5%. Although this partly reflects cyclical developments in the Norwegian economy and variations in weather conditions, the underlying trend is significantly different from the steady increase that was expected to continue into the 1990s. In addition to the CO_2 tax, which was implemented with effect from 1991, the ample supply of hydropower and low economic activity have contributed to this development. The main increase since 1991 has been in emissions from the petroleum industry as production and export of oil and natural gas increased. In addition, emissions from diesel vehicles and coastal traffic rose. The preliminary figure for emissions of CO_2 in 1996 is about 41 million tonnes, which is 7,5% higher than in 1995. This increase is explained by a considerable increase in consumption of fuel oil stimulated by an increase in electricity prices through 1996, a further increase in oil and gas production and a further increase in emissions from diesel vehicles and coastal traffic.

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[5] *From 1.1.94 the only changes has been adjustments for inflation.*

[6] *From 1.1.91 the CO_2 tax was levied in addition to an already established fiscal duty of 0.32 NOK/litre. The fiscal duty was reduced to 0.17 NOK from 1.7.92 and to zero from 1.1.93.*

From 1970 to 1990 the consumption of petrol nearly doubled, and both the price and tax level in real terms were slightly lower in 1990 than at the beginning of the 1970s. Until the late 1980s the petrol tax was not deliberately used by the authorities to limit growth in consumption of petrol. Throughout the period, however, the tax level has been relatively high. It may therefore be assumed that petrol consumption and emissions after 1970 would have been substantially higher without a petrol tax or with a lower tax level. From 1990 to 1995 there was a steady decrease in national petrol consumption and the consumption in 1996 was about the same as in 1995. The introduction of the CO_2 tax has been one contributory factor, but it is difficult to precisely estimate the exact effect of the tax. It should also be mentioned that during the same period the consumption of auto diesel, which is taxed at a lower rate, has risen.

The real price for most mineral oil products was about the same in 1996 as in the mid-1980s, but lower than at the beginning of the 1980s. The periodic fluctuations in consumption seem to be related to fluctuations in real prices for heating oils and trends in changes in relative prices for heating oils and electricity.

The CO_2 taxes introduced on 1 January 1991 are high compared to similar taxes that have been introduced or proposed in other countries. The development of Norwegian CO_2 taxes illustrates the problems a small open economy faces in being at the forefront of efforts to introduce efficient instruments designed at limiting global environmental problems. A lack of international implementation and coordination of such instruments may lead to leakage effects, and this in turn may mean that a country incurs substantial costs in achieving a given reduction in national emissions. Such leakage effects will mean that the contribution to global reductions is less than the national reduction. However, due to the careful design of the CO_2 tax system, the competitive position of the Norwegian industries has not been significantly affected.

A study by Statistics Norway indicates that during the period 1991-1993, emissions from sources covered by the study (households, transport and stationary sources) may have been 3-4% lower than they would have been without the CO_2 tax applied. In addition to this reduction, the emissions per unit produced from production and transport of oil and gas have been reduced as a result of the CO_2 tax. The CO_2 tax contributes to a reduction in emissions through several mechanisms:

- reduced demand for fossil fuels because of higher prices relative to those of other goods
- changes in the sectoral composition of the economy
- changes in energy intensity
- changes in the energy mix

The influence of the CO_2 tax on various sectors will depend on how energy-intensive and energy-efficient they are. The sectoral composition of the economy may therefore shift towards less energy-intensive sectors as a result of the CO_2 tax. Technological changes may also be accelerated as a result of the CO_2 tax, thus contributing to lower emissions. The CO_2 tax may also contribute to a switch in the fuel mix towards energy carriers with lower or no carbon content.

Energy policy and energy efficiency

The Energy Act that entered into force on 1 January 1991 established general terms and conditions designed to ensure more efficient utilisation of hydropower. It has brought about deregulation and keener competition in the power sector, and the power market has changed substantially since its introduction. From 1991 to 1996 growing competition led to a reduction in power prices for several categories of customers. However, in 1996 the extremely low degree of filling of the reservoirs led to steep price increases in the spot market. This increased the price for end users significantly.

In 1993 Norway introduced a change in its energy efficiency policy based on Report to the Storting No. 41 (1992-93). The main recommendations given in the report have now been implemented (see section 4.2.5).

4.2.2 Energy and transformation industries

Electricity production on the mainland
Almost all electricity generated in Norway is hydropower and nearly all emissions of CO_2 from electricity production are generated by the offshore petroleum production. A Norwegian (Naturkraft AS) is, however, in the process of licencing for two 350 MW gas-fired power stations.

Offshore petroleum sector
Greenhouse gas emissions from this sector are mainly connected to energy production by gas turbines. Flaring is the second most important source of emissions offshore.

The CO_2 tax has raised awareness of environmental issues in the petroleum industry and given stronger incentives to develop more energy-efficient technologies. The CO_2 tax applies to flaring and burning of natural gas and diesel in the petroleum sector. The tax rate is currently 0.87 NOK/Sm^3 and 0.87 NOK/litre respectively (see table 4.1). Flaring is only allowed for safety purposes and is regulated by emission permits issued by the Norwegian Petroleum Directorate.

Development of more efficient gas turbines is the single most important means of reducing emissions of CO_2 from oil and gas production. The petroleum industry has made substantial efforts in this area - and results. One example of the progress made in this respect is the Ekofisk field, where new gas turbines and infrastructure are expected to reduce CO_2 emissions by about 40%.

Another recent development is the installation of equipment on the Sleipner field to separate CO_2 from the well stream and re-inject it under the sea bed. This solution is expected to reduce emissions with 0.8 million tonnes CO_2 yearly. In addition, new technology introduced on some fields can reduce flaring, and thus emissions, significantly.

In 1995, the Ministry of Industry and Energy appointed a committee (MILJØSOK) with the objective to ensure that extraction, transport and processing of oil and gas in the Norwegian petroleum sector meet the highest possible environmental standards. The committee included members from the petroleum industry, the authorities as well as research and conservation groups. In a report submitted to the Ministry of Petroleum and Energy in December 1996, the committee established the goal of reducing CO_2 emissions per kWh produced from the petroleum sector by 30-40% within 15 years, provided that certain assumptions are fulfilled.

4.2.3 Transport

CO_2 taxes

The CO_2 tax is the main instrument for limiting CO_2 emissions from the transport sector (cf. section 4.2.1). The tax rates are currently 0.87 NOK/l petrol and 0.435 NOK/l diesel. The demand for transport oils is influenced by the total taxes on these products, regardless of why they are imposed. Norwegian taxes on transport oils are among the highest in the world, currently 4.89 NOK/l petrol and 3.785 NOK/l diesel. VAT is not included in these figures. Petrol taxes are more than 70% higher in 1997 than in 1990.

The introduction of the CO_2 tax and the general growth in tax rates have contributed to a considerable reduction of petrol consumption. Consumption dropped by more than 8% between 1990 and 1995 in the transport sector.

In the shipping sector, domestic ferries and passenger ships are subject to the CO_2 tax. These ships have been taxed since 1992.

Other measures

Although the CO_2 tax is the main policy instrument in this field, a number of other transport policy measures also contribute to the reduction of CO_2 emissions from the transport sector. The purchase tax on cars is among the highest in world, and has from 1996 been differentiated according to carweight, engine output and engine volume. The purchase tax scheme is to a certain degree designed to act as an incentive to buy more energy- efficient cars. The maximum speed limits in Norway are low by international standards, thus contributing to relatively low fuel consumption.

To encourage research and development in the field of alternative fuels in the transport sector in Norway, funds have in recent years been allocated to projects on the use of natural gas in buses and the development and testing of electric and hybrid vehicles. Funds have also been allocated for research on and tests of several alternative fuels. Preparations are currently in progress for tests of the use of natural gas in ferries.

There are toll rings around the largest towns and these may to some extent reduce congestion and adverse environmental effects. The Government's policy on road pricing will be presented to the Storting in spring 1997.

In the longer term regional and local land-use and transport planning may have some influence on the development of transport. The national policy guidelines for coordinated land-use and transport planning (laid down pursuant to the Planning and Building Act) define limitation of the need for transport and increased use of environmentally sound modes of transport as two important objectives for planning at local and regional level.

Subsidies for the expansion of public transport may under certain circumstances limit CO_2 emissions from the transport sector, but it is difficult to evaluate their net environmental effect. The effect of a given level of subsidies varies according to the strategies followed in the transport sector. The Government gives high priority to public transport, especially railway transport. A special programme has been established to support the country's four largest towns in building infrastructure for public transport.

The EURO-vehicle inspection system will be fully implemented from 1998. This is expected to give some improvements in average energy efficiency.

4.2.4 Industry

In recent years CO_2 emissions from energy use in industry have decreased considerably as a result of improved energy efficiency and changes in the energy mix. In 1996, however, the CO_2 emissions rose since high electricity prices led to more use of heating oil. CO_2 emissions are expected to decrease again. Energy efficiency has been improved by general capital replacement and operational changes, which received some support from an earlier grant scheme for energy efficiency measures. In the industrial sector electricity and bioenergy have to a large extent replaced mineral oils as an energy source. This has been especially pronounced in the pulp and paper industry, which is increasingly using bark and other biological waste products as fuel. These changes took place in the early 1980s, mainly because measures were introduced to regulate emissions of waste. Except in 1996 the price of mineral oil has generally been higher than that of electricity during the 1990s, and this has also helped to bring about changes in the energy mix. The introduction of a CO_2 tax on mineral oils from 1 January 1991 and the abolition of the excise tax on electricity for manufacturing industries from 1 January 1993 have also made mineral oils relatively more expensive.

The Industrial Energy Efficiency Network has continued to grow since it was established in 1989. Its members now represent 80% of total energy use in Norwegian domestic industry. In addition to collection of energy and production data, the network also offers assistance in the development of energy efficiency analyses for various branches of industry.

<u>Ammonia production</u>
In 1995, emissions of CO_2 from ammonia production were estimated at about 0.9 million tonnes per year (around 2% of Norway's total emissions). Emissions are caused by the use of natural gas liquid (NGL) as raw material for hydrogen production, and amount to approximately 2 tonnes of CO_2 per tonne of ammonia produced.

<u>Oil refineries</u>
In 1995, Norway's three refineries emitted a total of approximately 1.7 million tonnes of CO_2, corresponding to about 4.5% of the country's total emissions. The emissions from these refineries are relatively stable.

<u>Cement production</u>
Emissions of CO_2 from Norwegian cement production are estimated to be about 1.35 million tonnes per year, corresponding to about 1 tonne CO_2 per tonne cement. Of this, about 60% is generated by the decomposition of limestone during the production process. Decomposition is a necessary part of the manufacturing process, and emissions are therefore directly dependent on the production volume. The remaining 40% of the emissions originate from the sources of energy, which are coal, waste oil and liquid organic hazardous waste. Beside the introduction of hazardous waste, replacement of coal with alternative fuels (tyres, plastic waste and various types of packaging waste) and improvements of energy efficiency have been tested as ways of reducing CO_2 emission. If successfully implemented, these measures are expected to reduce emissions of CO_2 per tonne clinker by about 10% compared with 1990 level.

<u>Metals</u>
Emissions of CO_2 from metals manufacturing were about 5.1 million tonnes in 1995, corresponding to 13-14% of total emissions of CO_2 in Norway. The largest emissions originate from the ferro-alloy industry, which alone accounts for about 7%. The manufacture of aluminium accounts for 4-5%. CO_2 emissions from metals manufacturing

derive from the use of coal and coke as a reducing agent, and are therefore primarily dependent on the volume of production. Hydropower is used as energy source, causing no CO_2 emissions.

Ferro-alloys

Ferro-alloys are manufactured by direct carbothermal reduction in electric smelting furnaces. It does not appear to be feasible to use other reducing agents than carbon. The carbon used is usually in the form of coal or coke but, for technical reasons, a small proportion of granulated wood is used for some alloys. It is technically feasible to use charcoal instead of fossil carbon, but this is economically possible only in places where charcoal is available in sufficient quantities.

Primary aluminium

Primary aluminium is manufactured by a combination of smelting and electrolysis, i.e. the raw material, aluminium oxide, is placed in a salt smelter that is electrolysed. The aluminium is then precipitated as molten metal, and the oxygen combines with the carbon at the anode, generating CO_2. The quantity of CO_2 generated is directly dependent on the level of production.

The only means of reducing CO_2 emissions per unit of aluminium produced is to use inert anodes, i.e. anodes made of a material which does not combine with oxygen in the reactive form in which it is found. The oxygen can then be removed as oxygen gas. Extensive research is being carried out on the development of inert anodes. It is still very uncertain when such a system may become technically feasible. One obstacle at present is that energy consumption has been shown to be much higher than for the presently applies carbon anodes. Thus, if the electricity is produced from fossil fuels, the benefit obtained by not using carbon anodes could be reduced or even outweighed by the increase in CO_2 emissions from energy production.

Petro-chemical industry

In 1995, the petro-chemical industry emitted a total of approximately 0.6 million tonnes of CO_2, corresponding to about 1.5% of the total CO_2 emissions in Norway. Almost all of this is generated by energy consumption (natural gas) during the production processes. Emissions are expected to increase by approximately 0.5 million tonnes as new installations come into operation during the period 1996-2000.

Reduced energy consumption through recycling

Production based on recycled material is generally less energy-consuming. The largest potential for saving energy by using recycled materials is in the production of metals, but a certain potential also exists in the paper, plastics and glass industries. Waste can also be used as a source of energy in the process industry, or as fuel in a waste-burning hot water generator.

Projects involving sorting of municipal waste at source are currently in progress. Grants have been offered for a number of projects to develop methods to reduce waste generation and increase recycling. Using car tyres as fuel in cement production and in other applications is an example of such projects.

The Norwegian authorities are actively seeking agreements with trade and industry to increase the amounts of waste recycled. Such agreements have already been reached for several product groups.

4.2.5 Residential, commercial and institutional (energy-related)

Energy efficiency

The role of the Ministry of Petroleum and Energy is to ensure that state funds are allocated rationally, to draw up a long term strategy for energy efficiency, and evaluate the need for changes in the use of energy efficiency instruments. In Report to the Storting No. 41 (1992-93), Norway's energy efficiency policy was evaluated. The main recommendations given in the report have now been implemented.

Experiences have shown that the main barrier to improved energy efficiency is lack of knowledge of appropriate measures and their cost efficiency. Information and training are therefore the most important instruments available to the authorities. The Norwegian Water Resources and Energy Administration is responsible for administration of the governmental efforts in the field of energy efficiency.

Responsibility for practical implementation of the various measures is largely delegated to institutions and organizations outside the central governmental administration, including regional energy efficiency centres. The centres provide customers with basic analyses and information on state funded energy efficiency programmes, energy use and prices. Energy efficiency centres have now been established in almost every county in Norway and they are financed by the local utilities. Energy efficiency measures may be financed by a supplementary charge of up to 0.003 NOK/kWh included in the transmission tariff at the lowest grid level.

During the last three years, information campaigns in media with nationwide coverage have helped to raise awareness of energy efficiency issues in private households and among other energy users.

The Government has allocated NOK 153 million for energy efficiency measures in 1997. In the budget, NOK 96 million was reserved for introduction of energy-efficient equipment and systems and new renewable energy resources. Of this, approximately NOK 50 million is to be used to intensify efforts in the field of bioenergy. Approximately NOK 42 million will be used on information and education activities.

Bioenergy

Today bioenergy accounts for approximately 5% of energy use in Norway. The barriers to wider use of bioenergy have been identified, and through the grant scheme the Government intends to intensify efforts to overcome these barriers. The most important barriers are:
- absence of systems for harvesting, transportation and storage
- limited use of water-carried central heating
- few suppliers of equipment for use of bioenergy and biofuels
- lack of knowledge and experience in the use of bioenergy

The Government's goal is to put bioenergy at a level playing field with other energy sources such as oil and electricity. Wider use of bioenergy will increase the flexibility of the energy supply system and reduce dependence on electricity for heating purposes. Bioenergy will reduce emissions of CO_2 if replacing fuel oils.

4.2.6 Fugitive fuel emissions

Petroleum sector

Emissions of non-methane volatile organic compounds (NMVOCs) from loading offshore and onshore can be reduced by installing recovery systems. Fugitive NMVOC emissions from loading oil should also be counted as CO_2 emissions according to the IPCC Guidelines. An onshore recovery system was installed at the Sture terminal in 1996. This system is expected to reduce NMVOC emissions from the terminal by about 85%. In 2000 the reduction in NMVOC emissions is expected to be about 10 000 tonnes NMVOCs. This is equivalent to 30 000 tonnes of CO_2. The reduction of VOC emissions is included in the VOC and CO_2 projections.

Pilot-scale recovery systems have been successfully tested on oil shuttle tankers in a project mainly intended to find ways of reducing NMVOC emissions. With this technology, it should be possible to recover about 70% of NMVOCs released each time the tanker is loaded. Installation of such recovery systems on the oil shuttle tankers, or alternative solutions, should reduce emissions of NMVOCs by about 120 000 tonnes, which is equivalent to 0.4 million tonnes CO_2. Such reduction of VOC emissions is not included in the projections of VOCs and CO_2.

Distribution and storage of petrol

Norway will implement EC Council Directive 94/63 (Stage I) on control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations during 1997. However, the technology required by the directive has already been installed in most of the petrol distribution and storage system, so that a large proportion of the emission reduction has already been achieved. This reduction in VOC emissions is included in projections of VOCs and CO_2.

4.3 CO_2 sinks

Long term fixation of carbon in biomass can be achieved by increasing forest biomass. One of the main objectives of Norwegian forestry policy has been to maintain and enhance forestry resources, mainly because this permits continued utilisation of the natural resource base for forestry purposes. Enhancing national forestry resources, through increased carbon fixation, contribute significantly to limit and reduce the atmospheric emissions of greenhouse gases.

Current forestry policy emphasizes the conservation, development and utilisation of natural resources, and has, as described in section 3.7, resulted in a steady increase in forest biomass and thus increased the yearly fixation of CO_2. It is possible to further increase the yearly net fixation of CO_2 in Norwegian forests through specific measures designed to stimulate forest growth. However, forest growth is a slow process, and most of the effect will appear after some decades.

A number of measures to increase the production of forest biomass have been evaluated and may be of interest in an integrated system of forest management. Continuous evaluation will be required to find the right balance locally between forestry and climate policy on the one hand and local environmental effects related to biodiversity, recreational value etc. on the other.

Recent research indicates that the carbon reservoir in buildings, furniture and other wood products in Norway is in the order of 10 million tonnes CO_2, and that it is increasing by approximately 0.7 million tonnes per year, as described in SFT report 96:04 «A balance of use of wood products in Norway». This increase in the CO_2 sink is not included in the inventory of the present report.

The Government is currently studying the possibilities for further enhancement of forest sinks by means of concrete action. The study is expected to be finalized in 1997.

4.4 Methane emissions

4.4.1 Waste management

There have been some improvements in the method of calculating emissions from landfills and thus in the reported figures. In earlier reports only municipal waste landfills were included, whereas the present report includes emissions both from municipal waste and from landfills containing industrial waste. In addition, the estimate of the amount of methane generated per tonne of municipal waste has been adjusted from 100 kg to 130 kg, due to new knowledge.

In 1995, 1.84 million tonnes of waste were deposited in municipal landfills in Norway, corresponding to 68% of all municipal waste. It is estimated that emissions of methane from municipal landfills in 1995 totalled about 222 000 tonnes, and that in the same year, 1 million tonnes of waste were deposited in industrial landfills and other landfills outside the municipal disposal system. Approximately 140 000 tonnes of this was degradable organic waste, mainly from the paper industry. Emissions of methane from non-municipal landfills in 1995 are estimated at about 100 000 tonnes.

To illustrate possible trends in methane emissions, two scenarios have been drawn up. Scenario 0 is based on today's situation, without new policy instruments or measures. It only includes effects of measures that have already been implemented (i.e. recycling schemes and gas recovery facilities that are in operation or under construction). It also assumes that the proportion of the waste generated that is deposited on municipal landfills remains constant at the 1995 level (i.e. 68%). This means that other methods of disposal must be developed as the quantity of waste generated increases. It is not assumed that the quantity of waste deposited on non-municipal landfills will increase after year 2000.

In practice, the rise in emissions will be lower than indicated for Scenario 0, because the implementation of new policy instruments will result in the introduction of various measures during the next few years. The effects of this are taken into account in Scenario 1. This indicates that annual emissions of methane from landfills will start to decrease from 1997-1998, whereas the total quantity of waste generated will continue to increase.

The drop in emissions shown in scenario 1 is caused by the combined effects of an expected increase in the extraction of gas from municipal landfills, reduced deliveries of waste to landfills which is a result of greater sorting and recycling of waste due to stricter requirements in both municipal and non-municipal landfill permits and the introduction of voluntary agreements on waste recycling between the central authorities and the business sector (extended producer responsibility).

During the last 5-6 years, emissions of methane have been reduced at several landfills by extracting the municipal landfill gas for energy purposes or by flaring it. Facilities were in operation at 15 landfills in 1996, and reduced emissions of methane by a total of 13 600 tonnes per year. As mentioned above, this reduction has been included in scenario 0.

According to plans and requirements that may be introduced in municipal landfill permits, the number of plants is expected to double in the next 2-3 years. The effect of this is taken into account in scenario 1. Scenario 1 is also based on the assumption that in the longer term (10-15 years), almost all large municipal landfills will be equipped with gas extraction systems. This is in accordance with the guidelines for municipal landfill permits issued by SFT, which state that any municipal landfill that emits significant amounts of combustible gas should be equipped with a gas extraction and burning system, preferably including energy utilisation.

Recyclable waste should be sorted out according to the guidelines for municipal landfill permits, and municipal landfills should as far as possible only be used for residual waste. Some municipal landfills therefore have restrictions on the types of waste that may be deposited, and at some sites it is prohibited to deposit food waste and similar waste types. In scenario 1, it is assumed that there will be a significant reduction of food waste etc. deposited in most of the country.

The results of waste management in some pilot municipalities show that the proportion of waste deposited on landfills can be reduced to 30% of the total by means of separation, recycling and composting. There is a potential for further reduction if incineration is introduced in addition to the other methods. Based on these results and the measures mentioned above, combined with further measures to ensure a high level of waste separation, the share of waste landfilled can be reduced substantially for the country as a whole in the period up to 2010-2015, cf. scenario 1. There are, however, uncertainties associated with this prognosis. Such a reduction in the amount of waste deposited on municipal landfills will result in a proportionate reduction in calculated gas production. However, the distribution of gas production over time means that the actual reduction in emissions will materialise after a time lag. If all the measures described above are introduced the potential reduction of emissions of methane is estimated to 70 000-130 000 tonnes in 2010 compared to 1990 level.

The Norwegian Government is evaluating the introduction of a tax on final waste disposal, including the consequences it would have for various actors. Such a tax is expected to be partly an alternative, partly in addition to the existing policy instruments and stimulate and intensify the introduction of the measures described above.

Implementation of a future EU directive on landfills may also restrict the deposition of organic waste in landfills. This is not included in the above scenarios.

Table 4.3 SCENARIO 0
Only measures already implemented. All landfills, municipal and industrial waste.

Year	Waste landfilled mill t	Methane generated 1000 t	Methane extracted 1000 t	Net emissions 1000 t
1990	2.55	302	0	302
1995	2.84	335	12.7	322
2000	2.74	332	25	307
2005	2.85	345	25	320
2010	3.05	370	25	345
2020	3.20	390	25	365

Table 4.4 SCENARIO 1
Measures already implemented, and also effects of new policy instruments and measures implemented in accordance with them. All landfills, municipal, industrial and other waste.

Year	Waste landfilled mill t	Methane generated 1000 t	Methane extracted 1000 t	Net emissions 1000 t
1990	2.55	302	0	302
1995	2.84	335	12.7	322
2000	2.5	300	20 - 30	270 - 275
2005	2.1 - 2.5	250 - 300	30 - 60	210 - 270
2010	1.9 - 2.3	230 - 280	40 -70	170 - 230
2020				170 - 230

4.4.2 Agriculture

Methane emissions from the agricultural sector constitute about 20 % of total methane emissions. Most of this is generated as an inevitable by-product of digestion in ruminants, (and also represents a loss of energy during the process). The storage and disposal of manure accounts for about 17% of methane emissions from agriculture. However, there may be ways of reducing methane production by altering the composition of animal fodder, for instance by increasing the amount of fat or other additives.

4.5 Nitrous oxide emissions

4.5.1 Industry (non-energy)

Nitrous oxide (N_2O) from nitric acid production
Nitrous oxide is generated during production of nitric acid. In 1995 emissions of nitrous oxide from this source amounted to about 5 300 tonnes per year. After reconstruction of some of the plants in 1991, emissions dropped from about 6 100 tonnes to about 5 000 tonnes in 1993. The emissions are expected to increase to 6 000-7 000 tonnes by the year 2000 if the production capacity is fully exploited. This estimated increase is included in the projections of N_2O.

N_2O emissions can be reduced by about 2 000-2 500 tonnes by the year 2000 if production units are reconstructed. The investment costs have been estimated to be about NOK 800 million.

4.5.2 Industry (energy-related)

Emissions of N_2O from stationary combustion in industry were estimated at about 900 tonnes in 1995, i.e. about 6% of total emissions of N_2O in Norway. However, this figure is very uncertain. It is estimated that about 40% of these emissions are associated with the use of wood, bark and black liquor in the pulp and paper industry. Except for the reduction obtained by generally more effective use of energy, the possibility of reducing emissions has not been investigated further.

4.5.3 Agriculture

Emissions of N_2O from agriculture were estimated at 6 500 tonnes in 1995, and have probably remained more or less unchanged since 1980. The processes controlling the production of N_2O in the soil are not fully understood. Emissions can be reduced by careful spreading of nitrogenous fertiliser, and by spreading it at specific times during the growing season when the crops make best use of the nitrogen. This may reduce the amount of fertiliser needed as well as the generation of N_2O. These and other routines for irrigating and preparing the soil have been published by the Norwegian fertiliser manufacturer and distributed to farmers. The manufacturer is continuing research on how to reduce emissions of N_2O. Research is also being carried out on the pathway followed by nitrogen from anthropogenic input to final deposition, where N_2O is one of the components. The aim is to identify possible reductions and evaluate costs.

4.5.4 Transport

Mobile sources contributed about 1 000 tonnes of N_2O emissions in 1995, corresponding to 7% of the total. The main source is road traffic. A report published by SFT in 1993, «Emissions from Road Traffic in Norway», shows that emissions from private cars with catalytic converters are 3-4 times higher than emissions from cars without such converters. No measures have been evaluated.

4.6 Other greenhouse gases

4.6.1 Industry (process and energy-related)

PFC emissions from aluminium production

Aluminium production is the only known significant anthropogenic source of emissions of the perfluorocarbons (tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6)). Fluorinated carbons are formed by a reaction between carbon and fluorine in electrolytic cells where carbon is the anode or reduction material. On the basis of measurements, emissions of PFCs are estimated to have been about 220 tonnes in 1995, corresponding to 1.4 million tonnes of CO_2. Emissions were reduced by about 43% between 1990 and 1995. Emissions can be further reduced in three different ways: 1) by converting Søderberg furnaces to prebake furnaces, 2) by reducing the anode effect frequency in Søderberg furnaces (partly by means of point suppliers) and 3) by reducing the frequency of anode effect in prebake furnaces. Ongoing discussions about an agreement with this industry are expected to lead to further reductions in emissions.

SF_6 emissions from magnesium production

The gas is used as an additive to air for covering the surface of liquid magnesium during the casting process. The covering gas is emitted to air after use. The amount of SF_6 used in

Norway has been reduced from about 90 tonnes in 1990 to about 17 tonnes in 1995 as a result of improved routines and maintenance in the plant as well as reduced production levels. There is limited scope for further reductions by tightening up routines, but the use of SO_2 is now being investigated as an alternative. If an acceptable working atmosphere can be maintained, it will be possible to use SO_2 as a substitute for SF_6 in the future.

4.6.2 Residential and commercial

Emission standards for residential woodburning stoves

Emission standards for residential woodburning stoves will be introduced to reduce emissions of particles/PAHs, because woodburning stoves are an important source of local pollution. The energy efficiency of most stoves that comply with the new emission standards will be improved, and this may reduce the need of fossil fuels for heating. Emission standards will also reduce methane emissions. The emission standards will be voluntary from 1997 and mandatory from 1998. In the year 2010, methane emissions are expected to be reduced by about 3 000-4 000 tonnes. This reduction corresponds to less than 1% of the total emissions of methane in Norway in 1995.

4.6.3 Solvent and other product use

Emissions of NMVOCs

The carbon content of NMVOC emissions is included in the CO_2 emissions inventory in Norway, as recommended by the IPCC. This is because the lifetime of NMVOCs is short and CO_2 is the end product of the chemical reactions. The ECE agreement on 30% reduction of NMVOC emissions, which Norway has ratified, will thus contribute to a reduction of CO_2 emissions. The indirect effect of NMVOCs as an ozone depletor is not included. The reduction around the year 2000 expressed as CO_2 emissions resulting from Norwegian compliance with the ECE commitments, will be about 0.3 million tonnes. This is not included in the projections in Chapter 5.

Use of HFCs

HFCs are halogenated carbon compounds that do not contain bromine or chlorine. They are not regulated by the Montreal Protocol as substances that deplete the ozone layer. Various HFC compounds are relevant as substitutes for CFCs and HCFCs, which are to be phased out in accordance with the obligations of the Montreal Protocol. The consumption of HFCs increased from 3 tonnes in 1990 to 108 tonnes in 1995. A further increase in HFC consumption is expected as CFCs and HCFCs are gradually phased out. According to the projections in Chapter 5 the consumption of HFCs is expected to be more than 1000 tonnes, or 1.6 million tonnes CO_2 equivalents, in 2010. The Norwegian Pollution Control Authority will evaluate the need for measures to limit these emissions.

SF_6 used in electrical equipment

In 1995, emissions of SF_6 from gas-insulated switchgears in Norway totalled 2.4 tonnes. Emissions occur only as a result of leakage or accidents, or if installations are destroyed without recovering the gas. The figure is based on the assumption that 1% of the gas in installed equipment is emitted every year. No measures have been evaluated.

5. Projections

5.1 Projections of emissions of CO_2

The Government recently presented its Long-term Programme for 1998-2001. Two alternative macroeconomic projections up to 2050 play a central role in the programme as a basis for discussions of challenges and opportunities in the coming decades.

The Baseline Alternative assumes stabilization in global CO_2 emissions at 1990 level realized through a global CO_2 tax. In this alternative the demand for energy is significantly lower than in the Reference Alternative, and CO_2 emissions are similarly lower. The Baseline Alternative with a climate agreement is the foundation for further development of the Government's overall policy in the period 1998-2001.

In the Reference Alternative without a climate agreement CO_2 taxes remain at their present level. It assumes that greater demand for electricity after 2010 will be met by increasing electricity production in Norway based on natural gas, and that there will be no increase in the consumption of new renewable energy sources such as biofuels.

Neither the Reference Alternative nor the Baseline Alternative should be seen as business-as-usual scenarios. The emission projections in this report are therefore based on a variant of the Reference Alternative, which more likely is assumed to illustrate the development in emissions under business-as-usual conditions. In these projections increased demand for energy after 2010 is met by other sources than electricity based on natural gas, except for two plants for which a Norwegian company is in the process of licencing. These plants will eventually be phased in around 2000 and will increase CO_2 emissions by about 2.1 million tonnes yearly. Consequently, the level of the CO_2 emissions in 2020, cfr. section 5.2 below, will lie between the estimates in the two alternatives which are presented in the Long-term Programme 1998-2001.

<u>Methodology and key assumptions</u>

Emission projections for Norway are based on macroeconomic model projections supplemented by sectoral studies (e.g. transport and petroleum production). For medium-term projections, up to ten years, the macroeconomic model MODAG has been used. The long-term projections are based on a general equilibrium model called MSG. The models underlying the projections are described in Annex B.

Table 5.1 shows the estimated development of key macroeconomic variables. Petroleum extraction is expected to reach a peak around the turn of the century and will then gradually drop from about 290 million Sm^3 oil equivalents (Sm^3 o.e.) in 2001 to about 160 million Sm^3 o.e. in 2020. In 1995-2010, gross domestic product is expected to grow at an average annual rate of 2%. GDP in mainland Norway will grow at approximately the same rate, while petroleum and ocean transport exhibit slower growth due to the reduction in offshore petroleum activities. Estimated GDP growth rates from 2010 to 2020 are generally lower than in the preceding period as a result of demographic developments and a further fall in oil extraction.

Table 5.1 Development of key macroeconomic variables and energy use

	Billion 1995 NOK 1995l	Annual average growth rate 1995-2010	Annual average growth rate 2010-2020
Gross domestic product	925.9	2.0	1.1
Mainland Norway	793.2	2.1	1.7
Manufacturing	118.1	1.9	1.3
Petroleum extraction and ocean transport	132.6	1.4	-2.7
Private consumption	457.1	3.0	2.3
Government consumption	192	1.7	0.7
Gross fixed capital formation	197.7	1.1	1.1
Mainland Norway	145.9	2.1	1.3
Petroleum extraction and ocean transport	51.8	-2.8	-0.4
Export of oil and natural gas	113.2	1.1	-4.3
Net import of other goods and services	57.5	2.0	2.0
Number of persons employed (1000)	2079	0.9	0.1
Net domestic energy use: *)			
Petroleum products (1000 t)	5704	1.3	0.6
Electricity (TWh)	104.2	0.8	0.9

*) *Except use in energy sectors and ocean transport*

Private consumption is expected to grow at about 3% annually in 1995-2010 and slightly more slowly from 2010 to 2020. Government consumption is assumed to grow at 1.7% annually in 1995-2010 and 0.7% in 2010-2020. Gross capital formation is expected to grow at about 1% per year in both periods, though there are significant variations between growth rates for mainland Norway and petroleum and ocean transport. Petroleum exports are expected to fall in 2010-2020. Net imports of other goods and services are expected to grow at an average rate of 2% per year in both periods.

Consumption of petroleum products is expected to grow at above 1% per year from 1995 to 2010 but more slowly in 2010-2020. Consumption of electricity is assumed to grow at about 1% per year during the projection period. The rate of energy efficiency improvement varies between sectors but is assumed to average about 1% per year.

CO_2 emissions

Table 5.2 shows estimated CO_2 emissions during the period 1995-2020 based on current policies, i.e. including the present CO_2 taxes. With Norwegian CO_2 taxes at present level CO_2 emissions are still expected to rise by about 26% from 1995 to 2010. This relatively large increase is explained by rises in emissions from petroleum extraction and transport, electricity generation, manufacturing and domestic transport. Emissions from petroleum extraction are expected to increase by about 3 million tonnes in 1995-2010, while emissions from electricity generation, manufacturing and domestic transport are expected to increase by about 2 million tonnes each. Production of electricity in Norway is currently based on hydropower. However, this source provides only limited scope for expansion and may not be sufficient to meet energy demand in the future. A Norwegian company is currently in the process of licencing two 350 MW gas-fired power plants.

Table 5.2 Gross emissions of CO_2 in Norway by sector. (Million tonnes)

	1989	1990	1993	1995	2000	2005	2010	2020
Petroleum sector	7	8	9	9	12	12	12	8
Domestic transport[1)]	4	4	5	5	6	6	7	8
Manufacturing	11	12	10	12	13	14	14	15
Households[2)]	6	6	5	5	5	5	6	7
Electricity generation	0	0	0	0	2	2	2	2
Other sectors	7	6	7	7	6	7	7	7
Total emissions[3)]	35	36	36	38	44	47	48	46

1) Excl. transport on own account in industry and households.
2) Incl. transport by private car.
3) Numbers may not add because of rounding errors.

Emissions of CO_2 are expected to be reduced somewhat from 2010 to 2020. The main reason for this reduction is that petroleum extraction is expected to reach a peak around the turn of the century and then gradually fall, resulting in lower emissions. Emissions from manufacturing sectors are expected to stabilize at about 15 million tonnes in the period 2010-2020.

Uncertainty

Several sources of uncertainty affect model projections. Economic relations in macroeconomic models are based on historical data. External factors such as technological progress may cause shifts in behaviour, thus making historical estimates inaccurate or irrelevant.

Another type of uncertainty is related to assumptions concerning variables such as real oil prices and other world market prices, petroleum activities, technological progress, energy efficiency, international economic growth etc. Changes in these variables may have a significant impact on the macroeconomic estimates and the level of CO_2 emissions.

Projections of CO_2 emissions are closely related to assumptions regarding the use of fossil fuels. If alternative energy sources are taken more into use, CO_2 emissions may deviate from the estimates presented above.

5.2 Projections of emissions of other greenhouse gases

Table 5.3 shows emissions and projected emissions of methane, nitrous oxide, perfluorocarbons, sulphur hexafluoride and HFCs. The GWP values used in table 5.3 are given in section 3.1.2.

Table 5.3 Emissions of the various greenhouse gases in 1989, 1990, 1995 and projections for 2000, 2005, 2010 and 2020. (The figures are given in million tonnes CO_2 equivalents)

	1989	1990	1995	2000	2005	2010	2020	Changes 1990-2010
Σ other greenhouse gases	18.8	18.6	16.5	16.1	16	15.6	16.1	-16%
Methane [*)]	9.0	9.1	9.9	8.7	7.9	7.0	6.8	-23%
Nitrous oxide	4.7	4.8	4.4	4.8	5.1	5.2	5.5	10 %
PFCs	2.5	2.5	1.4	1.3	1.2	1.2	1.2	-52 %
Sulphur hexafluoride	2.6	2.2	0.6	0.5	0.5	0.6	0.7	-75 %
HFCs	0.0	0.0	0.2	0.8	1.3	1.6	1.9	..

[*)] The projections on methane from landfills are based on scenario 1, (see section 4.4.1)

Projected emissions of CF_4 and N_2O from stationary and mobile combustion are based on the reference scenario in the report from the Green Tax Commission. In addition, some information on industrial processes has been collected by the Norwegian Pollution Control Authority.

Historical methane emissions from municipal waste have been adjusted using figures from SFT (1995) and Det Norske Veritas (1996). The data for emissions from landfills containing industrial waste are now included in the Norwegian emission inventory, which they were not in the previous report, see section 3.1.1. To illustrate possible trends in methane emissions from landfills, two scenarios have been drawn up in section 4.4.1. The projections in table 5.3 are based on Scenario 1, which assumes that implementation of existing or new policy instruments will reduce the methane emissions from landfills by about 33% by 2010 compared to 1990. There are, however, uncertainties associated with this prognosis. Scenario 0 includes only the effects of measures that already have been implemented, without new policy instruments or measures. The emissions from landfills in this scenario is expected to increase by about 15% by 2010.

The projections of methane emissions from the petroleum sector are based on information from oil companies operating in the North Sea collected by the Norwegian Petroleum Directorate.

Emissions from wood-burning stoves have been adjusted downwards from the figure used in the reference scenario from the Green Tax Commission since emission standards for wood-burning stoves were introduced in Norway from 1 January 1997.

Emissions of N_2O from nitric acid production accounts for about 45% of the total N_2O emissions in Norway. Projections of emissions from this source are based on expected levels of production supplied by the two Norwegian producers.

Projections of emissions of perfluorocarbons (CF_4 and C_2F_6), sulphur hexafluoride (SF_6) and HFCs have been drawn up by the Norwegian Pollution Control Authority (SFT) on the basis of research done for SFT by Haukås (1996), information from the suppliers and assessments by SFT.

Emissions of greenhouse gases other than CO_2 are expected to decrease by approximately 16% from 1990 to the year 2010. The main reason for this is that emissions of methane are expected to drop by almost 23% from 1990 to 2010. Another reason is that emissions of CF_4, C_2F_6 and SF_6 are expected to decrease during this period. Consumption of HFCs is expected to increase as CFCs are phased out. Emissions of nitrous oxide are expected to remain relatively stable throughout the period.

5.3 Projections of emissions of precursors

Table 5.4 shows projections of emissions of ozone precursors and SO_2. These are based on the same assumptions as for CO_2, as described in section 5.1.

Table 5.4 Summary of projections of anthropogenic emissions of precursors and SO_2. (1000 tonnes)

	1990	1995	2000	2005	2010	2020
CO	961	829	657	621	614	622
NO_X	227	222	208	220	225	226
NMVOCs	299	378	337	261	236	215
SO_2	53	35	32	34	35	36

5.4 Projections of CO_2 sinks

The results are presented at five-year intervals, and the figures for 2005 and 2015 are averages for the surrounding ten-year period. Table 5.5 shows the projections of CO_2 sinks in the period 1990-2020. Important factors in such projections are the levels of harvesting and natural losses. The actual level of harvest is difficult to estimate as it will depend strongly in the world market price for timber. The maximum path assumes that the harvest will remain at a relatively low level as in 1990-1994. The minimum path illustrates the effect of a considerable increase in the natural losses. This is plausible, since the forest will age. The rate of natural losses rises to 12% in the year 2010 and 16% in 2020 in the minimum estimate.

Table 5.5 Net CO_2 removals in Norwegian forests in the period 1990-2020. (Million tonnes)

	1990	2000	2005	2010	2015	2020
Maximum	9.4	12.1	13.9	15.6	16.2	16.8
Best estimate	9.4	11.0	12.9	14.8	15.3	15.7
Minimum	9.4	11.0	12.2	13.4	13.1	12.8
Best estimate compared with 1990	-	1.6	3.5	5.4	5.9	6.3

The fact that carbon is stored in harvested or naturally lost timber for a period of time and not oxidised to carbon dioxide immediately has not been reflected in the calculations.

6. Expected impacts of climate change, vulnerability assessment and adaptation measures

The Intergovernmental Panel on Climate Change predicts that the global mean surface temperature will increase by 3.0 ± 1.5 ºC as a consequence of a doubling of the atmospheric CO_2 concentration (IPCC 1992). It is anticipated that the elevated temperature will produce a substantially wetter atmosphere, giving higher precipitation. The effects of global warming are expected to be greatest in northern and high altitude areas. The climatic scenario for Norway if the atmospheric concentration of CO_2 doubles is expected to involve a temperature increase of 2 ^{0} C in the summer and 3-4 ^{0} C in the winter towards 2030. Precipitation is expected to increase by 5-15%, and most of the increase is assumed to occur in spring in the western parts of the country. Eastern Norway and the county of Finnmark may become dryer because of increased evapotranspiration. Considerable uncertainty still surrounds the predictions of climate change provided by regional models (IPCC 1992 and 1995). This must also be taken into account when considering climate change and its impacts in Norway.

In addition to climate change caused by an increase in mean temperature, Norway may, because of its geography and long coastline, be particularly vulnerable to changes in the frequency of weather patterns and extreme events such as storms, floods and spring tides. A report evaluating the consequences of increased storm activity for various ecosystems was published in 1995 (DN, 1995). Further investigations are still needed, both on the possible relationship between changes in the frequencies of such extreme events and global climate change, and on the ecological and socioeconomic impacts of such changes.

6.1 Impacts of climate change on terrestrial ecosystems

Soil processes

If the soil moisture level is maintained, a temperature rise is expected to increase microbiological activity and speed up the decomposition and mineralization rates of detritus throughout the year. Enhanced microbial activity during the winter season may lead to more leaching of mineralized nutrients from the soil, and over a period of time also reduce the content of organic carbon.

Biota

In plants native to the boreal zone a rise in temperature may lead to a greater rise in respiration and photorespiration rates than in the photosynthesis rate. Thus, the rise in the photosynthesis rate caused by a higher CO_2 concentration may be outweighed by the effects of a higher temperature, but it is difficult to predict where the equilibrium between these two opposing processes will lie. It has been demonstrated that in alpine plants, a temperature rise may reduce the higher capacity for growth and reproduction resulting from an increase in the respiration rate.

A temperature rise may lead to a shift of climate zones both in altitude and latitude. Higher plants migrate more slowly than the rate at which the climate is predicted to change. As a consequence, plant species may be exposed to a climate to which they are not adapted. Over time it is therefore expected that climate change may cause changes in the species composition, abundance and distribution of plants, invertebrates and vertebrates. Extreme climatic events such as storms, drought and episodes of frost in spring might be as significant as the rate of temperature change as regards alterations in species composition, competition and ecosystem processes. The varied topography of Norway makes it possible for some species of plants and animals to migrate short distances in altitude and thus follow the climatic conditions to which they are adapted. Species with a higher temperature optimum that migrate upwards may outcompete natural alpine species. As a result of climate change and differences in species' capacity for migration, the distribution and population size of species native to alpine forests and other alpine habitats may decrease.

It is assumed that climate change may have a severe impact on the flora and fauna of bogs and marshes. In Eastern Norway and Finnmark, such habitats may change character through changed precipitation patterns and higher temperatures, which may slow down their formation and speed up decomposition. Suitable habitats for species that are dependent on bogs and marshes may therefore become much more patchily distributed than is the case today.

Alpine areas, bogs and marshes are expected to alter most during changes in the climatic conditions as described above. A warmer climate may therefore endanger species found in such areas.

Most invertebrates are capable of migration, have an extensive distribution, and can probably cope with climate change as indicated through adaptation. However, climate change will expose insects adapted to cold environments to warmer conditions which may alter their development. Vertebrates have generally good dispersal abilities and presumably tolerate a wide range of climatic conditions. They are able to migrate faster than vegetation in response to climate change. Nevertheless, it is difficult to predict the extent to which vertebrates will become established in newly formed habitats created by climate change.

<u>Interactions between tropic levels</u>
A number of changes may lead to interactions between tropic levels. In most species of higher plants, the photosynthesis rate is found to rise with CO_2 concentration, which results in a lower carbon-to-nitrogen ratio in tissue grown at elevated CO_2 concentrations. Insect performance and fitness is impaired if the nitrogen content of the leaves that form their diet is reduced, and increases of 20-80% in consumption rate have been measured as a response to poorer tissue quality.

In a high-CO_2 environment, the decomposition rate and nitrogen mineralization rate in litter may be slower as a result of the lower nitrogen content. However, it is difficult to predict where a balance will be found between a higher decomposition rate caused by elevated temperatures and a lower decomposition rate caused by poorer litter quality.

Animals and plants may also become threatened by pests, pathogens and predators or herbivores whose distribution was formerly limited by low temperature. Species that were formerly geographically separated by climatic factors may become sympatric, and in such cases the pattern of interaction between species may be dramatically changed.

In conclusion, given current knowledge it is difficult to predict more precisely the effects of higher temperature, alterations in storm and precipitation patterns and elevated CO_2 concentration on terrestrial ecosystem processes and dynamics in Norway.

6.2 Impacts of climate change on fresh water ecosystems

The predicted temperature rise will probably not lead to a loss of species diversity in Norwegian fresh water ecosystems, but some species may disappear from certain localities. Higher nitrogen concentrations caused by increased runoff from soil, changes in physicochemical and hydrological conditions, and a higher carbon dioxide concentration may lead to changes in competition between some species of primary producers and consumers. For specialized species of phytoplankton, zooplankton, vertebrates and cold stenothermic glacial relicts, the forecasted climate change could be critical in some localities. Fresh water systems are isolated, and some species of fish and crustaceans may be unable to migrate to alternative habitats. An increase in storm activity may result in the escape of larger numbers of farmed salmon to Norwegian rivers (see section 6.3 below)

6.3 Impacts of climate change on marine ecosystems

There is no indication that the expected rise in temperature is critical for marine ecosystems. Most marine species are capable of moving quickly to favourable growing and spawning areas. Climate change may however result in changes in the distribution and stock size of most fish species. A general northward shift in the distribution of fish stocks may be expected. A higher sea temperature may lead to immigration of new marine species, but the overall effects of this on marine ecosystems are not easily predicted. The immigration of new phytoplankton species may cause toxic algal blooms. In the Barents Sea higher sea temperature and a smaller area of ice in summer may contribute to greater biological production.

An increase in storm activity is expected to result in increased damage to fish farming installations, and thus in escapes of farmed fish. Escaped farmed salmon in Norwegian rivers already constitute a problem, and the negative consequences include genetic interactions between farmed fish and wild fish, and the possible transmission of harmful organisms to wild fish populations.

An increase in storm activity will also increase the risk of shipping accidents and oil spills along the Norwegian coast.

6.4 Adaptation measures

Protected areas are important for monitoring and research on the effects of climate change on ecosystems. Because of the expected shift of climate zones, areas that are protected may change character in the future. It may therefore be necessary for example to protect new areas or enlarge those already established in order to ensure that a representative sample of the variety of habitats found in the country is protected. This is essential to preserve species and genetic variability within species, maintain biodiversity and establish migration corridors to enable species to follow the climate to which they are adapted.

Discussion of how the management of protected areas can be adapted to cope with a changing climate has already started. To be better prepared for this situation, Norway is focusing on ways of improving the knowledge of the impact of climate change on ecosystems, for example by expanding research activities. A report describing the effects of climate change on Norwegian ecosystems was published in 1994 by the Directorate for Nature Management. Storms and severe weather conditions may occur more frequently as a result of climate change, and an evaluation of the consequences of such episodes for environmental management was published in 1995 (DN 1995).

7. Financial resources and transfer of technology

The Norwegian Government considers the financial mechanism and the transfer of climate-friendly technology to be essential to the implementation of the Convention.

The Government of Norway has officially notified the World Bank as Trustee of the interim operating entity of the financial mechanism of the Convention of its participation in the Global Environment Facility Trust Fund (GEF). The annual contribution to the facility based on IDA10 basic shares for the years 1994-97 has been in the order of NOK 54 million. In addition to this assessed contribution, the Government of Norway each year has been providing an extra grant, levelling the total annual contribution for 1994, 1995 and 1996 at the amount of NOK 55 million (the equivalent of approximately USD 8.5 million). This level corresponds to the level contributed to the GEF during the GEF pilot phase. The Norwegian contributions to the GEF are over and above the United Nations' agreed 0.7% target of development assistance in relation to GNP.

The Government of Norway has provided extra cofinancing to the Poland Coal-to-Gas Boiler Conversion Project and to the Mexico ILUMEX Project in addition to the Norwegian contributions to the facility. These cofinancing arrangements, which were entered into as Joint Implementation (now referred to as Activities Implemented Jointly), have served to expand the project scopes beyond what would have been undertaken in the absence of such cofinancing. The Norwegian financing is covering the expanded incremental cost financing requirement and is as such additional to the obligations under the financial mechanism. Further projects under the Activities Implemented Jointly Pilot Phase have been entered into with Costa Rica (implemented through private sector and Government participation) and with Burkina Faso (implemented through the World Bank) and others are in a planning stage. The public financing of projects under the Activities Implemented Jointly Pilot Phase comes from a governmental climate change fund established separate from, and in addition to, the development assistance accounts. For a more complete report on AIJ under the pilot phase and their contribution to financial and technological transfer, reference is given to the separate reports - submitted to COP 2 and the forthcoming report to be submitted to COP 3.

The official development assistance (ODA) provided by the Government of Norway for the years 1994, 1995 and 1996 corresponded to about 1% of GNP. The ODA is poverty oriented and not geared towards producing global environmental benefits. At the same time, transfer of technology and know-how in order to promote development and energy availability/efficiency constitute a significant element of Norwegian ODA, which may have significant environmental side-effects consistent with promoting the Convention. Because such effects are not the primary purpose of development assistance they have been rather scarcely recorded and assessed. Work is now under way to address such recording and assessment, and the outcome will be fully reflected in future reports to the Convention. Currently, all statistical information is organised according to DAC sector codes.

ODA funds that have been designed specifically with the view to disburse technology and ensure private sector participation include a programme for countries in Asia. This assistance, while promoting the Convention, have amounted to NOK 50 million in 1995, NOK 150 million in 1996 and will in 1997 be provided in the order of NOK 118 million.

General technical assistance to Annex I Parties with economies in transition have been provided with an emphasis on capacity building and transfer of know-how and technology.

This assistance, while promoting the Convention, have amounted to NOK 249 million in 1994, NOK 373 million in 1995 and NOK 386 million in 1996. The programme will in 1997 total NOK 269 million. The assistance to countries with economies in transition is provided in addition Norwegian ODA.

Assistance for the purpose of supporting adaptation activities of developing country Parties that are particularly vulnerable to the adverse effects of climate change is channelled through the general contributions to multilateral development institutions, including the UNDP.

8. Research and systematic observation

In Norway, research related to climate change involves a range of disciplines in various programmes and projects. The bulk of public and governmental funding goes into technical R&D, but there are substantial contribution to the basic natural sciences, economics and social sciences as well.

Within the broad range of research disciplines in the area of climate change, special priority is given to areas where Norway is in a particularly good position to advance scientific knowledge and understanding as a result of its geographical situation, research traditions or know-how. Furthermore, close attention is paid to areas where new scientific knowledge could significantly reduce uncertainties in the understanding and prediction of future climate change.

The Norwegian Climate and Ozone Research Programme provides the framework for the main thrust of Norwegian research into future changes in global climate and the ozone layer. The programme was established in 1989, and is run under the auspices of the Research Council of Norway. It provides funding for scientists at Norwegian universities and other research institutes. In addition, climate change research is supported through the general allocation to the universities and the research institutes. The Norwegian Climate and Ozone Research Programme was evaluated by an international expert group in 1996. The group reached the conclusion that the Norwegian scientists had provided valuable input to international research and policy-making both in Norway and internationally.

The programme gives priority to research on the following topics:

- Interactions between different greenhouse gases and their impact on radiative forcing,
- The impact of aerosols on climate change,
- Development and application of numerical models for atmospheric chemistry,
- The role of the ocean, i.e. deep water formation, the ocean as a CO_2 sink,
- Development and application of general circulation models, with emphasis on regional climate,
- Paleoclimatological research,
- Biospheric responses to climate change and stratospheric ozone depletion and
- Emission factors and calculation methodologies.

Norway has felt a special responsibility to develop regional climate change models for Scandinavia and the North Atlantic Ocean with the aim of reducing uncertainties in predictions of future climate change. This is also in accordance with the recommendations of the IPCC in its Second Assessment Report of December 1995, which sets out the special need to develop climate change models which could describe regional developments more precisely. Such models could provide new and better information both on regional development in these areas and on the impacts that changes in these areas, including changes in ocean circulation, could have on the global climate. A major research project under the Norwegian Climate and Ozone Research Programme on regional climate modelling and prediction was launched in 1997 to meet these challenges.

Some of the projects funded by the Norwegian Climate and Ozone Research Programme and/or other financial sources are described in more detail below.

8.1 Modelling and prediction, including global circulation models

<u>Atmosphere</u>
Several Norwegian research groups are collaborating in atmospheric chemistry modelling. These include the geophysics departments at the Universities of Oslo and Bergen and the Norwegian Institute of Air Research (NILU). The focus has been on modelling the atmospheric cycle of trace gases. The oxidizing capacity of the atmosphere and the influence of pollution in Europe on the level of tropospheric ozone have been studied. A global 3-D model for the troposphere driven by meteorological data is being used at the University of Oslo to study global ozone distribution. There are plans to couple the atmospheric 3-D model with a simple biospheric model to study the global methane cycle.

Scientists at the Universities of Oslo and Bergen are taking part in international cooperation using Global Circulation Models (GCM). The effects on atmospheric circulation of changes in radiative forcing caused by changes in greenhouse gas concentrations (in particular ozone) and the role of aerosols and clouds are being studied. Some of this work is being carried out on a Nordic basis.

<u>Ocean</u>
Oceanic models are being used in Norway to study the North Atlantic and the response of the circulation to small changes in boundary conditions, e.g. changes in solar radiation at the surface (Nansen Environmental and Remote Sensing Centre and the University of Bergen). Both circulation of the water masses and the carbon cycle have been studied. The role of mesoscale features, i.e. vortices, in heat transport in the Nordic seas has been studied and a new model has been developed for this purpose (Norwegian Meteorological Institute and Nansen Environmental and Remote Sensing Centre). The circulation in the Weddell Sea and its sensitivity to the amount of heat and fresh water exchanged at the surface are being studied using an oceanographic model (University of Bergen).

8.2 Climate process and climate system studies

<u>Ocean</u>
Most of the research effort in oceanography devoted to climate change is carried out by the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, and the University of Bergen. The formation of cold bottom water is the subject of extensive studies both in the Greenland-Iceland-Norwegian (GIN) Seas and in the Weddell Sea in Antarctica. Norway has a long tradition of Antarctic research, in which oceanography has been a strong component. The CO_2 balance in the GIN Seas is being studied in a major international project to which Norway is making a substantial contribution, including the use of an oceanographic research vessel. A major sink of atmospheric CO_2 is thought to

have been found in the northern Atlantic. This project is partly funded by the Norwegian authorities and partly by the Nordic Council of Ministers and the European Commission. It is hoped that measurements of the carbon balance in surface water and in the atmosphere above the ocean surface together with other parameters describing transfer of material both from the atmosphere to the ocean and within the ocean, will provide a more detailed picture of the CO_2 budget in the GIN Seas. The heat content and circulation of the abyssal water in the Nordic seas are also being studied.

Another major activity is a Nordic extension of the World Ocean Circulation Experiment. Its aim is to quantify the flow of warm, saline water into the GIN Seas and the return flow of cold, less saline water. This is being organized in a joint Nordic project funded partly at Nordic level and partly through national contributions, in which about seven acoustic Doppler current meters are deployed at strategic locations to provide new information on the climatology of the ocean currents.

Paleoclimatology

Several Norwegian research groups are working on aspects of palaeoclimatology, including studies of ocean floor sediment cores and glaciers, tree ring studies and investigations of written historical material. The incorporation of such groups into climate research has proved very fruitful, and has yielded much historical information and time series on past climate change. Material of this kind can be used to test GCMs and other models with input conditions quite different from those prevailing today. For instance, interesting results have been obtained concerning the relationship between the rise in CO_2 and the temperature rise through late-glacial climate reconstructions in Western Norway (University of Bergen). Some of the projects are Norwegian contributions to international programmes.

Biosphere-atmosphere interactions

Trace gas fluxes in terrestrial systems, and especially methane oxidation and nitrous oxide release from denitrifying and ammonium oxidizing bacteria, are being studied by the Norwegian University of Agriculture. At the University of Oslo a 3-D Chemical Tracer Model is being used to study the transport of methane between the atmosphere and the biosphere.

Stratospheric ozone

Long term monitoring of total ozone as well as theoretical ozone research has a long tradition in Norway. Norwegian scientists were among the first to publish calculations of the ozone balance in the stratosphere (around 1970). The Norwegian Institute of Air Research (NILU) has played an important role in European ozone research in recent years, and has been stronger involved in two large scale projects, the European Arctic Stratospheric Ozone Experiment (EASOE) and the Second Stratospheric Arctic and Middle Latitude Experiment (SESAME).

8.3 Data collection, monitoring and systematic observation, including data banks

Atmosphere

The Norwegian Institute of Air Research (NILU) has the main responsibility for greenhouse gas observation in Norway. Both tropospheric and stratospheric ozone and carbon dioxide, methane, nitrous oxide and chlorofluorocarbons are measured at the Arctic atmospheric baseline station in Ny-Ålesund on Svalbard. This is part of the Global Atmospheric Watch

(GAW) and the Network for Detection of Stratospheric Change (NDSC). NILU hosts the European part of the NDSC data base and is also running the European data base for stratospheric ozone (NADIR), which contains data from the large European research projects on stratospheric ozone.

Norway is also participating in the North Atlantic Climatological Dataset (NACD) which is a project intended to produce a consistent climate database covering the entire North Atlantic, the North Sea and the Baltic Sea. The project is partly funded by the Nordic Council of Ministers.

The Archaeological Museum in Stavanger has developed a historical (pre-1990) meteorological database. This is a part of a European Science Foundation project and provides data for the international maritime historical database Comprehensive Ocean Atmospheric Data Set (COADS), hosted by the US.

Oceanography

At the weather ship «Polarfront» at approximately 66°N and 0° longitude, temperature and salinity records have been maintained since just after the Second World War, and studies document highly significant but slow changes in deep ocean temperatures.

Terrestrial

As a part of the programme for terrestrial monitoring (TOV), a project involving the monitoring of vegetation in permanent plots was started in 1990. The aim of the project is to detect environmental impacts of pollution at an early stage, and to study changes in ecosystems over time. Some of the methodological parameters used in relation to the project will show the environmental impacts of climate change as well.

The use of growth rates of lichens as an indicator of climate change is currently being tested.

Inventories

Research on the role of nitrogen and its flow and use in society have been conducted by the Norwegian University of Agriculture. This is particularly important in determining present and future N_2O emissions and may also be valuable in studies of carbon uptake through the biological cycle.

Statistics Norway is studying the flow of carbon in products.

The development of emission inventory methodologies is a continuous process, which is organized as a programme run by the Norwegian Pollution Control Authority. Much of the research is conducted by Statistics Norway.

8.4 Research on impacts of climate change

Four approaches to impact studies are being emphasised, i.e. statistical modelling, laboratory experiments in which species of interest are grown under a range of environmental variables, field experiments in which the environment is manipulated, and natural experiments from the past using paleoecological methods.

Projects on statistical modelling of Norwegian mountain plants growth in relation to climate, and on the effects of increased CO_2 and temperature on plant and salmon growth have been undertaken. One project which forms part of the International Tundra Experiment (ITEX), is studying the effect of experimentally induced warming on the reproduction of mountain plants.

The CLIMEX project (Climate Change Experiment) is a whole-ecosystem experiment in which ambient atmospheric and climatic conditions are manipulated using a large (1200 m^2) greenhouse. The project is addressing the effects of increased atmospheric CO_2 concentration and temperature on natural vegetation/soil/water systems. The project receives national and EU funds.

During the last 4-5 years 15-20 % of the funds of the Norwegian Climate and Ozone Research Programme have been allocated to climate impact studies. Planning of a new research programme on biological diversity started in January 1997. This activity will deal with natural variations as well as the impacts of climate change. It is expected that priority will be given to research on the combined effects of different kinds of anthropogenic emissions (e.g. higher levels of nitrogen and CO_2 and higher temperature). The new programme will constitute to a strengthening in the research on climate impacts in Norway.

8.5 Socio-economic analysis

Various Norwegian institutes and sponsors have been involved in policy-oriented studies on climate change over a number of years, particularly in the field of economics.

In 1996 the Research Council of Norway established the research programme Constraints, Measures and Possibilities in Norwegian Energy and Environmental Policy. This five-year programme follows on from related programmes which started in 1989. Socio-economic aspects of climate change are dealt with directly or indirectly in many of the projects financed by the programme. The total budget from 1996 to 2000 amounts to NOK 50 million. The Research Council of Norway is also planning to strengthen social science and interdisciplinary research related to the human dimensions of global environmental change which will include aspects of climate change.

CICERO, the Center for International Climate and Environmental Research, Oslo, conducts research and publishes reports and information on national and international climate policies. The Center has a multi-disciplinary staff with expertise in the social and natural sciences. CICERO actively participates in the work of the IPCC and the processes related to the UN Climate Convention, to which it has contributed knowledge and strategic input. Its research includes studies of the indirect effects of emissions on climate through chemical interactions in the atmosphere. This forms the scientific basis for developing a comprehensive approach which takes the effects of several gases into account and which may be used in the formulation of cost-effective measures and strategies. Further research focuses on how a comprehensive approach may be used in negotiations on the developing of a global climate regime. This is related to studies of issues relevant to the ongoing negotiations on climate change, such as burden sharing, activities implemented jointly, etc.

The Institute for Energy Technology (IFE) is participating in energy modelling work related to the MARKAL model, coordinated by the International Energy Agency (IEA). The analysis includes elements such as efficient use of energy, transition to less CO_2-intensive energy sources and renewable energy sources. The aim of the modelling work is to obtain cost-effective abatement strategies. Currently activities are focusing on studies of burden-sharing among OECD countries, which are relevant to the negotiations under the Climate Convention.

The research development department of Statistics Norway conducts research on interactions between international economic development, developments in the international energy market, economic policies, pollution and climate change. It focuses particularly on the development and introduction of cost-effective international instruments to counteract the enhancement of the greenhouse effect. The effectiveness of taxes, tradable quotas, activities implemented jointly, bilateral contacts in emission development and cost effectiveness of these instruments are the subject of several studies. The research department of Statistics Norway has published several articles in international journals addressing such issues, and has taken part in international workshops and discussions and expert groups throughout the world.

The Fridtjof Nansen Institute (FNI) is an independent foundation engaged in applied social science research on issues related to international resource management, climate change policies and energy market developments. In the past ten years, the institute has participated in the major research programmes on climate change and international energy policies run by the Norwegian Research Council. FNI has also been involved in several EU research projects on energy policies and climate change. The interplay between ideological, political, economic and institutional factors in the development of national energy and climate policies is a major focus of research. Several country studies have been conducted with regard to the energy and climate change policies, including analyses of the role of Norway, the US, the EU and developing countries in the international climate negotiations. The Institute focuses on political science and economics, but maintains a broader interdisciplinary approach through extensive collaboration with other research institutes in Norway and internationally.

ECON Centre for Economic Analysis is working on a wide range of climate policy issues. Its clients are government agencies, industry associations and international organisations such as OECD, the World Bank and the FCCC secretariat. An important field of study is effects and cost-efficiency of carbon taxation, including analysis of green tax impacts on competitiveness (for individual industries as well as at national level) and international fuel markets. Other areas such as energy conservation, voluntary agreements and transport sector policies are also important areas of climate-related research. The impacts on electricity markets of various modes of allocating emission allowances have been examined. Like CICERO, ECON has been active in the conceptual development and practical adaptation of Activites Implemented Jointly (AIJ). Recent projects cover issues such as the relations between AIJ and tradable emission permits, criteria for JI, incentives for industry involvement in AIJ, and the overall potential for AIJ and emission trading under differing assumptions. ECON has also participated in operational AIJ project development in Central and Eastern Europe, Russia and China.

The theoretical research on climate change issues carried out by the Foundation for Research in Economics and Business Administration (SNF) have examined the optimal design of international climate agreements when all countries are signatories. Later, the focus has been on the analysis of international climate agreements with limited participation, examining both demand and supply measures. At present, this research is being continued by examining the optimal design of climate agreements in the case of market failure (e.g. unemployment) in the signatory countries.

8.6 Technology

The development of energy-related technology has been the main area of research related to reductions in greenhouse gas emissions. In 1996, about NOK 100 million was spent on R&D related to effective energy technology and renewable energy sources. In addition, about NOK 40 million was spent on introduction and demonstration.

Energy related research in Norway focuses mainly on large hydropower installations since our electricity supply is largely based on hydropower. With new transmission cables to Germany and the Netherlands now under construction, power exchange with the thermal power system in Europe will become more important in a few years time. Power exchange will make it possible to use the Norwegian hydropower system to meet peak consumption in other countries to a larger extent, thus reducing the need for new fossil-based capacity in other countries. R&D related to this topic is given high priority in Norway.

A part from hydropower, bioenergy is considered to be the most important renewable energy source in Norway. To promote the use of bioenergy in Norway, NOK 50 million has been allocated to introduction and demonstration of bioenergy in the 1997 budget. In addition to bioenergy, R&D related to wind energy, solar energy, and other selected technologies is supported.

In 1995, the Ministry of Industry and Energy appointed a committee (MILJØSOK) with a mandate to investigate an effective environmental strategy to ensure that extraction, transport and processing of oil and gas in the Norwegian continental shelf meet the highest possible environmental standards and to improve the industry's cost-effectiveness and competitiveness. In its recommendations, presented in December 1996, the committee devoted substantial attention to the problems related to CO_2 emissions from the petroleum sector. Under certain conditions, the findings indicate that it may be possible to reduce CO_2 emissions (per kWh produced) by 30-40% from the current level during the next 15 years.

In the Report to the Storting No. 41 (1994-95) on «Norwegian policy to mitigate climate change and reduce emissions of nitrogen oxides (NOx), the Government proposed the establishment of a new R&D program to develop and implement technologies with the potential to significantly reduce emissions of CO_2 and other greenhouse gases. In 1997, the programme was launched under the auspices of the Research Council of Norway. The programme will primarily focus on full-scale implementation of technology, and 75% of the funding is to be allocated for this purpose. The remaining 25% will be allocated to long-term R&D with the aim of stimulating and achieving a technology shift in the area. The programme is targeted towards the petroleum and process industries and the transport sector. The budget for the programme in 1997 is NOK 22.3 million with a planned, additional private funding of approximately NOK 70-80 million.

8.7 Norwegian contributions to international global change programmes

The International Geosphere-Biosphere Programme (IGBP)
Norway has been a member of the IGBP since 1989. Norwegian scientists are doing research in several fields which are relevant to the objectives of the IGBP Core Projects, but many of the projects are not formally affiliated with the IGBP. The Norwegian IGBP committee is trying to promote closer links between national research and IGBP Core Project research.

Joint Global Ocean Flux Studies (JGOFS)
Norway is hosting the international Core Project Office for JGOFS, located at the University of Bergen. The main Norwegian contribution to JGOFS is the CARDEEP project, which is a Norwegian-based research programme designed to improve the understanding of the role deepwater-forming regions of the GIN seas play in global oceanic CO_2 uptake. The project is supported by EU, the Nordic Council of Ministers and the Research Council of Norway.

Biospheric Aspects of the Hydrological Cycle (BAHC)
Norwegian researchers participate in BAHC through NOPEX, which is a Nordic hydro-meteorological pilot experiment to improve understanding of climate processes through studies of evapotranspiration and the interaction between land surface and atmosphere. The project is mainly funded by the Nordic Council of Ministers.

Global Change and Terrestrial Ecosystems (GCTE)
Norway participates in GCTE research through CLIMEX, which is a Climate Change Experiment. The objective is to quantify the impact of CO_2 enrichment and elevated temperature on ecosystem response, by means of whole catchment manipulation. Several other projects are related to GCTE.

International Global Atmospheric Chemistry Project (IGAC)
Norwegian scientists are involved in three IGAC sub-projects. One is the North Atlantic Regional Experiment (NARE), where three research groups have taken part with modelling studies. A scientific secretariat for the sub-project Global Emissions Inventory Activity (GEIA) has been established at the Norwegian Institute for Air Research (NILU). Finally, modelling of ozone as a greenhouse gas at the University of Oslo forms part of the sub-project GIM (Global Integration and Modelling).

Land Ocean Interaction in the Coastal Zone (LOICZ)
A number of current Norwegian research activities are relevant to LOICZ. The Norwegian IGBP committee organized a workshop in 1994 to promote participation by Norwegian scientists in the Core Project. The Norwegian research includes a wide range of topics related to coastal zone and the fjords, the interplay of freshwater and marine systems, the carbon budget in coastal systems, causes of plankton blooms, biochemical cycles in coastal waters and sediment-water interactions.

Relations with the World Climate Research Programme (WCRP).
Norway is hosting the International ACSYS (Arctic Climate System Study) Project Office under the WCRP. The office is located at the Norwegian Polar Research Institute in Oslo. In addition Norway is contributing to the World Ocean Circulation Experiment (WOCE) which is organised under WCRP, through the Nordic World Ocean Circulation Experiment. This project is an extension of WOCE into the Greenland-Iceland-Norwegian Seas, and

runs according to WOCE guidelines. Norway also contributes to the Climate Variability (CLIVAR) and Stratospheric Processes and their Role in Climate (SPARC) projects.

Contribution to Intergovernmental Panel on Climate Change (IPCC)
Several Norwegian scientists from various research institutions contributed to the Second Assessment Report of the IPCC in 1995 as lead authors, contributors and peer reviewers. Contributions by the University of Oslo, CICERO, the Norwegian Institute for Air Research, and Telemark College (Working Group I), the Norwegian Institute for Nature Research (Working Group II), and the University of Oslo and CICERO (Working Group III) should be especially noted.

Capacity-building in developing countries
The Government has initiated cooperation with the Research Council of Norway on a strategy to strengthen human resource development and research related to Norway's relations with developing countries. Strengthening of capacity-building in developing countries through better coordination of Norwegian research efforts is one of the main aims of the strategy. The Research Council's programme "Supporting Norwegian collaborators in developing countries", currently makes funds available for Norwegian scientists for projects involving collaboration with colleagues from developing countries.

9. Education, training and public awareness

The text of the Climate Convention refers directly to the issue of education, training and public awareness, and encourages all Parties to promote activities designed to give the general public a better understanding of climate change and its effects. This in turn should result in support for policy measures to deal with climate change and also encourage public participation in climate-related measures.

In 1990, the Norwegian Government decided to establish CICERO, the Center for International Climate and Environmental Research. CICERO was established as a private non-profit organization with the University of Oslo as founder. Its work is based on two main objectives:

- To develop the research basis for initiatives in national and international climate policy.
- To keep politicians, government, business, educational systems, media, the public and the international community informed about the development of international climate policy.

Active involvement in the public debate on climate issues is of special importance for CICERO. Four times a year, it publishes the newsletter «CICERONE», which has a circulation among ministries, directorates, the business sector, research institutions and schools. The newsletter includes reports on the development of international climate policy as well as research findings. In 1996 CICERO translated the IPCC Second Assessment Report to Norwegian, and the newsletter also provides information on the ongoing negotiations.

CICERO also arranges the Climate Forum, which brings together representatives of industry and business as well as government and researchers. Climate Forum is organized to provide information on development trends in international climate research and policies, and to improve the dialogue between the various parties involved.

In addition CICERO often organizes international conferences. The two most recent of these addressed the challenge that climate change represents for the African continent. One of these was arranged jointly by CICERO and the World Bank.

The annual publication «Miljøtilstanden i Norge», produced by the Norwegian Pollution Control Authority and the Directorate for Nature Management, gives an updated review of emissions of pollutants, the state of the environment and anticipated developments. Great emphasis has been put on making the report readily accessible to the general public and politicians. The publication is free of charge and is widely used by students at various levels. Detailed figures and analyses are also published by Statistics Norway, especially in the annual «Natural Resources and the Environment».

Experiences have shown that the main barrier to improved energy efficiency is lack of knowledge of appropriate measures and their cost efficiency. Information and training are therefore the most important instruments available to the authorities.

During the last years, information campaigns in media with nationwide coverage helped to raise the awareness of energy efficiency issues in private households and among other energy users. The Industrial Energy Efficiency Network has continued to grow since it was established in 1989. Its members now represent 80% of the total energy use in the Norwegian domestic industry.

The Norwegian Information Centre for Energy Efficiency (OFE) has for some years now arranged training courses and seminars in energy efficiency. The target groups are consultants, caretakers, maintenance personnel and architects.

Energy efficiency centres have now been established in almost every county in Norway. The centres provide customers with basic analyses and information on state funded energy efficiency programmes, energy use and prices.

Together with the other countries in the European Economic Area, Norway has introduced a system of energy labelling of household appliances. In 1996 regulations relating to energy labelling of refrigerators, freezers and their combinations, tumble dryers and washing machines were introduced in Norway. Further types of household appliances will be energy labelled in the future, and combined washer-dryers are next. Appliances are required to carry a label showing their energy efficiency class and energy consumption. Further information is contained in product brochures. Energy efficiency labelling is an important means of increasing public awareness of energy consumption by different appliances.

Norway is arranging an international workshop in May 1997 with the overall goal of increasing understanding of the relationship between nitrogen dissipation from society and atmospheric N_2O. The strategic goals include drawing up thorough accounts of nitrogen consumption by society and comprehensive budgets for recipients of nitrogen emissions, such as forests, open-water bodies, sea, cultivated and uncultivated land.

In 1996, the Research Council of Norway produced an overview of the state of the art regarding climate change and ozone layer depletion. The 60-page booklet was distributed free of charge to the teachers in all Norwegian upper secondary schools. The response has been very positive.

Nature and Youth carried out a climate campaign in 1996 which focused on giving information about the climate problem to schools all over the country, and on information to and communication with local communities about the need for local climate action plans.

MEIS (Environment Energy Indoor climate in Schools) is a national programme for environmental education that is intended to raise the level of competence in the fields of environment, energy, indoor climate and health. The programme aim to reduce energy consumption in schools by means of active participation from pupils. It has been documented that 50 schools reduced annual emissions of CO_2 by approximately 210 tonnes over a three-years period.

Annex

A. Key assumptions

Emission coefficients by source and sector are calibrated to a base year, and are projected by taking into account environmental instruments or policies that have already been implemented or decided. The projections presented therefore represent future developments based on current economic and environmental policies and future economic developments. The projections also depend on many uncertain assumptions concerning key variables and parameters.

The projections are based on measures implemented in 1997, i.e. a CO_2 tax of 0.87 NOK/litre for petrol, 0.435 NOK/litre for mineral oil, 0.435 NOK/kg for coal and coke for energy purposes, 0.87 NOK/litre for oil in the North Sea and 0.87 NOK/Sm^3 for gas in the North Sea.

The development of the petroleum market is highly uncertain. The projections are based on a technical assumption that the price of crude oil will remain constant at about NOK 115 per barrel throughout the simulation period, measured in 1997 prices. The prices of oil and natural gas have various implications for Norwegian emissions of CO_2. In addition to their influence on the domestic use of oil products, they affect the level of activity in the petroleum industry in the long run and thus emissions from this industry. Norwegian petroleum production is assumed to increase from 220 million Sm^3 of oil equivalents (Sm^3 o.e.) in 1996 to about 292 million Sm^3 o.e. in 2001. After the turn of the century, petroleum production is expected to fall as a result of reduced oil extraction.

It is also assumed that energy-intensive manufacturing industries will keep their existing power contracts and that it will not be profitable for such industries to expand production by buying additional electricity. If energy-intensive industries expand production significantly more than assumed, emissions of CO_2 and possibly other greenhouse gases from these industries will increase more than specified in Table 5.2 in Chapter 5.

Some more key assumptions are listed below:

- The average annual rate of GDP growth in trading partner countries is expected to be 2.5% until the year 2000. Annual GDP growth is assumed to slow down to 2% in 2000-2010 and to 1.25% in 2010-2020 as a result of various factors. Population growth is expected to decline in the OECD countries and even become negative after 2030, resulting in lower economic activity. In addition, GDP growth is forecast to fall as GDP per capita rises. Services will account for a growing share of GDP, and since they exhibit lower productivity growth than the production of commodities, this will contribute further to the slowdown in economic growth. However, assumptions about international economic growth are not decisive for long-term projections. Research based on historical data from industrialized countries indicates that it is a country's ability to utilise the resources at its disposal that determines growth in the long term.
- The annual increase in consumer prices in trading partner countries is assumed to be 3%.
- Growth in international tradables is expected to be 2.5% per annum.
- The international interest rate is assumed to be 4% in real terms.
- The rate of autonomous energy efficiency improvement varies between sectors, but is on average assumed to be about 1% per year.
- The level of direct and indirect taxes will remain broadly unchanged.

– The household savings rate will be roughly unchanged.

Table A.1 Real GDP and population in Norway. (Percentage annual growth in fixed 1992 prices)

	1992-level[1)]	1992-2010	2010-2020
GDP	784.3	2.3	1.1
Population	4.3	0.5	0.4

1) GDP in billion 1992-NOK. Population in million inhabitants.

Table A.2 Supply and use of electricity [1)] (TWh)

	1970	1995	2010	2020
Net domestic use Of which:	52	105	117	128
The economy excluding energy-intensive industry	28	77	87	98
+Net export	1	6	12	2
+Power losses	5	12	7	8
= Production	58	123	136	137
Hydropower	57	122	130	131
Other types of power[2)]	0	1	6	6

1) Figures may not sum up due to rounding errors
2) The projections are based on the assumption that two gas-fired power stations will be built

Table A.3 Net domestic use of transport and heating oil [1)] (1000 tonnes)

	1992	2010	2020
Transport oil	4351	5486	5815
Heating oil	1208	1472	1599

1) Figures may not sum up due to rounding errors

Table A.4 Supply and use of petrol and autodiesel[1)] (1000 tonnes)

	1992	2010	2020
Total supply	10936	15123	17757
Production	9884	13119	15459
Import	1051	2004	2297
Export	6752	9804	12108
Statistical differences, changes in inventories	-167	-167	-167
Net domestic use	4351	5486	5815
Energy-intensive industry	10	11	11
The rest of the economy	4341	5475	5804

1) Figures may not sum up due to rounding errors

Table A.5 Electricity per unit of production. (GWh/million 1992 NOK)

	1992	2010	2020
Totally	0.05	0.04	0.04
Energy-intensive industry	0.70	0.57	0.55
The rest of the economy	0.03	0.03	0.02

Table A.6 Heating oil per unit of production. (1000 tonnes/million 1992 NOK)

	1992	2010	2020
Totally	0.6	0.5	0.5
Energy-intensive industry	2.7	2.2	2.1
The rest of the economy	0.6	0.5	0.5

Table A.7 Petrol and autodiesel per unit of production. (1000 tonnes/million 1992 NOK)

	1992	2010	2020
Totally	2.1	1.9	1.8
Energy-intensive industry	0.2	0.2	0.2
The rest of the economy	2.3	2.1	2.0

Table A.8 Real capital in private housing in fixed 1992 NOK.(Average annual growth)

	1992[1)]	1992-2010	2010-2020
Real capital in private housing	74576	3.6	3.3

1) Million 1992-NOK

B. Methodology - projections

B.1 CO_2 emissions

<u>Short-term projections</u>

MODAG is a Keynesian-type macroeconomic model that is basically demand driven. The model is constructed and updated by Statistics Norway, and its main user is the Ministry of Finance. The model is used regularly as an analytical aid in preparing the National Budget and the Government's Long-term Programme, which present overall government policy in the form of reports to the Storting. The Norwegian national accounting system forms the conceptual framework and the empirical basis of the model. Nearly all parameters are estimated econometrically and the model is re-estimated every year. The model is relatively disaggregated with 28 production sectors, 40 commodities and 14 categories of private consumption. Activity in the petroleum sector, which is very important for the Norwegian economy and for emissions of CO_2, is exogenous to the model.

Total energy demand is proportional to gross output by industry, but is corrected by the model operator for developments in energy efficiency. Furthermore, it is an aggregate composed of electricity and petroleum products. The decision to use electricity or petroleum products depends on the relative prices of electricity and fuels and a trend variable. A rise in fuel prices reduces demand for fossil fuels and increases demand for electricity, but total energy demand remains unchanged.

A trend variable has been included in the modelling of the distribution of energy demand between electricity and oil. The trend variable is a proxy for omitted and partly unobservable variables, such as increased use of electricity-specific equipment and high installation costs for oil heaters combined with uncertainty about the future oil price. If relative prices remain constant, the effect of the trend variable is to cause electricity to make up a gradually increasing share of total energy demand.

One of the main advantages of using macroeconomic models for emission projections is that they provide consistency between macroeconomic forecasts, expected growth in energy use and the resulting emissions to air. Synergistic (indirect) effects, like the effects of CO_2 taxes on other pollutants, are also captured by the model.

It should be noted that there is no substitution between total energy and other input factors. The effects of relative price changes can to some extent be adequately reflected by adjusting energy efficiency parameters exogenously. These have been assumed to grow at average rates from 0.75% to 1% per year. Furthermore, the sectoral composition of the model is not specifically designed for environmental purposes, e.g. the transport sector is rather aggregated. However, for medium-term projections (up to the year 2005) the model is considered to be quite satisfactory for energy and environmental purposes as well.

Emissions from four types of sources are calculated in a supplementary model to MODAG. Emissions from industry and private households due to stationary combustion are associated with the use of fuel oils, mobile combustion emissions are associated with the use of petrol, process emissions are associated with the use of intermediate materials other than energy commodities, and evaporation is associated with industrial use of materials (proxy for use of solvent), total demand for petrol (evaporation from storage and handling of petrol) and private consumption (proxy for use of paints etc.).

Long-term projections

The long-term projections of CO_2 emissions are based on a macroeconomic model of the Norwegian economy called MSG (Multi-Sectoral Growth). Various versions of the model, which was developed by Statistics Norway, have been used in the Ministry of Finance since the 1960s.

MSG is a general equilibrium model. The main determinants of growth are capital formation, labour supply, the availability of natural resources and the rate of technological improvement. As all resources are fully utilised, the model is not suitable for analysing short-term adjustment problems like unemployment or closure of industries due to changes in policy or international prices.

The model boasts a disaggregated structure. It consists of 40 private production sectors, 7 government sectors and 17 private consumption sectors. The main production factors are material inputs, labour, three types of real capital, two types of energy and various types of polluting and non-polluting transport services. A certain degree of substitution between production factors is assumed in the model depending on changes in their relative prices and the exogenous assumptions about factor productivity developments.

MSG is a model of heterogeneous industries. Producers enjoy some market power at home, a feature supported by empirical analyses of the Norwegian economy. Producer behaviour at home is therefore characterized by monopoly competition. On the world market, however, prices are fixed, suggesting that producers are confronted with free competition and act as price takers in the export markets. In each sector, real capital formation is determined in a way that ensures that expected return on capital equals an exogenously given return on capital.

The electricity model in MSG, as it is used in this projection, is based on hydropower generation in Norway and free access to import and export of electricity. Alternative sources of energy like bioenergy are not included in the model or in the simulation results for energy use in Norway.

A detailed emission model is incorporated in MSG, turning it into an effective tool for assessing pollution at various levels of economic activity. Nine pollutants disaggregated by source and sector have been specified in the model. Results are, however, corrected for emissions from the two planned gas-fired power plants with a total capacity of 5.6 TWh for which a Norwegian company is in the process of licencing. These plants will eventually be phased in around 2000 and will increase CO_2 emissions by about 2.1 million tonnes yearly.

It should be emphasised that adjustment lags are not taken into account in MSG. A drastic change in policy might require considerable adjustment costs. Simulation results, therefore, should be considered realistic only after allowing for a certain period of adjustment.

Estimates of the following main assumptions are provided by the model operator:
- Labour supply
- Rate of technological improvement in the various production sectors
- Production, real investments and prices in the petroleum sector
- World market prices
- Requirement for the rate of return on capital
- Requirement for the current account and the financial balances of the government sector and households
- Demographic estimates including the number of pensioners
- Tax regulation

B.2 Other greenhouse gases

Table B.1 shows emissions and projected emissions of methane, nitrous oxide, perfluorocarbons, sulphur hexafluoride and HFCs. The GWP values used in table B.1 are given in section 3.1.2.

Table B.1 Emissions of the various greenhouse gases in 1989, 1990, 1995 and projections for 2000, 2005, 2010 and 2020. (The figures are given in million tonnes CO_2 equivalents)

	1989	1990	1995	2000	2005	2010	2020	Changes 1990-2010
Σ other greenhouse gases	18.8	18.6	16.5	16.1	16	15.6	16.1	-16%
Methane*)	9.0	9.1	9.9	8.7	7.9	7.0	6.8	-23%
Nitrous oxide	4.7	4.8	4.4	4.8	5.1	5.2	5.5	10 %
PFCs	2.5	2.5	1.4	1.3	1.2	1.2	1.2	-52 %
Sulphur hexafluoride	2.6	2.2	0.6	0.5	0.5	0.6	0.7	-75 %
HFCs	0.0	0.0	0.2	0.8	1.3	1.6	1.9	..

*) The projections on methane from landfills are based on scenario 1 in section 4.4.1, which assumes that implementation of existing or new policy instruments will reduce the methane emissions from landfills by 33% by 2010.

The methodology used in the projections of non-CO_2 gases is described in section 5.2. Tables B.2-B.5 summarizes projections of anthropogenic emissions of CH_4, N_2O, other greenhouse gases, precursors and SO_2. The tables are filled in according to the IPCC Guidelines.

Table B.2 Summary of projections of anthropogenic emissions of CH_4 (1000 tonnes)

	1990	1995	2000	2005	2010	2020
Fuel combustion	14	18	18	17	15	12
Fugitive emissions from fuel	21	30	23	20	17	13
Industrial processes	1	1	1	2	2	2
Enteric fermentation	76	80	96	96	96	96
Animal waste	15	16	*	*	*	*
Rice cultivation	0	0	0	0	0	0
Waste	302	322	273	240	200	200
Other (mobile combustion)	2	2	2	2	2	2
Total	432	469	414	377	332	325

*) Included in enteric fermentation.

Table B.3 Summary of projections of anthropogenic emissions of N_2O (1000 tonnes)

	1990	1995	2000	2005	2010	2020
Transport	0.8	1.0	1.3	1.5	1.9	2.7
Other energy sources	1.6	1.5	1.6	1.8	1.9	1.9
Industrial processes	6.7	5.3	6.7	6.7	6.7	6.7
Agriculture	6.3	6.5	6.5	6.5	6.5	6.5
Waste	-	-	-	-	-	-
Total	15.3	14.2	16.0	16.5	16.9	17.7

Table B.4 Summary of projections of anthropogenic emissions of other greenhouse gases (tonnes)

	1990	1995	2000	2005	2010	2020
SF_6	92	24	22	22	23	30
HFCs	3	108	478	848	1004	1192
PFCs	387	217	184	184	184	184

Table B.5 Summary of projections of anthropogenic emissions of precursors and SO_2 (1000 tonnes)

	1990	1995	2000	2005	2010	2020
CO	961	829	657	621	614	622
NO_X	227	222	208	220	225	226
NMVOCs	299	378	337	261	236	215
SO_2	53	35	32	34	35	36

B.3. CO_2 sinks

The calculations are based on the planning programme AVVIRK3 run by the Norwegian Institute of Land Inventory. All areas are included. Net removals are estimated on the basis of increments and losses in the forest. Volume and biomass are converted to CO_2 equivalents using the same factors as in the calculations for 1995.

<u>Future gross increments</u>
Increments will be influenced by the forest policy set by the authorities. A change of policy will, however, have little influence on the increments for a few decades as the time lag between actions and actual growth is considerable. For this reason, it is assumed that the net removals until 2020 will be controlled by the level of harvest more than by any change in forest politics.

<u>Future harvest and losses</u>
Although commercial harvest varies from year to year, the long-term trend shows little variation. In modelling future removals it has been assumed that the level of harvest will be the same as in 1988, which corresponded to 18 million tonnes of CO_2. Natural losses are set at 0.6% of the total number of trees, which is approximately 8% of the annual increments.

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