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Statistiske analyser
Statistical Analyses

Natural Resources and the Environment 1995

Statistics Norway
Statistisk sentralbyrå

Natural Resources and the Environment 1995

Statistisk sentralbyrå • Statistics Norway
Oslo-Kongsvinger 1995

Standard symbols in the tables	Symbol
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Provisional figures	*

ISBN 82-537-4147-2
ISSN 0804-3221

Emnegruppe
10 Ressurs- og miljøregnskap og andre generelle ressurs- og miljøemner
Ny 1995: 01 Naturressurser og naturmiljø (Environment)

Emneord
Avfall
CO_2-avgift
Energireserver
Forurensning
Miljøpriser, Miljøøkonomi
Naturmiljø, Ressursoversikter
Utslipp

Design: Enzo Finger Design
Printed: Falch Hurtigtrykk
Illustrations: Tone Veiby

Preface

Statistics Norway (SN) compiles statistics on the state of the environment, as well as accounts for a number of important natural resources. Statistics Norway also develops methods and models to analyze the inter-relationships between socio-economic conditions, use of resources, and environmental conditions. The publication *Natural Resources and the Environment* contains an annual concentrated overview of this work.

Natural Resources and Environment 1995 presents, in part I, updated resource accounts for energy and emissions accounts for emissions to air. The report also includes key figures for fishing, sealing and whaling, agricultural pollution, forest resources and forest damage, municipal waste water treatment plants and waste management. Some results from Statistics Norway's research on the economics of resources and the environment are presented in part II. Emphasis is placed on analyses of the environment and economic growth, management of the environment and natural resources, and international analyses. The publication also contains a comprehensive appendix of tables, part III.

Statistics Norway wishes to thank all the institutions that have supplied data for *Natural Resources and the Environment 1995*.

The report is a joint publication from the Division for Environmental Statistics, Department of Economic Statistics, and the Resource and Environmental Economics Division, Research Department. The report has been edited by Ola K. Hunnes. Part II has been prepared by an editorial committee consisting of Kjell Arne Brekke, Bodil M. Larsen, Solfrid Malo and Gina Spurkland. Mary Bjærum has translated the Norwegian version into English.

Statistics Norway
Oslo/Kongsvinger, 10 April 1995

Svein Longva

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Introduction

Natural Resources and the Environment 1995 provides information on important Norwegian natural resources and the natural environment in the form of statistics (*parts I and III*) and analyses (*part II*). Most of the statistics have been prepared by Statistics Norway, but data have also been obtained from other sources.

Part I describes status and trends for a number of important resources and environmental parameters in Norway. Part II presents some analyses of the interrelationships between use of resources, the environment and the economy. The appendix of tables comprising part III contains more detailed statistics on resources and environmental conditions in Norway.

The first chapter, on *energy*, includes updated statistics on resources, extraction and use of crude oil, natural gas, hydropower and several other sources of energy in Norway and abroad. This year's edition also includes, among other things, the results of a survey of energy use in households in Norway, price trends for important sources of energy, and conditions influencing the future use of energy.

Emissions of pollutants can cause adverse effects at local, regional and global level. A chapter on *emissions to air* discusses both emissions and pollution at these three levels. A fundamental question is whether Norway will be able to realize the national targets and meet the commitments defined in the international agreements on emissions of gases such as CO_2, SO_2, NO_x and volatile organic gases. Global problems connected to depletion of the ozone layer and climate change are also discussed.

The chapter on *fishing, sealing and whaling* presents figures on fish stocks, catches and exports, and some key figures on fish farming. The chapter on *forests* contains statistics on forestry and forest resources in Norway, and on forest damage in Norway and Europe.

Norway has signed the North Sea Declarations, and has thus undertaken to halve discharges of nitrogen and phosphorus to the North Sea by 1995, with 1985 as base year. *Natural Resources and the Environment 1995* contains new statistics and results of analyses of relevance for monitoring discharges of nutrients into the North Sea. These statistics apply to discharges from *waste water treatment plants* and *agriculture*.

The chapter on *waste* presents results from a sample survey of generation, recycling and other treatment of industrial waste and hazardous waste from industry. It also includes data on collection and management of municipal waste, as well as statistics based on annual records of delivered amounts of hazardous waste.

Part II presents research work focusing on how economic growth affects the natural environment and how natural resources should be managed. The various issues discussed in this connection include the effects of a carbon tax, the economic effects of measures to reduce emissions of NO_X, and the effect of the tax reform on the economy and the environment.

Many environmental problems are global problems. It can therefore be useful to consider the environmental policies in different countries in relation to each other. For example, some of the analyses shed light on the effects of other countries' measures to prevent an enhanced greenhouse effect. Such measures could affect Norway's petroleum wealth and our trade with neighbouring countries in hydroelectricity and in electricity generated at gas-fired power plants, if this were to take place.

Part I Resources and environmental statistics

1. Energy

Petroleum extraction is at present Norway's most important industry. Norway is the seventh largest producer of crude oil, and the third largest exporter of crude oil in the world. Only Saudi Arabia and Iran exported more crude oil in 1994. Norway is also an important generator of hydropower. Most of this power is used domestically.

1.1 Resource base and reserves

Crude oil and natural gas

The reserves of petroleum are defined as the share of the total proven resources that can be extracted profitably with today's prices and by known technology. At the end of 1994, the Norwegian reserves of crude oil in developed fields and in licensed fields amounted to 1 216 million tonnes, corresponding to 0.9 per cent of the world reserves of crude oil. The reserves of natural gas in developed fields and in licensed fields amounted to 1 346 billion Sm^3 (standard cubic metres), corresponding to 1.4 per cent of the world reserves. Changes in the estimates of Norwegian reserves are shown in tables A1 and A2 in part III. Expressed in terms of *oil equivalents*, this gives a total reserve of about 2 500 million tonnes (Mtoe). With today's level of production and known production technology, the oil reserves in developed fields and in licensed fields will last for 9 years, while the reserves of natural gas will last for 45 years. This ratio between reserves and production, the R/P ratio, will change in the years to come, depending on rate of extraction, prices, new discoveries and new production technologies. The historical trend in this ratio is illustrated in figure 1.1. The estimated reserves in fields that are not yet licensed amount to about 600 million tonnes of crude oil (including natural gas liquids - NGL), and about 1 500 billion Sm^3 natural gas. The R/P ratio, including fields that have not yet been licensed, is 14 years for crude oil and 96 years for natural gas.

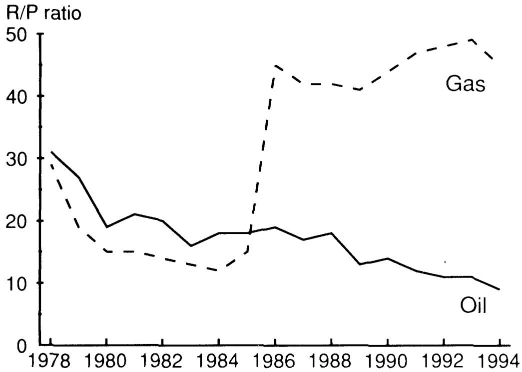
Energy units

	PJ	TWh	Mtoe	GSm^3
1 PJ	1	0.278	0.024	0.025
1 TWh	3.6	1	0.085	0.088
1 Mtoe	42.3	11.8	1	1.03
1 GSm^3	40.9	11.4	0.97	1

1 Mtoe = 1 million tonnes (crude) oil equivalents.
1 GSm^3 = 1 billion standard m^3 (natural gas).

On 1 January 1995 Norway had the largest proven reserves of both oil and gas in

Figure 1.1. Ratio between reserves and production of oil and gas (R/P ratio). Developed fields and fields to be developed (licensed). 1979-1994



Sources: Statistics Norway and the Norwegian Petroleum Directorate

Table 1.1. World reserves[1] of oil and gas. 1 January 1995. Billion toe

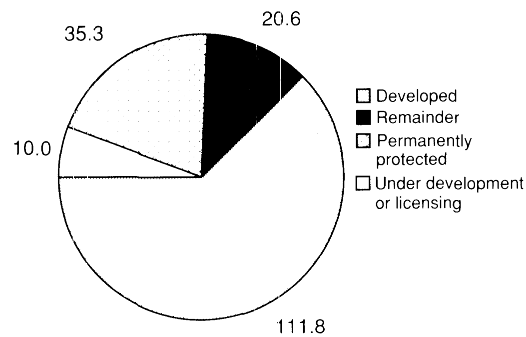
	Oil	Per cent	Gas	Per cent
World	135.1	100.0	124.5	100.0
North America	3.8	2.8	6.0	4.9
Latin America	17.4	12.9	6.5	5.2
Western Europe	2.2	1.7	4.8	3.8
Eastern Europe and CIS	8.0	5.9	50.0	40.2
Middle East	89.2	66.0	39.9	32.0
Africa	8.4	6.2	8.5	6.9
Asia and Australasia	6.0	4.4	8.8	7.0
OPEC	104.1	77.0	50.8	40.8
Norway	1.3	0.9	1.8	1.4

[1] For most countries, the reserves comprise discovered resources that can be exploited with today's technology and prices.

Source: Oil & Gas Journal, 1994

Europe, after Russia. In Western Europe, 57 per cent of the oil reserves and 37 per cent of the gas reserves are located on the Norwegian continental shelf (table 1.1). At the end of 1994, the R/P ratio for the world's petroleum reserves was 45 years for crude oil and 65 years for natural gas.

Figure 1.2. Exploitable hydropower. 1 January 1995. TWh



Source: Norwegian Watercourses and Energy Administration (NVE)

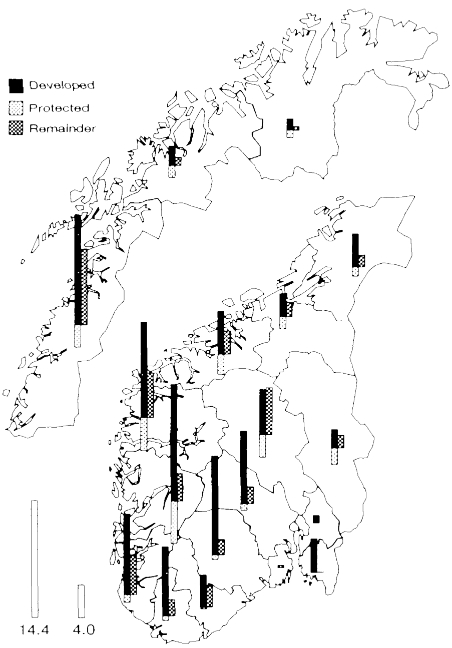
Hydropower

The hydropower reserves can be distributed between developed reserves, reserves for which a license has been granted or is being considered, protected watercourses and the remainder, i.e. the rest of the watercourses evaluated in the current Master Plan for Water Resources. On 1 January 1995, the total economically exploitable hydropower reserves in Norway amounted to 177.7 TWh. Of this amount, 111.8 TWh had been developed (average power potential; defined as the production capacity of the power stations in a year with normal precipitation; average for the period 1931 to 1990) and 35.3 TWh was permanently protected (figure 1.2). The counties of Hordaland, Nordland, Telemark and Sogn og Fjordane account for as much as 46 per cent of the country's production capacity (figure 1.3).

Coal

At the end of 1994, Norway's proven coal reserves amounted to 6.1 million tonnes. Changes in the estimates of reserves are shown in table A3 in part III. At the present rate of extraction and today's coal prices, the coal reserves will last 20 years. At the

Figure 1.3. Hydropower reserves in Norway distributed by county. 1 January 1995. TWh



Source: Norwegian Watercourses and Energy Administration (NVE)

Prefixes

Name	Symbol	Factor
Kilo	k	10^3
Mega	M	10^6
Giga	G	10^9
Tera	T	10^{12}
Peta	P	10^{15}
Exa	E	10^{18}

end of 1993 the world's exploitable resources of coal amounted to 1 039 billion tonnes. At the present rate of extraction and with today's prices the world's coal reserves will last 236 years. The largest reserves are located in the United States, the former Soviet Union and China.

Uranium

On 1 January 1993 the world's exploitable reserves of uranium amounted to about 3.0 million tonnes (OECD 1994), calculated with an extraction cost of USD 130 per kg. This does not include estimates of resources in, among other countries, Kazakhstan, Russia, Mongolia, China and Uzbekistan. The estimates of resources in these countries have been calculated on the basis of deviating definitions to 1.4 million tonnes of uranium. More than half the world's total reserves are located in Australia, Kazakhstan, the United States and South Africa.

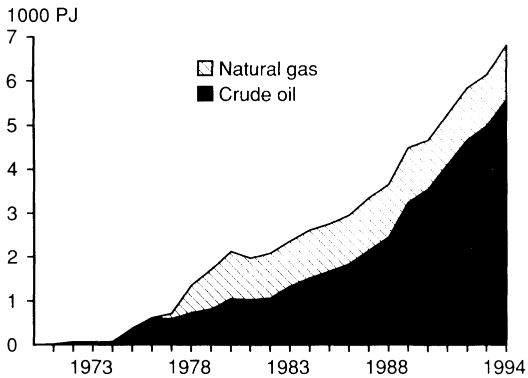
1.2 Extraction and production

Crude oil and natural gas

In 1994, Norway's net production of crude oil, natural gas liquids and condensates averaged 2.73 million barrels per day (figure 1.4), or a total of 128.5 million tonnes. This is 12 per cent more than in 1993. In December, production reached its highest peak so far, about 2.9 million barrels per day. The Statfjord, Gullfaks and Oseberg fields alone accounted for 63 per cent of the net production of crude oil on the Norwegian continental shelf in 1994. The Brage, Draugen and Snorre fields accounted for the largest share of the *increase* in production. In 1995, production of crude oil is expected to increase by about 10 per cent compared with 1994. The reasons for the expected increase include start of production on the new fields Frøy, Heidrun and Statfjord North, and the first complete year of production on the fields Tordis and Statfjord East.

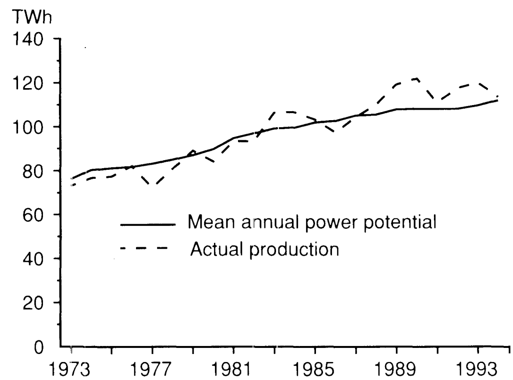
Norway's net production of natural gas amounted to 26.8 billion Sm^3 in 1994, corresponding to about 26 Mtoe (figure 1.4).

Figure 1.4. Extraction of crude oil and natural gas in Norway. 1970-1994. 1 000 PJ



Source: Statistics Norway

Figure 1.5. Mean annual power potential[1] and actual generation in the Norwegian hydropower system. 1973-1994. TWh



[1] From 1994, the calculations are based on a new period of normal flow (1931-1990).
Source: NVE

Table 1.2. World production of crude oil and natural gas. 1994* Mtoe

	Oil	Gas
The world	3202.5	2093.7
North America	497.8	700.0
Latin America	408.9	94.8
Western Europe	283.5	216.5
Eastern Europe and CIS	367.8	729.1
Middle East	936.6	107.1
Africa	332.9	68.3
Asia and Australasia	339.0	178.0
OPEC	1325.4	226.9
Norway	130.5	25.4

Sources: Petroleum Economist 1995 and Oil & Gas Journal 1995

This is 8 per cent more than in 1993. The Ekofisk, Statfjord and Sleipner fields accounted for 53 per cent of the net production of natural gas in 1994. Production on the Frigg field dropped considerably also in 1994. The increase in production on the Sleipner field, which experienced its first complete year of production, compensated for the drop in production on the Frigg field and, in addition, accounted for the largest share of the increase in production on the Norwegian continental shelf during the last year. Production of gas is expected to increase considerably from 1996, owing to the planned start of production on Troll East and Sleipner West. An annual production of 33.5 billion Sm^3 is planned for these two fields alone.

In 1994, Norway accounted for 4.1 per cent of the world production of crude oil and 1.2 per cent of the gas production (table 1.2). In 1994, Norway exported 111 million tonnes of crude oil, to a value of NOK 92.6 billion (SN 1995). This is about 12 million tonnes more than in 1993. In 1994, Norway was the next largest producer of crude oil in Europe, second to Russia, and the largest exporter of crude oil in the world after Saudi Arabia and Iran. The value of the exported natural gas was NOK 15.5 billion in 1994.

Electricity

113.6 TWh electricity was generated in Norway in 1994. Of this amount, 0.7 TWh was thermal power, 0.01 TWh was wind power and the rest was hydropower. Given the existing technical power potential, the annual hydropower generation varies with variations in the flow to the reservoirs. Both the average power potential and the actual power generation have increased substantially since the beginning of the 1970s, owing to a strong expansion of capacity. In the last few years, the actual generation has exceeded the average power potential because of very good flow to the reservoirs (figure 1.5). In 1993, the world production of hydroelectricity used for consumption was 2 343 TWh. Norway's share of this production was 4.8 per cent. In Europe (including the earlier Soviet Union) the production used for consumption amounted to 756 TWh, of which Norway's share was 15 per cent.

Biological fuels
Wood, wood wastes and black liquor are the most important biological fuels in Norway. Production of these fuels, including production for own consumption, is estimated to be about 38 PJ per year (this figure is uncertain). In 1993, energy amounting to about 4.5 PJ was generated for district heating from incineration of waste, and about 90 per cent of this can be regarded as bioenergy. In 1993, methane gas equivalent to 8.8 PJ was generated from Norwegian landfills. In 1992, 4.3 per cent (0.4 PJ) of this gas from landfills was flared and 1.2 per cent (0.1 PJ) was utilized as energy. Most of the methane from landfills is biogas.

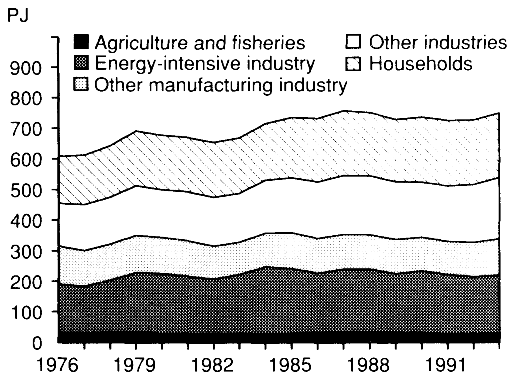
Coal
According to the provisional figures, coal production in Svalbard was equivalent to 9 PJ in 1994, as against 8 PJ in 1993. World coal production was about 91 EJ in 1993. China and the United States were each responsible for 25 per cent of the production.

Nuclear power
The world's uranium production amounted to about 36 200 tonnes in 1992 (OECD 1994). This is more than 39 per cent less than in 1988, and a further decrease in production is expected for 1993. The largest producers of uranium were Canada, Niger and Russia. In 1992, consumption of uranium at nuclear power plants amounted to about 57 000 tonnes, and is expected to increase to about 63 500 tonnes in the year 2000. The difference between annual production and annual consumption is covered at present by commercial and military stores. As of January 1, 1995, there were 431 operative nuclear power plants in the world. During 1993 and 1994, 12 new nuclear power plants became operable (five of them in Japan). During the same period, 5 nuclear power plants were closed down permanently, including Dounray in the United Kingdom. A total of 2 214 TWh electricity was produced at the world's nuclear power plants in 1994 (EIA 1995). This is an increase in generated energy of 1.3 per cent, compared with 1993. In 1991, in addition to the nuclear power plants connected to the electricity network there were 323 research reactors in operation in the world (UNEP 1993), two of them in Norway.

1.3 Energy consumption

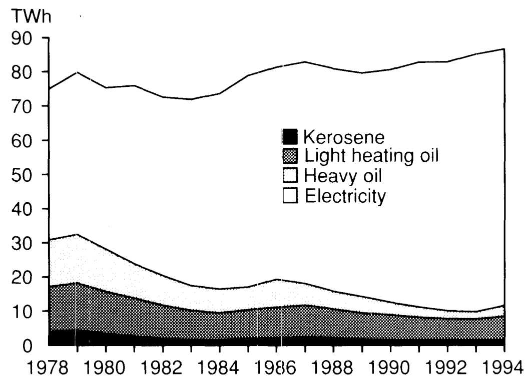
Total energy consumption
Net consumption of energy in the energy sectors (the sectors responsible for production of primary and secondary sources of energy) amounted to about 19 per cent of Norway's total energy consumption in 1993, not including the energy used in ocean transport. Energy consumption in the energy sectors increased from 34 PJ in 1976 to 185 PJ in 1994 (provisional figure), of which natural gas accounted for 12 PJ in 1976 and 134 PJ in 1994 (see table A6 in part III). The reason for this strong increase in energy consumption in the energy sectors is the

Figure 1.6. Domestic energy consumption by user group. 1973-1993. PJ



Source: Statistics Norway

Figure 1.7. Electricity consumption, energy-intensive industry excluded, and sales of heating oil and kerosene. 1978-1994. TWh utilized energy



Source: Statistics Norway

increased petroleum activities on the continental shelf. The activities requiring especially large amounts of energy are power production on the oil platforms and operation of the pipeline systems for transport of crude oil and natural gas. However, energy consumption per produced unit of crude oil and natural gas was reduced during the same period.

The total consumption of energy sources in Norway, when the energy sectors and ocean transport are excluded, was 749 PJ in 1993 (figure 1.6 and table A5 in part III), and 761 PJ in 1994 (provisional figure). The consumption increased by an average of 2.0 per cent per year from 1976 to 1987, while consumption in 1994 was slightly above the consumption in 1987. The reason for the increase in consumption of about 1.6 per cent from 1993 to 1994 is the general improvement of the economy in 1994, with increased activity in many industries. Most of the increase can be put down to increased use of heating oils and coal in 1994. Hydroelectricity accounted for 48 per cent of the energy used in 1994.

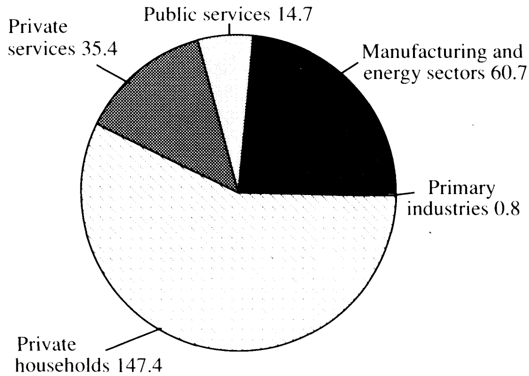
Total consumption of oil decreased by 18 per cent (provisional figure) from 1976 to 1994, in spite of an increase of 38 per cent in the oil used for transport. Consumption of oil for transport now accounts for 79 per cent of the total oil consumption, as against 47 per cent in 1976. Consumption of oil in Norway for stationary purposes decreased by as much as 67 per cent from 1976 to 1994. In 1978 these oil sales, calculated in terms of utilized energy, amounted to about 31 TWh, while in 1994 they accounted for less than 12 TWh (figure 1.7). The reduction in consumption was particularly marked for heavy oils. During the same period, consumption of electricity increased by 70 per cent, energy-intensive industry not included (see also table A7 in part III). The switch from use of heating oil to use of electricity occurred mainly during the first half of the 1980s. One reason was the high price of heating oil during this period, but others were the high investment costs for oil-based heating installations and the high maintenance costs for existing installations. From 1993 to 1994, however, the decreasing trend in the stationary consumption of

Table 1.3. Specific energy consumption by type of household and energy source. Norway. 1993. kWh/m² theoretical energy content

Type of household	Specific energy consumption	Electricity	Oil / kerosene	Solid fuels
Farm dwelling	260	164	7	89
Detached house	226	176	22	28
Row house etc.	199	174	10	15
Apartment block etc.	161	151	6	4

Source: Djupskås and Nesbakken 1995, Statistics Norway

Figure 1.8. Energy use for stationary combustion, by user group. Kristiansand municipality. 1992. TWh theoretical energy content



Source: Statistics Norway

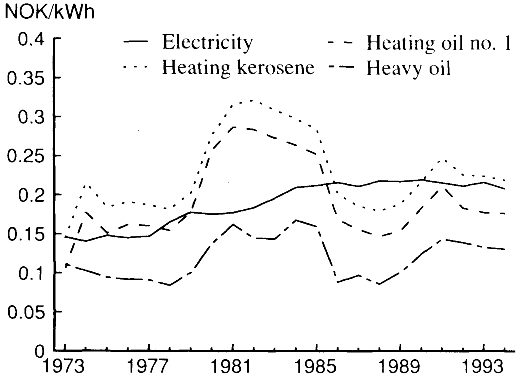
heating oils is broken. Provisional figures show that consumption of light heating oils increased by 7 per cent and consumption of heavy heating oils by as much as 68 per cent. The increase occurred mainly in manufacturing industry.

Use of energy in households

The largest share of the energy consumption in Norway (the energy sectors and ocean transport excluded) occurs in private households (figure 1.6 and table A4 in part III). About 28 per cent of the energy consumption (theoretical energy content) to private households consists of gasoline and autodiesel. Of the energy supplied to households for stationary purposes, electricity accounted for 80 per cent, wood for 12 per cent, petroleum products for 8 per cent and district heating, coal and coke for less than 1 per cent (Djupskås and Nesbakken 1995). About 67 per cent of all households in Norway have a wood-burning stove or fireplace, and the Population and Housing Census in 1990 showed that almost 106 000 households in Norway (6 per cent) still use wood as the only source of heating. Many of the households that use mainly wood for heating probably live in dwellings connected with farms. Households living in farm dwellings comprise 9 per cent of the households in Norway, but account for 36 per cent of the consumption of wood. In 1993, average energy consumption in a farm dwelling was as much as 33 000 kWh, and 35 per cent of the energy came from wood. One of the reasons for the relatively high consumption of energy in farm dwellings is the low fuel efficiency of wood. Other reasons are that most farm dwellings are usually older and larger than other dwellings and are not as well insulated, and therefore require more energy to heat than newer dwellings do. In 1993, the average energy consumption in block apartments was only 11 900 kWh. Most of the difference in energy consumption per unit of living area in the different types of dwellings, shown in table 1.3, can be explained by the different fuel efficiencies of the various sources of energy, and the age and insulation of the dwelling.

The average energy consumption in households was 22 700 kWh in 1993. Distribution of the energy consumption by region shows that energy consumption per household in Oslo was only 14 800 kWh, while it varied between 21 500 kWh and 26 300 kWh in

Figure 1.9. Prices of oils and electricity used for heating purposes. Utilized energy. 1973-1994. Fixed 1980-prices, all taxes included. NOK per kWh



Sources: Statistics Norway and Norwegian Petroleum Institute

the rest of the country. One of the reasons is the large proportion of households with low energy consumption per unit of living area (apartment blocks) in Oslo.

Energy consumption in the municipalities
Statistics Norway calculates the annual consumption of fossil fuels and biological fuels used for energy purposes in the municipalities. The consumption can be distributed, for example, by source of energy and by industry. As an example, figure 1.8 shows energy consumption (theoretical energy content) for stationary combustion in Kristiansand municipality in 1992 (see also table A9 in part III).

World consumption
In 1992, Norway accounted for slightly less than 0.27 per cent of the world's total use of energy (table A10 in part III) and the OECD countries for just over half. Consumption of energy per capita is much higher in Norway than the average in the world, but only slightly higher than the average in the OECD countries. The energy intensity in Norway, measured as consumption of energy per unit GDP, is slightly higher than for the OECD countries. The composition of the energy consumption varies for different parts of the world. However, oil, coal and natural gas are important sources of energy in all parts of the world.

Energy prices
The trend in total consumption of energy can be partly explained by changes in the prices of fossil sources of energy for stationary consumption, seen in relation to the price of electricity (figure 1.9). Table A8 in part III shows the average prices of supplied energy. Including all taxes, the average price of electricity to households was NOK 0.475 per kWh in 1994. Converted into price per kWh *utilized* energy, the price of kerosene was NOK 0.501 per kWh, while the price of light heating oil was NOK 0.387 per kWh in 1994. This shows that, as far as average prices are concerned, heating with light heating oil can compete with heating by electricity.

Internationally, the prices of energy vary considerably. Compared with the prices in other West European countries, the Norwegian energy prices are low for electricity, but highest for heavy oil and gasoline. It is not the Norwegian taxes, however, that make gasoline and heavy oil most expensive in Norway. Even when taxes are deducted, the price of these energy sources is still highest in Norway. One of the reasons for the high price of gasoline in Norway is the low sales of gasoline at filling stations, combined with their scattered location and therefore high distribution costs. In some countries, e.g. France (the country with the highest taxes on gasoline), sale of cheap gasoline is used to attract customers to the shopping centres. Another reason for the lower price of gasoline in other countries may be a larger share of automatic filling stations, where the costs are kept down by the station not having any staff. As yet, only about 1-2 per cent of the Norwegian gasoline sales are from such stations.

1.4 Future use of energy

If variations in energy consumption due to fluctuations in temperature are excluded, the consumption of energy is determined mainly by the level of activity, the prices of energy, and technical developments. Use of energy in industry and the service sector will follow the trend in the economy in Norway and in the world. The use of energy by households will increase, for example, with an increase in the household's disposable income and in the number of households. In the projections of future use of energy, these factors are expected to show an upward trend, thus leading to increased use of energy.

Given an unrestricted energy market, and increased trading of electricity across national borders, the price of electricity will be decided by supply and demand in a larger Nordic or European market. Increased export and import of electricity will stabilize electricity prices in Norway, especially in years with little precipitation and in years with high precipitation. At the same time, there is reason to assume a continued increase in the domestic consumption of electricity. The international energy prices, and the taxes on energy in Norway and other countries, will affect the total energy consumption, and the composition of the consumption, divided between oil and electricity. For example, a higher carbon tax could lead to an increase in consumption of electricity in relation to oil. The possibilities of substituting the different sources of energy will depend on the choice of type of heating equipment in households and commercial enterprises. The choice of equipment will be influenced by the expected future price of electricity relative to oil.

As yet, there has been little possibility of using forms of energy other than oil in the transport sector. However, a renewal of the motor vehicle stock to include more energy-efficient vehicles will help to reduce consumption of gasoline. The possibilities of using, for example, electricity, ethanol or methanol produced from biomass in motorized vehicles will depend on technological developments.

Different trends in energy consumption (scenarios) can be analyzed by means of economic models. Part II of this publication contains examples of the use of such models.

Further information from: Ola K. Hunnes, Ole Tom Djupskås and Lisbet Høgset.

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Table 1.4. Average energy content and fuel efficiency by energy source[1]

Energy source	Theoretical energy content	Fuel efficiencies: Manufacturing and mining	Transport	Other consumption
Coal	28.1 GJ/tonne	0.80	0.10	0.60
Coal coke	28.5 GJ/tonne	0.80	-	0.60
Petrol coke	35.0 GJ/tonne	0.80	-	-
Crude oil	43.0 GJ/tonne = 36.6 GJ/m^3	..	..	..
Refinery gass	48.6 GJ/tonne	..	..	..
Natural gas (1993)[2]	40.9 GJ/1000 Sm^3	..	..	..
Liquid propane and butane (LPG)	46.1 GJ/tonne = 23.5 GJ/m^3	0.95	..	0.95
Gasoline	43.9 GJ/tonne = 32.5 GJ/m^3	0.20	0.20	0.20
Kerosene	43.1 GJ/tonne = 34.5 GJ/m^3	0.80	0.30	0.75
Diesel. gas and heating oils no. 1 and 2	43.1 GJ/tonne = 36.2 GJ/m^3	0.80	0.30	0.70
Heavy oil	40.6 GJ/tonne = 39.4 GJ/m^3	0.90	0.30	0.75
Methane	50.2 GJ/tonne	..	..	..
Wood	16.8 GJ/tonne = 8.4 GJ/solid m^3	0.65	-	0.65
Wood waste (dry matter)	14.0 GJ/tonne	..	..	..
Black liquor (dry matter)	16.8 GJ/tonne	..	..	..
Waste	10.5 GJ/tonne	..	..	..
Electricity	3.6 GJ/MWh	1.00	0.95	1.00
Uranium	430 TJ/tonne - 688 TJ/tonne	..	..	..

[1] The theoretical energy content can vary for one and the same source of energy. The values are therefore average values.

[2] Sm^3 = standard cubic meters (15° C and 1 atmosphere pressure).

2. Air

Emissions of pollutants to air can have adverse effects at local, regional and global level. *Local effects* consist mainly of the effects of various substances on human health. These problems occur most often in cities and urban areas. The most serious

Air pollutants and their harmful effects

Component	Symbol	Harmful effects
Carbon dioxide	CO_2	Intensifies greenhouse effect.
Methane	CH_4	Intensifies greenhouse effect and contributes to formation of surface (tropospheric) O_3.
Nitrous oxide	N_2O	Intensifies greenhouse effect.
Sulphur dioxide	SO_2	Increases risk of respiratory disease. Acidifies soil and water and corrodes materials.
Nitrogen oxides	NO_x	Cause respiratory diseases (especially NO_2). Contribute to formation of O_3. Contributes to acidification and corrosion of materials.
Ammonia	NH_3	Contributes to acidification of water and soil.
Volatile organic compounds, excluding methane	NMVOC	May contain carcinogenic substances. Contribute to formation of surface O_3.
Carbon monoxide	CO	Increases risk of heart disease in persons with cardiovascular disorders.
Suspended particulates	PM_{10}	Together with other components, increases risk of respiratory diseases.
Ozone (surface)	O_3	Causes respiratory disorders and has adverse effects on vegetation.
Lead	Pb	No harmful effects on health with present concentrations in air in Norway.

International environmental agreements

Protocols are the most binding environmental agreements. They usually contain specific commitments for the different countries.

Protocols:

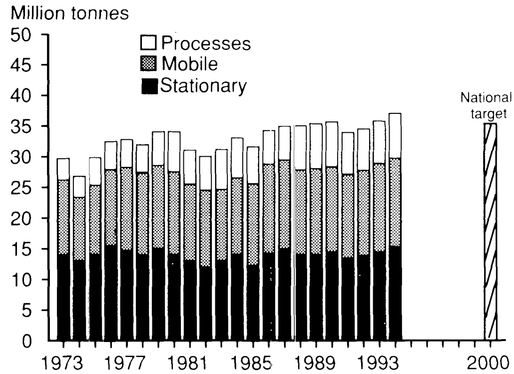
Sophia	Stabilization of NO_x-emissions to the 1987 level by the end of 1994.
Geneva	30 per cent reduction of emissions of NMVOCs by 1999, with 1989 as base year. Applies to all mainland Norway and Norway's economic zone south of latitude 62° N.
Oslo	76 per cent reduction of SO_2-emissions by the end of year 2000, with 1980 as base year.

regional problems are acidification of water and soil and damage to vegetation. The *global effects* are depletion of the ozone layer and changes in climate. The different pollutants and their harmful effects are listed in the box on the previous page.

2.1 Trends in national levels of emissions

Emissions of the greenhouse gas carbon dioxide (CO_2) are increasing, and provisional figures for 1994 show that these emissions amount to 37.2 million tonnes. This is clearly higher than the emissions in 1989 and 1990 (figure 2.1 and table B1 in part III). In the intervening years, the emissions have been somewhat lower. The main reason for this was lower consumption of oil, both for transport and for heating, and lower emissions from industrial processes in the metals and cement industries as a result of reduced production. Now, however, oil consumption has increased, both for transport and as a result of higher production in

Figure 2.1. Emissions of CO_2 by source. 1973-1994*. Million tonnes

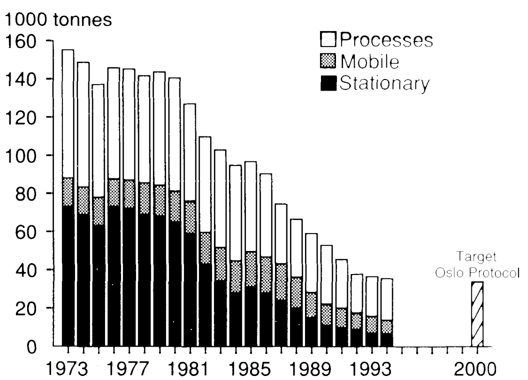


Sources: Statistics Norway and the Norwegian Pollution Control Authority

the metals and cement industries. The reduced emissions in 1973 to 1974, 1980 to 1981 and 1990 to 1991 coincided with higher oil prices. Norway has a national objective to stabilize emissions at the 1989-level by the end of year 2000. The possibilities of achieving this goal depend mainly on whether we succeed in limiting emissions from petroleum activities. The most important sources of CO_2-emissions in Norway are oil-related activities (30 per cent) and road traffic (24 per cent).

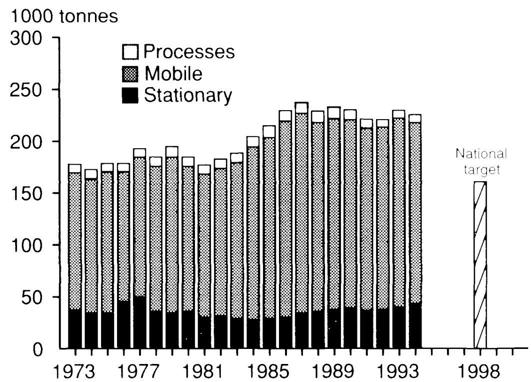
Emissions of ammonia (NH_3) and the greenhouse gas methane (CH_4) have remained stable in recent years, but emissions of the greenhouse gas nitrous oxide (N_2O) have decreased slightly. In the case of CH_4, the most important sources of emissions are decomposition of waste (57 per cent) and domestic animals/manure (32 per cent). The emissions of N_2O and NH_3 are dominated by emissions from use of manure and mineral fertilizer in agriculture. Production of nitric acid is another important source of emissions of N_2O. The levels of emissions of these components are associated, however, with a high degree of uncertainty.

Figure 2.2. Emissions of SO_2 by source. 1973-1994*. 1 000 tonnes



Sources: Statistics Norway and the Norwegian Pollution Control Authority

Figure 2.3. Emissions of NO_x by source. 1973-1994*. 1 000 tonnes

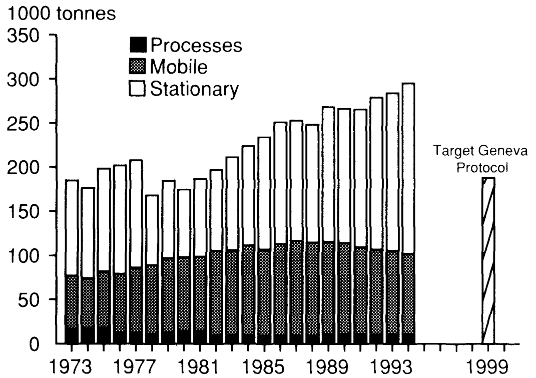


Sources: Statistics Norway and the Norwegian Pollution Control Authority

Emissions of sulphur dioxide (SO_2) decreased by 77 per cent from 1973 to 1994 (figure 2.2). The decrease from 1980 to 1994 was 75 per cent. Both the target in the Helsinki Protocol (30 per cent reduction from 1980 to 1993) and the national target (50 per cent reduction from 1980 to 1993) have thus been achieved. The Helsinki Protocol was re-negotiated in summer 1994, and has now been named the Oslo Protocol. In this Protocol, Norway has undertaken to reduce SO_2-emissions by 76 per cent from 1980 to year 2000. The reduced SO_2-emissions from combustion can be explained by a lower sulphur content in oil products, a change to the use of lighter oil products and electricity, and more and better cleaning installations. About 57 per cent of the SO_2-emissions in 1993 originated from industrial processes. The decrease in emissions from such processes since the early 1980s can be put down to the fact that a number of enterprises were required to install a cleaning plant, and that some of the most polluting enterprises have been closed down.

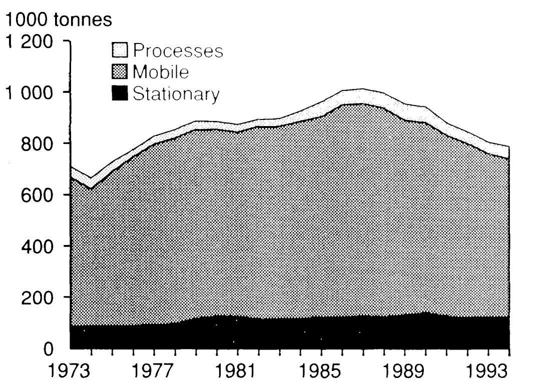
There was a marked increase in emissions of nitrogen oxides (NO_x) up to 1987 (figure 2.3). The main reason for this increase was increased use of private cars. According to the Sophia Protocol, Norway has undertaken to stabilize the emissions at the 1987 level by the end of 1994. The emissions were reduced by 7 per cent from 1987 to 1992 (see table B1 in part III). The main reason for the reduction was less flaring in the North Sea, decreased use of gasoline, more cars with a three-way catalytic converter, lower consumption of fuels by the fishing industry and shipping, and reduced emissions from industrial processes. In 1993, the emissions increased considerably, mainly due to increased consumption of autodiesel and marine fuels. However, provisional figures for 1994 show a reduction in emissions compared with 1993, and that the emissions are now 5 per cent under the 1987 level. The greater part of this reduction can be put down to reduced consumption of marine fuels and reduced emissions from road traffic. In addition, Norway has a national target to reduce emissions by 30 per cent by the end of 1998, with 1986 as base year. If this target is to be achieved, use of fuels for transport will have to be reduced, the renewal of the vehicle stock to vehicles with a three-way catalytic converter will have to be accelerated, and emissions

Figure 2.4. Emissions of NMVOC by source. 1973-1994*. 1 000 tonnes



Sources: Statistics Norway and the Norwegian Pollution Control Authority

Figure 2.5. Emissions of CO by source. 1973-1994*. 1 000 tonnes

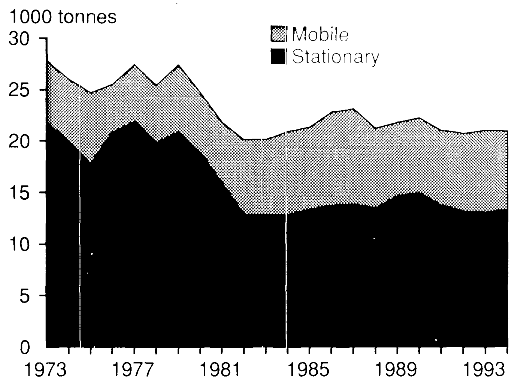


Sources: Statistics Norway and the Norwegian Pollution Control Authority

from shipping will have to be reduced considerably. The most important sources of emissions of NO_x in Norway in 1993 were road traffic (35 per cent) and shipping (35 per cent).

Emissions of non-methane volatile organic compounds (NMVOC) have increased considerably since the end of the 1970s (figure 2.4). The most important sources of emissions in Norway are evaporation from

Figure 2.6. Emissions of suspended particulates from combustion, by source. 1973-1994*. 1 000 tonnes



Sources: Statistics Norway and the Norwegian Pollution Control Authority

loading of crude oil (40 per cent) and emissions from gasoline vehicles and gasoline distribution (28 per cent). The increased emissions during the period were caused by a higher level of activity in the North Sea, especially loading of crude oil, but also increased use of gasoline cars during the period 1973 to 1987. For the whole of mainland Norway and Norway's economic zone south of 62^{o} N, Norway is committed to the Geneva Protocol, which requires a 30 per cent reduction in emissions by the end of 1999, with 1989 as base year. In order to reduce emissions of NMVOC to this level, further measures will have to be taken to reduce emissions from loading of crude oil. The quantity of crude oil that is loaded will increase in the years to come, and will therefore contribute to *increased* emissions. The increasing share of new gasoline cars with more stringent exhaust emissions requirements and measures to reduce evaporation of gasoline will help to reduce the emissions of NMVOC.

Emissions of carbon monoxide (CO) increased from 1973 to the mid-1980s (figure

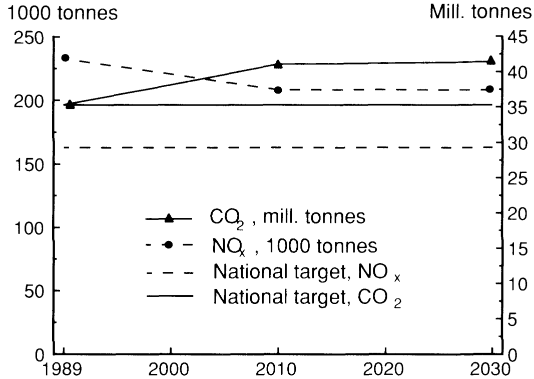
2.5). Since then, however, there has been a clear reduction. The main reasons for this reduction are better technology and lower consumption of gasoline. The dominating source of emissions of CO is road traffic (75 per cent).

Emissions of suspended particulates from combustion were reduced considerably from 1973 to 1982 (figure 2.6). This can be explained by decreased use of heavy oil for heating. Through the 1980s, there was a slight increase in emissions from stationary combustion, owing to increased use of wood. In 1993, emissions from stationary combustion accounted for 62 per cent of the total emissions, most of it from burning wood. During the period 1973 to 1987, emissions from mobile sources increased, due to a larger amount of road and ships traffic. Statistics Norway and the Norwegian Pollution Control Authority do *not* estimate emissions of suspended particulates from processes (asphalt dust owing to use of studded tyres, etc.).

Emissions of lead were reduced by more than 95 per cent from 1973 to 1994. In January and February 1995, leaded gasoline accounted for about 4 per cent of the total sales of gasoline. Today, lead pollution in the air is much lower than the level assumed to be harmful to human health.

There has been a marked decrease in emissions of SO_2 in the OECD countries during the last 20 years. SO_2-emissions per capita are lower in Norway than the average for the OECD countries as a whole. Per capita CO_2-emissions are also lower in Norway (see table B7 in part III). The main reason is that, in Norway, a very large share of the energy consumption is covered by hydroelectricity. However, for the world as a whole, the per capita average is only half the average for Norway. NO_X-emissions per capita are higher in Norway than the average for OECD. There are two reasons for this: firstly, the fact that a large share of the combustion in Norway takes place in gas turbines, and secondly the large amount of coastal shipping. Both these sources lead to a high level of NO_X-emissions per unit of burned source of energy.

Figure 2.7. Projection of emissions to air, from the Government's Long-Term Programme, baseline alternative



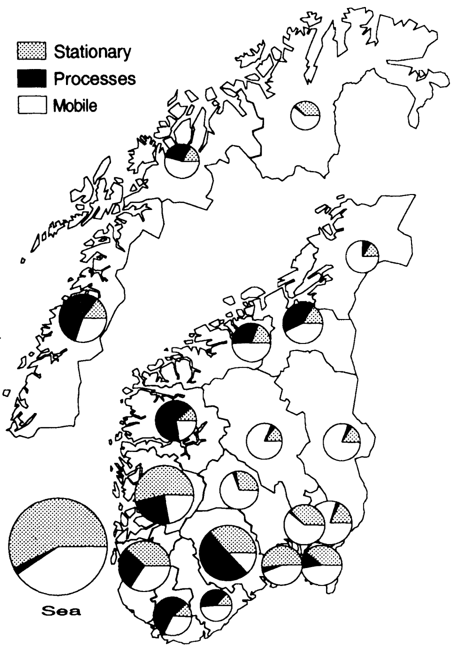
Source: Report No. 4 to the Storting (1992-93)

Future emissions to air

The latest official projections of emissions to air were made using the macro-economic equilibrium model MSG-5 (see part II for a more detailed description of the model) in the Government's Long-Term Programme. In a projection of this kind, important factors with regard to the general picture of emissions are trends in the consumption of oil and input of goods (which depend on the general level of activity), the industrial composition, the composition and level of the households' consumption, the possibilities of substituting different sources of energy, and assumptions concerning technical changes and cleaning measures (Brendemoen et al. 1994 and Holmøy et al. 1994).

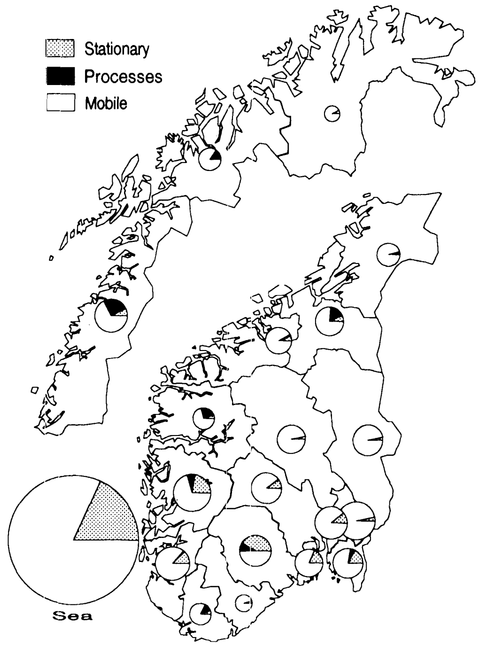
In the projection (baseline alternative) emissions of pollutants to air increase to a less

Figure 2.8. CO_2-emissions by source in 1992. County



Sources: Statistics Norway and the Norwegian Pollution Control Authority

Figure 2.9. NO_x-emissions by source in 1992. County



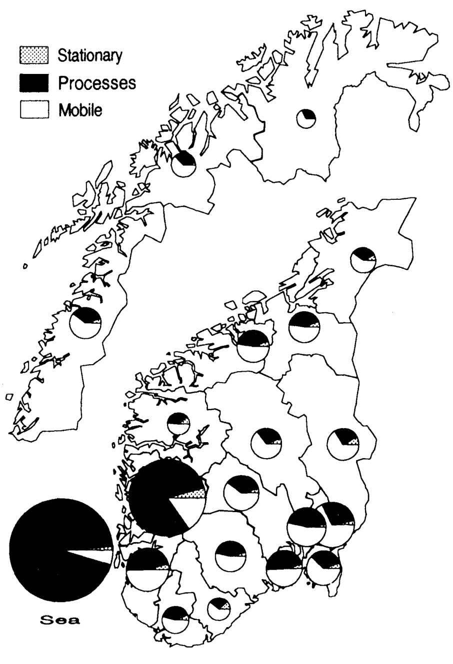
Sources: Statistics Norway and the Norwegian Pollution Control Authority

extent than GDP and private consumption. In the calculations, NO_x-emissions decrease. The reduction is due to the fact that cleaning requirements at certain types of emission sources are incorporated into the calculation, an expected reduction of petroleum activities at the end of the period, and a relatively marked improvement in technology. In addition it is assumed that production of services expands more strongly than production of goods, that the need for heating is covered to a greater extent by electricity, and that the increase in the use of private cars gradually declines. However, in the baseline alternative the current national targets for CO_2- and NO_x-emissions are not realized. In connection with the plan of action to reduce emissions of greenhouse gases and NO_x, it is indicated that more stringent requirements will be imposed for emissions of NO_x from the coastal fleet, ferries and the fishing fleet, which are responsible for 1/3 of the NO_x-emissions.

2.2 Emissions by county

In mainland Norway, emissions of CO_2 (figure 2.8) are highest in Hordaland. Other counties with large emissions of CO_2 are Telemark, Rogaland and Nordland. Oil refineries are responsible for the largest emissions in Hordaland. Metals manufacturing makes a relatively large contribution in all four counties. In addition, fertilizer and

Figure 2.10. NMVOC-emissions by source in 1992. County



Sources: Statistics Norway and the Norwegian Pollution Control Authority

cement production and the petrochemical industry make large contributions to emissions in Telemark. Emissions of CH_4 and NH_3 are highest in Rogaland. The main reason is that emissions from domestic animal husbandry and manure are twice as high here than in most other counties. The coal mines in Svalbard are a large single source of emissions of CH_4. The processes used in production of commercial fertilizer in Telemark and Nordland account for over a third of the country's emissions of N_2O. The largest mainland emissions of SO_2 occur in Hordaland, Østfold and Nordland (see table B5 in part III). The main sources are refining, manufacture of ferro-alloys and the chemicals industry. In all counties the

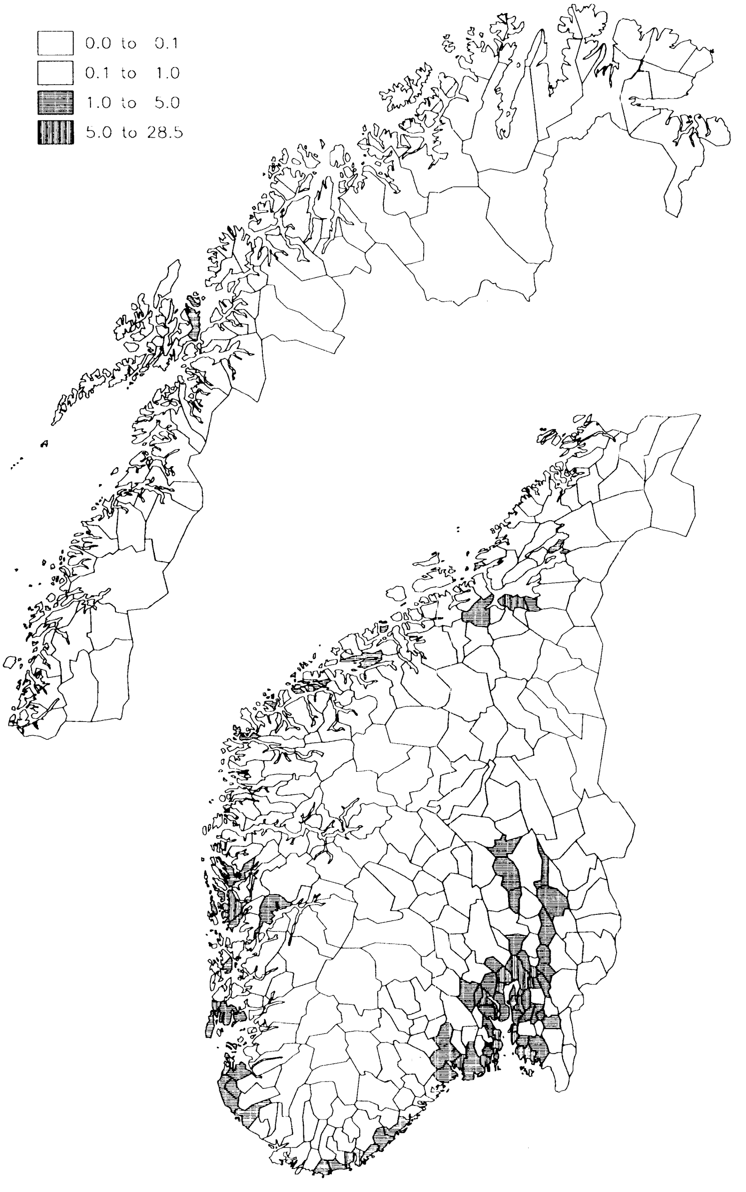
Emissions to air by municipality

These figures *include* emissions in Norwegian territory from Norwegian ships engaged in ocean transportation, international flights by Norwegian aircraft, and foreign activities in Norway. The figures for the national levels of emissions, on the other hand, *do not include* these activities. The methods used to calculate emissions to air are documented in Bang et al. (1993), Rypdal (1993 and 1995) and Daasvatn et al. (1994).

NO_X-emissions are dominated by mobile sources (figure 2.9), and in Akershus, with the largest emissions of NO_X, 96 per cent of the NO_X-emissions originate from mobile sources. However, owing to emissions from industry, Rogaland, Telemark and Hordaland are also among the counties with the largest emissions of NO_X. Emissions of NMVOC (figure 2.10) are three times higher in Hordaland than in any other county. The main sources of emissions are processes such as loading and refining of crude oil. Emissions of CO originate mainly from road traffic, with Akershus making the largest contribution. Emissions of suspended particulates are highest in Hordaland, followed by Hedmark, Akershus and Rogaland. The main sources of these emissions are heating with wood and road traffic.

Large emissions of CO_2, a third of Norway's total emissions, occur in marine areas (figure 2.8 and table B5 in part III). Stationary combustion on the oil fields accounts for 57 per cent of these emissions, shipping for 38 per cent. Marine areas also make the largest regional contribution to Norwegian emissions of SO_2, NO_X and NMVOC. Shipping is the main source of emissions of SO_2 and NO_X, while loading of crude oil from buoys at the oil fields is most important for emissions of NMVOCs.

Figure 2.11. NO$_x$-emissions in 1992. Municipality. Tonnes per km^2



Sources: Statistics Norway and the Norwegian Pollution Control Authority

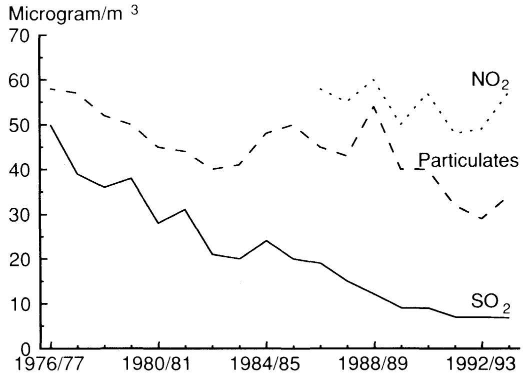
2.3 Air quality and local emissions

The content of harmful substances in the air is determined by the amount of the emissions and by the weather and the terrain. Local emissions are usually most important for air quality in cities and urban areas. Long-range transported emissions are not so important in this connection (concerning ozone, see section 2.4). In Norway, road traffic is the most important cause of local pollution by NO_2, CO and suspended particulates. Industrial installations are the most important source of high concentrations of SO_2.

In 1992, the largest emissions of NO_X occurred in the municipalities of Oslo, Porsgrunn and Bergen. A first approach to determining air quality can be to calculate emissions per km^2 and per capita. As far as emissions per km^2 are concerned, the highest values are found for Stavanger and Porsgrunn (see figure 2.11). In general, the largest emissions per km^2 are found for municipalities with a high population density and containing national highways. The largest NO_X-emissions per capita were recorded in Sørfold, followed by Lindås, Bremanger and Tysfjord, the main source being manufacturing industry. A few municipalities with few inhabitants but containing a national highway also show high per capita emissions of NO_X. Table B6 in part III shows emissions to air by municipality.

In places where the emissions could lead to high concentrations of pollutants, the air quality is regularly monitored by the Norwegian Institute for Air Research (NILU). Most of the monitoring stations are located in city streets with a heavy load of traffic or near industrial plants. In 1993/94 the limit of the 24-hour mean values of NO_2 was exceeded at eight out of eleven monitoring stations located in the cities (table B11 in part III). At most of the monitoring stations, a higher mean value was recorded than during the previous winters, because of

Figure 2.12 Winter mean concentrations of NO_2, suspended particulates and SO_2 at eight selected monitoring stations[1] 1976/77-1993/94. $\mu g/m^3$



[1]Fredrikstad, Oslo, Drammen, Skien, Kristiansand, Stavanger, Bergen and Trondheim.
Source: Norwegian Institute for Air Research

colder weather, which led to poor dispersion conditions. The concentration of SO_2 was low at most of the stations, but the recommended limit was exceeded in certain placed affected by emissions from industry.

To a large degree, the trend in air quality in the largest cities correlates with the trend in the emissions of the corresponding component (figure 2.12). The concentration of SO_2 has decreased considerably in recent years, in step with the decreased emissions. No great changes have been observed in the concentration of suspended particulates. The reduction after 1989 may be connected with mild winters and good dispersion conditions. In recent years, sales of gasoline and autodiesel have increased slightly and, combined with the weather conditions, this led to higher concentrations of suspended particulates and NO_2 in the winter of 1993/94.

2.4 Long-range transported air pollution

Norway is one of the countries in Europe with the lowest emissions of SO_2 and NO_x. In relation to the number of inhabitants, however, Norway has the highest emissions of NO_x, but still very low emissions of SO_2. The emissions of SO_2 are particularly high in Eastern Europe, the earlier East Germany and the United Kingdom. A large share of the emissions in Europe originates from single installations, especially coal and oil-fired power plants. It is estimated that the hundred largest plants account for 40 per cent of the total emissions in Europe (Acid News 1994). 54 of these are located in Eastern Europe, 40 in EU countries (e.g. 12 in the United Kingdom and 12 in Germany), and 6 in Turkey. The Russian smelting works at Nikel, near the border with Finnmark, is ranked in 5th place on this list. This smelting works emits almost 10 times as much SO_2 per year as emitted from Norway as a whole.

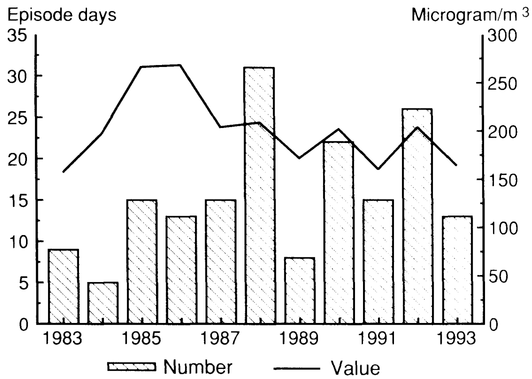
Some of the pollution released into the air falls in the vicinity of the source of the emissions, and some is transported over long distances by air currents. Sulphur and to some extent nitrogen components have an acidifying effect on soil and water. The extent of the damage depends on the type of soil and the vegetation. Norway has soil that is lacking in lime and vulnerable vegetation, implying that the effects of the acidification precipitation are more serious than in many places with higher depositions. Today, the critical load for acidification is exceeded in 37 per cent of Norway. The most serious adverse effects are on life in fresh water, and are observed in particular in Southern Norway, and the southern parts of Western and Eastern Norway. Sør-Varanger also receives acid precipitation from sources in Russia.

In 1993, 98 000 tonnes of acid *sulphur* was deposited over Norway (see table B10 in part III). This is 5 times as much as sulphur as emitted in Norway itself. Around 20 per cent of the sulphur depositions reaching Norway came from the United Kingdom. Germany and Russia were also relatively large contributors. Of the sulphur emitted in Norway, about 5 per cent was deposited in Norway, while a larger share of this pollution was deposited in Sweden and in marine areas. From 1985 to 1993, the deposition of sulphur over Norway was reduced by an average of 5 per cent yearly, as a result of steadily reduced emissions in Europe.

The depositions of *nitrogen* in 1993 amounted to 112 000 tonnes (see tables B8 and B9 in part III). 19 per cent of this amount was from Norwegian emissions. Emissions from the United Kingdom, followed by Germany, also made an important contribution to deposition of nitrogen in Norway. The deposition of nitrogen compounds has not changed much in the last few years.

Surface (tropospheric) ozone can also be transported from Europe towards Southern Norway by the air currents, and can have adverse effects on health and vegetation. Tropospheric ozone is created by chemical reactions between oxygen, NO_x and NMVOC in the presence of sunlight. During periods in the summer, with prolonged high pressure and much sunlight, ozone concentrations higher than the recommended air quality guidelines (ozone episodes) are recorded both in Southern Norway and in most of Europe. In connection with the EEA Agreement, Norwegian authorities are now under obligation to inform the population when the concentration of ozone exceeds 180 $\mu g/m^3$ (in Norway, the recommended air quality guideline for ozone is 100 $\mu g/m^3$). No trend can be observed for the number of ozone episodes and the maximum concentrations of ozone during the last few years

Figure 2.13. Number of episode days[1] and maximum one-hour average values. Norway. 1983-1993. Number and $\mu g/m^3$



[1] An episode day is defined as a day (24 hours) with a maximum one-hour average value exceeding 200 $\mu g/m^3$ at one monitoring station or exceeding 120 $\mu g/m^3$ at several monitoring stations.
Source: SFT 1994

(figure 2.13). In summer 1994, there was a prolonged period of higher pressure over Western Europe, which resulted in large quantities of ozone both in Central Europe and in England. Provisional results of measurements in 1994 show no concentrations exceeding 180 $\mu g/m^3$ at Norwegian monitoring stations.

In order to prevent values exceeding the recommended air quality guidelines for tropospheric ozone, it is necessary to reduce emissions of both NMVOCs and NO_x by more than 70 per cent in large parts of Europe. So far, these emissions have not been reduced to any significant extent.

2.5 Global environmental problems

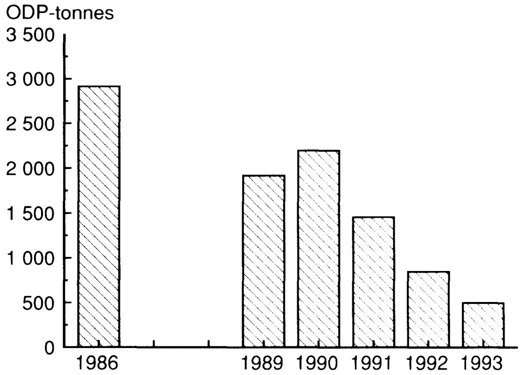
Depletion of the ozone layer

The ozone layer in the atmosphere prevents harmful ultraviolet (UV) radiation from the sun from reaching the earth. About 90 per cent of the gas ozone (O_3) is found in the stratosphere, 10-40 km above the ground. This layer, with elevated concentrations of ozone, is usually called the ozone layer. The ozone layer is the site of natural decomposition and formation of ozone. Ozone is formed at the equator and is transported towards the poles. In the course of the year, natural variations occur in the quantity of ozone in the stratosphere. There may be twice as much ozone in the spring as in the autumn.

In several years, during the spring months, episodes with very little ozone in the stratosphere and high levels of UV-radiation penetrating the atmosphere have occurred over the Antarctic. It has been observed that the quantity of ozone in the stratosphere at middle latitudes and over the northern areas decreased by about 3 per cent in the course of the 1980s (UNEP 1993). This ozone depletion is caused partly by anthropogenic emissions of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons and other chlorinated or brominated gases. These gases are transported with the air currents up to the ozone layer in the stratosphere. There, under specific meteorological conditions, they can cause chemical decomposition of the ozone which does not occur naturally. The result of a thinner ozone layer is an increase in the UV-radiation that reaches the earth, which can raise the incidence of skin cancer, eye injury and impairment of the immune system. Increased UV-radiation can also reduce the growth of plants, both on land and in the sea (algae).

Satellite measurements of ozone in the atmosphere over Oslo, from 1979 to 1993, show that the total quantity of ozone has decreased by about 0.7 per cent per year (NILU 1993). The reduction was particularly large in the winter/spring months in 1992 and 1993, when 10-20 per cent less ozone was measured than the normal concentra-

Figure 2.14. Import of ozone-depleting substances. 1986 and 1989-1993. Norway. ODP-tonnes



Source: Norwegian Pollution Control Authority

tion over Oslo. This reduction in 1992 and 1993 was probably due to a combination of decomposition of ozone as a result of anthropogenic emissions of chlorinated and brominated compounds, natural causes such as unfavourable circulation in the atmosphere, as well as sulphur particles from the eruption of the Mt Pinatubo volcano in 1991. Measurements of ozone over Oslo in spring 1994 showed more normal values.

Consumption of ozone-depleting substances in Norway, measured in terms of imports (see figure 2.14) have decreased from the mid-1980s measured in terms of CFC-11 equivalents (as regards ozone-depleting potential; ODP-tonnes). Most of this consumption is sooner or later released into the air, only small quantities are destroyed. According to the revised Montreal Protocol, Norway is committed to cease consumption of newly produced halons by the end of 1994 and of, among other substances, CFCs by the end of 1996. Norway is also committed to prepare time schedules for reduction of consumption or a prohibition on the use of several other ozone-depleting substances. An overview of this, and more about the ozone layer and ozone-depleting substances can be found in SN/SFT/DN (1994).

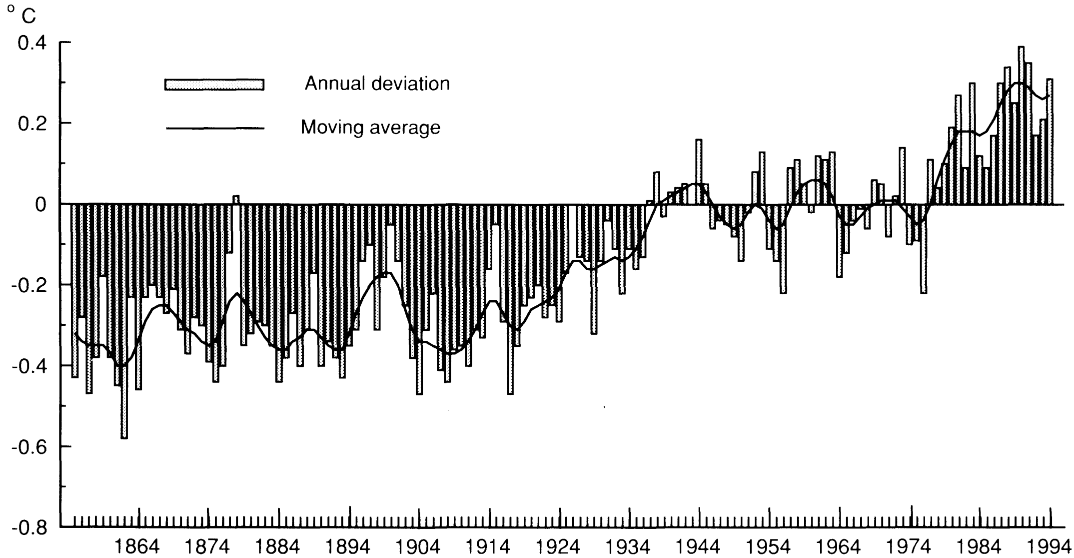
Changes in climate

The greenhouse effect of the atmosphere is an important prerequisite for life on earth as we know it. Without this effect, the global mean surface temperature would have been -18 °C and not +15 °C as it is now. The atmosphere's thermal balance depends on the chemical composition of the atmosphere. Anthropogenic emissions of the so-called greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases can disturb this chemical composition in an unnaturally rapid manner. The climatic conditions on the earth can, because of this, change more quickly than natural (i.e. not caused by human activity) changes in climate.

The rise in the concentration of CO_2 in the atmosphere in the course of the 1980s has averaged 0.4 per cent per year. This implies that about half of the anthropogenic emissions of CO_2 remain in the atmosphere. The rate of increase decreased slightly during the period 1991 to 1993, but increased again in 1994. Analyses of observed changes in the CO_2-content of the atmosphere, from ice cores and from direct measurements in the atmosphere, confirm that the observed increase really was caused by emissions from human activities. The atmospheric concentrations of other greenhouse gases have also increased, and are increasing, considerably.

The global mean surface temperature has increased by between 0.3 °C and 0.6 °C in the course of the last 100 years (figure 2.15). To a large degree, this is consistent with the increase in temperature as a result of higher concentrations of greenhouse gases in the atmosphere, calculated on the basis of models. However, the increase is not greater than that it could be due to

Figure 2.15. Variations in global mean surface temperature in relation to the normal value for the period 1951-1980, annually and moving average. 1855-1994. Degrees C



Source: P. D. Jones, University of East Anglia

natural variations. Irrespective of this, calculations carried out by the UN Panel on Climate Change indicate that the global mean surface temperature could increase by between 1.5 °C and 4.5 °C in the course of the next 100 years. The effects of a further increase in temperature are very uncertain, but probable effects could include changes in the pattern of precipitation, several cases of extreme weather conditions, displacement of climatic zones and a further rise in sea level. This could have serious impacts, for example, on the world's agricultural production and in low-lying areas.

A term that is used in order to be able to compare the contribution made by the different gases to a possible increase in the greenhouse effect is global warming potential (GWP). The GWP-value for a gas is defined as the accumulated influence on the greenhouse effect of 1 tonne of emissions compared with 1 tonne of emissions of CO_2 over a specified period of time (usually 100 years). For Norway, the total anthropogenic emissions are summed up in table 2.1. The decrease was 1.7 per cent from 1989 to 1994. Much of the reduction can be put down to reduced emissions of fluorinated gases from the magnesium and aluminium industries.

Norway has signed the United Nations Convention on Climate Change, where all industrialized countries undertake to work to reduce anthropogenic emissions of greenhouse gases and to simultaneously preserve greenhouse gas sinks (e.g. forest). In addition, Norway has a national target to stabilize emissions of the greenhouse gas CO_2 at the 1989 level by the end of year 2000. Given the continued economic growth, this target can be difficult to realize without introducing very stringent measures (see also section 2.1 on the prognoses for CO_2-emissions in the Government's Long-Term

Table 2.1. Total emissions of greenhouse gases in Norway. 1989-1994*. Million tonnes CO_2-equivalents

	CO_2	CH_4	N_2O	Others[1]	Sum
GWP[2]	1	24.5	320	..	
1989	35.3	7.0	4.9	5.1	52.4
1990	35.5	7.1	5.0	4.8	52.4
1991	33.9	7.1	4.7	4.3	50.0
1992	34.4	7.2	4.2	2.4	48.1
1993*	35.7	7.1	4.4	2.6	49.8
1994*	37.2	7.2	4.5	2.6	51.5

[1] Mainly CF_4, C_2F_6, SF_6 and HFC.
[2] Including indirect effects.
Sources: Statistics Norway and the Norwegian Pollution Control Authority

Programme). The most important measure used by Norway so far to realize this goal is to impose a carbon tax on much of the petroleum consumption. It is clear, however, that this tax alone is not enough to stabilize the emissions in Norway, and that it must therefore be increased or combined with/replaced by other measures in order to realize the goal.

More information from: Ketil Flugsrud, Ola K. Hunnes and Kristin Rypdal.

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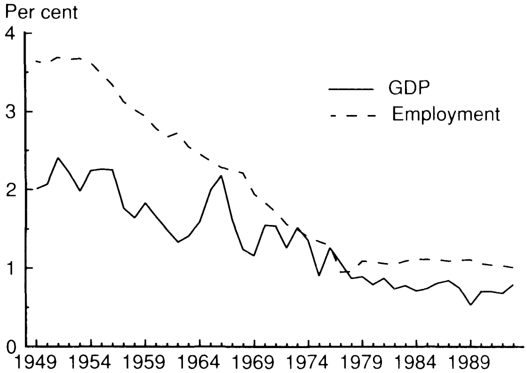
3. Fishing, sealing and whaling

Figure 3.1. Fishing, sealing, whaling and aquaculture. Share of GDP and employment. 1949-1993. Per cent



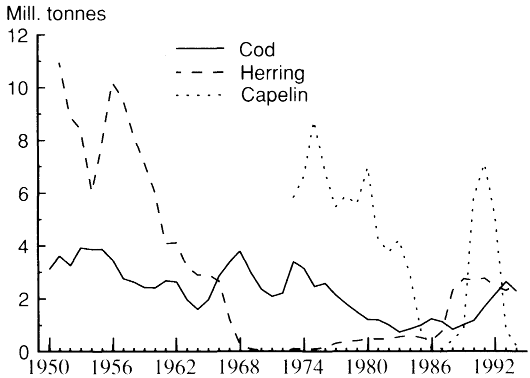
Source: Statistics Norway, National Accounts Statistics

The share of the gross domestic product (GDP) obtained from the fishing, sealing and whaling industry has decreased from about 2 per cent in 1949 to 0.8 per cent in 1993. The share of total employment has decreased from 3.6 per cent to 1 per cent during the same period (figure 3.1).

3.1 Stock development

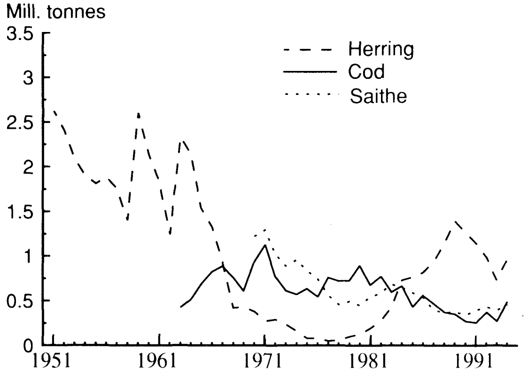
Norwegian spring spawning herring, Barents Sea capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Since the end of the 1960s, the stock sizes of all three species have reached historically low levels at times (figure 3.2). The stock of spring spawning herring was fished right down at the end of the 1960s. The capelin stock broke down in 1986/87, partly as a result of taxation, but also from natural causes. For cod, the stock size was low throughout the 1980s. In recent years, a positive development has been registered for both North-East Arctic cod

Figure 3.2. Stock development for North-East Arctic cod[1], Norwegian spring spawning herring[2] and Barents Sea capelin[3]. 1950-1994. Million tonnes



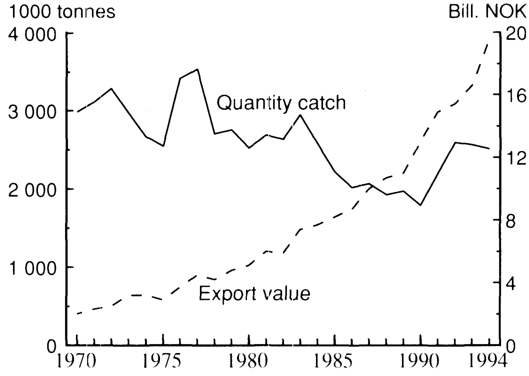
[1] Fish that are 3 years old or more. [2] Spawning stock.
[3] Fish that are 1 year old or more.
Sources: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research, Bergen

Figure 3.3. Stock development of cod in the North Sea[1], saithe in the North Sea[1], and North Sea herring[2]. 1951-1994. Million tonnes



[1] Fish that are one year old or more.
[2] Spawning stock.
Sources: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research, Bergen

Figure 3.4. Quantity of catch and export value. 1970-1994*. 1 000 tonnes and billion NOK



Sources: Statistics Norway and the Directorate of Fisheries

and Norwegian spring spawning herring (see table C1 in part III). The stock of Barents Sea capelin increased rapidly after the breakdown in 1986/87, but is now at a very low level again. The decrease in this stock is due to a large rise in natural mortality, both of larvae and older capelin. The reason is that cod and marine mammals in particular feed on the adult capelin, and young herring feed on the capelin larvae. The capelin population will remain at a low level for at least 2 or 3 years to come (Institute of Marine Research 1995).

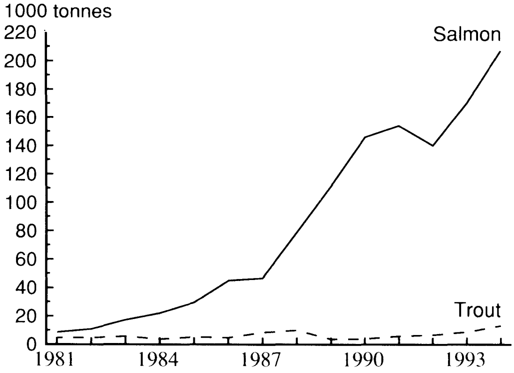
The stock of North Sea herring increased steadily after 1980, but during the 1990s the spawning stock has decreased considerably (figure 3.3 and table C1 in part III). The stocks of demersal fish in the North Sea are currently at historically low levels, so that the natural mortality of young herring is probably not as great as could normally be expected. However, small herring are fished extensively, both in Skagerrak and in the North Sea. This fishing must be restricted in order to achieve new growth of the spawning stock. Fishing pressure on the adult population should also be reduced (Institute of Marine Research 1994a and 1995).

3.2 Catch and aquaculture

In 1994, the total catch (including crustaceans, molluscs and seaweed) in the Norwegian fisheries was 2.5 million tonnes (figure 3.4 and table C2 in part III), with a first-hand value of NOK 7.3 billion. The volume of the catch was about the same as in 1993, but the value increased by more than NOK 1 billion. The catch of herring and cod increased substantially in 1994, but the catch of capelin was reduced considerably as a result of the ban imposed on fishing of capelin in the Barents Sea. Fishing for capelin in the Barents sea will not be permitted in 1995 either.

There has been a marked increase in production of reared fish since this industry was started in the early 1970s. The quantity of slaughtered fish increased from about 170 000 tonnes in 1993 to as much as 207 000 tonnes in 1994 (figure 3.5). In

Figure 3.5. Rearing of fish. Slaughtered quantities of salmon and rainbow trout. 1981-1994*. 1 000 tonnes



Sources: Statistics Norway, Norwegian Fish Farmers' Association and Kontali AS

1993, Norway was responsible for 55 per cent of the world's production of reared Atlantic salmon (Institute of Marine Research, 1994b). Trout production has remained more stable than salmon production, but increased in 1994 to a record high level of 14 000 tonnes.

The most common bacterial diseases in the Norwegian fish farming industry have been vibriosis, cold water vibriosis and furunculosis. Effective vaccines are available against vibriosis and cold water vibriosis, so that furunculosis is currently the most serious problem in this respect, even though fish are also vaccinated against this disease (Institute of Marine Research, 1994b). The use of medicines in the aquaculture industry has been reduced substantially in recent years. The probable reasons are new vaccines and better rearing routines. Consumption of anti-bacterial agents decreased from more than 27 tonnes in 1992 to about 6 tonnes in 1993. This consumption was further reduced to 1.4 tonnes in 1994 (table C3 in part III). It is important to limit the use of these agents, and to use them sensibly, in order to avoid spreading them to other organisms and to prevent the development of resistant bacteria.

3.3 Exports

According to the provisional figures, exports of fish and fish products increased in 1994 to about 1.5 million tonnes, with an export value of NOK 19.6 billion (figure 3.4 and tables C4 and C5 in part III). The export to EU countries was worth NOK 11.7 billion, or 60 per cent of the total export value.

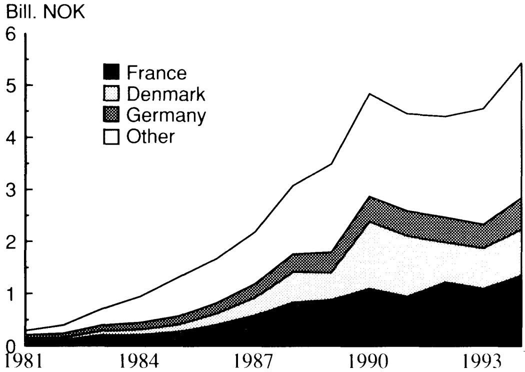
Exports of fresh and frozen reared salmon amounted to 154 080 tonnes, with an export value of NOK 5.4 billion (figure 3.6 and table C6 in part III). To this must be added exports of smoked salmon and salmon fillets, with an export value of more than NOK 1 billion, implying that in 1994 total exports of salmon amounted to NOK 6.5 billion. This corresponds to 33 per cent of the total value of Norwegian exports of fish. France and Denmark have been the most important purchasers of reared salmon for many years. Salmon exports to the USA have decreased substantially since 1990, owing to the high import tax on fish products, but there has been a marked increase in exports to Japan.

In 1994, the total export value of fish and fish products amounted to just over 15 per cent of the total traditional export of commodities from Norway (i.e. commodity exports excluding crude oil, natural gas, ships and oil platforms). During the period from 1978 to 1990, this share varied between 10 and 13 per cent, but in the later 1990s amounted to between 14 and 15 per cent.

3.4 Sealing and whaling

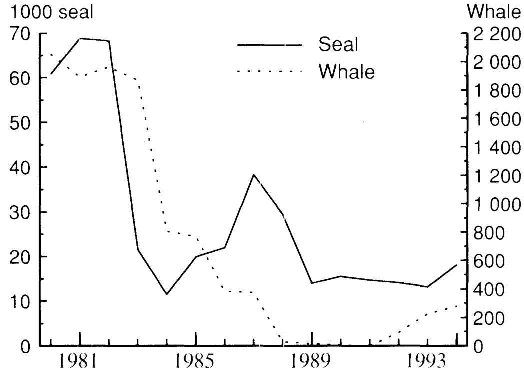
Since 1983, Norwegian sealing has taken place mainly in the fields in the Jan Mayen area and the White Sea. The level of the catch has been low, with a yield of about

Figure 3.6. Exports of fresh, cooled and frozen reared salmon, by main purchasing countries. 1981-1994*. Billion NOK



Source: Statistics Norway, Foreign Trade Statistics

Figure 3.7. Norwegian catches of seal and small whales[1]. 1980-1994



[1] During the period 1988-1992, catching for research purposes only.
Source: Directorate of Fisheries

10 000 to 40 000 animals per season (figure 3.7). In 1994, the total catch was 18 113 animals (17 621 harp seals and 492 hooded seals). The catching of young seals has been prohibited since the end of the 1980s.

Up to the early 1980s, the annual value of the seal catch was between NOK 10 million and NOK 40 million. Since then it dropped to between NOK 1 million and NOK 3 million, and since 1989 the catch has not been sold.

The Norwegian catch of small whales has consisted mainly of the baleen whale, the minke whale. Commercial whaling was discontinued after the 1987 season, but was started again in 1993, with a total catch of 226 whales (69 of these were included in the catch for research purposes). In 1994, the total catch was 278 minke whales. Of this number, 205 were caught commercially, and 73 for research purposes. The catch consisted of 53 per cent males and 47 per cent females.

During the two years preceding the ban on commercial whaling the value of the catch was about NOK 20 million, after reaching a level of NOK 45 million in 1983. In 1994 the value of the catch was NOK 12 million. There is a current ban on export of whale meat.

Further information from: Frode Brunvoll.

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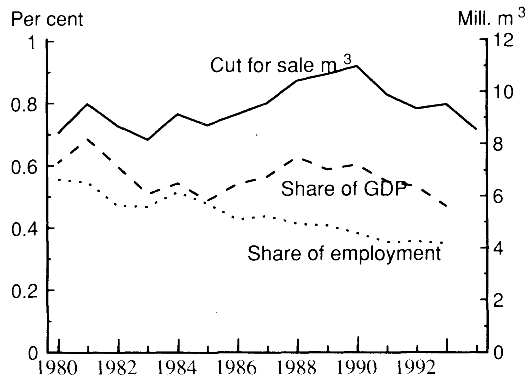
4. Forest

Employment in forestry (sawmilling and the pulp and paper industry excluded), measured in terms of normal man-years for paid employees and self-employed persons, decreased from 9 400 man-years in 1980 to 6 100 man-years in 1993 (figure 4.1). This amounted to 0.35 per cent of the total employment. Forestry now accounts for about 0.5 per cent of the gross domestic product. In 1994, 8.5 million m^3 was cut for sale and industrial production (SN 1995). This is a decrease of about 10 per cent in relation to the year before, and 21 per cent less than in the peak year 1990. The value of the gross production from forestry decreased from NOK 2.7 billion to NOK 2.5 billion.

Figure 4.1. Employment in forestry and share of GDP. Volume of roundwood cut for sale and industrial production 1980-1994*. Per cent and million m^3

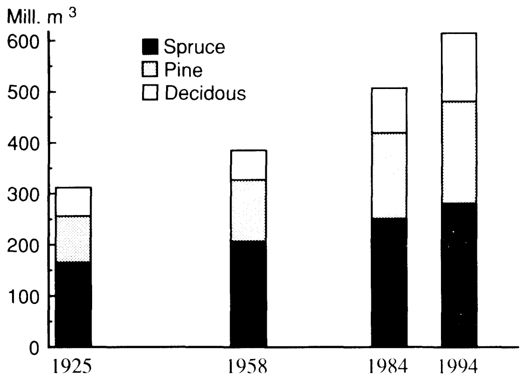


Source: Statistics Norway

4.1 Forest resources

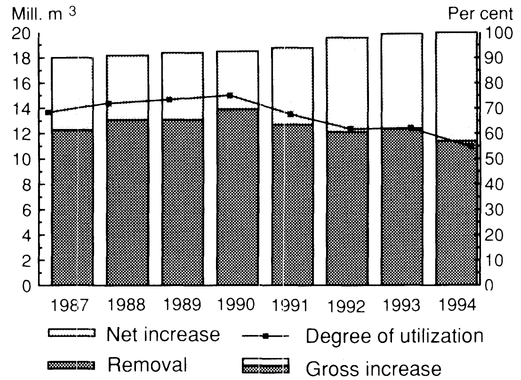
Norway has a total forest area of 119 000 km^2, of which about 72 000 km^2 is regarded as productive forest. This productive forest is distributed between 125 000 forest properties. About 79 per cent of the productive forest area is owned by private individuals, and more than half the forest properties are operated in combination with agriculture. For hundreds of years, Norwegian forests have been exploited intensively for export of roundwood, sawn timber and wood tar, and for production of charcoal. In addition, there is a long tradition of using the forests for domestic animal grazing and game hunting. Today, in economic terms, the forest is important first and foremost as a source of raw materials for the sawmilling and pulp and paper industries. The forest, and the biological diversity in the forest, is also of considerable value in itself as an ecological resource and as an area of recreation for a steadily more urbanized population.

Figure 4.2. Cubic mass of forest according to the forest inventories in 1925, 1958 and 1984. Calculated cubic mass in 1994. Spruce, pine and deciduous forest. Whole country . Million m^3 without bark



Sources: Statistics Norway and Norwegian Institute of Land Inventory (NIJOS)

Figure 4.3. Gross increase, total removal and degree of utilization of cubic mass. Whole country. 1987-1994. Million m^3 and per cent



Source: Statistics Norway

Standing volume

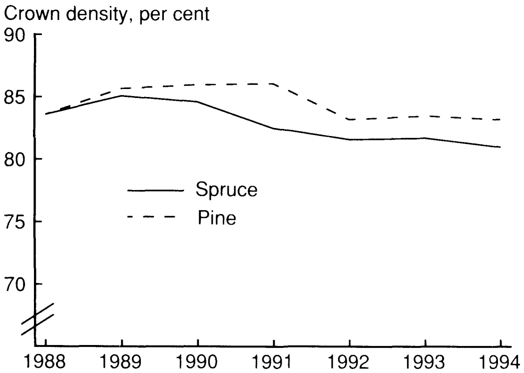
The results of the forest inventories and calculations of the cubic mass show that the volume of standing forest, below the coniferous forest limit, increased by more than 95 per cent from 1925 to 1994 (figure 4.2). The increase was particularly strong at the end of the period. An annual account of the cubic mass, *a forest balance,* shows the annual stock of forest at the beginning and end of the year, measured in terms of volume. The calculated forest balance for 1994 shows a standing cubic mass of forest of 616 million m^3, calculated without bark, at the end of the year. This volume was distributed between 46 per cent spruce, 33 per cent pine and 22 per cent deciduous trees. In 1994 the *net* increase (increment minus removal) in cubic mass was 9.5 million m^3, or 1.5 per cent of the total cubic mass of standing forest (figure 4.3, and tables D1 and D2 in part III). The net increase was greatest for deciduous trees and pine. The degree of utilization decreased from 1990 to 1994, and was about 55 per cent in 1994.

A degree of utilization of less than 100 per cent leads to an increase in the biomass of forest, implying that a steadily increasing amount of CO_2 from the atmosphere is assimilated by the trees. In 1994, the net amount of CO_2 assimilated by forest was 15 million tonnes, which amounts to about 40 per cent of Norway's anthropogenic emissions of CO_2. This figure also includes assimilation in bark, roots and other biomass.

4.2 Forest damage

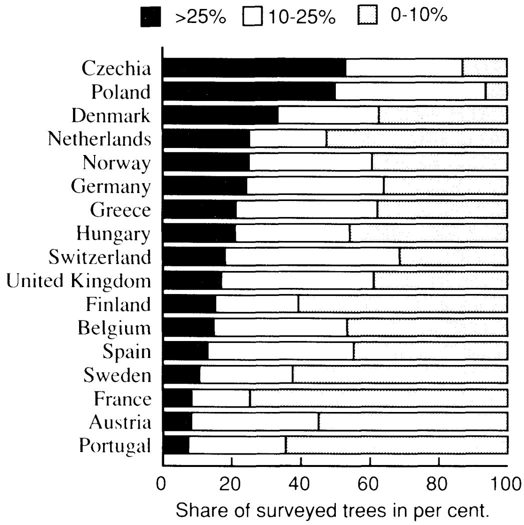
The results of the programme to monitor forest damage (NIJOS 1995) show forest health status for the country as a whole, measured in terms of average crown density and crown colour (tables D3 and D4 in part III). For spruce, the average crown density decreased from 85 per cent to 81 per cent from 1989 to 1994 (figure 4.4). For pine, the average crown density remained around 86 per cent during the period 1989 to 1991, but decreased to 83 per cent in 1992, and has remained at about this level in subsequent years. In the case of pine, the share

Figure 4.4. Average crown density for spruce and pine. Norway. 1988-1994. Per cent



Source: Norwegian Institute of Land Inventory (NIJOS)

Figure 4.5. Distribution of surveyed trees by defoliation. All kinds of trees. Some European countries. 1993. Per cent



Source: EC-UN/ECE 1994

of trees in the best crown density class decreased dramatically by as much as 10.1 percentage points from 1991 to 1992. The crown colour of both spruce and pine has remained relatively stable, with only small annual variations during the period 1988 to 1994.

Birch has been included in the monitoring programme since 1992, with preliminary recordings of birch in coniferous forest since 1990. During the period 1992 to 1994, the average crown density decreased from 73.8 to 70.4 per cent. However, deciduous trees react quickly to natural influences such as drought and insect attack, and observations over several years are necessary for a satisfactory evaluation of the results.

Since 1985, international cooperation has been established to record and monitor the effects of air pollution on forest. The investigations cover about 70 per cent of Europe's forest area. About two thirds of the surveyed trees have been pine, spruce, silver fir, beech or oak. Experience from previous years indicates that a defoliation of from 20 to 25 per cent does not necessarily indicate deteriorated health status, but can be regarded as a natural adjustment of the trees to variations in climate and supply of nutrients. The results show, however, that 23 per cent of all the surveyed trees exhibited more than 25 per cent defoliation (EC-UN/ECE 1994).

The results of observations in the different countries show that the forest damage is particularly extensive in Poland and the Czech Republic (figure 4.5). The estimate of forest damage in the United Kingdom has been strongly adjusted downwards, now that the method of observation has been harmonized with the method used in the other countries. In Portugal, a long period of drought came to an end, and the number of damaged trees decreased from 23 per cent to 7 per cent. The main causes of forest damage are presumed to be unfavourable weather, attacks by insects and fungi, forest fires and air pollution.

Further information from: Ketil Flugsrud.

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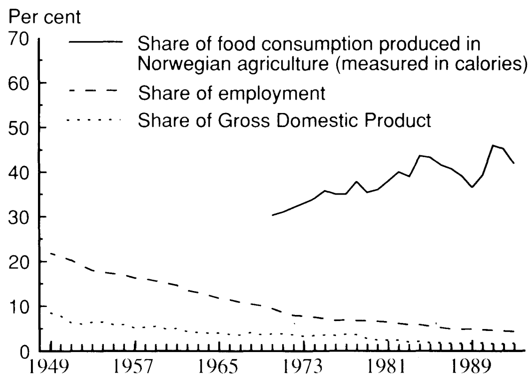
5. Agriculture

The importance of agriculture for the national economy has decreased continuously in post-war years. In 1949, agriculture's share of the country's total employment was 21.8 per cent. In 1993 this share had fallen to 4.3 per cent (figure 5.1). In absolute figures, the number of normal man-years employed in agriculture decreased from about 300 000 in 1949 to about 75 000 in 1993. Agriculture's share of the gross domestic product (GDP) has also declined steadily in post-war years, from 8.5 per cent in 1949 to 1.7 per cent in 1993. For the period as a whole, this is about the same relative decrease as for employment. The share of the population's food consumption obtained from Norwegian agriculture (measured in calories) increased from 30 to 42 per cent during the period 1970 to 1993 (The National Nutrition Council, 1994).

Figure 5.1. The importance of agriculture. Some indicators. 1949-1993. Percentage of national figures

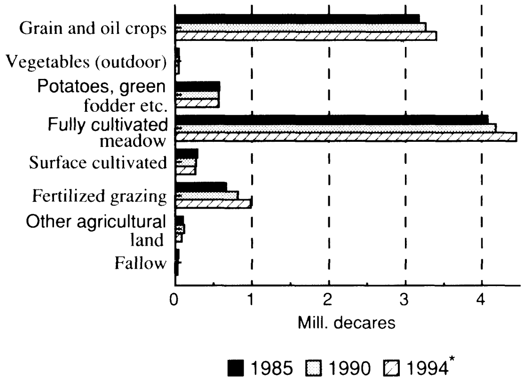


Sources: Statistics Norway and National Nutrition Council

5.1 Land use

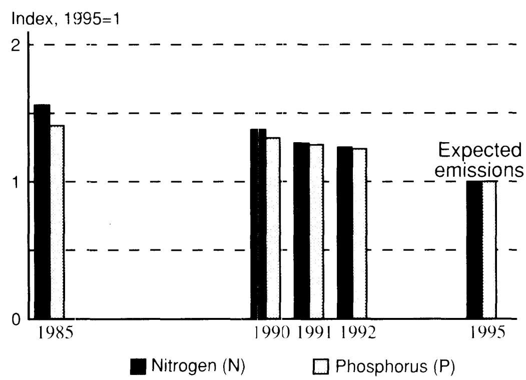
According to the figures stated in the applications for production subsidies, a total of 9.8 million decares of agricultural area was in use in 1994 (figure 5.2 and table E1 in part III). About 5.0 million decares of this land is subject to the North Sea Declarations. (These constitute a Treaty where the North Sea states have undertaken, among other things, to reduce their discharges of nutrients to the North Sea by half by 1995, with 1985 as base year. The Norwegian area comprises the counties of Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold, Telemark and East and West Agder, hereafter called the North Sea counties). In 1994, 34.6 per cent of the total agricultural area in use was used for grain production, while 45.3 per cent was fully cultivated meadow. There was a slight increase in the area of grain land and of fully cultivated meadow from 1985 to 1994, but a reduction in the amount of surface cultivated

Figure 5.2. Use of agricultural area. 1985, 1990 and 1994. Million decares



Source: Applications for production subsidies, Ministry of Agriculture

Figure 5.3. Estimated discharges of N and P to the North Sea from agriculture in 1985 and 1990-1992, in relation to the expected discharges in 1995. 1995=1



Source: Norwegian Pollution Control Authority

meadow. The area of fertilized grazing land increased by as much as 49 per cent during the same period (see table E1 in part III). Part of the increase can be explained by the fact that a larger share of the land is registered in the systems of subsidies.

5.2 Impacts on the environment

Estimated discharges of nutrients

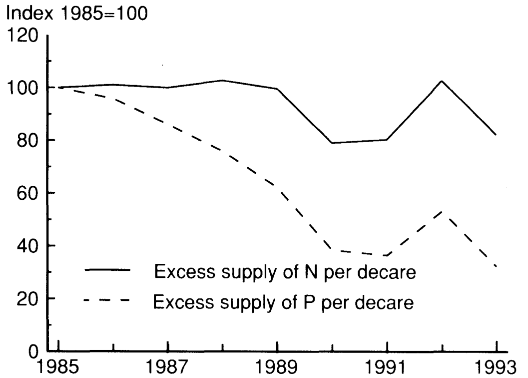
One of the most serious pollution problems caused by agriculture is the discharge of the nutrients nitrogen and phosphorus to water. Agriculture is also the source of extensive discharges of organic material, soil particles and various hazardous substances. Norway's anthropogenic inputs of nitrogen and phosphorus to the North Sea in 1992 were estimated to 23 000 tonnes nitrogen (N) and 900 tonnes phosphorus (P). Of this amount, agriculture is responsible for 45 per cent of the inputs of nitrogen and 23 per cent of the inputs of phosphorus. Figure 5.3 shows the estimated discharges of N and P to the North Sea from agriculture, seen in relation to the expected discharges in 1995. The discharges of nutrients from agriculture can be traced to two types of sources; point discharges (leakages from manure stores and silos) and diffuse discharges (area runoff). Investigations show that 90 per cent of the discharges are area runoff and 10 per cent come from point sources.

Nutrient balance

The nutrient balance for agricultural area in use is calculated by preparing accounts over the quantity of nutrients supplied to the land with commercial fertilizer and manure and the quantity removed by the crops. A large surplus indicates high risk of leakage (pollution) from the land. Figure 5.4 shows the relative trend in the total nitrogen and phosphorus balance during the years 1985 to 1993. The balance is adjusted for loss of nitrogen from manure in the form of evaporation of ammonia, and nitrogen and phosphorus in droppings on outfields used for grazing.

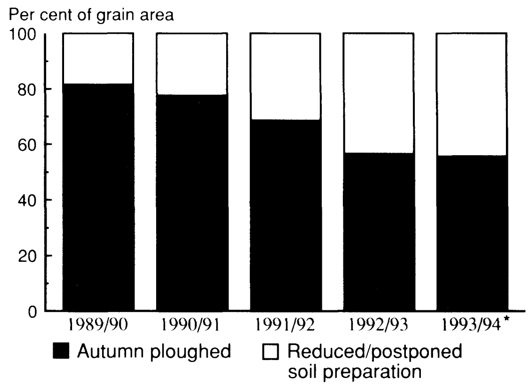
The excess nutrients can either be stored in the soil, run off with the surplus water or, in the case of nitrogen, disappear into the air.

Figure 5.4. Relative trend in the nutrient balance per decare agricultural area in use. Whole country. 1985-1993. 1985=100



Source: Statistics Norway

Figure 5.5. Share of the area used for grain and oil crops that is autumn ploughed. 1989-1993*. Per cent



Source: Statistics Norway

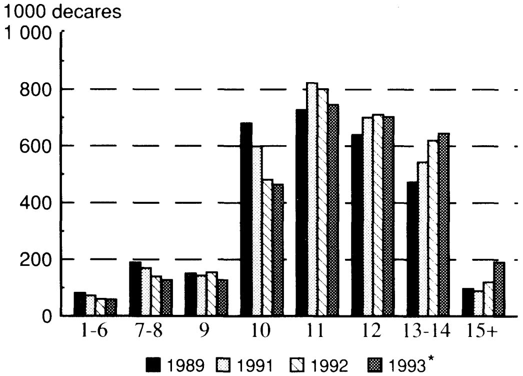
In 1985, according to this method of calculation, the excess supply of nutrient was 7.4 kg N and 2.0 kg P per decare agricultural area in use. The figure shows that, relatively speaking, the reduction in the excess has been greater for phosphorus than for nitrogen. The main reason is that farmers now spread far less phosphorus in commercial fertilizer. The uneven results from year to year are due to the fact that the crops vary with the weather conditions. Some of the basic numbers for figure 5.4 are contained in table E3 in part III.

Soil preparation
Less soil preparation in the autumn substantially reduces the loss of soil and nutrients. The share of autumn ploughed grain land decreased by 26 percentage points from autumn 1989 to autumn 1993, when it was down to 56 per cent (figure 5.5 and table E2 part III). The area used for autumn sown grain has increased from 108 000 decares in 1989/90 to 368 000 decares in 1993/94, and in the latter season accounted for about 10 per cent of the grain area. Prognoses from Statkorn for 1994/95 indicate a slight reduction in the area of autumn sown grain.

Fertilization
For the country as a whole, sales of commercial fertilizer with phosphorus decreased by 44 per cent from 1984/85 to 1993/94, while sales of nitrogen fertilizer remained more or less the same. Seen in relation to the slight increase in the area of agricultural area in use during the period, this implies a considerable reduction in the average quantity of phosphorus fertilizer per decare, but about the same amount, or a slight reduction, of fertilization with nitrogen. The sample censuses show a reduction from 1989 to 1992 in the shares of meadow land with a very high or very low fertilization density, but during 1993 the share of such areas increased again. Nitrogen fertilization of grain has increased in recent years (figure 5.6). This is partly due to an increase in the area of land used for autumn sown grain.

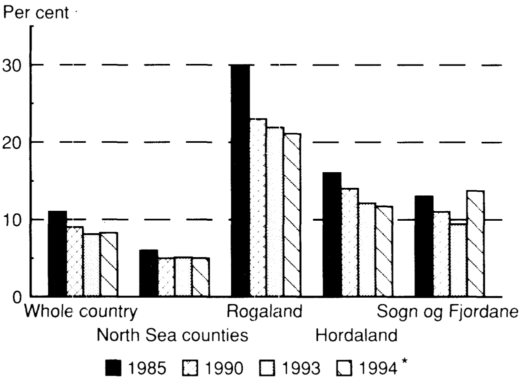
The number of domestic animals, and therefore the amount of manure, changed very little from 1985 to 1994. The share of the

Figure 5.6. Area used for grain and oil crops by kg nitrogen (N) commercial fertilizer per decare. 1989 and 1991-1993*. 1 000 decares



Source: Statistics Norway

Figure 5.7. Share of surplus animal manure units. Whole country and selected counties. 1985, 1990, 1993 and 1994*. Per cent



Source: Statistics Norway

manure spread in the growing season, calculated in terms of N, increased from 80 per cent in 1989 to 86 per cent in 1993. The number of "surplus animal manure units" indicates a possible lack of spreading area for animal manure in relation to the requirements imposed by the authorities. The number of surplus animal manure units was reduced from 11 per cent of all animal manure units in 1985 to 8 per cent of all animal manure units in 1994 (figure 5.7 and table E4 in part III). There are large variations between counties. Reports from the county agricultural offices indicate that more local adjustments to the authorities' requirements have been made than shown by the calculations based on applications for production subsidies.

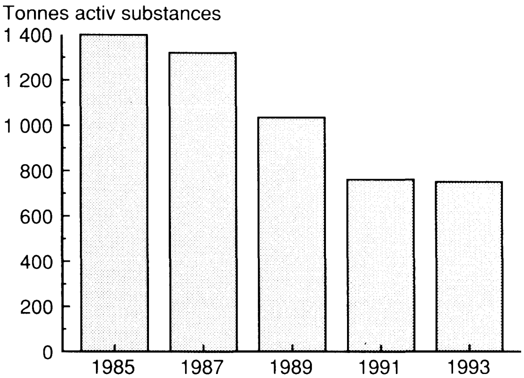
Use of pesticides

Pesticide residues in soil, water and food products can have adverse effects on health and the environment. Improper storage and use of pesticides can cause local poisoning on individual farms.

Total consumption of pesticides, calculated in terms of the active substance, decreased substantially from 1985 to 1993 (figure 5.8). The use of fungicides has remained relatively constant, but the use of the other types of pesticides has been reduced considerably. Preparing statistics on the sum of the quantities of the different active substances implies in reality adding up substances that are not truly alike. Nor do such statistics give any indication of possible changes over time in the type of active substance used. Different substances degrade at different rates, and differ as regards selectivity and toxicity. These factors are of major importance for how the substances affect the surrounding environment. However, the changes in total consumption of pesticides does give an indication of whether the load on the environment is increasing or decreasing.

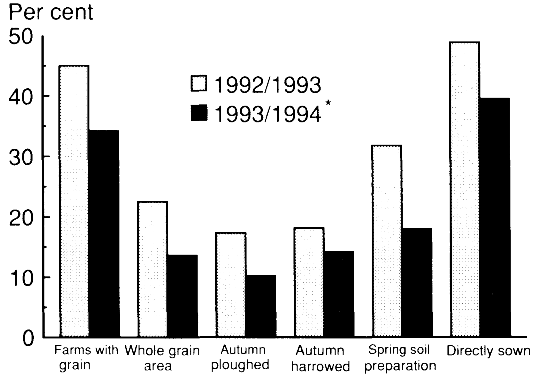
The sample censuses for agriculture show that about 14 per cent of the grain area in the North Sea counties was sprayed with herbicides to kill perennial weeds in autumn 1993 or before sowing in spring 1994

Figure 5.8. Sales of active substances in pesticides. 1985-1993. Tonnes



Source: The National Agricultural Inspection Service

Figure 5.9. Share of the grain area sprayed with herbicide against perennial weeds by form of soil preparation. The North Sea counties. 1992/93 and 1993/94*. Per cent



Source: Statistics Norway

(figure 5.9). This was a marked decrease from the year before, when the corresponding figure was 22 per cent. The corresponding figures for the country as a whole were 13 and 21 per cent respectively. The probable reason for the large decrease is late and difficult harvesting of grain in autumn 1993. 40 per cent of the directly sown grain land was sprayed with herbicide to kill perennial weeds, while only 10 per cent of the autumn ploughed land was sprayed in this way.

Further information from: Henning Høie.

Literature:

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SN (1995): *Resultatkontroll jordbruk 1995. Gjennomføring av tiltak mot forurensninger* (Result Control Agriculture 1995. Implementation of measures against pollution). Reports 95/5. Statistics Norway, Oslo - Kongsvinger. (Summary in English.)

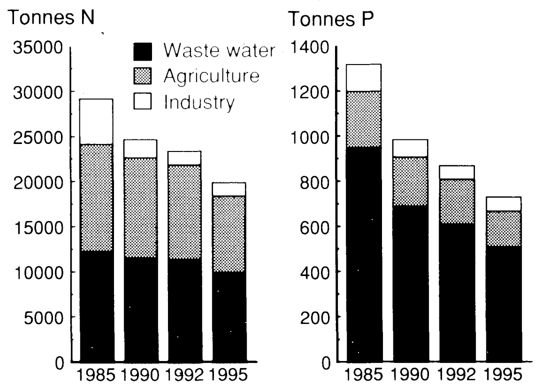
6. Waste water treatment

Statistics Norway and the Norwegian Pollution Control Authority (SFT) cooperate on the annual registration of data from all waste water treatment plants in the country. The data program SSB-AVLØP has been installed at all county governors' environmental agencies, which are responsible for collecting data from the municipalities. The county environmental agencies then send the data to Statistics Norway on disc. Since 1994 onwards, the reporting system SSB-AVLØP has been extended to include data on scattered settlements, the waste water pipeline network, economic figures and complete pollution accounts.

Discharge figures from SSB-AVLØP are reported to the Norwegian Institute for Water Research (NIVA). NIVA uses these figures in a model (TEOTIL) to calculate the total discharges of phosphorus and nitrogen to the North Sea area. Discharges from agriculture and industry are also included, and the figures take into account *self-purification* (retention) in fjords and watercourses.

In accordance with the North Sea Declarations, Norway has undertaken to reduce discharges of phosphorus (P) and nitrogen (N) to the North Sea (the stretch of the coast from the Norwegian/Swedish border to Lindesnes) by 50 per cent by the end of

Figure 6.1. Norwegian anthropogenic inputs of N and P to the North Sea. 1985, 1990, 1992 and expected inputs in 1995. Tonnes

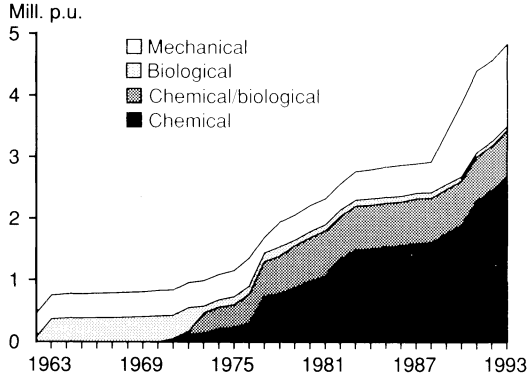


Source: Norwegian Pollution Control Authority

1995, with 1985 as base year. So far it seems as if Norway will achieve a reduction of 45 per cent in phosphorus discharges and of 31 per cent in nitrogen discharges by the end of 1995 (figure 6.1).

Inputs of nitrogen and phosphorus from Norway to the North Sea are relatively moderate compared with inputs from the continent (table F1 in part III).

Figure 6.2. Hydraulic capacity by purification principle. 1962-1993. Million p.u.

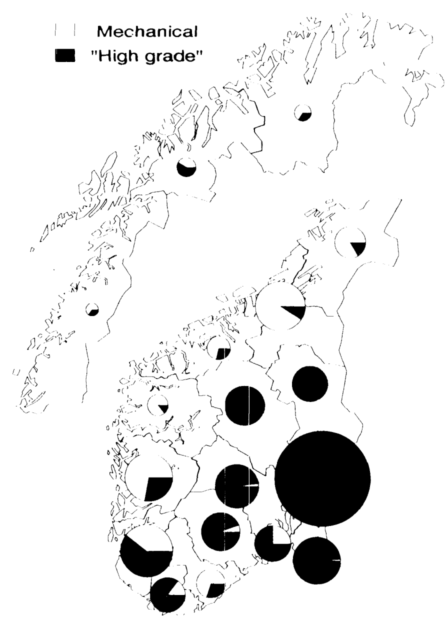


Source: Statistics Norway

6.1 Waste water treatment plants

Most of the waste water treatment plants in Norway have been built during the last 30 years (figure 6.2). The earliest plants were based mainly on mechanical and/or biological purification processes. However, from the beginning of the 1970s it became more common to build plants with a chemical purification process for removal of phosphorus. Since the end of the 1970s there has been a clear dominance of plants with a chemical phase ("high grade" purification). The main reason for the apparent increase in the purification capacity of the mechanical plants from 1988 to 1990 is that, from 1990 onwards, strainers and sludge separators were also registered in this category. In Norway, priority has been given to removal of phosphorus in order to prevent algal growth in fjords and watercourses. This implies that considerable resources have been invested in chemical purification of waste water. In other European countries, biological purification processes are more common, since these countries have attached greater importance to removal of organic material (SFT 1995).

Figure 6.3. Hydraulic capacity distributed between mechanical and "high grade" waste water treatment plants. County. 1993



Source: Statistics Norway

In Eastern and Southern Norway a large share of the municipal waste water is purified in "high grade" plants (figure 6.3). In Hordaland and northwards along the coast, the greater part of the waste water is treated mechanically.

About 3.66 million population units (p.u.) of waste water was treated at municipal waste water treatment plants in 1993. Of a total of 1822 plants that were registered at the end of 1993, 16 had a hydraulic capacity of more than 50 000 p.u. Almost half of all the municipal waste water is treated at these 16 plants.

6.2 Sludge

Sludge is a residual product of the purification process at waste water treatment plants and contains both organic material and nutrients, which make it useful as fertilizer and soil amendment material.

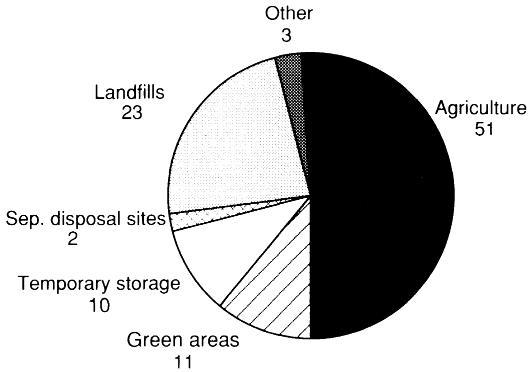
In 1993, a total of 77 700 tonnes of sludge was registered, calculated as dry matter. This is a reduction of 5 per cent compared with 1992. Quantities of sludge were reported from 438 plants, and these accounted for 85 per cent of the total hydraulic load. At Vestfjordens Avløpsselskap's plant in Akershus (VEAS), which is Norway's largest waste water treatment plant, with a hydraulic capacity of 700 000 p.u., a sludge digestion tank was put into operation in 1993. This led to an approximately 30 per cent reduction in the quantity of sludge at this plant, from 24 500 tonnes in 1992 to 16 600 tonnes in 1993. Much of the sludge is used in agriculture. In 1993 this share was 51 per cent (figure 6.4).

The composition of the sludge varies considerably from plant to plant. The content of heavy metals (table 6.1) and nutrients (table 6.2) in the sludge is determined by the quantity and type of water the plant receives. The various purification processes will also affect the composition of the sludge.

6.3 Waste water pipeline network

The reported figures for 1993 for type of waste water pipeline network, on the length, age and material of the pipes, and on overflow and pumping stations are incomplete. Figures from 172 municipalities (54 per cent of the population) show a length of waste water pipes totalling 18 000 km, corresponding to 8 metres per inhabitant. Combined sewerage systems accounted for 24 per cent of this length, separate sewers for 50 per cent and storm water sewers for 26 per cent.

Figure 6.4. Disposal of sludge. 1993. Per cent



Source: Statistics Norway

Table 6.1. Heavy metals in sludge. 1993. mg per kg dry matter

Heavy metal	No. plants	Aver. value	Min. value	Max. value	Std. dev.
Cadmium	247	1.2	0.2	8.3	0.9
Lead	249	28.9	1.8	209.0	19.3
Mercury	244	1.5	0.1	7.2	1.2
Nickel	230	10.9	2.0	87.0	7.9
Zinc	231	340.6	52.0	1820.0	181.5
Chromium	231	21.5	3.1	198.0	19.6
Copper	231	333.0	28.0	1750.0	278.0

Source: Statistics Norway

Table 6.2. Nutrients and organic material in sludge. 1993. Percentage of dry matter

	No. plants	Aver. value	Min. value	Max. value	Std. dev.
Organic material	79	60.2	4.9	78.6	14.8
Nitrogen	156	2.5	0.0	5.1	1.0
Phosphorus	100	1.3	0.1	4.0	0.6
Potassium	96	0.2	0.0	1.9	0.3
Calcium	95	3.4	0.0	36.0	7.0

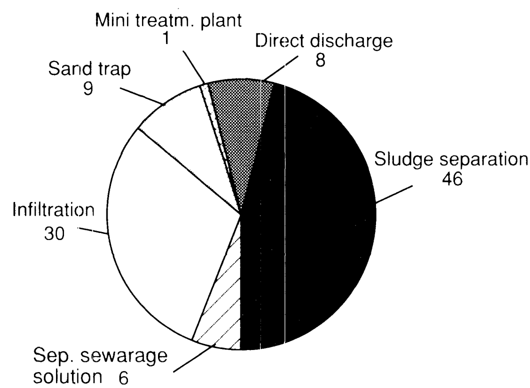
Source: Statistics Norway

In a survey conducted in 1984 (Brunvoll 1987), the total length of the waste water pipeline network in Norway was estimated to be 27 400 km, corresponding to 6.5 metres per inhabitant. However, the uncertainty of the figures for both 1984 and 1993 make it impossible to say anything definite about the trend.

6.4 Scattered settlements

While the county governor is the pollution control authority for municipal discharges, the municipality is the pollution control authority for separate discharges in scattered settlements. A discharge permit must be obtained in accordance with the *regulations concerning discharges from separate waste water treatment plants*, which also outline what kinds of treatment may be used.

Figure 6.5. Purification principles for waste water from scattered settlements. 1993. Per cent

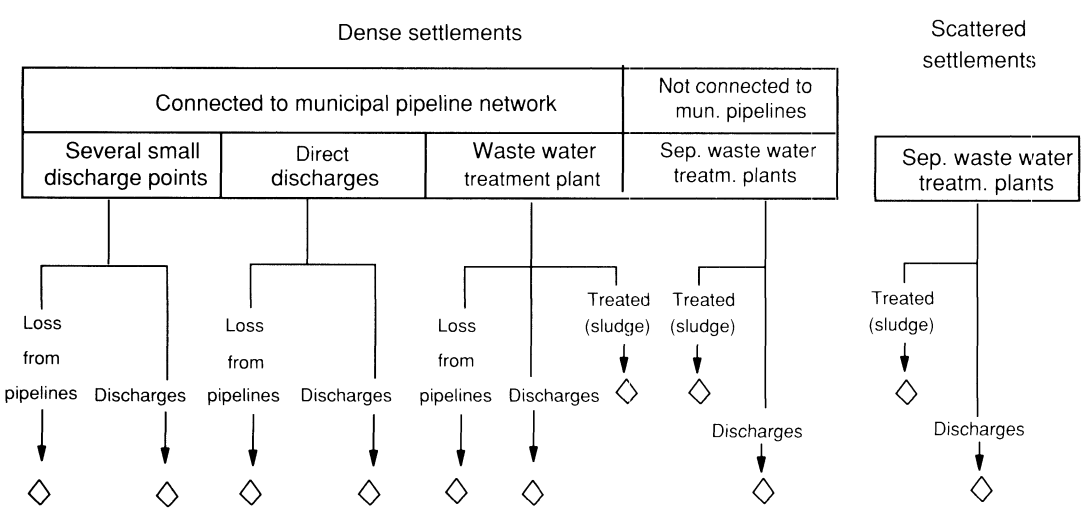


Source: Statistics Norway

Slightly less than 300 000 separate waste water treatment plants for permanent dwellings in scattered settlements were registered in 1993. These plants served 870 000 persons, giving an average of 2.9 persons connected to each plant. The figures were obtained from 399 out of 439 municipalities, corresponding to 94 per cent of the population.

Sludge separators and infiltration are the most common methods of treatment of waste water from scattered settlements (figure 6.5).

Figure 6.6. Flow chart for waste water



6.5 Phosphorus accounts and discharges

The pollution accounts are based on a division of densely built-up areas into "catchment areas". A specific geographical area (in a municipality) that is served by a waste water treatment plant is defined as a catchment area. A "catchment area" may also contain direct discharges, in which case the discharge pipe is regarded as a "treatment plant" with 0 per cent purification. In some areas the discharges take place via several small discharge points. The sum of these discharge points in a municipality is then regarded as one "catchment area". In SSB-AVLØP, scattered settlements are settlements with separate waste water treatment plants (see box), located outside a defined catchment area. Separate waste water treatment plants may also be found in densely built-up areas. Figure 6.6 shows the flows of waste water diagrammatically.

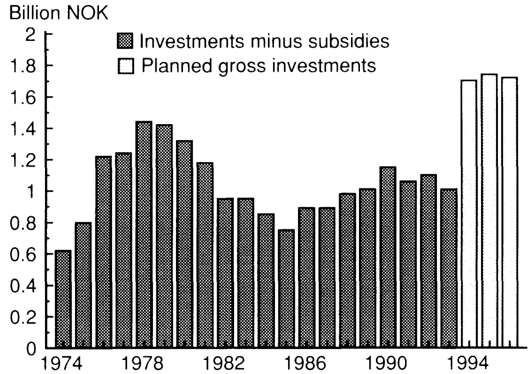
In the counties discharging into the North Sea (Østfold to Vest-Agder, both counties inclusive), the average share of phosphorus removed at the waste water treatment plants is as much as 87 per cent. The high level of purification is a result of the large and modern waste water treatment plants in this part of the country, and the discharges of phosphorus in this area are lower than in the rest of Norway. Scattered settlements are a major source of discharges in Norway, and these discharges have increased in importance (relatively) as the municipal discharges have been gradually reduced (SFT 1995).

6.6 Municipal economy in the waste water sector

Investments

During the period 1974 to 1993, the total investments in the municipal waste water sector, minus subsidies, amounted to approximately 21 billion 1993-NOK (figure 6.7).

Figure 6.7. Municipal waste water treatment. Investments minus subsidies. 1974-1993. Planned gross investments 1994-1996. Whole country. Billions 1993-NOK[1]

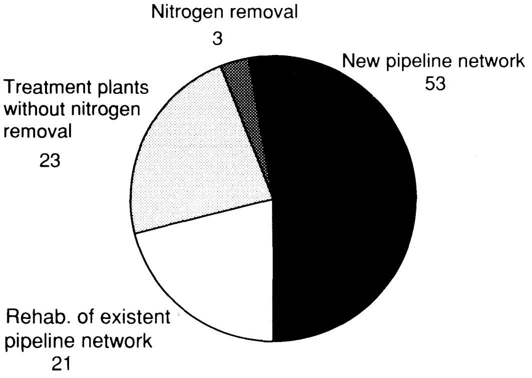


[1] The conversion of the figures to 1993-NOK is based on Statistics Norway's building cost index (apartment block, total costs) for the period 1978-1993. The building cost index was not prepared before 1978. It is assumed that the rise in prices was constant during the period 1974-1978.
Source: Statistics Norway

The investments reached a peak at the end of the 1970s. The rise in investments in the 1990s is connected with the efforts to follow up the commitments of the North Sea Declarations. According to the municipalities' plans for 1994 to 1996 inclusive, the total gross investments during this period will be just over 5 billion 1993-NOK.

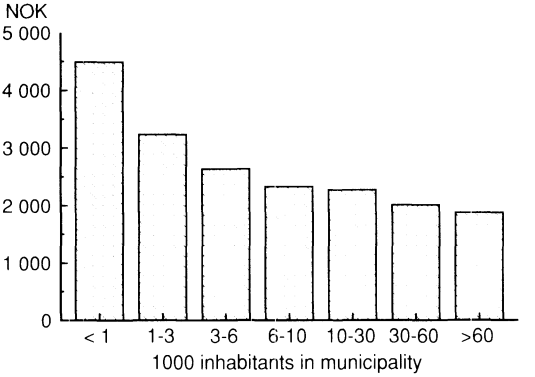
In 1993, about 74 per cent of the investments went to extension and rehabilitation of the waste water pipeline network (figure 6.8). Investments in waste water treatment plants with a nitrogen removal phase accounted for only 3 per cent of the investments in 1993. According to SFT's plan of action to reduce discharges of nutrients to the North Sea, higher investments in nitrogen removal plants can be expected in the years to come (SFT 1992).

Figure 6.8. Municipal waste water treatment. Investments by type of project. Whole country. 1993. Per cent



Source: Statistics Norway

Figure 6.9. Municipal waste water treatment. Annual cost per subscriber[1] by size of municipality. Weighted average. 1993. NOK



[1] Connected commercial/industrial activity is converted into household subscribers: 1 subscriber corresponds to 3 population equivalents (p.e.).

Source: Statistics Norway

Annual costs and charges

The municipalities collect charges in the form of a fee for connection to the waste water treatment system and an annual charge. They have the right to collect a total sum which covers the costs of capital, calculated on the basis of investments minus subsidies, and operation of the system. In 1993 the collected charges covered only 80 per cent of the cost of the municipal waste water treatment system, i.e. NOK 3.1 billion. Of this amount, NOK 1.5 billion was operating costs and NOK 1.6 billion was capital costs.

The costs for administration and maintenance of the municipal waste water treatment system shall be included in the operating costs. Since the cost of administration is entered under *joint administration* in the municipal accounts, it can be difficult for the municipalities to extract the part that refers to waste water treatment. Therefore the operating costs may be underestimated. On the other hand, some of the municipalities have not subtracted grants etc., which shall not be included in the basis for calculating the charges. Therefore the net investments, and thus the capital costs, may be too high.

Annual cost per subscriber

The annual costs for waste water treatment distributed between subscribers connected to the waste water pipeline network averaged about NOK 2 200 in 1993. The cost level in the municipality, and thus the annual cost per subscriber, is affected by the size of the municipality and its geographical location (figure 6.9). In the North Sea counties the average annual cost per subscriber was about NOK 2 600, while the average for the rest of the country was about NOK 1 600. The high costs in the North Sea counties are due to more stringent cleaning requirements in these counties.

Further information from: Bjørn-Vidar Grande and Toril Austbø.

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SFT (1992): *Nordsjø-deklarasjonen. Tiltak for å redusere næringssalttilførslene* (North Sea Declaration - Measures to reduce inputs of nutrients). SFT-report 92:14. Norwegian Pollution Control Authority, Oslo.

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Waste water treatment plants are traditionally grouped into three main categories, depending on purification principle: mechanical, chemical and biological. Some plants combine these basic forms of treatment.

Mechanical plants include sludge separators, screens, strainers, sand traps and sedimentation plants, and remove the largest particles from the waste water.

"High grade" plants are plants with a biological and/or chemical phase. The biological phase involves use of microorganisms to remove mainly easily degradable organic material. In chemical plants, various chemicals are added during the purification process in order to remove phosphorus. High grade plants are more effective than mechanical plants in reducing the amount of phosphorus and other pollutants.

Population equivalents (p.e.) means waste water from industry, institutions etc. converted into the quantity of waste water from an equivalent number of persons.

Population units (p.u.) means the number of residents plus the number of population equivalents in a specific area.

Hydraulic capacity is the quantity of waste water a waste water treatment plant is designed to receive.

Hydraulic load is the quantity of waste water that a waste water treatment plant actually purifies.

A separate waste water treatment plant is a plant designed to receive waste water which in quantity or composition corresponds to waste water from up to 7 housing or holiday home units.

Investments minus subsidies are the investments that can be included in the municipalities' basis for calculating the waste water treatment charges, and are covered by the subscribers through these charges. Investments in municipal waste water treatment can also be financed in other ways, e.g. by grants from the Ministry of Environment, other government subsidies, private grants, and reimbursement of costs in accordance with the Planning and Building Act. The costs that are covered in these ways shall not be included in the basis for calculating the waste water treatment charges.

When calculating the *capital costs* the depreciation time for the investments is 20 years, with interest charges of 10 per cent. This is consistent with the model used by the municipalities to calculate the basis for the charges.

7. Waste

Waste represents a pollution problem and can be characterized as resources that have gone astray. The problems are connected to both existing and earlier management of waste.

Statistics Norway divides waste into two main categories by origin: *Industrial waste* and *household waste*. Industrial waste can be further divided according to the sector in which it is generated (agricultural waste, manufacturing waste, construction waste, etc.) Household waste is waste from the ordinary activities of a household, and consists of, among other things, food remains, packaging and paper, as well as discarded furniture and garden waste.

In the Pollution Control Act, the waste is divided into three main categories:

- *Consumer waste* is ordinary waste, including larger objects such as furnishings from households, small shops, offices etc.

- *Production waste* is waste from industrial activity and provision of services which in type or quantity is significantly different from consumer waste.

- *Hazardous waste* is waste which cannot be appropriately treated together with consumer waste because it can lead to serious pollution or risk of injury to persons or animals.

The collective term *municipal waste* is used to describe all waste dealt with by the municipal waste collection and management systems. Municipal waste includes the greater part of all consumer waste and varying quantities of production waste.

7.1 Generation of waste

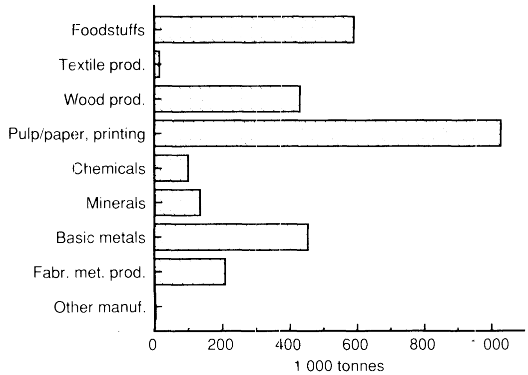
The term generation of waste refers to the quantities of waste created in connection with production and consumption. Owing to storage, export/import and illegal disposal of waste, there may be large deviations between the quantities that are generated and the quantities that are collected/deposited annually.

Complete statistics on the quantities generated are lacking, but it is possible to present calculated figures for the waste generated in households and industry, and for the components of the hazardous waste that are subject to regulations.

The environmental authorities have given high priority to developing a system of official statistics on waste and recycling of waste for the whole country. Statistics on municipal waste and industrial waste will be elaborated by Statistics Norway in cooperation with the Norwegian Pollution Control Authority (SFT). In 1993, all Norwegian municipalities and waste management facilities supplied information on municipal waste and waste management. In 1994, data were collected from selected municipalities, as a basis for calculating national figures. In the case of industrial waste from the petroleum sector and mining, manufacturing industry and construction, a survey was carried out in 1994, based on interviews at a sample of establishments. As regards *hazardous waste,* during the last few years SFT has undertaken nation-wide surveys of old waste disposal sites. Norsas AS (the Norwegian competence centre for waste and recycling), a company established specially to administer the management of hazardous waste in Norway, has registered the quantities of hazardous waste delivered each year for disposal. However, a more comprehensive system of statistics on waste is needed, and in 1995 Statistics Norway will start to develop national accounts for waste.

It is difficult to make international comparisons of quantities of waste, because the types of waste include different kinds of waste in the different countries. Both ECE and EU have been working for some time to prepare a common classification for waste, but have still not reached a final recommendation.

Figure 7.1. Calculated quantity of production waste and consumer waste generated in manufacturing industry, by sector. 1993. 1 000 tonnes



Source: Statistics Norway

Household waste

Statistics Norway has calculated that 1.13 million tonnes of waste was generated in households in 1993. This corresponds to 262 kg per capita. The calculations are based on the following assumptions:

- that households covered by the municipal collection system delivered all their waste, and that this was later recorded as household waste
- that households not covered by the municipal collection system generated just as much waste as the households that were covered by the system
- that the degree of coverage was the same in 1993 as in 1992.

The quantity of household waste generated per capita in 1992 was calculated to be 250 kg (SN/SFT/DN 1994). In the early 1980s, the quantity of household waste was estimated to 198 kg per capita (Halmø 1984).

Industrial waste

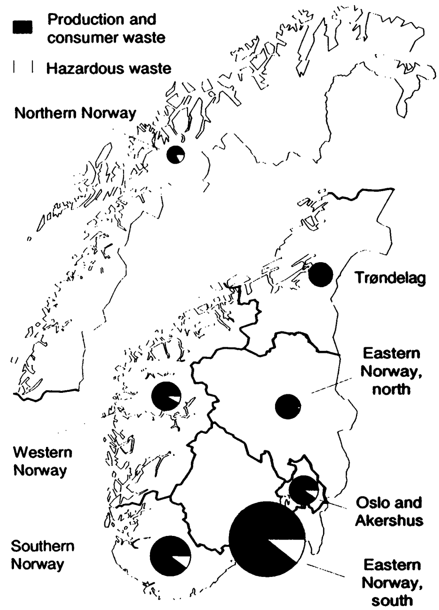
The term industrial waste refers to all waste generated during industrial activity (limited to main category D, i.e. Manufacturing, in

Table 7.1. Calculated quantity of hazardous waste generated in manufacturing industry, by category of hazardous waste. 1993. Tonnes

Total		320 300
1	Waste oil, lubricating oil etc.	11 600
2.1	Oily waste from oil-water separators	5 900
2.2	Oil-contam. waste from drilling operations	200
3	Oil emulsions	1 800
4.1	Organic solvents containing halogen	700
4.2	Organic solvents not containing halogen	20 700
5	Paint, glue, varnish and printer's ink	9 800
6/7	Distillation residues and tarry waste	600
8/9	Waste/batteries containing heavy metals	17 300
10	Waste containing cyanide	6 000
11	Discarded pesticides	0
12	Waste containing PCBs	0
13	Isocyanates	0
14	Other organic waste	44 800
15	Strong acids	175 900
16	Strong alkalis	6 200
17	Other inorganic waste	18 700
18	Aerosol containers	0
19	Laboratory waste	100
20	Unknown	0

Source: SN 1994a

Figure 7.2. Calculated quantities of industrial waste, by region. 1993



Source: Statistics Norway

Statistics Norway's Standard Industrial Classification - SIC94). This includes production waste, consumer waste (e.g. waste from canteens and offices, and packaging) and hazardous waste. *Recycling and re-use on own premises are not included.*

In 1993, 2.97 million tonnes of production and consumer waste was generated in industry (figure 7.1 and tables G5, G6 and G7 in part III). To this must be added 320 000 tonnes of hazardous waste (table 7.1 and tables G8 and G9 in part III). When the industrial waste is distributed geographically (see figure 7.2), it is found that 54 per cent of the waste was generated in the region comprising the southern part of Eastern Norway (counties of Telemark, Buskerud, Vestfold and Østfold). The least industrial waste (3 per cent) was generated in North-

Table 7.2. Calculated quantity of hazardous waste and production and consumer waste per industrial establishment. 1993. Tonnes

Industrial sector	Prod. and cons. waste	Hazardous waste
All	2 500	271
Food, beverages and tobacco	2 400	17
Textiles, wearing apparel and leather prod.	300	5
Wood and wood products	3 300	6
Pulp/paper prod., publishing/printing	6 600	40
Chemicals, coke, refined petroleum, chemical, rubber and plastic products	1 100	2 623
Manuf. of mineral products	2 800	7
Manuf. of of basic metals	16 800	1 876
Manuf. fabr. metal products	500	37
Other manuf. industries	100	2

Source: Statistics Norway

ern Norway (Nordland, Troms and Finnmark counties).

If one considers the generated quantity per establishment, the largest quantity of production and consumer waste was generated in the metals manufacturing sector (table 7.2). The largest amount of hazardous waste per establishment was generated in the chemicals industry, followed by metals manufacturing. In both categories of industry, however, one single establishment was responsible for raising the average figure for hazardous waste. As a rule, there is a correlation between quantity of waste and number of employees, although there were large variations between the different sectors.

The pulp and paper industry (including publishing etc.) contributed 35 per cent of the waste, the food, beverages and tobacco industry contributed 20 per cent and metals manufacturing 15 per cent. The remaining 30 per cent came from the rest of manufacturing industry combined.

As far as the material composition of the production and consumer waste in manufacturing industry is concerned, the largest share, 30 per cent, was pulp and paper waste. Food, slaughterhouse waste and fish waste accounted for 15 per cent, paper and cardboard for 7 per cent, and excavated material, such as stone and gravel, for 5 per cent.

Of a total of 320 000 tonnes of hazardous waste, 76 per cent was generated in the chemicals industry. More than half the hazardous waste consisted of acids; in the case, however, 93 per cent came from one single establishment. The group other organic waste accounted for 14 per cent, and all types of oil-contaminated waste combined for only 6 per cent.

Packaging accounted for 5 per cent (150 900 tonnes) of the production and consumer waste. Paper and cardboard accounted for 62 300 tonnes, and glass for 40 900 tonnes.

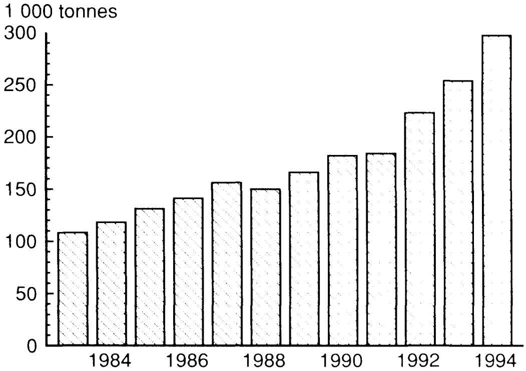
Hazardous waste
If the hazardous waste dealt with on the companies' own premises is excluded, calculations by Norsas show that about 150 000 tonnes of hazardous waste was generated in Norway in 1993 (Norsas 1995a). Norsas only includes hazardous waste that is subject to the regulations concerning hazardous waste. This leads to large deviations in relation to Statistics Norway's figures for industry (see above).

7.2 Recycling

Recycling means utilization of waste and other residual products. Recycling can be divided into re-use, recovery of materials and recovery of energy. No complete figures are available for how much waste is recycled, but Norsas is currently establishing continuous routines for this purpose. Sections 7.1 and 7.3 report the quantities of waste that are *delivered* for recycling from industrial activities and the municipal waste collection system. Because of the definitions of what is waste and what is returned raw materials are somewhat unclear, it is especially difficult to quantify the amount of waste that is recycled at the establishments themselves (recycling on own premises).

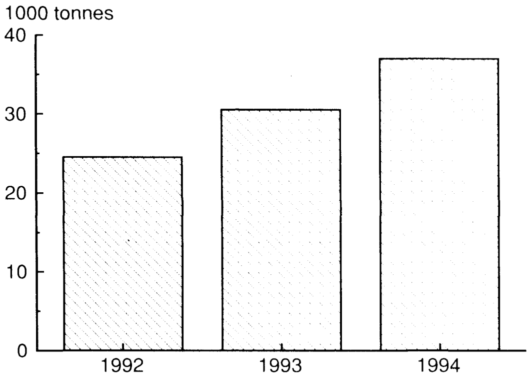
Re-use
The most important established systems of re-use in Norway are the systems for return of bottles for beer, mineral waters, wine and spirits. Between 95 and 100 per cent of the beer and mineral water bottles are returned, but only between 65 and 70 per cent of the bottles used for wine and spirits (SN 1994c). All in all, 400 000 tonnes of glass

Figure 7.3. Collected paper and cardboard. 1983-1994. 1 000 tonnes



Sources: Statistics Norway and the Norwegian Pulp and Paper Association

Figure 7.4. Collected glass. 1992-1994. 1 000 tonnes



Source: Norsk Glassgjenvinning AS

containers were re-used in Norway in 1991 (Report No. 44 to the Storting (1991-92)).

Recovery of materials
In 1992, there were more than 200 waste reception facilities for different types of sorted waste in Norway (SFT 1992a). All municipalities had established reception systems for waste paper, and only Finnmark lacked a reception facility for scrap iron.

Updated statistics are kept for paper and cardboard, which show that the collected amount has increased steadily over the last ten years (figure 7.3). The collected amount as a share of the consumption started to increase in 1989, and reached more than 30 per cent for the first time in 1992.

Since 1992 there has been a marked increase in the amount of broken glass delivered for recycling (see figure 7.4). Calculated as a share of an annual total consumption of 48 700 tonnes of glass containers, the degree of recycling had reached 76 per cent in 1994.

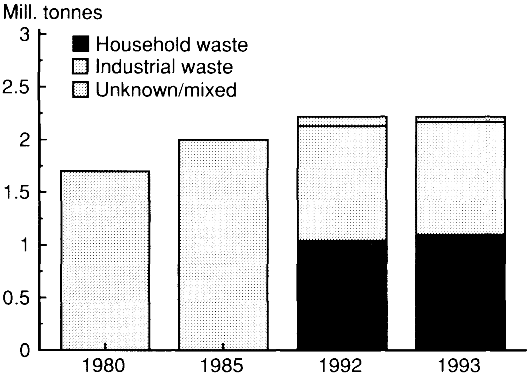
A total of about 300 000 tonnes of scrap iron is delivered each year to Norwegian steelworks and foundries. An increasing amount of the scrap consists of "shredder", that is to say, scrap that has been broken into small pieces. In 1993, about 20 per cent of the shredder came from wrecked cars and household appliances.

7.3 Management of the waste

Municipal waste
In 1993, a total of 2.22 million tonnes of waste was handled by the municipal systems for collection of waste. Of this amount, 1.10 million tonnes came from households, 1.07 million tonnes from business and industry, and 0.05 million tonnes from mixed/unknown sources. The total quantity was about the same as in 1992, but contained slightly more household waste and slightly less unknown/mixed waste and waste from business and industry (figure 7.5). On average, the amount of municipal waste dealt with per capita was 513 kg. Of this amount, 254 kg was household waste.

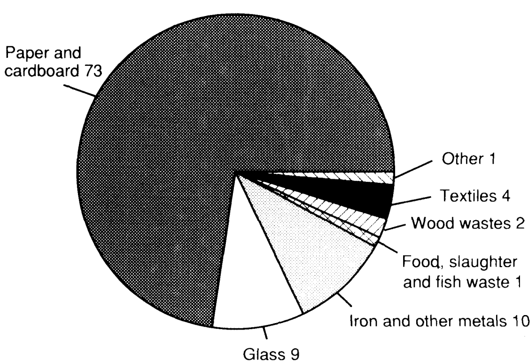
In 1993, 240 000 tonnes of municipal waste was delivered for recovery of materials. This accounted for 11 per cent of the municipal waste, and is an increase of 3 percentage points compared with 1992. 14 per cent (155 000 tonnes) of the household waste

Figure 7.5. Municipal waste in all. 1980, 1985, 1992 and 1993. Million tonnes



Source: Statistics Norway

Figure 7.6. Household waste delivered for recovery of materials, by material. 1993. Per cent



Source: Statistics Norway

was delivered for recovery of materials. This is an increase of 5 percentage points compared with 1992. Paper and cardboard accounted for 73 per cent and glass for 9 per cent of the household waste delivered for recycling (figure 7.6). About 85 000 tonnes of the industrial waste included in the municipal waste was delivered for recycling. 34 per cent of this waste consisted of paper and cardboard, 22 per cent was iron and metals, and 19 per cent was wood waste.

About 56 per cent of the waste delivered for recovery of materials was sorted at the place where the waste was generated. The rest of the waste was either sorted in containers placed in residential neighbourhoods, at shopping centres etc., or at the waste treatment facility (figure 7.7). Just over 70 per cent of the waste paper and cardboard was sorted where it was generated.

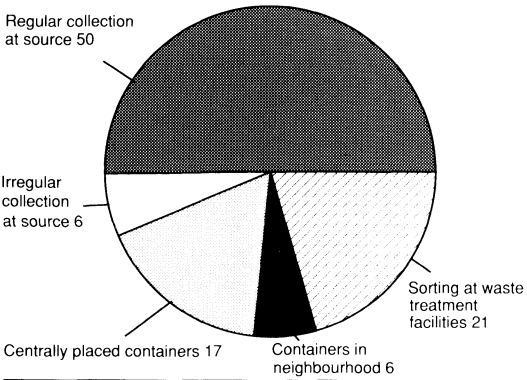
Most of the municipal waste is deposited on landfills. Calculated in terms of initial treatment, 72 per cent of the waste was deposited directly on landfills in 1992, while 19 per cent was incinerated, 8 per cent was delivered for recovery of materials and 1 per cent was treated biologically. In 1993, 11 per cent of the municipal waste was delivered for recovery of materials. According to SFT, 20 per cent of the municipal waste was incinerated in 1993. The quantities deposited on landfills or treated biologically were not recorded. Assuming that the amount that was treated biologically was the same as in 1992, then 68 per cent of the municipal waste was deposited directly on landfills in 1993 (figure 7.8).

Municipal waste charges

About 97 per cent of the population is covered by the municipal systems for collection of waste (SN 1994b). In 1993, a normal subscriber, with a sack or container that is emptied once a week, paid on average about NOK 810 per year for this service (SFT 1994). The county average varied from NOK 685 per year in Rogaland to NOK 1 076 per year in Oslo. A person had to pay on average about NOK 390 per tonne for delivering waste directly to a waste deposit site. The rates are stated without VAT.

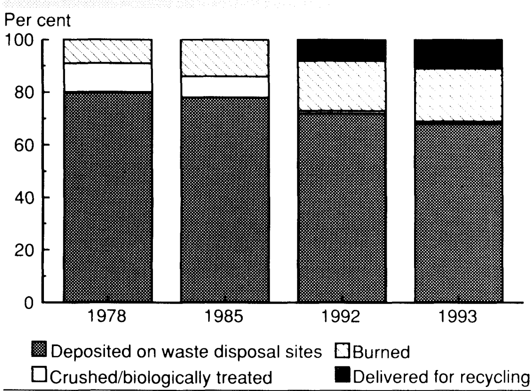
The level of the charges depends partly on the method of treatment. Municipalities with composting plants and/or incineration plants charge higher rates than municipalities that deposit the waste on landfills. The

Figure 7.7. Municipal waste delivered for recovery of materials, by method of sorting. 1993. Per cent



Source: Statistics Norway

Figure 7.8. Municipal waste by method of treatment. 1978, 1985, 1992 and 1993. Per cent



Source: Statistics Norway

Probably not all the waste that is delivered for recycling is actually recycled, partly because of the varying quality of the material. Today, no information is available on the difference between the amount delivered for recycling and the amount actually recycled.

charges are also somewhat higher in the municipalities participating in intermunicipal waste collection systems. There is also reason to believe that the intermunicipal companies have better knowledge about the actual costs of the waste management, and that these costs are used to a greater extent as a basis for calculating the charges. Incineration and composting are the most common methods of treatment at intermunicipal facilities.

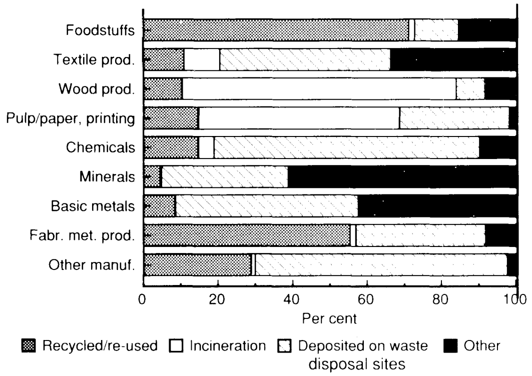
As from the beginning of 1995, the environmental authorities' policy on waste will also be based on the principle that the polluter shall pay. The Pollution Control Act now requires that the charges imposed for waste management should cover the total costs incurred by the municipalities in this respect (total cost-coverage). SFT assumes that very few municipalities have operated with total cost-coverage for waste management services before, and that the charges will therefore increase in 1995.

Industrial waste

In 1993, 26 per cent of the total production and consumer waste from industry (see section 7.1) was delivered for recovery of materials, 29 per cent was incinerated and 28 per cent was deposited on municipal or private disposal sites. The rest, 17 per cent, was either treated biologically, used as filling material or managed in some other way (figure 7.9).

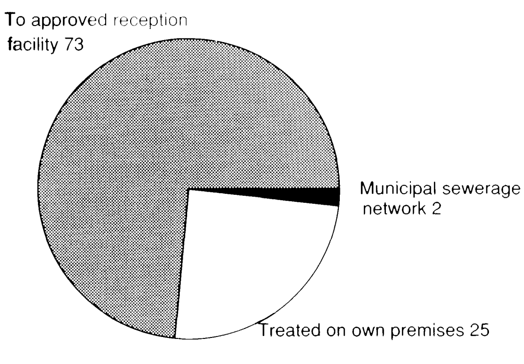
All in all, 46 per cent of the production and consumer waste from industry was deposited/treated on the establishment's own premises; that is to say deposited on its own disposal site, incinerated in its own plant, used as filling material on own ground, stored or flushed into the sewerage system. Of a total of 850 000 tonnes of industrial waste deposited on disposal sites, about 500 000 tonnes was deposited on industry's own disposal sites.

Figure 7.9. Production and consumer waste from industry, by sector and method of treatment[1]. 1993. Per cent



[1] Applies to waste delivered to external waste treatment facilities plus waste dealt with in own facilities.
Source: Statistics Norway

Figure 7.10. Calculated quantities of hazardous waste from industry, by method of treatment. 1993. Per cent



Source: Statistics Norway

The share delivered for recycling was largest for iron and metals. A total of 88 per cent of this kind of waste was delivered for recycling in 1993. 75 per cent of the paper and cardboard was delivered for recycling, 2 per cent was burned and the rest was deposited on landfills. 80 per cent of the glass and 81 per cent of the food, slaughterhouse and fish waste was delivered for recycling. Most of the wood wastes, 81 per cent, was burned.

The foodstuffs industry delivered 71 per cent of its waste for recycling, while the wood products industry burned 74 per cent and the chemicals industry (including manufacture of rubber and plastic products) deposited 71 per cent of its waste.

73 per cent of the hazardous waste was delivered to approved facilities for management of hazardous waste, while 25 per cent was managed on the establishment's own premises (figure 7.10). Management on own premises includes storage, incineration or giving the waste to employees for their own use. There is no record of hazardous waste being deposited on own disposal sites. 2 per cent of the hazardous waste, 5 800 tonnes, was flushed down the municipal sewerage network.

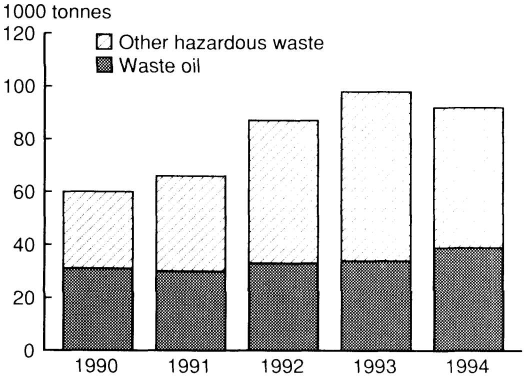
Hazardous waste

Norsas collects data on the share of hazardous waste that is subject to the regulations on hazardous waste and is delivered to approved reception facilities. Hazardous waste from all types of industries are included. Some large deliveries from industry are not covered by the regulations (e.g. waste transported to Langøya in the Oslofjord) and are therefore not included.

After increasing for several years, the quantities of delivered hazardous waste decreased slightly from 1993 to 1994 (figure 7.11 and table G10 in part III). The reason for the decrease is the smaller quantity of waste from oil drilling operations that was delivered to reception facilities in Western Norway.

Even though the quantity of hazardous waste is small compared with the quantity

Figure 7.11. Delivered hazardous waste. 1990-1994. 1 000 tonnes



Sources: Norwegian Pollution Control Authority and Norsas AS

Table 7.3. Hazardous waste delivered to the system for management of hazardous waste. Norway. 1994*. Tonnes

Total		91 963
1	Waste oil, lubricating oil, etc.	38 916
2.1	Oily waste from oil-water separators	12 790
2.2	Oil-contam. waste from drilling operations	19 867
3	Oil emulsions	2 813
4.1	Organic solvents containing halogen	1 425
4.2	Organic solvents not containing halogen	3 440
5	Paint, glue, varnish and printer's ink	2 773
6/7	Distillation residues and tarry waste	889
8/9	Waste/batteries containing heavy metals	1 390
10	Waste containing cyanide	24
11	Discarded pesticides	52
12	Waste containing PCBs	909
13	Isocyanates	38
14	Other organic wastes	1 647
15	Strong acids	778
16	Strong alkalis	355
17	Other inorganic wastes	3 771
18	Aerosol containers	5
19	Laboratory waste	64
20	Unknown	17

Source: Norsas 1995b

Table 7.4. Delivered quantities of hazardous waste by industry. 1994*. Tonnes

Industry	Quantity
Total	91 963
Agriculture, forestry, fishing, sealing and whaling	205
Oil production and mining	26 086
Manufacturing industry	21 353
Electricity and water supply	1 221
Construction	2 724
Wholesale and retail trade, hotels and restaurants	12 066
Transportation, storage, post and telecommunications	8 886
Bank and finance, insurance, estate agents etc.	1 602
Public, social and private services	14 026
Not distributed by industry	3 794

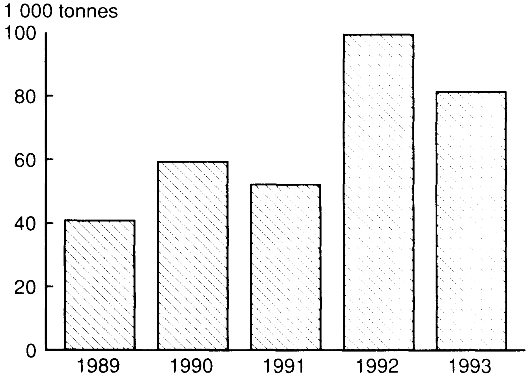
Source: Norsas 1995b

of ordinary waste, hazardous waste represents a serious threat to the environment owing to the high concentrations of hazardous substances it contains.

Oily waste and oily waste from drilling operations together comprise about 81 per cent of the total quantity of hazardous waste delivered to the system (table 7.3). Oily waste from drilling operations includes oil-contaminated drill cuttings from the petroleum activities. Even when waste from oil drilling operations is excluded, Hordaland and Rogaland are the counties delivering the largest quantities of hazardous waste (see table G11 in part III).

In 1994, 96 per cent of the hazardous waste could be distributed according to which types of industries or commercial enterprises that delivered the waste. Oil extraction and mining accounted for the largest total deliveries. The figures were also high for manufacturing, wholesale and retail trade plus hotels and restaurants, and public and private services (table 7.4). When oily

Figure 7.12. Hazardous waste treated in Norway. 1989-1993. 1 000 tonnes



Source: Norsas AS

Table 7.5. Export and import of hazardous waste. 1986-1993. Tonnes

	Total exports	Of this, waste oil	Total imports
1986	1 700	-	-
1987	18 000	12 000	-
1988	4 000	-	-
1989	8 000	4 800	-
1990	21 800	12 500	-
1991	14 600	-	2 400
1992	14 500	-	6 300
1993	17 000	200	15 200

Source: Norwegian Pollution Control Authority

waste from drilling operations is excluded, the average amount of hazardous waste delivered by each establishment in 1994 was 4 800 kg. The average delivery varied considerably with the number of employees in the establishment, and was much larger for large establishments than for small ones.

A large share of the hazardous waste is treated at Norwegian establishments with a permit from SFT (figure 7.12). There are several reasons why the quantity treated each year is not the same as the quantity delivered; export other than export through the system for management of hazardous waste, storing within the system, inadequate declaration of the waste etc. In the case of most enterprises that treat hazardous waste, this is not their main function. Often waste oil and other organic waste is used as an energy supplement, or the waste is treated by means of the existing production equipment.

7.4 Export/import of waste

With SFT's permission, hazardous waste has regularly been exported from Norway for treatment in other countries (table 7.5). The quantity and composition can vary considerably from year to year. In 1992, for example, 87 per cent of the total quantity of exported waste consisted of lead accumulators and tarry waste. Since 1991, some hazardous waste has also been imported, most of it waste oil.

No statistics are kept on the import or export of ordinary waste but, according to SFT, this applies to only small quantities.

7.5 Old landfills and contaminated ground

Sites containing hazardous waste are ranked into five categories, depending on information on quantity and type of hazardous waste, degree of conflict with the surrounding environment and the need for follow-up investigations and measures:

Category 1:	Sites requiring immediate investigations or measures.
Category 2*:	The case is being considered by SFT.
Category 2:	Need to be investigated.
Category 3:	Need to be investigated in the event of any change of land use or recipient.
Category 4:	No investigations needed.

Table 7.6. Landfills and contaminated ground containing hazardous wastes, by category and type of site[1]. Norway. February 1995

Type of site	Total	Category 1	2*	2	3	4
All	2 854	89	46	524	1 446	748
Waste disposal sites						
Municipal	1 034	12	1	150	535	337
Industrial	613	25	15	141	272	160
Other	608	17	6	78	254	251
Contaminated ground						
Industrial	361	13	19	70	259	-
Other	121	7	1	35	78	-
Waste disposal sites with contaminated ground	117	15	4	50	48	-

[1] In addition, 40 unranked sites in Finnmark.
Source: Norwegian Pollution Control Authority

Out of a total of 2 854 registered sites, hazardous waste has been found or is suspected to exist in 2 106 sites (Categories 1-3) (table 7.6). 33 per cent of these sites are municipal landfills, 22 per cent are industrial waste disposal sites and 23 per cent are defined as contaminated ground. Industrial or other commercial activities are responsible for most of the cases of disposal sites or contaminated ground suspected of containing hazardous waste. The percentage of the sites related to industry is highest in Categories 1 and 2*, dominated by the chemicals industry and metals manufacturing. The types of hazardous waste found in municipal landfills often originate from small and medium-sized enterprises, since in many cases the larger enterprises have established their own waste disposal sites.

Table 7.7. Waste disposal sites and contaminated ground containing hazardous waste[1], by status as regards implementation of measures. 1993

	Measures not started	Investigations in progress	Measures in progress	Measures completed
Category 1	31	26	11	3
Category 2*	12	24	5	4

[1] Defence establishment sites not included.
Source: Norwegian Pollution Control Authority

Probably, many sites with hazardous waste have still not been discovered.

The results from the nationwide registration have provided a basis for preparing a plan of action to clean up hazardous waste that has been deposited or discarded, as well as contaminated ground and contaminated sediments (SFT, 1992b). The proposed measures are intended to be implemented between now and the year 2000, and the goal is to reduce risk of serious pollution from these sources to a minimum. In 1993, work was started at the sites in the highest priority categories 1 and 2*, at 56 per cent of the sites in category 1 and at 74 per cent of the sites in category 2* (table 7.7).

Further information from: Astrid Busengdal (municipal waste), Åse Kaurin (industrial waste) and Ole Osvald Moss (hazardous waste and waste in general).

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Part II Economic research on resources and the environment

1. Overview

Much of our economic activity has adverse effects on the environment, and requires use of both renewable and non-renewable resources. On the other hand, the load on the environment affects the economic activities, for example, because pollution leads to more sick leave, and buildings become corroded by acid rain. Therefore we have become increasingly aware of the need to recognize the link between desirable economic growth and responsible management of our natural resources and environment. The economic theory called attention to pollution and use of resources already at the beginning of this century, but not to any great extent until the last 20-25 years.

Norway has a long tradition of using comprehensive macro-economic models based on the National Accounts in the work on the National Budget and the Government's Long-Term Programme (see box for a description of the model MSG, Multi-Sectoral Growth). The Research Department at Statistics Norway has been a major contributor to the development of these models, and a pioneer as regards integrating dimensions connected with resources and the environment. This has been possible partly because the resource accounts and environmental statistics presented in part I of this publication employ definitions and standards consistent with those used in the National Accounts.

One of the main elements of the research is the further development and application of the models, to make them suitable for studying the impacts of various changes in policy on the economy and the environment. Another important element is the application of recently advanced theories and the development of new models. Efforts are also made to improve the models, as regards both their description of the economy and the selection of environmental variables included. This will be demonstrated by the projects presented below.

The relationship between the environment and economic growth has been the subject of much discussion. On the one hand, economic growth can increase the loads on the environment. Therefore, some people have argued that zero growth is a prerequisite for preserving the environment. On the other hand, economic growth provides more money for environmental protection. Therefore others, including the Brundtland Commission, maintain that continued growth is a prerequisite for preserving the environment.

Statistics Norway's set of models cannot provide a final answer to this debate, but can help to shed light on it. It is possible to study the expected development if no measures are taken, and the impacts on the environment and the economy if different measures are introduced. Several analyses are presented below which illustrate the use of the models for this purpose. The analyses that are briefly described, especially those under the heading "the environment and economic growth", include studies of the impacts of changes in taxes and duties. They analyze both the impacts on the environment and the purely economic effects. Other chapters describe expansions of the theoretical foundation and the models themselves; for example, macro-economic projections of waste and studies of the connection between infrastructure and economic growth.

The interest for sustainable development and for environmental issues in general has drawn attention to how the country is following up the environmental problems. Ideally, methods that can measure wear on the environment and tapping of natural resources in terms of value and physical units should show the environmental impacts of human activities. These conditions can be difficult to measure, however, in a consistent way. For this reason, environmental indicators are receiving increasing attention as an aid in quantifying the changes in the state of the environment, nationally and internationally, and in identifying important environmental issues. The work being done in the Nordic countries on environmental indicators is briefly described. To be able to compare data between countries, either for use in the system of environmental indicators or to find out whether national targets are being realized and international agreements complied with, the basic data must be continuously improved and the methods of calculations must be standardized.

Chapter 3.2 describes improvements to the method of calculating emissions of solvents.

The use of natural resources such as forest, fish, water, oil, gas and minerals is the source of a large current and potential income for Norway. Today, almost 3/4 of Norway's total exports consist of natural resources or processed products based on natural resources. One of the projects calculates the rent of these resources, that is to say, the share of the income from resource-based industries that can be directly attributed to the resource. Other projects study the management of hydropower resources and fish resources.

It is more difficult to estimate the monetary value of environmental resources such as clean air, for example, because such goods are not sold on any market. However, if the policies we follow are to be sustainable, the effects of these policies are an important element of the foundation for making decisions. Chapter 4.3 describes a project that tries to determine the most useful basis for decisions.

Many environmental problems are international, and it can be useful to study the environmental policies of the different countries collectively. One example showing that the load on the environment is an international issue is the increasing greenhouse effect, where the harmful effects in the different countries depend on the global emissions of greenhouse gases. As far as Norway is concerned, other countries' efforts against the increasing greenhouse effect also affect this country by affecting the price of oil. A project is described which estimates the extent of the effect on the Norwegian petroleum wealth. Another project studies the gain derived from more trade in energy between the Nordic countries.

Also other types of emissions affect several countries. For example, the greater part of the acid precipitation over Norway is caused by emissions, of sulphur especially, in other countries. Moreover, the environmental problems are interconnected, so that measures to reduce CO_2-emissions will also affect emissions of SO_2 and NO_x. Some of the studies take up the question of how a proposed tax on the carbon in fuel (a CO_2-tax) and a re-organization of power production, would affect the goals as regards reduced emissions of sulphur.

The presentation of the projects in part II provides a brief review of some of the economic analyses conducted at Statistics Norway in 1994 in connection with resources and the environment. The articles are intended to give a brief summary of the work. More detailed information can be obtained from the documentation and references listed at the end of each article.

The MSG Model

Several of the research projects carried out in 1994 are based on the MSG model, which is a multi-sectoral equilibrium model for the Norwegian economy. Different versions of this model have been used by the Ministry of Finance since the end of the 1960s to analyze the long-term trends in the Norwegian economy, that is to say, changes in main macro-economic dimensions and the development of economy activity. Statistics Norway maintains and develops two main versions of the model: MSG-5 and MSG-EE. The latter version is particularly suitable for analyzing issues concerning natural resources and the environment. Transport in particular is specified in several sectors.

In the model, the growth in production is determined by assumptions concerning technological development, changes in the return on capital, total supply of man-hours and supply of raw materials and natural resources. By assumption, supply is equal to demand on all markets, and consumers and producers use the resources that are available. This implies, in particular, that all the labour offered is used. Therefore the model is not suitable for analyzing short-term problems of re-organization or trends in unemployment.

The most important assumptions in the model calculations that the users of the model have to establishe beforehand are total growth in the number of executed man-hours, technological changes in the different production sectors, changes in production and income in the petroleum sector, public purchases of goods and services, trends in the international economy, prices on the world market, the requirement for return on investment of real capital, requirements as regards the development of the operating balance and financial balances for households and the public administration, and rules governing taxes, duties and subsidies.

On the basis of these assumptions, the model is used to calculate, for example, changes in the total production and how this is distributed between industries, employment in the different sectors, changes in the stock of real capital, private consumption, prices of Norwegian manufactured goods and trends in wages.

The model also provides a fairly detailed description of production and use of energy in Norway. A supplementary model has also been developed which calculates emissions of different pollutants in Norway caused by use of fossil fuels and various production processes. The model can therefore be used to make an integrated evaluation of changes in the economy, use of energy and certain environmental conditions.

MSG is based on figures and definitions from the National Accounts, making it easy to compare the results with the historical trend. The detailed division into sectors makes it possible to study the structure of the economy, and its re-organization, during a process of growth.

2. Environment and economic growth

2.1 Sustainable economy?

The Project for an Alternative Future and Friends of the Earth, Norway (previously called the Norwegian Society for Conservation of Nature) are cooperating on a comprehensive project to investigate the possibilities for sustainable development in Norway. As part of this project, Statistics Norway has carried out a number of macro-economic projections based on the system of models used, for example, by the Ministry of Finance in its work on the Long-Term Programme and other official reports. The purpose has not been to prepare detailed prognoses for the future. On the other hand, the analyses can shed some light on the growth potential and the composition of the economic growth, given certain assumptions concerning technological developments and supply of resources. The analyses show that several strategies can be used to reduce pollutant emissions. The choice of the "favourite alternative" will be decided by how damaging the various emissions are believed to be, and how the damage is evaluated in relation to the economic costs of the measures introduced to reduce the pollution.

The macro-economic model MSG (Multi-Sectoral Growth) can shed light on only a small part of the very comprehensive concept "sustainable development". However, analyses based on the model can help to elucidate important choices of strategy which Norway will have to face in the near future. A comparison of the project's alternative scenarios with the so-called basic scenario in the most recent Long-Term Programme[1] makes it possible to show the importance of different political initiatives for various aspects of the environment and for economic development in the future.

The following conditions are elucidated by means of simulations using the macro-economic equilibrium model MSG-5:

- The importance of reducing extraction of oil and gas in vulnerable areas.
- The importance of a high tax on the carbon in fuels (CO_2-tax).
- The importance of exempting certain sectors from the CO_2-tax.
- The importance of a reduced work force as a result of more leisure time.

[1] Long-Term Programme 1994 - 1997, Report No. 4 (1992-93) to the Storting, Ministry of Finance.

Reduced oil and gas extraction primarily affects emissions of NMVOC. CO_2-emissions are reduced to some degree, while the level of emissions of SO_2 increases. A high CO_2-tax has a positive effect on emissions of CO_2 and SO_2, but, on its own, has very unfortunate consequences for energy-intensive industry. A dispensation from the CO_2-tax for energy-intensive industry would lead to a moderate increase in CO_2-emissions, but to a large increase in SO_2-emissions compared with the scenario with the same CO_2-tax in all sectors. Another way of avoiding the worst effects for energy-intensive industry would be to lower the tax slightly, but combine this with reduced activity in the petroleum sector.

Reducing working time by 10 per cent would reduce all emissions by 3 to 7 per cent. However, reducing working time is an expensive way of reducing emissions, measured in terms of a reduction in the GDP. The benefit people obtain from having more leisure time has not been taken into account. Therefore the question of whether such a strategy is good or not depends on the value people place on leisure time.

A high CO_2-tax is obviously to be preferred from the point of view of the greenhouse gas issue, and also from the aspect of SO_2 pollution, owing to the strong reduction of activity in the energy-intensive sector. However, by no means all the costs connected with a smaller or larger reduction of energy-intensive industry are included here. The model used in the project does not take into account the costs of reorganization of industry. Seen in the light of NMVOC emissions, the alternatives aimed most directly at the petroleum sector are to be preferred.

All in all, the calculations carried out in the project indicate that a strategy with a pure and high CO_2-tax, with no dispensation arrangements, is to be preferred. It is necessary, however, to take into account the costs of reorganization in the event of a strong reduction of activity in energy-intensive industry (replacement of workers, loss of basic capital and know-how, possibilities of alternative use of the resources currently used in this industry, etc.). Moreover, the loss of income incurred in all the alternatives, and the achieved reduction in emissions, must be weighed against the difficulties in financing care of the elderly, for example, in the future. On the other hand, the calculations have not taken into account the value of increased leisure time as a benefit in itself, or of reducing the threats to the environment in ocean areas where petroleum activities are taking place.

Project personnel: Knut H. Alfsen, Bodil M. Larsen and Haakon Vennemo.

Financed by: Project for an Alternative Future and Friends of the Earth Norway.

Documentation: Alfsen, K. H., B. M. Larsen and H. Vennemo (1995): Bærekraftig økonomi? Noen alternative modellscenarier for Norge mot år 2030 (Sustainable economy? Some alternative model scenarios for Norway towards the year 2030). To be printed as a report from the project: Sustainable economy. Project for an Alternative Future and Friends of the Earth Norway, Oslo.

2.2 Projections of quantities of waste in Norway

Waste is a source of serious environmental problems, because, for example, decomposition of waste generates emissions of greenhouse gases, the seepage from waste deposit sites contains hazardous substances, landfills occupy large areas of land and incineration of waste causes emissions of pollutants. Much of the waste also represents squandering of renewable as well as non-renewable resources.

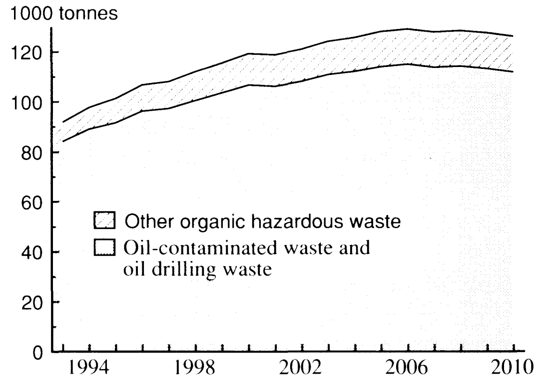
In order to be able to introduce political measures, the public authorities need to quantify trends in the quantity of waste generated in the future. The projection of the quantity of hazardous waste generated in Norway shows an increase of almost 40 per cent from 1993 to the year 2010.

The primary purpose of the project is to estimate the trend as regards hazardous waste, and the composition of this waste, during the period up to the year 2010. Hazardous waste has been divided into three main groups: oil-contaminated waste and oil drilling waste, other organic waste and inorganic waste.

The projections are based on statistics from Norsas AS (Norwegian competence centre for waste and recycling) on the quantities of hazardous waste delivered to the company. In the first place, there is assumed to be a constant relation between generated waste and production in a particular sector, where production in the specific sector is projected by means of the macro-economic equilibrium model MSG-EE (Multi-Sectoral Growth - Energy and Environment). The changes in important economic variables are based on the assumptions applied when preparing the Long-Term Programme 1994-97.

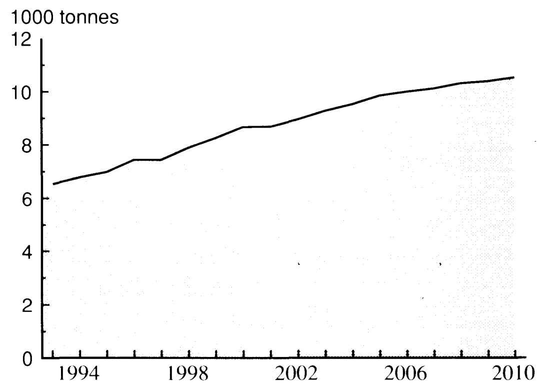
Given a fixed relation between production and generated waste, oil-contaminated waste and oil drilling waste increases by just over 30 per cent by year 2010. Oil-contaminated waste and oil drilling waste accounts for between 80 and 85 per cent of the total quantity of hazardous waste during the projection period. A large share of this waste is incinerated, and therefore does not pose a storage problem. However, incineration generates emissions to air. Figure 2.2.1 shows that the increase in oil contaminated waste and oil drilling waste declines after year 2005. The main reason is the expected reduction in production of oil and gas in the North Sea. This development could be changed by new finds of oil and gas and new drilling technology.

Figure 2.2.1. Projection of generated organic hazardous waste. 1000 tonnes



Source: Statistics Norway

Figure 2.2.2. Projection of generated inorganic hazardous waste. 1000 tonnes



Source: Statistics Norway

Other organic waste increases by just over 80 per cent up to the year 2010, from almost 8 thousand tonnes to just over 14 thousand tonnes (assuming a fixed relation between production and generated waste). Here too there is a tendency for the increase to decline around the year 2005. The sector producing mineral oil, coal, rubber and plastic products accounts for roughly 50 per cent of the other organic waste during the period.

Given a corresponding fixed relation between production and generated waste, the increase in inorganic waste is just over 60 per cent, see figure 2.2.2. Between 20 and 30 per cent of this type of waste is produced in engineering workshops. The rest of the waste is distributed between most sectors of production.

Corresponding projections are to be carried out for municipal waste and industrial waste. The material will be used as a basis for studying the effects of possible technological developments and planned policies, and the environmental and economic consequences of different ways of managing the waste. This will provide more realistic information on the future trend as regards quantities of waste.

Project personnel: Annegrete Bruvoll and Gina Spurkland.

Financed by: The Norwegian Research Council, MILFOR (Environmental Pollution) programme.

Documentation: Bruvoll, A. and G. Spurkland (1995): *Avfall i Norge fram til 2010* (Waste in Norway up to 2010). Reports 95/8. Statistics Norway, Oslo - Kongsvinger.

2.3 The effects of the CO_2-tax

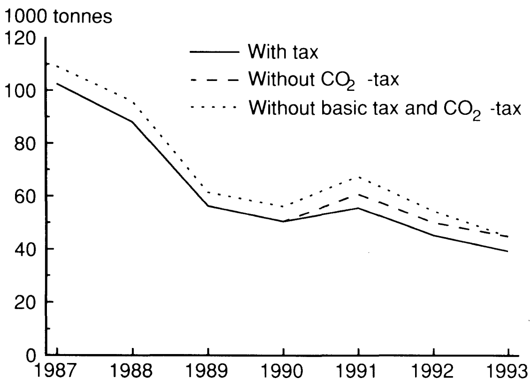
Norway has had a CO_2-tax (a tax on fuel carbon) for four years. The total emissions of CO_2 increased steadily during the latter half of the 1980s. From 1990 to 1991, however, emissions were reduced by about 5 per cent. Since the CO_2-tax was introduced in 1991, one could easily be led to conclude that the tax has had a marked effect. However, in a developing society the emissions can be affected by many different conditions: technological change, price changes, establishment of new industries, etc. This project shows that the reasons for the changes in emissions of CO_2 are very complex, and that the CO_2-tax is only one of the factors affecting these emissions.

In Norway, awareness of the environment is generally high, and there is a definite wish to find cost-effective instruments to improve the environment. The system of taxes on fossil fuels now covers most petroleum products through the tax on gasoline and mineral oils[1]. In 1991 an explicit tax was imposed, directed at the carbon content of these oils. Various dispensation arrangements imply that the tax covers about 60 per cent of the total CO_2-emissions. This project analyses different sources of CO_2-emissions. Emissions from stationary sources are emissions caused by use of oil for heating purposes, emissions from mobile sources are emissions from all types of transport, and emissions from processes comprise all other types of emissions (e.g. gasoline vapour and reduction of ore to metals). Coal and coke used for industrial processes are exempted from both the CO_2-tax and the basic tax. However, in a total context, it is interesting to study how changes in these emissions (for reasons other than the CO_2-tax) contribute to the total changes in CO_2-emissions.

Emissions of CO_2 from mobile sources account for about 40 per cent of the total emissions. Therefore changes in these emissions are important. In the project the change in emissions from transport per produced

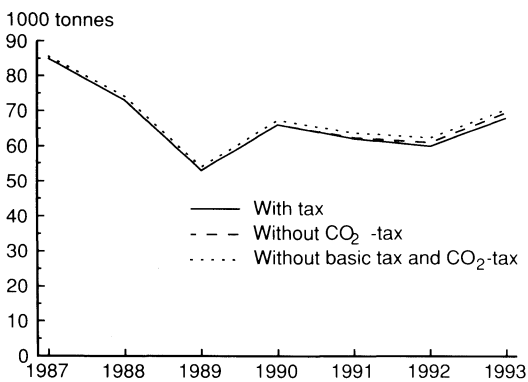
[1] The tax on mineral oils covers (with certain exceptions) all types of petroleum products that can be used for heating purposes or as fuel (with the exception of gasoline, which has its own rate of tax). The tax has been composed of a basic tax and an additional sulphur-dependent tax, and since 1991 a tax on CO_2.

Figure 2.3.1. Use of oil for heating purposes in the manufacturing of paper and paper products, with an oil price with and without taxes. 1 000 tonnes



Source: Statistics Norway

Figure 2.3.2. Use of oil for heating purposes in wholesale and retail trade, with an oil price with and without taxes. 1 000 tonnes



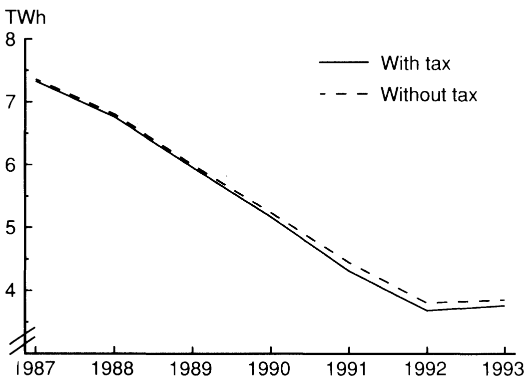
Source: Statistics Norway

unit (hereafter called the CO_2-intensity) is decomposed between change in the composition of industries, change in energy consumption per produced unit (hereafter called the energy intensity) and change in the composition of fuel consumption. The different kinds of industries use transport to very varying degrees in their production. This implies that emissions from transport depend, for example, on which types of industries expand, and that a CO_2-tax affects production costs to differing degrees in manufacturing industries and production of services. The tax can also affect the energy intensity, through, for example, technological progress or a change to other forms of transport which use less fuel to carry out the same transport service. For each sector a change in CO_2-intensity is explained almost exclusively by a change in energy intensity, because it is difficult to replace fossil fuel by other types of fuel in motorized vehicles.

The results show that the reduction in CO_2-intensity in transport from 1988 to 1992 (average 3 per cent per year) was mainly due to a change in the composition of the industries. The CO_2-tax has probably influenced this composition, because industries with a high CO_2-intensity will be adversely affected by the tax, while the profitability of other industries will not be affected to the same degree.

Emissions of CO_2 from stationary sources in manufacturing industries and provision of services has been analyzed by using the estimated equations for energy demand in the macro-economic model MSG-EE (Multi-Sectoral Growth - Energy and Environment) (see Mysen 1991). The effect of the CO_2-tax in the different production sectors varies (see figures 2.3.1 and 2.3.2), a fact which reflects differing possibilities of substitution between oil and electricity. The results show that, because of the CO_2-tax and the basic tax, CO_2-emissions were reduced by between 50 000 and 100 000 tonnes per year during the period from 1987 to 1993 (depending on the size of the taxes), or by 0.1 to 0.3 per cent of the total Norwegian emissions of CO_2. This is a low estimate, how-

Figure 2.3.3. Total actual use of kerosene/oil in households given a CO_2-tax, and estimated use of kerosene/oil without a CO_2-tax. TWh



Source: Statistics Norway

ever, since it has been assumed in the project that the total energy consumption is not affected by the tax.

The effects of the CO_2-tax on stationary use of energy in households are based on an analysis of energy use per household (Nesbakken and Strøm 1993). The results show that the effects of a CO_2-tax on the total use of energy for residential heating is moderate. However, only about 23 per cent of the households used heating equipment based on oil and kerosene. If we study changes in energy use only in relation to consumption of oil and kerosene, the reduction as a result of the CO_2-tax is 3 to 4 per cent in the year with the highest tax (see figure 2.3.3). The tax may therefore have had some effect. The consumption of electricity is kept constant in the analysis, and differences in temperature are taken into account. Central heating is excluded, which implies that the effects of the CO_2-tax on oil consumption in households are somewhat underestimated.

Project personnel: Torstein Bye, Mona I. Hansen, Tor Arnt Johnsen, Bodil M. Larsen and Runa Nesbakken.

Financed by: Ministry of Environment.

Documentation: Larsen, B. M. and R. Nesbakken (1995): *Norske CO_2-utslipp 1986-1993. En studie av CO_2-avgiftens effekt* (Norwegian CO_2-emissions 1986-1993. A study of the effect of the CO_2-tax). To be published in the Reports series. Statistics Norway, Oslo - Kongsvinger.

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Nesbakken, R. and S. Strøm (1993): *Energiforbruk til oppvarmingsformål i husholdningene* (Use of energy for heating purposes in households). Reports 93/10. Statistics Norway, Oslo - Kongsvinger.

2.4 Emission taxes and welfare effects

Earlier analyses in Norway indicate that the introduction of a national tax on emissions would lead to a reduction of the gross domestic product (GDP). In this analysis a macroeconomic model is used to show, among other things, that the introduction of CO_2-taxes, for example, can lead to changes in prices and in the quantity of exports and imports (terms of trade effects). Changes in GDP, corrected for these changes in the balance of goods and services measured in Norwegian prices, causes changes in Norway's real gross national income (GNI). The analysis shows that, given certain assumptions, the GNI and private consumption in Norway may increase with the *introduction of CO_2-taxes. The analysis also shows that the consequences of a change in such taxes would be very different for different types of households. For example, the effect would be relatively more favourable for rich households than for poor households.*

In recent decades, several national and international studies have analyzed the effect on GDP in a single country, or in several countries combined, of introducing taxes on emissions, for example, a CO_2-tax. The main conclusion of these studies has been that such a tax would cause only a small reduction of GDP. Some studies supplement this conclusion by showing that the benefit of reduced pollution, e.g. in the form of reduced injury to health, damage from corrosion and injuries in traffic, etc. could outweigh the reduction of GDP.

The study focuses on the effect on other economic measures than GDP, such as GNI and private consumption in Norway. It is found that the use of such measures may alter the conclusions. The study also analyses the distributional effects of the introduction of a CO_2-tax in relation to different types of households. It is assumed in the calculations that the Norwegian taxes do not cause a change in international oil prices. It is also assumed that the CO_2-tax is compensated for by reducing other taxes.

It is usual to assume that individual companies are unable to influence the prices on the world market of the products they themselves manufacture (they are price takers). This implies that, given an increase in production costs at home, e.g. as a result of an increase in the tax on CO_2, the company will have to reduce other costs (possibly reduce profit) in order to be able to sell its products. It is impossible to compensate for the increase in costs by raising the price.

An increase in the CO_2-tax will not only affect the individual company, but whole *industries*. Certain Norwegian industries are so large that a reduction in production could contribute to a rise in the world market price of the product. At the same time, the increase in costs will tend to shift the industrial structure towards sectors where it is possible to obtain a higher yield from the different input factors. Over time, it has been shown that Norwegian industries competing on the export market have been capable of cancelling out the higher costs in Norway through higher average export prices for their products, see Lindquist (1993) and Naug (1995).

GDP is a quantitative measure, that is to say, a reduction of GDP means that less is produced, but that the increase in the price of the products is not reflected. Analyzing changes in GNI instead of changes in GDP will take into account such possible changes in prices. In the project, the effect on GNI of an increase in national CO_2-taxes has been calculated within the framework of the macroeconomic model MSG-EE (Multi-Sectoral Growth - Energy and Environment). The main conclusion is that a tax that would result in stabilization of CO_2-emissions to 1989 level by the year 2020 would cause a reduction of GDP of 0.7 per cent, but the increase in GNI has been estimated to just over 1 per cent. Thus, based on historical data, it has been calculated that the changes in prices can be strong enough to contradict the conclusion that CO_2-taxes have a negative effect on the Norwegian economy.

At the same time as GNI increases, and therefore also consumption, changes in relative prices occur among both producers and consumers. This will turn consumption of goods away from commodities that are more expensive, relatively speaking, to commodities that are relatively cheaper. For consumers this implies that the change in their material standard of living (their money metric utility) will be more positive than indicated by the trend in consumption measured in fixed prices. Furthermore, the change in standard of living of the different types of households (rich, poor, single-member, couples with children, etc.) will be different, since products that will become much higher in price (e.g. gasoline and heating oil) account for different budget shares in the different households.

These changes can be calculated using the detailed empirically based system of consumption incorporated into the macroeconomic model MSG-EE, see Aasness and Holtsmark (1993). Calculations of the total effect of a change in GNI and the effect on the composition of the consumption shows that all types of households are favourably affected by an increase in the CO_2-tax, but that rich households are more favourably affected than poor households and that households with several members are more favourably affected than single-member households.

Project personnel: Jørgen Aasness, Torstein Bye and Hans Terje Mysen.

Financed by: The Norwgian Research Council, through the SAMMEN programme.

Documentation: Aasness, J., T. Bye and H. T. Mysen (1995): Welfare Effects of emissions Taxes in Norway. To be printed as Discussion Papers. Statistics Norway. Oslo.

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Aasness, J. and B. Holtsmark (1993): Consumer Demand in a General Equilibrium Model for Environmental Analyses. Discussion Paper No. 105. Statistics Norway, Oslo.

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Naug, B. E. (1995): *En økonometrisk modell for norsk eksport av industrielle råvarer* (An econometric model for Norwegian export of industrial raw materials). Reports 95/2. Statistics Norway, Oslo - Kongsvinger.

2.5 Impacts on the Norwegian economy of reducing NO_X-emissions by technical means

The social costs of measures to reduce emissions of NOx through the introduction of more stringent exhaust emission criteria for road vehicles and more stringent requirements to industry are small, measured in terms of reduction of GDP or households' private consumption. At the same time, the reductions in emissions can be substantial. The calculations have been carried out using the macroeconomic equilibrium model MSG-EE (Multi-Sectoral Growth - Energy and Environment). The main purpose has been to focus on possible changes in economic variables over and above the direct costs of the measures for the company concerned.

Emissions of nitrogen oxides (NO_X) have harmful effects on both human health and the environment, e.g. by increasing the risk of respiratory diseases, and contributing to acidification of soil and water. The most important sources of emissions of NO_X in Norway are road traffic (35 per cent) and domestic sea transport (35 per cent). Emissions of NO_X increased substantially during the period 1980 to 1987, mainly owing to increased use of private cars for passenger transport. Norway has undertaken to stabilize emissions of NO_X to 1987 level by the end of 1994 (Sophia Protocol). This target seems to have been achieved. Norway has also set a national target of a 30 per cent reduction of emissions in relation to the 1986 level by the end of 1998. However, the Ministry of Environment has estimated a reduction of only 15 per cent by the end of year 2000. Therefore, in order to achieve further reductions, new measures must be introduced, directed in particular at road traffic, sea transport and petroleum activities.

On the basis of cost estimates from the Norwegian Pollution Control Authority, the economic impacts of the following requirements (all involving technical measures) have been analyzed using the MSG-EE model:

1. The California-1995 emission requirements for passenger cars

For Norwegian vehicles that comply with the current Norwegian exhaust emission criteria, the California-1995 requirements will imply an approximately 60 per cent reduction of NO_X-emissions from each vehicle unit. Only a small share of the stock of passenger cars comply with today's exhaust emission criteria, introduced in 1989 for gasoline vehicles and in 1990 for diesel vehicles. The emissions will therefore be reduced considerably as the vehicle stock is gradually renewed, also without any new measures.

2. Electrically heated catalytic convertors for passenger cars

This measure implies pre-heating the catalytic convertor before ignition by means of electric hot wires or suchlike. In relation to the California requirements the emissions of NO_X from passenger cars will be reduced by a further 50 per cent.

3. USA-1994 requirements for commercial vehicles[1]

The current Norwegian exhaust emission criteria for heavier diesel and gasoline commercial vehicles were introduced on 1 October 1992. Introducing even more stringent exhaust emission criteria for commercial vehicles would lead to a reduction of NO_X-emissions of approximately 23 per cent from each vehicle unit.

4. USA-1998 requirements for heavy-duty vehicles

On 1 October 1993, Norway introduced the EU Phase 1 requirement for heavy-duty vehicles, with an emission limit for NO_X of 9 g/kWh. Phase 2 will be introduced in the EU and in Norway on 1 October 1996. The US-98 requirement will require technical modifications to engines to reduce NO_X-emissions from heavy-duty vehicles to maximum 5.6 g/kWh, that is to say, a reduction in emissions from the individual vehicle by an additional 20 per cent compared with the phase 2 emission limit.

5. Requirements directed at coastal traffic and the fishing fleet

Measures to reduce NO_X-emissions from coastal shipping and the fishing fleet will require technical modifications to engines, which will reduce NO_X-emissions from the existing Norwegian fleet by about 8 per cent at full effect, that is to say, an approximately 2.5 per cent reduction in total emissions of NO_X.

6. Requirements directed at the petrochemical industry

The requirement concerns installation of a system for catalytic cleaning of exhaust gases at Hydro Rafnes. It is possible to

[1] The measures directed at commercial vans and heavy-duty vehicles are treated collectively (called heavy-duty traffic in figure 2.5.1).

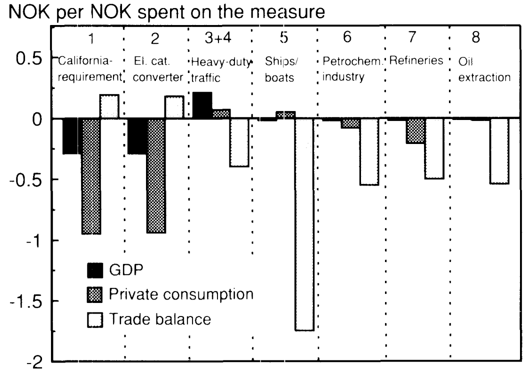
achieve a 70 - 90 per cent reduction of NO_X-emissions at Hydro Rafnes, corresponding to a reduction of about 0.2 per cent in total emissions of NO_X.

7. Requirements directed at petroleum refineries
The measures involve catalytic cleaning of exhaust gases at Statoil Mongstad, which is responsible for about 65 per cent of the NO_X-emissions from refineries in Norway. The cleaning could reduce Statoil Mongstad's emissions of NO_X by 50 per cent, and the total emissions of NO_X by about 0.5 per cent.

8. Requirements directed at oil extraction
The measure involves installation of low-NO_X turbines on the platforms, which could reduce emissions from each individual turbine by 25 - 80 per cent. Total Norwegian emissions of NO_X could thereby be reduced by 1 - 5 per cent.

Impacts on the Norwegian economy
Figure 2.5.1 compares changes in GDP, private consumption and the trade balance (goods and services) with the cost of the measures[2]. GDP and private consumption decrease as a result of the introduction of measures to reduce emissions of NO_X. GDP increases in the case of the measures directed at commercial and heavy-duty vehicles (measures 3 and 4). The reason is increased investments and increased import of transport vehicles, resulting in an increase in indirect taxes (especially special taxes on import). The requirements for systems to clean emissions from petrochemical industry, refineries and oil extraction (measures 6 - 8), and requirements directed at domestic shipping and the fishing fleet (measure 5) have

Figure 2.5.1. Relative effects of the measures NOK per NOK spent on the measure



Source: Statistics Norway

very small impacts on the rest of the economy. The measures directed at heavy-duty traffic (measures 3 and 4) have a somewhat greater, though still moderate, effect on the economy. The repercussions on the rest of the economy are somewhat greater for the measures directed at passenger cars (measures 1 and 2), measured in terms of changes in the GDP or private consumption per NOK spent on the measure.

Project personnel: Knut H. Alfsen, Bodil M. Larsen and Haakon Vennemo.

Financed by: Ministry of Environment.

Documentation: Larsen, B. M. (1994): Macro-economic impacts of reducing NO_X-emissions in Norway. *Economic Survey 3/94*, 19-25. Statistics Norway.

2.6 Is the environment a drag on economic growth and welfare?

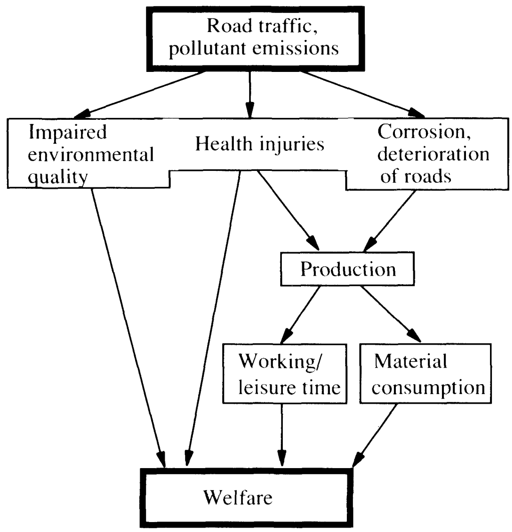
Economic analyses have traditionally given little consideration to the interaction between the economy and the environment. This study is based on the Norwegian model DREAM -

[2] The cost of the measures means the direct cost to the company or consumer concerned as a result of investment in cleaning systems etc.

Dynamic Resource/Environment Applied Model - which gives special consideration to this interaction. The model is long-term, in order to take into account the fact that natural resources are limited over time and that damage to the environment is cumulative. By comparing this model with a corresponding model that does not take the environment into account, it is possible to illustrate how the environment can affect welfare and economic growth.

The concept of welfare used in this analysis is not intended to be comprehensive, but rather to point out the direction in which welfare is developing, taking into account not only *consumption of goods and services* but also *leisure* and *the environment*. Wealth indicates how rich we are and usually describes material welfare. The term welfare in this study corresponds to such a concept of wealth, but leisure time and environmental quality are included as well. In the model, the environmental damage is caused by road traffic and emissions to air, which lead, for example, to corrosion, depreciation of roads, damage to buildings and injuries to health. These kinds of damage reduce production capacity in the economy. This in turn leads to a reduction of welfare, as a result of lower consumption of traditional goods and services. Health injuries and a reduction of environmental quality also lead to reduced welfare. In addition, the model takes into account that more leisure time can result in increased welfare. These mechanisms are illustrated in figure 2.6.1.

Figure 2.6.1. Illustration of the interaction between the economy and the environment in the model DREAM



Source: Statistics Norway

This study shows that total welfare is reduced by almost 10 per cent if environmental impacts are included. 90 per cent of this reflects the reduction in welfare due to a poorer environment. The remainder of the welfare reduction represents lower consumption of goods and services. The environmental costs consist mainly of health injuries due to emissions of NO_X, time loss due to traffic congestion, and traffic accidents which lead both to personal injuries and material damage. These adverse environmental effects reduce the annual growth in gross domestic product (GDP) by about 0.1 per cent. Thus, over the course of 100 years, GDP is about 9 per cent lower than it would be if the environment did not have any feedbacks on the economy. With lower value added, there is less to consume. However, people work less, and this increase in leisure time pulls in the direction of slightly higher welfare.

The total future loss of welfare towards the year 2100 is estimated to be about 700 billion 1989-NOK. In other words, if all the negative feedbacks from the environment are eliminated, society's welfare will increase by the same amount minus the cost of eliminating them. Complete elimination of environmental damage is probably neither desirable, nor realistic. By including long-term environmental damage and the welfare stemming from enjoyment of the environment in the analysis, it is possible to obtain a more comprehensive picture of the current political initiatives.

Project personnel: Annegrete Bruvoll, Solveig Glomsrød and Haakon Vennemo.

Financed by: The Norwegian Research Council, through the research programme "Economy and Ecology - Management Tools for Sustainable Development".

Documentation: Bruvoll, A., S. Glomsrød and H. Vennemo (1995): The Environmental Drag on Long-Term Economic Performance: Evidence from Norway. To be printed as Discussion Papers. Statistics Norway, Oslo.

Vennemo, H. (1994): *A Growth Model of Norway with a Two-way Link to the Environment.* Reports 94/5. Statistics Norway, Oslo - Kongsvinger.

2.7 The effects of the tax reform on the economy and the environment

The purpose of the Norwegian tax reform in 1992 was to reduce ineffective use of society's resources. However, the reform also has an environmental aspect, because a policy that affects the economy also affects the environment. This project studies the effects of the tax reform on the economy and the environment. The conclusion is that the reform increases the potential for consumption without causing adverse effects on the environment!

The objective of the tax reform was to promote more efficient use of the available human and material resources, in order to increase production and consumption. On the other hand, there is a fear that the tax reform could harm the environment, since experience has shown that higher production and consumption adversely affect the environment. A total evaluation of the tax reform therefores depend on the size of the strain on the environment relative to the economic gain.

This issue is analyzed by means of the economic equilibrium model DREAM - Dynamic Resource/Environment Applied Model. This is a model for Norway which gives special consideration to the interdependence between economic activity and the environment. It focuses on long-term economic trends, and the consequent long-term loads on the environment.

The aspects of the tax reform studied in the analysis are: A reduction in the marginal tax rate on capital income, an increase in the tax base for capital income, a reduction in the marginal tax rate on labour income, a reduction in employers' contributions to social security (pay roll tax), an increase in VAT, and the introduction of a tax on CO_2-emissions (with differentiated rates).

The analysis indicates that the tax reform provides a potential for 0.9 per cent higher consumption each year in the future. Some of this takes the form of less time spent at work. The environment is not affected to any degree by the increase in consumption. Consumer purchases of heating oil, gasoline and private means of transport increase, but the analysis shows that the use of fossil fuel in industries is reduced to an extent that compensates for the increased consumer demand.

The decrease in industrial consumption of fossil fuels can be partly explained by the fact that the CO_2-tax makes fossil fuels more expensive than they would have been otherwise, a situation to which companies adjust in the long term by reducing their demand for fuel relative to what they would otherwise have used. Another contributing factor is the tendency to reduce the time spent at work.

The project also studies how the different components of the tax reform contribute to the outcome. In isolation, reduced marginal tax on capital, combined with a wider basis for taxation, leads to lower production and consumption, and a better environment. The reason is that this part of the reform makes it less profitable to work, which reduces production over time, but is favourable to the environment. A lower marginal tax on labour income encourages people to work. Therefore this component leads to a higher level of employment and a poorer environment over time. The effect of the CO_2-tax is then to reduce the use of fossil fuels, so that the strain on the environment in the model calculations is eliminated. The gain in the form of increased consumption is maintained. Thus we arrive at the effect of the complete reform, which is an increased potential for consumption without adverse effects on the environment.

Project personnel: Haakon Vennemo.

Financed by: The Norwegian Research Council, through the programme "Economy and Ecology - Management Tools for Sustainable Development".

Documentation: Vennemo, H. (1994): Welfare and the Environment. Implications of a recent tax reform in Norway. Documents 94/1. Statistics Norway, Oslo.

2.8 Infrastructure investment and economic growth

A substantial share of the total investments in Norway are in infrastructure, for example, in road building, airports and telecommunications. In the international economic literature and in political circles it is debated whether investments in infrastructure generate economic growth, or whether the correlation between them is only coincidental. This project involves a critical review of some earlier studies of the relation between infrastructure investment and economic growth. Some earlier hypotheses are tested on the basis of data from Norway. The project shows that the results are strongly dependent on the method of estimation employed. According to this analysis, investments in improving and expanding the transport infrastructure in the course of the last 20 years have influenced the return to other input factors.

According to the National Accounts, Norway invested about NOK 8.4 billion per year in infrastructure projects in the transport sector between 1981 and 1991. The public capital stock in transport infrastructure is about 30 per cent higher than the capital stock in industry, and in 1991 investment in this type of infrastructure accounted for 10 per cent of all investment in mainland Norway. In the public debate, it is often suggested that infrastructure investment should receive priority, as a means of generating economic growth. This issue has been raised, for example, both in the "Roads Plan" and the "Report on Railways", and in the discussions about a new main airport. This debate is based to some extent on international studies, which claim that much of the reduction in economic growth in the 1970s and 1980s, for example in the USA, was a result of reduced investments in infrastructure.

Based on Norwegian data (1971-1991) on investments in five types of transport infrastructure (roads, airports, railways, harbours and post/telecommunications) and production trends at the national and sector levels, the project has reviewed different statistical methods for testing the causal relationship between these investments and economic growth. The project shows that several of the international studies are misleading, since the models employed have been too simple. Many of the international studies also contain major econometric weaknesses, since the results have not been corrected for the non-stationarity of the observed data. In this analysis, the models have been further developed, and newer statistical methods have been used in an attempt to avoid distortion of the results due to non-stationarity of the data material.

The analyses carried out as part of the project show a decreasing, yet positive, correlation between high infrastructure investments and economic growth at national level. The infrastructure investments help to reduce the cost of producing goods and services by increasing the productivity of the private inputs, labour and real private capital. This holds in spite of the fact that the national figures obviously include several unprofitable road and tunnel projects, especially in rural districts, and some clearly unprofitable airports.

The project has also investigated the relationship between infrastructure investment and economic growth at the sector level. The different sectors of the Norwegian economy depend to varying degrees on investments in roads, harbours, telecommunications, etc. According to the analysis, investments in roads and tunnels have a decreasing impact on cost development in the petroleum sector and the hydropower sector in the Norwegian economy. However, the effect on productivity in the manufacturing sector is considerable.

Project personnel: Alexandra Katz, Torstein Bye and Solveig Glomsrød.

Financed by: The Norwegian Research Council, through the SAMMEN programme.

Documentation: Katz, A. and T. Bye (1995): Returns to Publicly Owned Transport Infrastructure Investment: A Cost Function/Cost Share Approach for Norway, 1971-1991. To be printed as Discussion Papers. Statistics Norway, Oslo.

3. The state of the environment

3.1 Environmental indicators

An environmental indicator is defined as a parameter or a value derived from a parameter which provides information on the state of the environment with a significance extending beyond that obtained directly from the measured properties (parameters) on which it is based. The purpose of such environmental indicators is to provide a simplified presentation of the state of the environment, in order to reduce the number of data measured and the parameters normally needed to provide a good picture of the existing situation.

As from 1994, the state of the environment in the Nordic countries is to be reported annually by means of environmental indicators. This has been established in *Den nordiske miljøstrategi* (The Nordic Environmental Strategy), signed by the Nordic Ministers of the Environment.

In the course of 1994, a preliminary report was prepared by an editorial committee at the request of the Nordic Council of Ministers. After being distributed for comment in 1995, this report will be further developed into the first official Nordic report on environmental indicators.

The indicators used in the report (figure 3.1.1) refer to different stages of the cause-effect change and are described as the - *Pressure-State-Response (PSR)* concept. Human activities exert *pressure* on the environment in different ways, through emissions and other influences, and this is reflected in changes in the quality and quantity of natural resources (*state*). The third step of the PSR-chain is society's *response* in order to prevent these changes or repair environmental damage.

A core set of environmental indicators, intended among other things as a tool for evaluating the environmental policies and measures of the OECD countries (*Environmental performance reviews*) was published in 1994 in *Environmental Indicators OECD Core Set* (OECD 1994). The work on the Nordic indicators closely follows OECD's development of indicators. The issues or problems that are to be studied by means of indicators (e.g. climate, eutrophication, toxic contamination etc.) are the same. The actual choice of indicators is also often the same as in the OECD set, but indicators particularly suited to conditions in the Nordic countries are used in some cases, even if these are not included in the OECD set.

Figure 3.1.1. Nordic environmental indicators

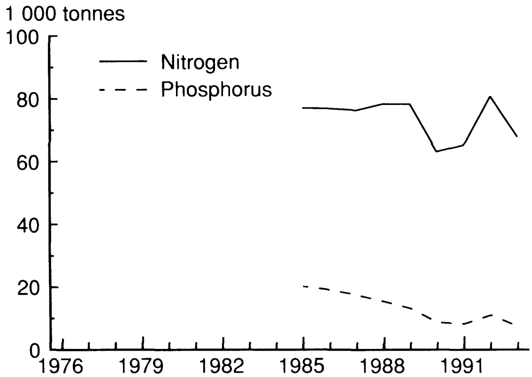
Issue	Pressure	State	Response
Climate change	Emissions of CO_2	Global mean temperature Annual mean temperature in the capitals	Changes in the use of fossil fuels
Ozone layer depletion	Use of ozone-depleting substances	Total ozone at selected monitoring stations	Targets for reduction of ozone-depleting substances
Eutrophication	Surplus supply of nitrogen and phosphorus in fertilizer	Algal chlorophyll Light penetration	Winter-green crop land Connection to "high grade" waste water treatment plants
Acidification	Deposition of acidifying compounds	Areas where the critical limit for sulphur has been exceeded	Liming of lakes and watercourses
Toxic contamination	Cadmium in moss	Heavy metals in selected organisms Organic hazardous substances in selected organisms	Collection of mercury, cadmium and PCBs
Urban environmental quality	Number of private cars and commercial vehicles in the capitals	Number of persons exposed to road traffic noise exceeding 55 dBA in the capitals	Number of vehicle-kilometres of public transport in the capitals
Biological diversity	Total length of road per unit of land	Endangered and vulnerable species	Protected areas
Cultural and natural landscapes	Forest ditches and drained area	Total wetland area	Restoration of wetlands
Waste	Quantity of household waste per capita		Share of the municipal waste deposited on landfills
Forest resources	Removal in relation to increment	Changes in standing volume	Planting and sowing of forest
Fish resources	Taxation - fishing mortality	Development of spawning stock	Quotas

Source: Statistics Norway

Example of an issue: Eutrophication
Eutrophication is a process that takes place in water, characterized by a development towards an environment rich in nutrients and proliferous plant production. The eutrophication process causes a change in the aquatic ecosystem. With particularly large inputs of nutrients the algal blooms can become excessive; much more algae are produced than the organisms that feed on them can consume. In the worst case, nutrient enrichment can also lead to blooms of toxic algae. When the algae die, the organic material is decomposed by fungi and bacteria. This process requires large amounts of oxygen, causing depletion of oxygen in the water. Visible effects of eutrophication are cloudy, discoloured water, an overgrown bed and shore and excessive plant growth. Other effects can be fish death, destruction of spawning grounds and a layer of sludge on the bottom.

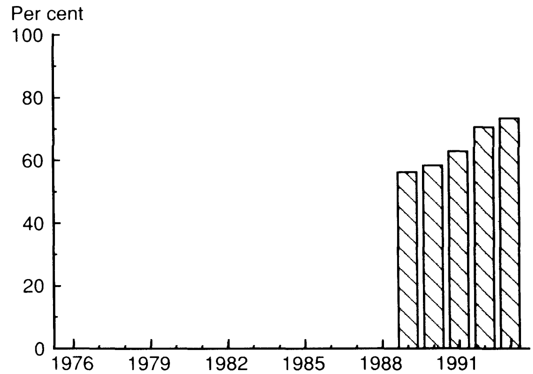
Pressure - P: The most important sources of anthropogenic inputs of the nutrients nitrogen and phosphorus to water are run-off from cultivated land and discharges from municipal waste water treatment plants. These inputs lead to undesirable algal growth in lakes, river and fjords. Today, far more nutrients are supplied to cultivated land than can be absorbed by the crops (figure 3.1.2). The surplus of nitrogen increased right up to 1990, but has since

Figure 3.1.2. Net inputs of nitrogen and phosphorus. 1985-1993. Norway. 1000 tonnes



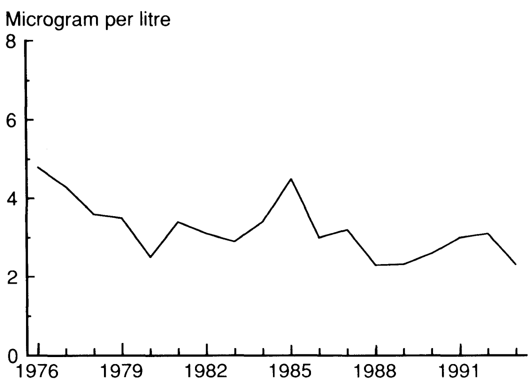
Source: Statistics Norway

Figure 3.1.4. The share of winter-green crop land and meadow land in Norway. 1989-1993. Per cent



Source: Statistics Norway

Figure 3.1.3. Algal chlorophyll in Lake Mjøsa. 1976-1993. Microgram per litre



Source: Norwegian Institute for Water Research (NIVA)

stabilized. The surplus of phosphorus is now less than half what it was at the beginning of the 1980s. This surplus can either be stored in the soil or leak out of the system into lakes, rivers and fjords.

State - S: The content of algal chlorophyll in the water masses is a measure of the plant production, and is often used, together with, for example, the phosphorus content, nitrogen content, and light penetration, to evaluate the water quality as regards extent of eutrophication. The state of the environment in Norway's largest lake, Mjøsa, has improved considerably since the first measures to reduce pollution were initiated as part of the *Mjøsa campaign* during the period 1971 to 1981 (figure 3.1.3). As far as eutrophication is concerned, the water quality in Lake Mjøsa is now the same as at the beginning of the 1950s.

Response - R: Through the North Sea Declarations, Norway is committed to reducing inputs of nitrogen and phosphorus to the North Sea by half by the end of 1995, with 1985 as base year. As far as the agricultural sector is concerned, the most important measures are improvement of manure stores, more effective use of fertilizer and changes in agricultural practices. Important measures are to postpone ploughing/soil preparation until the spring, or to sow the grain in the autumn in those parts of the country where this is possible. This gives the land a cover of vegetation throughout the winter (winter-green), which helps to reduce both erosion and run-off of nutrients. The share of winter-green crop land and meadow land in Norway has increased from about 56 per cent in 1989 to about 73 per cent in 1993 (figure 3.1.4).

Project personnel: Frode Brunvoll and Ola K. Hunnes.

Financed by: Nordic Council of Ministers.

Documentation: Brunvoll, F., O. K. Hunnes, B. Chytraeus, B. Röndell, E. Hermannsdóttir, L. Kopperoinen and J. Holten-Andersen (1995): Nordic Environmental Indicators. Draft document. Prepared for the Nordic Environmental Monitoring and Data Group, Nordic Council of Ministers. Statistics Norway, Oslo.

References:
OECD (1994): *Environmental Indicators.* OECD Core Set. OECD, Paris.

3.2 Material flow analyses: Solvents

Emissions of volatile organic compounds (NMVOC) to air from use of products containing solvents are large in most countries. In Norway this is the third largest source of emissions of NMVOC, the first two being loading of crude oil in the North Sea and gasoline-driven passenger cars. Some emissions occur from large industrial plants, but the many small sources of emissions are of greater importance. Examples are use of paint and white spirit. Norway has undertaken to reduce emissions of NMVOC by 30 per cent by the end of 1999, with 1989 as base year. In order to obtain the best possible basis for how the emissions can be reduced it is necessary to know how large they are, and where they originate. It is also necessary to know how the emissions change from one year to the next.

Emissions can be determined in different ways. In the case of large sources of emissions, such as emissions from single industrial plants, the emissions should be determined on the basis of a mass balance or measurements at each individual plant. Since the sources of the emissions are often small, however, this is not a good method for determining the size of the emissions from Norway as a whole. In this project we have used a solvent balance, a material flow analysis of solvents, in an attempt to find out the quantity of solvents and solvent-containing products used in Norway, and how much of this quantity is emitted to air. We have also used information from the Norwegian Pollution Control Authority on emissions from large industrial plants.

The solvents used in a country must either be produced there or imported. The greater part of the solvents that are used are released into the air. Solvents that are not released into the air are either exported, used as raw material, destroyed by incineration or decomposed in water. The solvent balance follows the flow of products containing solvents from import and production, via conversion to other products, to export, destruction or consumption.

The balance is based on commodities containing solvents in the list of commodities from the Directorate of Customs and Excise. Examples of important commodities are white spirit and paint that is not water-based. Each of these commodities is followed through the balance. Emissions from use of each commodity are distributed between industries.

The following data are included in the solvent balance:

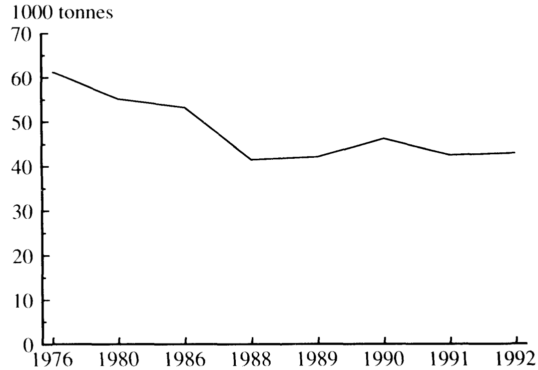
- *Imports and exports,* obtained from Statistics Norway's statistics on foreign trade.
- *Production in Norway,* obtained from Statistics Norway's industrial statistics.

Table 3.2.1. Emissions of NMVOC from use of solvents by product. Average 1988-1992. 1000 tonnes

Total	43.0
Alcohols	1.7
Aromatic compounds	1.1
White spirit and extraction gasoline	7.6
Asphalt and bitumen	1.9
Hydrocarbons	2.3
Ethers	3.0
Ketones	0.4
Paint and varnish	11.5
Putty, fillers and glue	1.2
Printer's ink and indian ink	4.4
Oils and cosmetics	2.1
Pesticides	1.7
Mixed solvents	1.1
Anti-freeze and de-icing solutions	1.7
Other	1.3

Sources: Statistics Norway and the Norwegian Pollution Control Authority.

Figure 3.2.1. Emissions of NMVOC from use of solvents. 1986-1992. 1000 tonnes



Sources: Statistics Norway and the Norwegian Pollution Control Authority.

- *Destruction* of solvent residues, paint and varnish, as reported by Norsas and the Norwegian Pollution Control Authority.
- Solvents used as *raw material*, obtained from Statistics Norway's industrial statistics.
- Information on *solvent content* in the products is obtained from several sources; e.g. the Product Register.
- *Share of emissions,* the share that is released into the air.
- Data on emissions from *large industrial plants* are supplied by the Norwegian Pollution Control Authority.

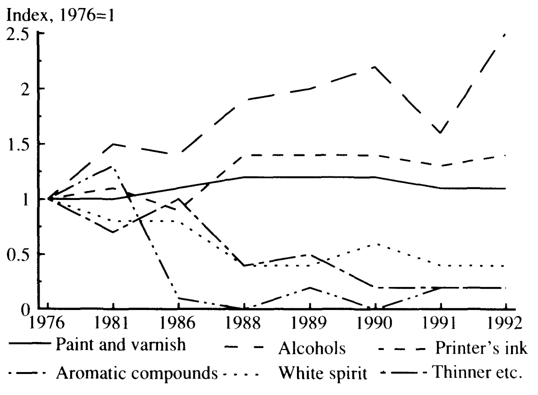
As far as possible, data that can be updated annually are used in the model. This implies that this method shows trends in emissions.

Use of paint and varnish is the most important source of emissions of solvents in Norway today (table 3.2.1). This source accounts for about a quarter of the total emissions. Use of white spirit and other petroleum products is also important. Other significant sources of emissions are use of ether, printer's ink and anti-freeze solution. In 1976 the picture was different: use of white spirit and petroleum products as solvents was the most important cause of emissions, with use of paint and varnish in second place. Use of aromatic compounds (e.g. creosote) and pesticides were also among the most important sources of emissions in 1976.

Total emissions were 61 000 tonnes in 1976 and about 43 000 tonnes in the years 1988 to 1992 (figure 3.2.1). Emissions were reduced by 30 per cent from 1976 to 1992. This reduction occurred during the period 1976 to 1988. During the period 1988 to 1992 the emissions have remained relatively stable.

The consumption of certain products has followed the economic development; an increase up to the end of the 1980s, followed by declining or stable consumption. In the case of other products the consumption is determined by shifts in the use of products as a result of information and regulations to reduce harm to health and the environment. In general, the trend in emissions follows

Figure 3.2.2. Consumption of solvents. 1976-1992. Index 1976=1



Source: Statistics Norway.

the trend in consumption (figure 3.2.2). The content of solvent in water-based paint and varnish has also been reduced. The most important reason for the reduction in emissions from 1976 to 1988 was reduced use of white spirit, aromatic compounds, mixed solvents and pesticides. The reduction in emissions from use of paint and varnish was not very big during this period. The total consumption of paint has increased, but this has been compensated to some extent by increased use of water-based paint and a lower share of organic solvents in the water-based paint. In recent years, the registered quantity of solvents that has been destroyed or recycled has increased. Without destruction, the emissions in 1988 would have been about 5 per cent higher than calculated in the model.

Not all the chemical compounds included in the emissions of NMVOC are necessarily equally harmful. Therefore, the emissions are ranked for each product according to the potential to produce, for example, - *tropospheric ozone* (surface ozone). In 1988, about 47 per cent of the emissions were categorized as "very important". Only 6 per cent were categorized as "least important".

A clear change in distribution occurred from 1976 to 1988. Emissions in the group "less important" increased at the expense of the two other groups. The reason was increased emissions of alcohols and ethers, and lower emissions of aromatic compounds, white spirit and chlorinated hydrocarbons. This implies that the most harmful share of the emissions may be reduced more than the total reduction in emissions.

Building and construction is the most important *industry*, accounting for a quarter of the emissions. More than half of the emissions originate from use of paint and varnish. Households contribute 16 per cent of the total emissions. The most important sources of emissions in this connection are use of paint and varnish, pure solvents, antifreeze solution and typical household products. About 40 per cent of the emissions originate from manufacturing industries. The most important of these are the graphical industry, engineering workshops and the pulp and paper industry. The main sources of emissions in these industries are use of printer's ink, paint and varnish, and white spirit. The distribution of emissions between industries is, however, uncertain.

Project personnel: Kristin Rypdal.

Financed by: The Norwegian Pollution Control Authority.

Documentation: Rypdal, K. (1995): *Løsemiddelbalanse for Norge - Utslipp, forbruk og metode* (Solvent balance for Norway - emissions, consumption and methodology). SFT Report 95:02. Norwegian Pollution Control Authority (SFT), Oslo. (Summary chapter in English).

4. Management of the environment and natural resources

4.1 Resource rent from Norwegian natural resources

Resource rent is defined as the share of income from resource-based activities which cannot be attributed to the factors of labour and capital. Calculations based on data from the National Accounts show that the rent from Norwegian natural resources amounted to NOK 43 billion in 1991, equivalent to 6 per cent of the gross domestic product. Almost 90 per cent of the total resource rent is earned in the petroleum sector.

Income that is neither used to cover current costs for intermediate consumption nor to cover the factor input costs of labour and capital is called *resource rent*, or simply *rent*. Rent may be viewed as additional income beyond what is usually obtained in ordinary economic activities. Assume, as an example, that a barrel of oil is sold for USD 15, while the extraction, including wages and capital costs, costs USD 10. Then the last USD 5 is rent, and can be attributed to the resource oil. *The natural resource wealth* is usually defined as the present value of future income. A simple assumption is that future income from the natural resources will be equivalent to the resource rent in a basic year. Given this assumption, the natural resource wealth in 1991 was calculated to NOK 654 billion.

For a long time the Norwegian economy has been based on the exploitation of natural resources. Today, nearly 25 per cent of the total value added occurs in resource-based industries, and natural resources or processed products based on natural resources account for about 70 per cent of Norwegian exports. Calculation of the resource rent is one way of demonstrating the actual income from natural resources. The estimates can also give some indication of the economic gain from the natural resources. In addition, calculations of the resource rent from different natural resources provide an indication of the size of the different components of the natural resource wealth.

In general, the resource rent is defined as follows:

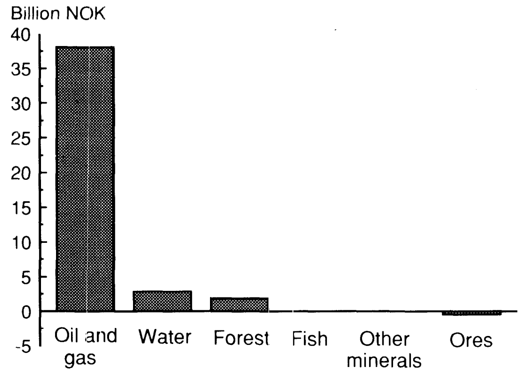
	Factor income
+	Special indirect taxes
-	Subsidies
-	Wages
-	Normal return on capital
=	Resource rent

The income derived from the production factors is called the factor income. In order to arrive at the sector's value added (the net product), the factor income is corrected for received subsidies and any special taxes paid. If wages are deducted from the net product, it gives the total return in the sector. The resource rent is then calculated by deducting the return on capital. It is customary to assume that the return on capital in the extraction sectors is equal to the average return on capital in other sectors. A normal assumption in Norwegian official surveys is to use a real return rate of 7 per cent.

The project has estimated the resource rent from the natural resources hydropower, forest, fish, petroleum and minerals during the period 1977 to 1991, based on data from the National Accounts. This gives an indication of how income from natural resources is recorded into the official figures for the economy's value added. It is important to note that these calculations will provide incomplete information on potential earnings from natural resources.

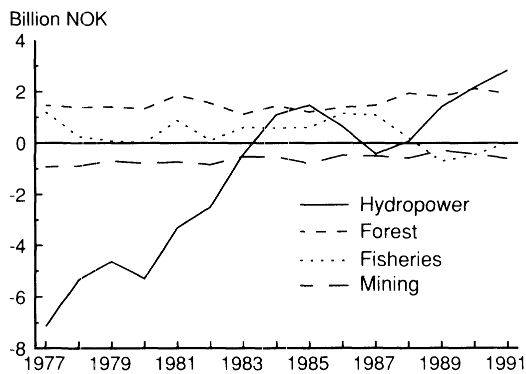
The resource rent from Norwegian natural resources totalled NOK 43 billion in 1991. Figure 4.1.1 shows the resource rent from the different resources. NOK 38 billion, or almost 90 per cent of the income is earned in the petroleum sector. The resource rent from hydropower amounted to NOK 2.8 billion, and from forests NOK 2 billion. The resource rent from both fish and extraction of minerals, excluding ores, was nil, while the resource rent from extraction of ores was negative. The main reasons for the fluctuations in the petroleum rent during the period 1977 to 1991 are changes in prices and production activity. Figure 4.1.2 shows a strong increase in the hydropower rent during the sample period. The main reason for the increase is a change in the energy policy[1] as a consequence of the report to

Figure 4.1.1. Resource rent for all natural resources. 1991. Billion NOK



Source: Statistics Norway

Figure 4.1.2. Resource rent for hydropower, forest, fish and mining. 1977-1991. Billion NOK



Source: Statistics Norway

the Storting in 1979-80. Power-intensive manufacturing industry and the pulp and paper industry can still purchase electricity at low prices, and this provides some justification for maintaining that some of the

[1] Report No. 54 (1979-80) to the Storting outlined a revision of the method for pricing hydropower. This implied raising the price of electricity for regular consumption, to make it correspond to the long-term marginal cost (the cost of expanding the production capacity)

hydropower rent can be ascribed to these industries.

The resource rent from forests has remained relatively stable. The resource rent from mining has made a negative contribution to the economy, the reason being that extraction of ores has taken place at a loss throughout the period. The loss decreased gradually towards the end of the period, probably because the least profitable mines were closed down first.

The rent from fish shows marked fluctuations, and in recent years Norway has not obtained any revenue from fish resources over and above the income needed to cover wages and normal return on capital. An underlying explanation of the reduction in the fish rent from 1997 to 1991 is the smaller quantity of the catch, while fluctuations in the price the fishermen receive for the catch are the main reason for the large fluctuations during the period. If we assume that future income is equal to the fish rent in 1991, and calculate the fish wealth on the basis of this dimension, then the result is a fish wealth equal to nil. The fact that the fish wealth is equal to nil does not imply that the fish are of little value, but that the costs of catching the fish are high. This does not mean that the fish resources are squandered, but can be interpreted to mean that Norway is in a position to realize other socio-economic objectives, for example, with regard to employment and settlement in coastal regions.

Project personnel: Hilde Lurås.

Financed by: Norwegian Research Council, through the research programme Economy and Ecology, Methodology Programme.

Documentation: Lurås, H. (1994): Grunnrente og formue av norske naturressurser (Resource rent and natural resource wealth from Norwegian natural resources). *Økonomiske analyser 8/94,* 9-17. Statistics Norway.

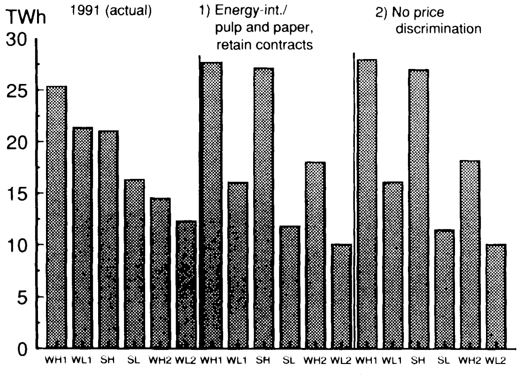
4.2 Modelling electric power exchange between Norway and other countries

Extended export and import of electricity between Norway and Europe could influence electricity prices and the pattern of electricity generation and consumption in Norway. It is of major importance for electricity prices whether or not energy-intensive industry retains its long-term contracts for electricity. This applies if export from Norway in high-load periods is compensated by import in low-load periods (power exchange), but especially if Norway increases exports unilaterally. More extensive exchange of electricity between other countries will have marked consequences on the distribution of the production over seasons, weeks and days in Norway.

The demand for electricity varies in the course of a day, a week and a year as a result of variations in temperature, daily rhythm, trade conditions and other circumstances. If the production capacity is to be used effectively, the electricity prices should vary with demand and with flow of water to the reservoirs in Norway, and with variations in prices abroad. In order to study the electricity market in Norway with prices that vary over time, the project has developed a simulation model where the year is divided into three seasons; a first winter period, a summer period and a second winter period. Each season is divided into a high-load and low-load period, where high-load refers to period with a high demand for electricity and low-load refers to night-time and non-working days.

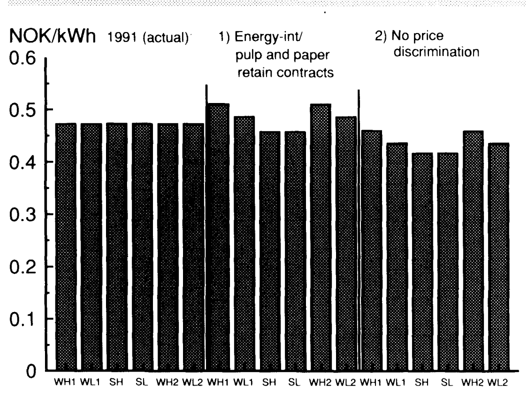
The main purpose of several of the power contracts negotiated by Norwegian ex-

Figure 4.2.1. Total electricity production. TWh



Source: Statistics Norway

Figure 4.2.2. Purchaser price of electricity to households, including all taxes. NOK/kWh



Source: Statistics Norway

porters of electricity is so-called power exchange. This implies that export in high-load periods shall be counterbalanced by import in low-load periods, so that the net export equals nil. A calculation has been carried out using the newly developed model, where export and import of electricity are fixed so that the transmission capacity to other countries is fully exploited during each period. The transmission capacity to/from Sweden, Denmark and Finland is currently 3050 MW. A power line to Germany of 600 MW (planned to be completed in 1988) is also included. Gross export and import is about 15 TWh.

Figure 4.2.1 shows total electricity production in the six load periods in the model, where WH1 means high load in the first winter period etc. The figure shows the actual realized production in 1991, and a situation 1), where the metals industry, chemical industry and the pulp and paper industry retain their long-term contracts with low prices while the prices in the other sectors are equilibrium prices, and situation 2), where there is no price discrimination. The introduction of more extensive exchange of electricity with other countries has dramatic consequences for the distribution of the production over seasons and load periods in Norway. In this case foreign power producers make use of the Norwegian power system to avoid large fluctuations in their thermal power production. Norwegian power production is turned strongly in the direction of the high-load periods. However, the existing power system has sufficient load capacity to satisfy this kind of distribution of production over the year.

Figure 4.2.2 shows that, in the scenario where energy-intensive industry and the pulp and paper industry retain their long-term contracts, the price of electricity to households falls in summer and increases in winter. The average price to households increases by 0.01 to 0.02 NOK/kWh. If the long-term contracts to the energy-intensive and pulp and paper industries are done away with, the price of electricity to households falls during all periods compared with the situation in 1991, and, on average, the purchaser price to households falls by 0.03 to 0.04 NOK/kWh. This is because, in this scenario, the domestic supply of electricity is very good. Lower prices to ordinary consumers implies that the reduced consumption in the energy-intensive and pulp and paper industries is absorbed domestically. Total domestic consumption increases when exchange of electricity is achieved. Electricity prices fall in most sectors, also leading to a switch from oil to electricity.

Project personnel: Tor Arnt Johnsen and Bodil Merethe Larsen.

Financed by: The Norwegian Research Council, through the SAMMEN project.

Documentation: Johnsen, T.A. and B. M. Larsen (1995): *Kraftmarkedsmodell med energi- og effektdimensjon* (Power market model with an energy and load dimension). To be published in the Reports series. Statistics Norway, Oslo - Kongsvinger.

4.3 Political decisions, project evaluations and the environment

If environmental considerations are to be taken into account in a cost-benefit analysis it is necessary to place a monetary value on the environmental goods concerned. Economists have therefore done a great deal of work to develop techniques for this kind of pricing. In the work summarized below, however, we demonstrate that it may be rational for politicians to disregard the results of a cost-benefit analysis. In order to make well-founded decisions, politicians in general need information on how different projects affect different groups, and on changes in the supply of environmental and other public goods. Based on the theoretical framework presented here, it is not certain that it is expedient to place a monetary value on environmental goods.

Cost-benefit analysis is a method used to evaluate the social efficiency of different measures, especially public investment projects. This method has been criticized, however, because it is based on implicit, controversial value judgements (see Brekke et al. 1993, also referred to in Statistics Norway 1994, p. 96-98). The method of analysis can be justified by the view that social welfare is determined by the sum of individual utility, together with an assumption that everyone obtains equally great utility from receiving one dollar more. A person's willingness to pay for a specific good then becomes a welfare measure. These assumptions do not permit a situation, for example, where it is regarded as more important to avoid loss of income for poor groups than for rich groups. The method is sometimes instead justified on the grounds that it is capable of identifying projects where the winners will be able to compensate the losers, so that no-one loses by the project in the end. However, the assumptions on which this reasoning is based are seldom fulfilled in practice, see Brekke et al. (1993).

Brekke et al. (1994) and Nyborg (1995) present an alternative approach to project analyses. This method has been developed especially for cases where the project description is included as background material in a political decision-making process. The following question has been studied by means of a theoretical model: What information does a politician need in order to arrive at a *well-founded* evaluation of different measures, and *at the same time* take into account his/her own political or ethical standpoints.

We assume that the decision as to which projects are to be undertaken is made by a political body, e.g. the Storting (the Norwegian National Assembly). An important characteristic of political decision-making processes is that the participants in the process do not necessarily agree as to what is best for society. This disagreement may be due to different conceptions of the actual consequences of a specific decision, but may also be a result of differing basic political or ethical standpoints. In economics, such basic views on what the goals for society should be are formalized as social *welfare functions.* Here we assume that different politicians may have different welfare functions. The purpose of the analysis is to identify indicators that can be used as *input* into an arbitrary welfare function. The actual ranking of the different measures can on the other hand be left to the politicians. Cost-benefit analysis, like various other analyses, can be interpreted as *output* from a specific welfare function.

When a politician has to evaluate the benefit of a given situation for society as a whole, he or she will probably be interested to know the benefit obtained by the different members of society in this situation. However, individual welfare is not something that can easily be measured and compared between persons. Several methods of measurement have been suggested in the economic literature, but none has received general support.

There is little doubt, however, that most people, in the course of their everyday lives, make intuitive evaluations of how well off they consider other people to be, and how important they think various conditions are for these people. In the light of this, we have assumed the following: If a politician has received information on person A's *income*, his/her *access to public goods* (e.g. the environment), and his/her *characteristics*, then the politician is in a position to form an opinion on how well off person A is, and how important a given change will be for him/her. In this connection, characteristics means conditions such as, for example, age, family status or domicile. We do not assume that all politicians reach the same conclusion. It is not even certain that it is possible for them to compare views, since such intuitive evaluations of welfare are difficult to express as an objective unit.

Thus it is assumed that political decision-makers actually undertake subjective evaluations both of what they believe to be important for individual welfare, and of what considerations should weigh heaviest for society as a whole. In order to carry out these evaluations in a well-founded manner they need information. Another assumption is that there are limits to how much information the politicians can receive. It is impossible for them to know everything. They must be content with a certain number of indicators, i.e. summarized information, on each project. All politicians should receive the same information.

Some of the most important conclusions concerning what kind of indicators politicians in general will need in order to form well-founded opinions are described below. For a more thorough explanation and justification of these results, see Brekke et al. (1994) and Nyborg (1995).

1. If the result of the analysis is supplied in the form of a benefit-cost fraction[1]*, it may be rational for the politician to disregard the figures provided.* The politicians who are certain that the priority given to different conditions in the analysis agrees with their own priorities will support the project that has the highest cost-benefit factor. On the other hand, the politicians who do not believe that the assumptions in the analysis agree with their own conceptions of what is important for achieving a good society, will not be able to base their evaluations on the cost-benefit analysis. If no other information

[1] A benefit-cost fraction is usually defined as the present value of the utility of the project, where utility is measured as the sum of individual willingness to pay, divided by the present value of the cost of the project. The precise definition can vary somewhat.

is provided, then in practice they have no information.

2. The indicators should have a moderately high level of aggregation. If a lot of detailed information is provided, the decision-makers tend to become confused rather than informed. On the other hand, information will always be lost as a result of aggregation, and there is always a possibility that some politicians are especially interested in just *that* information.

3. The following information should be provided:

- How will the project affect the standard of the environment and other public goods? Information on this may be provided by means of physical indicators.
- Are there any groups that will experience a large change in income if the project is carried out?
- Are there any groups that may be assumed to be especially strongly affected by the change in the availability of public goods? If, for example, the project leads to changed air quality, persons with asthma may be such a group.
- Are there any groups that can reasonably be assumed to be particularly sensitive to changes in income? In this connection it may be natural, for example, to study groups with a particularly low income to start with, or groups with a large family to support.

Hence, it should be possible to see *which groups* will lose by the project, and which groups will win, and how.

It should be noted that the pricing of environmental goods in terms of money is not mentioned here. When using cost-benefit analyses, such information is of major importance, since the pricing is necessary in order to integrate environmental considerations into these analyses. This is not necessary with the method described above. However, under certain conditions, studies of willingness to pay can provide useful information. In the framework presented here, however, this will not occupy a special position as compared to several other kinds of descriptive data.

The type of information described in the three points above does not perhaps represent anything new. Although many economists have argued that cost-benefit analyses should be used more extensively, it is still most common to describe public projects by listing the most important effects of the project, without any formal attempt to weigh the benefit against the costs. In the economic textbooks, this is often described as a less ideal method of procedure than cost-benefit analysis, since it does not provide any clear ranking of the various proposed measures.

The theory presented here can be regarded as a welfare theoretical justification that such simple lists of effects may, in fact, be preferable, because the actual ranking can then be left to the decision-makers themselves. The theory can also provide certain clues as to what information it is important to include in such a list.

The model that has been used here is fairly general. For example, it can also be used as grounds for stating that it is not necessarily desirable to create a "green GDP" in order to make the gross domestic product a better measure of welfare. Since the decision-makers are unlikely to agree on what "welfare" consists of, it may be more appropriate to develop a set of indicators, including both economic indicators and physical environmental indicators, which politicians can use in their own evaluations. The model will be further developed, and an attempt will be made to use it to shed light on specific issues.

Project personnel: Kjell Arne Brekke, Hilde Lurås and Karine Nyborg.

Financed by: Norwegian Research Council, Economy and Ecology Programme, Methodology Programme.

Documentation: Brekke, K. A., H. Lurås and K. Nyborg (1994): Sufficient Welfare Indicators: Allowing Disagreement in Evaluations of Social Welfare. Discussion Papers No. 119. Statistics Norway, Oslo.

Nyborg, K. (1995): Project Evaluations and Decision Processes. Discussion Papers No. 137. Statistics Norway, Oslo.

References:
Brekke, K. A., A. Bruvoll, H. Lurås and K. Nyborg (1993): Nytte-kostnadsanalyser og miljøprising. En moralfilosofisk kritikk (Cost-benefit analyses and environmental pricing. A moral-philosophical criticism). *Sosialøkonomen nr. 7/8, 1993.*

Statistics Norway (1994): *Natural Resources and the Environment 1993.* Statistical analyses 3. Statistics Norway, Oslo - Kongsvinger.

4.4 Management of capelin and cod in the Barents Sea

This work sheds light on the management of capelin and cod in the Barents Sea by means of a simple two-species model. The calculations indicate that in the case of capelin stocks of less than 7 million tonnes, the capelin are more valuable as food for the cod than when fished and sold. Fishing of capelin becomes profitable only with large stocks. The model calculations also indicate that the optimal taxation of cod should be larger with small than with large stocks of capelin.

During the project, a model was developed for optimal management of cod and capelin stocks in the Barents Sea. The model was developed as part of an experiment designed to study how decision-makers use different kinds of model tools as an aid in making decisions under uncertainty.

The size of each stock is represented by tonnes of biomass (cod and capelin respectively). The growth rate of each stock is dependent on the size of the stocks, and takes into account that the cod feed on the capelin. If the stocks of a species become large, this leads to competition for food, which limits growth. The annual growth of the biomass is assumed to be uncertain, but with a known distribution of probability. The model employs a very simplified description of the biological system; it does not take into account year classes or geographical distribution. Nor does it take into account the fact that, even if the capelin are numerous, there is a physical limit on how much food the cod can consume.

It was assumed that the biomass of cod will grow by about one kilogram per two kilograms of capelin consumed[1]. Given a price per kilogram of NOK 6 for cod and NOK 0.5 for capelin, this indicates that capelin are most valuable as food for cod. Even if the costs of catching the fish differ for capelin and cod, this does not change the conclusion to any significant degree. However, in the case of large stocks of capelin, competition within the capelin stock itself will make it profitable to fish capelin, but only when the stock exceeds 7 million tonnes. There is reason to believe that this figure would have been reduced considerably if

[1] The parameters in the model have not been estimated directly from empirical data, but have instead been chosen to suit a more detailed model developed by Moxnes (1993).

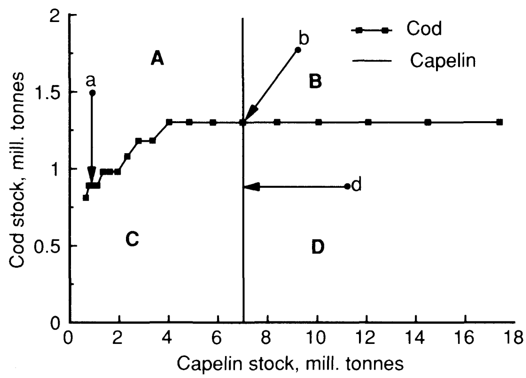
the amount of capelin the cod are physically capable of consuming had been taken into account, since in practice the cod will be capable of exploiting only a relatively small share of the extra supply of capelin made available with large stocks.

The model calculates the fisheries strategy that maximizes the expected present value of the future resource rent from the total fishing of capelin and cod. It was found that the optimal strategy is to fix target escapements, i.e. targets for how large the stocks should be at the end of the fishing season. For capelin it was found that the optimal situation was to leave behind a stock of 7 million tonnes, while the optimal stock of cod varies from 0.8 to 1.3 million tonnes, depending on the capelin stock.

The strategy is illustrated in figure 4.4.1. In area A the cod stock is higher than the target, while the capelin stock is lower. In this case the strategy dictates that the capelin should not be fished, and that the cod stock should be fished down to the size of the stock indicated by the curve for cod. For example, at point a, the cod stock is higher than the target, while the capelin stock is lower. The strategy is then to undertake fishing that reduces cod stock down to the line, while the capelin stock remains constant, as illustrated by the arrow. The strategy is the opposite in area D, where the optimal strategy is to fish only capelin, and then down to a stock equal to 7 million tonnes, as illustrated by the arrow from point d. In area B, the strategy is to fish both stocks, down to the point where the two lines intersect, as illustrated by the arrow from point b. In the case of stock sizes in area C, the strategy is not to fish either of the stocks at all.

Thus, for cod, the optimal fishing strategy will depend on the size of the capelin stock. In the case of very low capelin stocks - less than 1 million tonnes - the cod stock will grow slowly. For cod stock sizes exceeding 0.8 millions the value that the cod represents will give greater return if the cod is fished and the money is placed in financial assets. In the case of large capelin stocks on the other hand (more than 4 million tonnes), the cod will grow more quickly. In the case of cod stocks of less than 1.3 million tonnes, the growth will be large enough to imply that the cod give greater return in the sea than if fished, and the money is placed in financial assets.

Figure 4.4.1. Optimal target escapements



Source: Statistics Norway

It is emphasized that the model employs a very simplified description of the biological system. Nor does it take into account the objective of the fisheries policy to maintain settlement in northern areas. Therefore the concrete strategy must not be conceived as a recommendation, but rather as a basis for further analyses, and as an illustration that it may be important to take into account the interconnection between different species, and that capelin may have a substantial alternative value as food for cod.

Project personnel: Kjell Arne Brekke.

Financed by: The Norwegian Research Council. The work is part of the cross-disciplinary project "Decisions under uncertainty, using different tools", under the research programme Economy and Ecology.

Documentation: Brekke, K. A.: Optimal quotas in a Stochastic Two-Species Fishery Model of the Barents Sea. Unpublished paper. Statistics Norway, Oslo.

References:
Moxnes, E. (1993): *Multispecies Management under Uncertainty.* SNF-Report 41/93. Foundation of research in economics and business administration (SNF), Bergen.

5. International analyses

5.1 Carbon taxes and the petroleum wealth

A global carbon tax could have marked impacts on the markets for oil and gas. In this project we have studied to what degree a tax would lead to lower prices for oil and gas producers. The impact of different carbon taxes has been investigated. The results indicate that the Norwegian petroleum wealth could be severely reduced by the introduction of a global carbon tax.

As part of the attempts to reduce emissions of CO_2, many countries have discussed introducing a carbon tax. If such a tax is introduced, either by international agreement or in the largest OECD countries, this could have marked impacts on the international petroleum markets. A tax will obviously imply that consumers will have to pay a higher price, or that the producers will receive a lower price, possibly both. Owing to Norway's large petroleum reserves, it is of major importance to obtain more knowledge about the degree to which a carbon tax will lead to *lower prices for producers.*

In this project, a simple, dynamic model (so-called Hotelling model) has been chosen to study the impact of a carbon tax. Since oil and gas are non-renewable resources, a dynamic model will take into account an important aspect, namely that it is important to decide *when* is the optimal time to extract and sell the resource. The model is based in other respects on simple assumptions, which implies that the numerical results stated below cannot be conceived as other than fairly simple indications.

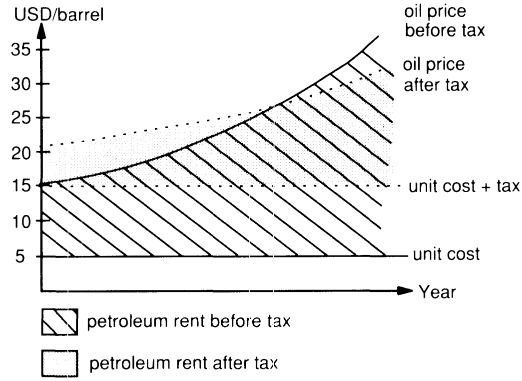
The theoretical analysis showed that the introduction of a permanent, constant carbon tax makes it optimal for the producers to change their rate of production, and that the burden of the tax will immediately be divided between consumers and producers. Given the world's oil reserves, total consumption over time, both with and without a tax, will be the same. However, if the consumer price will always be higher with than without a tax, the demand will always be lower, and the total oil reserves will not be sold. This implies that in order to obtain the same consumption over time, the prices that the consumer pays must, at some time or other, be lower than in a situation without a tax. At that particular time, the price the producers receive is reduced by *more* than the amount of the tax.

The project has also used the model to carry out numerical analyses, and has studied the impact on the oil price of imposing a constant carbon tax. Three different levels of tax were used. Another analysis was undertaken to find out what an optimal path for a global tax would look like. By this we mean a tax path which tries to take into account the long-term effects on the global climate because consumption of fossil fuels intensifies the greenhouse effect in the atmosphere. The impact of such a tax path on the oil price is then investigated.

According to the results, the consumers will pay the larger share of a permanent carbon tax during the initial period. The results indicate, however, that the impact on the global oil wealth, i.e. the discounted value of the petroleum rent to the world's oil producers, may be considerable. The EU is considering imposing a combined energy/carbon tax which will increase from USD 3 to USD 10 per barrel of oil. The analysis indicates that, with a global tax of USD 3 per barrel of oil, the value of the global oil wealth could be reduced by just over 10 per cent. If a tax of USD 10 per barrel is imposed, the analysis indicates that more than a third of the oil wealth could be lost. This is illustrated in figure 5.1.1. In order to reduce CO_2-emissions to a sufficient degree, a carbon tax of USD 20 per barrel may be necessary. The results of the analysis indicate that such a tax could imply a reduction in the global oil wealth of about two thirds.

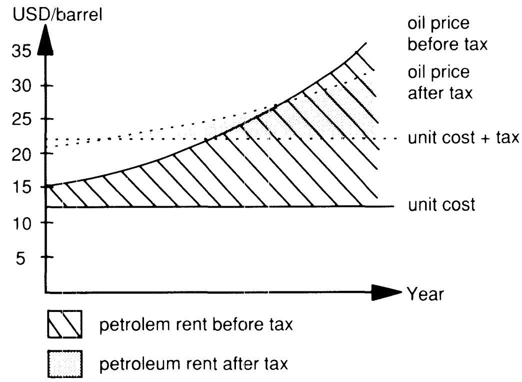
The project assumes that Norway's petroleum rent is lower than the average for the rest of the world, owing to the relatively high costs of Norwegian oil and gas production. Moreover, on the basis of earlier studies (e.g. ECON 1990) it has been assumed that the price paid to the producers for Norwegian gas follows the producer price for oil, both before and after the imposition of a carbon tax. This implies that the impact on Norway's petroleum wealth could be even greater than stated above. According to the analysis, a CO_2-tax of USD 3 per barrel could reduce the wealth by almost 15 per cent, and a carbon tax of USD 10 per barrel could eliminate almost half of the wealth (see illustration figure 5.1.2). According to the model analysis, a tax of USD 20 per barrel could imply that more or less the whole of the remaining petroleum wealth might disappear.

Figure 5.1.1. Impacts on the global oil wealth of a carbon tax of USD 10 per barrel of oil. USD/barrel



Source: Statistics Norway

Figure 5.1.2. Impacts on the Norwegian petroleum wealth of a carbon tax of USD 10 per barrel of oil. USD/barrel



Source: Statistics Norway

The shape of the optimal tax path that has been developed depends on, among other things, the assumptions made concerning the costs of changes in climate. The project considers two alternative scenarios. The first assumes that the cost is a function of the *concentration* of greenhouse gases in the atmosphere. The simulations indicate that, in this case, the carbon tax will first increase, and will then decline over time. Owing to the large degree of uncertainty associated with the long-term horizon for the greenhouse effect, there is strong disagreement about the level of such an optimal tax path. In this case the work is based on two different studies; Fankhauser (1994) and Hoel and Isaksen (1994). On the basis of these two studies it was found that the tax path indicates a reduction of about 15 per cent in the Norwegian petroleum wealth in the first case, and of about 50 per cent in the second.

The other scenario considers the cost of climate changes as a function of *changes* in the level of the atmospheric concentration of greenhouse gases, as a result of the costs of adjusting to a changing climate. Simulations based on such an assumption, together with calculations by Hoel and Isaksen (1994), indicate that the carbon tax will be relatively high to start with, but will then be reduced and will become negative in the long term. Thus an implementation of this tax path indicates a reduction in Norway's petroleum wealth of just over 30 per cent.

One of the weaknesses of the analyses is that the model does not take into account the substitutability of different types of fuels. For example, there may be reason to believe that a carbon tax will lead to better prices for natural gas than assumed in the analysis, since gas emits less CO_2 than emitted by oil and coal per unit of energy. For this reason, it is planned to extend the model to include several types of fuel simultaneously.

Project personnel: Snorre Kverndokk, Kjell Arne Brekke, Tom Karlsen and Knut Einar Rosendahl.

Financed by: The Norwegian Research Council, Programme for social science-related petroleum research.

Documentation: Karlsen, T. (1994): Optimal karbonbeskatning og virkningen på norsk petroleumsformue (Optimal taxation of carbon and the impacts on the Norwegian petroleum wealth). Main thesis at the Department of Economics, University of Oslo.

Rosendahl, K. E. (1994): Carbon taxes and the Petroleum Wealth. Discussion Papers No. 128. Statistics Norway, Oslo.

References:
ECON (1990): Virkninger av klimapolitikk på olje- og gassmarkedene (Impacts of the climate policy on the oil and gas markets). ECON Report 10/90. ECON, Oslo.

Fankhauser, S. (1994): The Social Costs of Greenhouse Gas Emissions: An Expected Value Approach. *The Energy Journal 15 (2),* 157-184.

Hoel, M. and I. Isaksen (1994): The Environmental Costs of Greenhouse Gas Emissions. Paper presented at the 5th EAERE Conference in Dublin, 22-24 June 1994.

5.2 Oslo Protocol for reduction of sulphur emissions in Europe

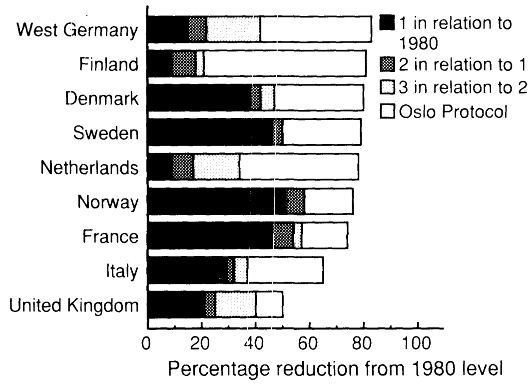
The international agreement on reduction of sulphur emissions to air in Europe has recently been re-negotiated, and was signed in Oslo in the summer of 1994. The level of ambition has been raised, and most West European -

countries have undertaken to reduce their emissions by more than 70 per cent by the turn of the century, with 1980 as base year. Calculations by Statistics Norway have shown that a change in Western Europe from coal-based power production to production based on natural gas would help substantially to meet the targets of the Oslo Protocol. The sulphur emissions would also be reduced by the introduction of a common carbon/energy tax in Western Europe, as proposed for the EU countries.

In the summer of 1994, the international agreement on reduction of sulphur emissions to air in Europe was renewed in Oslo. By this agreement, most of the countries of Western Europe have undertaken to reduce sulphur emissions by 70 per cent in relation to the 1980 level by the end of the year 2000. This project analyzes how EU's proposed carbon/energy tax, and a re-organization of power production in Western Europe, can help to realize the new agreement for reduction of sulphur emissions. The analysis has been carried out by means of calculations based on the model SEEM - Sectoral European Energy Model. SEEM estimates the future demand for solid fuels, oil, gas and electricity in 5 economic sectors in 9 European countries. In the SEEM model the demand for fuel is especially dependent on prices of and taxes on the different kinds of energy, and on the economic growth. Energy used in the processing industries is not included in SEEM. Based on the use of energy as calculated using the SEEM model, the acid precipitation model RAINS - Regional Acidification Information and Simulation Model - is used to estimate emissions of SO_2 in Europe.

The model is used to study three paths of development, or scenarios, with a time horizon to the year 2000. *Scenario 1* is a reference scenario based on relatively moderate economic growth. *Scenario 2* is like the reference scenario, except that EU's proposed carbon/energy tax is imposed in all nine countries as from 1993. *Scenario 3* is like scenario 2, except for the assumption that power production in Western Europe will be re-organized. In the first two scenarios, investments and production in the power sector follow the plans made by the authorities in the different countries. Out of consideration for securing an adequate supply of power, and for employment, priority is given to use of domestically produced sources of energy. This favours use of coal for power production in many countries. In scenario 3 it is assumed that producing electricity as cheaply as possible will be decisive for the choice between developing coal-fired power plants or gas-fired power plants. This would favour gas.

Figure 5.2.1. Reduction in emissions from the 1980 level by the year 2000, seen in relation to the requirements of the Oslo Protocol. Per cent



Source: Statistics Norway

Figure 5.2.1 illustrates some of the results of the calculations. In the figure, the total length of the columns shows the necessary percentage reduction that must be achieved in order to realize the new targets for emissions of SO_2 (The Oslo Protocol), for each country by the year 2000, seen in relation to the 1980 level. For the Nordic countries, France, the Netherlands and West Germany[1], the Oslo requirements imply a reduction of more than 70 per cent. The United Kingdom has to reduce its emissions by only 50 per cent by the year 2000, with 1980 as base year. The figure also shows countrywise SO_2-emissions in the year 2000 in the different scenarios, seen in relation to the 1980 level.

The first part of each column shows how much lower the emissions are in scenario 1 in the year 2000 than in 1980. The reductions in emissions from 1980 to year 2000 in the reference scenario are partly due to a change from the use of heavy to lighter qualities of oil with a lower sulphur content, and a growth in the market share of almost sulphur-free natural gas. There are large differences between countries. Norway, France, Sweden and Denmark show the best result in relation to the Oslo Protocol. In Norway's case, it looks as if about two thirds of the targeted reduction is achieved in the reference scenario. The share of the target achieved by France, the Netherlands and West Germany is very small. The reason for this is an increase in electricity production based on coal and other solid fuels in these countries in the reference scenario. Emissions from this production account for a large share of the total emissions of SO_2.

The next sections of the columns show the reduction in SO_2-emissions as a result of an EU tax on carbon and energy (scenario 2). The EU tax increases the price of all sources of energy. This reduces their use, which in turn leads to a reduction in emissions of SO_2. The tax implies that the countries come between 4 and 9 percentage points closer to achieving the targets of the Oslo Protocol.

For some countries, the emission effect of a change to more cost-based development of thermal power is greater than the effect of the EU tax. This is indicated in the third section of the columns (scenario 3). In countries with relatively extensive thermal power production (West Germany, the Netherlands and the United Kingdom), a change of behaviour in the power sector reduces emissions of SO_2 by as much as 15 to 20 per cent in relation to the 1980 level. Energy use in thermal power production is switched from coal with a high content of sulphur to natural gas.

The scenarios indicate that measures intended primarily to reduce emissions of CO_2 and make power production less expensive, also help substantially to achieve the new targets for SO_2-emissions. For some countries, these contributions may constitute more than a third of the reductions in emissions required by the Oslo Protocol. As indicated in figure 5.2.1, according to the analysis, the effects that have been studied will not be sufficient to realize the targets of the Oslo Protocol by the year 2000. Therefore, with the reservation that the calculations are associated with a large element of uncertainty, further measures to reduce SO_2-emissions will be required. However, this depends on, among other things, the estimates for economic growth, price trends for fossil fuels and cleaning measures used in the calculations. A development with more moderate economic growth, more stringent cleaning requirements, and a requirement to reduce the sulphur content of fuels towards the year 2000, could lead to smaller emissions than indicated in our calculations.

Project personnel: Knut H. Alfsen and Morten Aaserud.

1 The target applies to Germany as a whole, but in the figure it refers to West Germany. The earlier East Germany is not included in SEEM

Financed by: Contribution from Statoil.

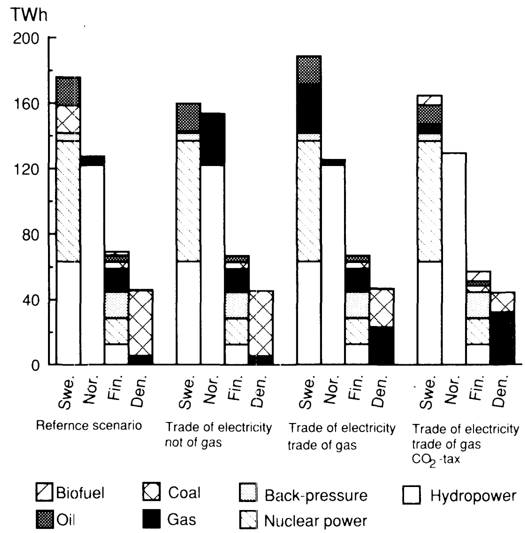
Documentation: Alfsen, K. H. and M. Aaserud (1994): Klimapolitikk, kraftproduksjon og sur nedbør (Climate policy, power production and acid precipitation). *Økonomiske analyser 8/94*, 18-26.

5.3 Natural gas in a Nordic electricity market

Several of the Nordic countries have deregulated or are planning to deregulate their national electricity markets. In addition to changing the domestic markets, this can also affect patterns of electricity trade among the countries. For Norway, the reform improves the possibilities for exporting electricity based on natural gas or for exporting natural gas directly to the other Nordic countries. In the long term, it will lead to a change in the distribution of emissions of the greenhouse gas CO2 within the Nordic countries.

Norway deregulated its national electricity market in 1991. Sweden has postponed deregulation for the time being, and Finland will probably deregulate its electricity market in the summer of 1995. The debate on deregulation also seems to be gaining momentum in Denmark. The price of electricity differs among these countries. This provides a good starting point for more trade. The generation systems are also different in the four Nordic countries. This results in different costs of generating electricity in both the short and long term, which creates a basis for trade in the short and the long run. A third stimulus for trade is that the supply of primary energy sources, such as natural gas and biofuels (wood, forestry waste, straw, peat etc.), differs among the Nordic countries. In this connection, it is relevant to export natural gas or gas-based electricity from Norway to Denmark, Sweden and Finland.

Figure 5.3.1. Electricity generation in the Nordic countries by technology in four scenarios. TWh



Source: Statistics Norway

Statistics Norway has developed a Nordic energy market model. The model specifies the behaviour of five user groups and contains a detailed description of the technology used for generation of electricity in each of the countries. The costs of transport between countries are specified, both for electricity and for natural gas. The model allows the user to specify restrictions on electricity and gas trading, to specify new generation technologies and to introduce political instruments, such as a tax on emissions of CO_2.

For this project, the model is used to construct four scenarios. In the reference scenario there is no trade of electricity and gas. Then we examine the consequences of unrestricted trading of electricity, trading of both electricity and natural gas, and then a higher tax on CO_2 is added. We run simulations until the year 2010.

According to the calculations, a transition from nationally distinct electricity markets to free trade of electricity among the Nordic countries leads to an increase in electricity generation of 2 per cent in the Nordic countries in the year 2010. Electricity generation in Norway increases by 20 per cent (26 TWh gas-based power). In Finland and Sweden, generation of electricity is reduced because it is cheaper to import electricity from Norway than to generate it domestically. Electricity imports from Norway replace coal dust-based electricity generation in Sweden and electricity produced from biofuel in Finland. Norwegian exports amount to 26 TWh in the year 2010. Free trade leads to a levelling of prices among the countries. As net exporter, Norway has the lowest prices in this case as well. Free trade of electricity ensures that electricity generation in the Nordic countries as a whole is as cheap as possible. Similarly, all users of electricity pay the same price, corrected for transport costs. Therefore, there is no longer any price discrimination among electricity consumers and all efficiency gains are used up. The total welfare gain for all four countries is about NOK 1.5 billion per year. Considerable redistribution takes place domestically since, in the importing countries, the producers of electricity lose income, while the consumers benefit from lower electricity prices. In Norway, higher electricity prices lead to losses for the purchasers and gains for the generators. For the Nordic countries as a whole, emissions of CO_2 remain unchanged. However, the trading of electricity implies that Norwegian emissions increase by more than 100 per cent, while Swedish emissions are reduced by 25 per cent. In the reference scenario (in the year 2010), emissions in Sweden are four times as high as in Norway (emissions from transport and production processes are not included in these emission figures).

The model can also be used to examine the consequences of allowing exports of natural gas from Norway to the other Nordic countries. Within the capacity of the existing transmission lines from Norway to Sweden and Denmark, it is cheaper to export electricity than to export natural gas to other countries for generation of electricity there. If it becomes necessary to invest in new transmission lines, it is cheaper to export natural gas by pipeline rather than to generate electricity in Norway using technology based on gas. In addition, the waste heat from gas-based generation in Sweden, Finland and Denmark could be used in the existing district heating network. This improves the profitability of a gas-based power plant in the other Nordic countries in relation to Norway, where the value of the waste heat is more uncertain. Given our assumptions, the opening of natural gas trade implies that the majority of the gas-based generation of electricity then takes place in Denmark and Sweden rather than in Norway, see figure 5.3.1. In this scenario, electricity generation requires such large quantities of natural gas as to justify the construction of gas pipelines instead of the further expansion of the transmission network for electricity exports to Denmark and Sweden. Trade in natural gas leads to a slight increase in total electricity generation in the Nordic countries. The average price level decreases slightly because more of the countries gain access to Norwegian natural gas. The Nordic emissions of CO_2 are reduced by 7 per cent. Emissions in Norway and Sweden are about the same as in the reference scenario, while emissions in Denmark are reduced because the coal, which was previously used to generate electricity, is replaced by natural gas. Electricity prices become even more equivalent in the different countries when trade in natural gas is permitted. In this case, the price is still lowest in Norway and highest in Finland.

With the introduction of a common Nordic CO_2-tax of NOK 350 per tonne CO_2 (the same level as currently imposed on gasoline in Norway), electricity generation in the Nordic countries decreases by 8 per cent (32 TWh). The tax, which applies to all fossil fuels (coal, oil and gas), implies that electricity prices in the Nordic countries increase by about 30 per cent. Even with higher prices, the tax means that Norwegian gas-based generation of electricity is unprofitable. However, higher electricity prices lead to more hydropower development, see figure 5.3.1. In the year 2010, a total of 129.5 TWh hydropower will have been developed, compared to the present normal level of production of about 112 TWh per year. In the other countries, which have no possibilities for further development of hydropower, it is the generation of electricity based on biofuels that increases. However, this technology involves high fixed costs, which implies that a strong rise in prices is necessary in order to limit demand. Welfare, measured as the sum of producer and consumer surplus in the electricity market, falls by about NOK 40 billion per year. For consumers, the price increases and the demand decreases. This reduces the consumer surplus. For producers of hydropower and nuclear power, the producer surplus increases. For generators of electricity based on fossil fuel, however, costs increase and, therefore, they sell a smaller quantity of electricity, which reduces the producer surplus. For the Nordic countries as a whole, the income from the CO_2-tax amounts to just over NOK 20 billion. Therefore, the gains from reduced emissions of CO_2, SO_2 and NO_x must be at least NOK 20 billion to make such a CO_2-tax profitable.

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Financed by: Nordic Council of Ministers.

Documentation: Bye, T., E. Gjelsvik, T. A. Johnsen, S. Kverndokk and H. T. Mysen (1994): *CO_2-utslipp og det nordiske elektrisitetsmarkedet. En modellanalyse* (CO_2-emissions and the Nordic electricity market. A model analysis). To be published as a report from the Nordic Council of Ministers, Copenhagen.

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Bye, T., T. A. Johnsen and H. T. Mysen (1995): Naturgass i et nordisk kraftmarked (Natural gas in a Nordic electricity market). *Sosialøkonomen no. 2. 1995*. Norwegian Association of Economists, Oslo.

Part III Appendix of tables

Table A1. Reserve accounts for crude oil. Developed fields and licensed fields. 1988-1994. Mill. tonnes

	1988	1989	1990	1991	1992	1993	1994
Reserves per 1/1	855	1000	982	1111	1112	1222	1209
New fields	143	-	103	93	94	4	28
Re-evaluation	58	56	108	2	123	97	109
Extraction	-56	-74	-82	-93	-107	-114	-129
Reserves per 31/12	1000	982	1111	1112	1222	1209	1216
R/P-ratio	18	13	14	12	11	11	9

Sources: Norwegian Petroleum Directorate and Statistics Norway

Table A2. Reserve accounts for natural gas. Developed and licensed fields. 1988-1994. Billion Sm^3

	1988	1989	1990	1991	1992	1993	1994
Reserves per 1/1	1247	1265	1261	1233	1274	1381	1356
New fields	10	-	15	54	138	1	2
Re-evaluation	38	27	-15	14	-2	2	17
Extraction	-30	-31	-28	-27	-29	-28	-30
Reserves per 31/12	1265	1261	1233	1274	1381	1356	1346
R/P-ratio	42	41	44	47	48	49	45

Sources: Norwegian Petroleum Directorate and Statistics Norway

Table A3. Reserve accounts for coal. 1988-1994. Mill. tonnes

	1988	1989	1990	1991	1992	1993	1994
Reserves per 1/1	13.1	13.6	13.3	13.0	4.5	4.1	4.0
Re-evaluation	0.7	0.1	-	-8.2	-	0.2	2.4
Extraction	-0.3	-0.3	-0.3	-0.3	-0.4	-0.3	-0.3
Reserves per 31/12	13.6	13.3	13.0	4.5	4.1	4.0	6.1
R/P-ratio	68	33	43	15	11	15	20

Source: Annual reports, Store Norske Spitsbergen Kulkompani

Table A4. Extraction, conversion and use[1] of energy sources. 1993*. PJ. Change in per cent

	Coal and coke	Fuel-wood, wood waste, black liquor, waste	Crude oil	Natural gas	Petro-leum-pro-ducts[2]	Elec-tri-city	District heat-ing	Total	Average annual change in per cent 1976-1991	1992-1993
Extraction of energy sources	8	-	4839	1141	73[3]	430	-	6491		
Energy use in extraction sectors	-	-	-	-125[4]	-13	-7	-	-145		
Import and Norwegian purchases abroad	45	0	57	-	247	2	-	352		
Export and foreign purchases in Norway	-11	0	-4283	-1002	-440	-30	-	-5767		
Stores (+decrease –increase)	2	.	-31	.	-4	.	.	-34		
Primary supply	43	0	583	13	-138	395	-	897		
Petroleum refineries	7	-	-579	-	541	-2	-	-33		
Other energy sectors, other supplies	-1	38	-	-	18	0	6	61		
Registered losses, statistical errors	-1	0	-3	-13	2	-27	-2	-45		
Registered use outside energy sectors	49	38	-	-	424	366	4	880	0.9	-
Domestic use	49	38	-	-	292	366	4	749	1.2	3.3
Agriculture and fisheries	0	-	-	-	25	2	0	28	-0.2	-
Energy intensive manufacturing	36	-	-	-	55	101	0	192	1.2	3.2
Other manufacturing and mining	12	20	-	-	23	64	1	119	-0.8	5.3
Other industries	-	-	-	-	116	81	2	199	1.7	5.3
Private households	0	18	-	-	74	118	1	211	2.3	0.5
Ocean transport	-	-	-	-	132	-	-	132	-0.4	-14.8

[1] Includes energy sources used as raw materials.
[2] Includes liquefied petroleum gas, refinery gas and excess gas from petrochemical industry. Coke includes petrol coke.
[3] Natural gas liquid and condensate from Kårstø.
[4] Includes gas terminal.
Source: Statistics Norway

Table A5. Use of energy sources outside the energy sectors and ocean transportation. 1976-1994*. PJ. Change in per cent

Energy source	1976	1980	1985	1987	1989	1990	1991	1992	1993*	1994*	Average annual change in per cent 1976-1987	1987-1994
Total	607	679	737	758	728	737	726	725	749	761	2.0	0.1
Electricity	241	269	329	335	340	349	356	358	366	368	3.0	1.4
Firm power	232	265	312	321	320	324	330	330	336	349	3.0	1.2
Surplus power	9	4	17	15	20	24	27	28	30	19	4.8	3.4
Oil total	300	294	263	278	255	245	237	233	239	247	-0.7	-1.7
Oil other than for transportation	159	138	80	84	64	58	51	45	44	53	-5.6	6.4
Kerosene, gasoline	26	19	9	11	8	7	7	7	7	7	-7.5	-6.3
Medium distillates	66	63	43	45	38	36	31	28	28	31	3.4	-5.2
Heavy oil	66	56	28	29	18	16	13	10	9	15	-7.2	-9.0
Oil for transportation	141	156	183	194	191	186	186	188	196	194	2.9	-
Gasoline	54	61	70	77	78	79	76	74	74	74	3.3	-0.6
Aviation gasoline, jet kerosene	20	21	23	25	25	21	21	22	23	24	2.0	-0.6
Medium distillates	64	70	83	84	82	83	86	90	96	94	2.5	1.6
Heavy oil	3	5	7	8	6	4	3	2	3	2	9.3	-18.0
Gas[1]	1	41	52	56	43	52	47	47	53	49	44.2	-1.9
District heating	.	.	2	3	3	3	4	4	4	4	.	4.2
Solid fuel	65	74	91	86	87	88	81	83	86	93	2.6	1.1
Coal, coke	47	48	57	50	51	50	45	45	49	55	0.6	1.4
Wood, wood waste, black liquor, waste	18	26	34	35	36	38	36	38	38	38	6.2	1.2

[1] Includes liquefied gas. From 1990, also gas from petrochemical industry and from landfills.
Source: Statistics Norway

Table A6. Net use[1] of energy in the energy sectors. 1976-1994*. PJ

	1976	1979	1980	1983	1985	1987	1989	1990	1991	1992	1993*	1994*
Total	34	57	65	66	75	82	96	122	154	164	173	185
Of which:												
Electricity	4	6	6	6	8	7	7	7	8	8	9	12
Natural gas	12	30	30	43	45	55	68	79	113	118	125	134

[1]Does not include energy use for conversion.
Source: Statistics Norway

Table A7. Electricity balance[1]. 1975-1994*. TWh. Change in per cent

	1975	1980	1985	1990	1992	1993*	1994*	Average annual change in per cent 1975-1985	1985-1994
Production	77.5	84.1	103.3	121.8	117.5	120.0	113.6	2.9	1.1
+ Imports	0.1	2.0	4.1	0.3	1.4	0.6	4.9	47.6	1.9
– Exports	5.7	2.5	4.6	16.2	10.1	8.4	5.0	-2.1	0.8
= Gross domestic consumption	71.9	83.6	102.7	105.9	108.8	112.2	113.5	3.6	1.1
– Consumption in pumping plants	0.1	0.5	0.8	0.3	0.6	0.6	1.5	20.8	7.4
– Consumption in power stations, losses and statistical differences	7.1	0.8	10.0	7.9	7.8	8.7	8.7	3.6	-1.6
= Net domestic consumption	64.7	75.1	9.9	97.7	100.4	102.9	103.3	3.6	1.3
– Surplus power	3.2	1.2	4.8	6.7	7.8	8.3	5.3	4.0	1.2
= Net firm power consumption	61.4	73.9	87.1	91.0	92.6	94.6	97.9	3.6	1.3
– Energy-intensive industry	26.2	27.9	30.0	29.6	27.5	27.6	28.2	1.4	-0.7
= Regular consumption	35.2	46.0	57.1	61.5	65.2	67.0	69.7	4.9	2.3
Regular consumption, adjusted for temperature	36.3	45.1	54.6	65.4	67.5	67.2	70.2	4.2	2.8

[1] Statistics Norway's electricity statistics are used up to and including 1992, with Statistics Norway's adjustments for temperature. NVE's figures are used for 1993 and 1994, also for temperature adjustments, but the import and export figures have been adjusted in accordance with Statistics Norway's figures for foreign trade.
Sources: Statistics Norway and NVE

Table A8. Average prices[1] of electricity[2] and selected petroleum products. Delivered energy. 1984-1994*

Energy source	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*	1994*
Heating products:					Price øre[4]/kWh						
Electricity[3]	30.5	32.7	35.6	37.9	41.7	43.5	45.7	45.5	46.6	48.7	47.5
	(26.5)	(28.5)	(31.6)	(34.3)	(37.2)	(38.6)	(41.4)	(42.2)	(41.6)	(43.0)	(42.0)
Heating kerosene	32.5	32.8	24.8	25.0	25.7	28.3	33.9	40.1	37.4	37.8	37.6
Fuel oil no. 1	26.9	27.2	19.4	19.6	19.7	21.6	26.6	31.9	28.3	28.0	28.2
Fuel oil no. 2	25.7	25.7	18.1	18.3	18.8	20.7	25.7	30.8	27.2	26.9	27.1
Heavy fuel oil	18.0	18.1	10.8	12.9	12.1	15.0	19.1	22.8	22.7	22.4	22.4
Transportation products:					Price øre/litre						
Gasoline											
leaded, high octane	520.9	512.8	476.0	510.0	536.0	578.5	642.8	741.0	795.0	836.2	851.0
unleaded 98 octane	-	-	-	-	-	-	622.1	705.0	747.0	787.1	791.0
unleaded 95 octane	-	-	457.0	489.0	503.0	540.5	594.4	677.0	717.0	757.4	761.0
Auto diesel	280.3	282.0	207.6	210.0	214.0	233.0	285.9	341.0	326.0	402.5	649.0

[1] All taxes included. [2] Households and agriculture. [3] The figures in parentheses comprise the variable part of the price (the energy part of the H4-tariff). [4] 100 øre = 1 NOK.
Sources: Statistics Norway, NVE and Norwegian Petroleum Institute

Table A9. Use of energy for combustion. Kristiansand municipality. 1991 og 1992. MWh theoretical energy content

	1991		1992	
	Fossil energy use	Bioenergy	Fossil energy use	Bioenergy
Total	534920	102002	529845	99109
Stationary combustion	166278	102002	159930	99109
Industry and energy sectors	49458	-	60709	-
Public services	17453	-	14736	-
Private services	35846	-	35448	-
Primary industries	1005	-	763	-
Private households	62515	102002	48274	99109
Gas from waste and landfills	-	0	-	0
Mobile combustion	368643	-	369916	-
Road traffic	310634	-	314382	-
-Private households	144043	-	142325	-
-Public transport	26752	-	28102	-
-Other transport	139839	-	143955	-
Motorized tools and tractors	22603	-	21720	-
-Households	422	-	422	-
-Other sectors	22181	-	21298	-
Railways	331	-	500	-
Air traffic below 1000 m	30948	-	28812	-
Ships and boats[1]	4127	-	4502	-

[1] Energy use calculated in harbours and from harbour out to the baseline. Energy use for ocean transportation is not included.
Source: Statistics Norway

Table A10. Total primary energy supply. The world. 1970-1992. Million toe

	1970 Mtoe	1980 Mtoe	1990 Mtoe	1991 Mtoe	1992 Mtoe	Per unit GDP (1992) (toe/1000 US$)	Per capita (1992) (toe/capita)
Whole world	4860.9	6454.9	7821.3	7922.5	7932.5	..	..
OECD	3054.6	3712.0	4084.7	4164.6	4194.8	0.39	4.84
Norway	13.9	18.9	21.5	21.9	21.3	0.32	4.96
Denmark	20.2	19.5	18.3	20.2	19.4	0.30	3.75
Finland	18.1	25.0	28.5	28.9	28.0	0.50	5.56
Sweden	38.0	41.0	47.8	49.3	46.7	0.43	5.38
France	147.3	190.7	220.7	232.0	231.2	0.37	4.03
United Kingdom	207.7	201.2	211.8	217.8	216.2	0.41	3.74
Germany	304.6	359.2	355.1	347.4	340.3	0.40	4.22
Turkey	12.2	31.9	53.2	54.0	55.5	0.73	0.94
Canada	132.1	194.4	211.5	211.0	216.3	0.55	7.88
USA	1545.9	1801.0	1920.6	1959.4	1984.1	0.43	7.78
Japan	257.8	347.1	432.6	443.0	451.1	0.26	3.63
Ethiopia	0.6	0.7	1.1	1.1	1.2	0.20	0.02
Guatemala	0.8	1.4	1.6	1.5	1.5	0.19	0.16
India	63.0	93.8	182.8	192.9	205.6	0.60	0.22
Bangladesh	1.3	2.8	6.6	6.2	6.5	0.32	0.06

Sources: OECD/IEA 1993 and OECD/IEA 1994

Table B1. Emissions to air. 1973-1994*. 1 000 tonnes unless specified otherwise

	CO_2 Mill. tonnes	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Pb Tonnes	Particulates[2]	Cadmium kg
1973	29.7	216.0[1]	12.2[1]	155.2	177.7	..	184.8	711.2	886	27.9	..
1974	26.8	..	..	148.6	172.5	..	176.4	663.9	831	26.0	..
1975	29.7	..	..	137.2	178.6	..	198.2	726.6	924	24.8	..
1976	32.4	..	..	145.7	178.4	..	201.7	775.4	759	25.5	..
1977	32.7	..	..	145.2	192.2	..	207.7	826.7	761	27.5	..
1978	31.9	..	..	141.6	184.9	..	167.9	852.5	784	25.4	..
1979	34.0	..	..	143.6	194.6	..	184.7	888.2	826	27.4	..
1980	33.9	264.0	14.3	140.5	184.3	..	174.3	886.3	775	24.7	..
1981	31.0	..	..	127.1	177.2	..	186.5	873.1	566	21.9	..
1982	30.1	..	..	109.8	182.5	..	196.6	893.7	632	20.1	..
1983	31.1	..	..	102.9	188.1	..	211.2	896.7	534	20.1	..
1984	33.0	..	..	95.0	203.6	..	223.6	926.3	369	20.9	..
1985	31.5	..	..	97.4	214.8	..	233.8	961.9	374	21.4	402
1986	34.1	..	..	90.7	229.2	..	250.8	1006.9	307	22.9	..
1987	34.7	280.7	15.1	74.4	237.0	..	252.9	1013.7	301	23.1	..
1988	35.0	280.5	15.1	67.0	228.6	39.1	248.5	997.2	302	21.2	..
1989	35.3	287.4	15.4	58.9	232.3	39.5	268.2	954.6	278	21.8	438
1990	35.5	289.7	15.5	53.5	229.7	39.4	266.1	941.2	230	22.2	416
1991	33.9	289.1	14.8	45.4	220.8	40.0	265.7	880.8	182	21.0	434
1992	34.4	292.7	13.0	37.2	220.3	40.7	278.8	848.6	150	20.7	425
1993*	35.7	290.4	13.8	36.2	229.3	40.3	283.7	805.3	107	21.0	440
1994*	37.2	293.4	14.2	35.4	225.1	40.5	295.2	789.0	31	20.9	473

[1] Applies to 1970.
[2] Emissions not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B2. Emissions to air by sector. 1992. 1 000 tonnes unless specified otherwise

	CO_2 Mill. tonnes	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb Tonnes	Particulates[3]
Total	34.4	292.7	13.0	37.2	220.3	40.7	278.8	848.6	150	20.7
Energy sectors	10.0	18.4	0.2	4.0	37.9	0.0	119.9	7.9	2	0.5
Extraction of oil and gas[1]	7.8	11.7	0.1	0.6	33.3	0.0	110.3	5.9	0	0.2
Extraction of coal	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
Oil refining	2.0	0.2	0.1	2.6	3.0	0.0	9.0	0.0	0	0.1
Electricity and water supply[2]	0.2	0.1	0.0	0.8	1.6	0.0	0.5	1.9	2	0.2
Manufacturing and mining	9.2	1.5	5.0	23.5	24.1	0.4	22.9	57.3	3	1.7
Oil drilling	0.3	0.3	0.0	0.2	5.5	0.0	0.4	0.4	0	0.1
Pulp and paper processing	0.2	0.3	0.4	2.1	1.4	0.0	0.7	1.6	0	0.3
Production of chemical raw materials	1.7	0.9	4.2	5.5	2.2	0.4	2.3	32.4	0	0.0
Minerals manufacturing	1.4	0.0	0.1	1.7	4.5	0.0	1.3	0.6	0	0.2
Manufacturing of iron, steel and ferro-alloys	2.7	0.0	0.0	7.5	5.5	0.0	1.6	0.0	2	0.0
Manufacturing of other metals	1.9	0.0	0.0	4.0	1.2	0.0	0.0	14.1	0	0.1
Manufacturing of metal products, boats, ships and platforms	0.2	0.0	0.0	0.2	0.7	0.0	3.7	1.4	0	0.0
Manufacturing of wood, plastic, rubber, graphical and chemical products	0.3	0.1	0.1	0.9	1.2	0.0	11.1	4.9	0	0.7
Manufacturing of consumer goods	0.6	0.0	0.1	1.4	1.9	0.0	1.8	1.9	0	0.2
Other	15.2	272.7	7.8	9.7	158.3	40.3	136.0	783.4	145	18.5
Building and construction	0.5	0.0	0.0	0.4	5.7	0.0	11.4	4.7	1	0.6
Agriculture and forestry	0.8	94.9	6.5	0.6	8.2	39.9	4.5	9.4	1	1.1
Fishing, sealing and whaling	1.3	0.4	0.1	1.1	27.7	0.0	1.0	2.5	0	0.5
Land transportation, domestic	2.3	0.1	0.3	1.8	25.4	0.0	5.2	21.6	2	2.6
Sea transportation, domestic	1.3	0.4	0.1	2.4	28.2	0.0	1.6	2.0	0	0.5
Air transportation, domestic	1.0	0.0	0.1	0.1	3.0	0.0	1.6	2.5	2	0.1
Other private services	1.9	0.3	0.2	0.9	14.9	0.1	25.2	120.3	27	0.5
Public communication activities	0.3	165.7	0.0	0.2	0.2	0.0	0.9	0.5	0	0.0
Public government activities	0.6	0.1	0.1	0.3	4.9	0.0	1.3	2.5	0	0.1
Private households	5.3	10.9	0.5	1.9	40.1	0.3	83.2	617.4	112	12.4

[1] Includes gas terminal, transport and supply ships. [2] Includes emissions from waste incineration plants.
[3] Emissions have not been calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B3. Emission to air by source. 1992. 1 000 tonnes unless specified otherwise

	CO_2 Mill. tonnes	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb Tonnes	Parti-culates
Total	34.4	292.7	13.0	37.2	220.3	40.7	278.8	848.6	150	20.7
Stationary combustion	13.8	12.8	1.4	8.3	37.2	-	10.4	120.8	2	13.1
Oil extraction	6.8	2.5	0.1	0.2	23.4	-	0.9	5.0	0	0.1
--Natural gas	5.7	2.2	0.0	-	15.4	-	0.6	4.2	-	-
--Diesel combustion	0.2	0.1	0.0	0.2	4.2	-	0.3	0.3	0	0.1
--Flaring	0.8	0.2	0.0	-	3.8	-	0.0	0.5	-	-
Gas terminal and oil refineries	2.2	0.3	0.1	0.1	3.4	-	0.9	0.2	0	0.1
Other industry	2.7	0.4	0.8	5.8	7.0	-	0.7	6.2	0	1.4
Dwellings, offices etc.	1.9	9.6	0.5	1.9	2.3	-	7.6	108.4	0	10.8
Incineration of wastes	0.1	0.1	0.0	0.3	1.2	-	0.3	0.3	1	0.0
Processes and evaporation	6.7	276.9	10.6	20.2	7.0	40.3	172.2	46.3	2	..
Oil and gas activities	0.4	9.2	-	2.5	-	-	117.2	-	-	..
--Ventilation, leakages etc.	0.0	5.2	-	-	-	-	3.6	-	-	..
--Oil loading	0.3	3.6	-	-	-	-	104.7	-	-	..
--Gas terminal and oil refineries	0.0	0.4	-	2.5	-	-	8.9	-	-	..
Gasoline distribution	0.0	-	-	-	-	-	8.9	-	-	..
Pulp and paper industry	-	-	-	0.9	-	-	-	-	-	..
Chemicals manufacturing	1.0	0.8	4.2	5.1	1.0	0.4	0.9	32.3	-	..
Cement, other minerals manuf.	0.6	-	-	0.4	-	-	-	-	-	..
Metals manufacturing	4.3	-	-	11.1	6.0	-	1.3	14.0	2	..
--Ferro alloys	2.5	-	-	7.3	5.1	-	1.3	-	-	..
--Aluminium	1.5	-	-	3.0	0.6	-	-	-	-	..
--Other	0.3	-	-	0.8	0.2	-	-	14.0	2	..
Agriculture	0.2	94.8	6.4	-	-	39.9	-	-	-	..
Landfills (waste)	0.1	165.5	-	-	-	-	-	-	-	..
Evaporation of solvents	0.1	-	-	-	-	-	42.9	-	-	..
Other process emissions	0.0	6.6	-	0.3	-	-	0.9	-	-	..
Mobile combustion	13.9	2.9	1.0	8.7	176.2	0.4	96.2	681.5	146	7.6
Motor vehicle traffic	8.0	1.6	0.6	3.3	79.4	0.4	76.6	638.1	140	4.2
-Gasoline-driven	5.1	1.6	0.3	1.0	48.9	0.4	72.0	621.1	140	0.7
--Passenger cars	4.8	1.5	0.3	0.9	44.5	0.4	66.4	574.8	130	0.6
--Light commercial vehicles	0.3	0.1	0.0	0.1	3.9	0.0	5.0	40.1	9	0.0
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.3	1	0.0
-Diesel-driven	2.8	0.1	0.3	2.3	30.5	0.0	4.6	17.0	0	3.5
--Passenger cars	0.3	0.0	0.0	0.2	1.0	0.0	0.3	1.3	0	0.5
--Light commercial vehicles	0.3	0.0	0.0	0.3	1.3	0.0	0.5	1.5	0	0.7
--Heavy vehicles	2.2	0.0	0.3	1.8	28.1	0.0	3.8	14.2	0	2.3
Motorcycles, mopeds, scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.6	2	0.0
Motorized tools	0.7	0.1	0.0	0.6	11.9	0.0	1.8	6.1	0	1.5
Railways	0.1	0.0	0.0	0.1	1.5	-	0.1	0.3	0	0.1
Air traffic	1.3	0.0	0.1	0.1	3.8	-	0.6	3.2	2	0.2
Ships and boats	3.7	1.1	0.2	4.5	79.6	-	11.9	20.2	3	1.6
--Coastal traffic, pleasureboats etc.	2.2	0.6	0.1	3.2	46.5	-	10.4	17.3	3	1.0
--Fishing fleet	1.3	0.4	0.1	1.1	27.7	-	1.0	2.5	0	0.5
--Mobile oil rigs etc.	0.2	0.1	0.0	0.2	5.4	-	0.4	0.4	0	0.1

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B4. Emission to air by source. 1993*. 1 000 tonnes unless specified otherwise

	CO_2 Mill. tonnes	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb Tonnes	Parti-culates
Total	35.7	290.4	13.8	36.2	229.3	40.3	283.7	805.3	107	21.0
Stationary combustion	14.3	12.8	1.4	6.8	39.5	-	10.6	121.3	2	13.0
Oil extraction	7.1	2.5	0.1	0.2	24.6	-	1.0	5.2	0	0.1
--Natural gas	6.0	2.3	0.0	-	16.0	-	0.6	4.3	-	-
--Diesel combustion	0.3	0.1	0.0	0.2	4.6	-	0.3	0.3	0	0.1
--Flaring	0.9	0.1	0.0	-	4.1	-	0.1	0.5	-	-
Gas terminal and oil refineries	2.3	0.3	0.1	0.1	3.5	-	0.9	0.3	0	0.1
Other industry	2.8	0.4	0.7	4.5	8.1	-	0.7	6.4	0	1.4
Dwellings, offices etc.	1.9	9.6	0.5	1.7	2.3	-	7.6	108.4	0	10.7
Incineration of wastes	0.1	0.1	0.0	0.3	0.9	-	0.3	0.3	1	0.0
Processes and evaporation	6.9	274.6	11.3	20.7	7.4	39.8	178.4	44.2	2	..
Oil and gas activities	0.4	9.9	-	2.1	-	-	124.2	-	-	..
--Ventilation, leakages etc.	0.0	5.4	-	-	-	-	3.1	-	-	..
--Oil loading	0.3	4.0	-	-	-	-	112.2	-	-	..
--Gas terminal and oil refineries	0.0	0.5	-	2.1	-	-	8.9	-	-	..
Gasoline distribution	0.0	-	-	-	-	-	8.7	-	-	..
Pulp and paper industry	-	-	-	0.6	-	-	-	-	-	..
Chemicals manufacturing	1.1	0.9	5.0	4.9	1.2	0.3	1.0	35.2	-	..
Cement, other minerals manuf.	0.8	-	-	0.7	-	-	-	-	-	..
Metals manufacturing	4.1	-	-	12.2	6.2	-	1.4	9.0	2	..
--Ferro alloys	2.4	-	-	9.7	5.4	-	1.4	-	-	..
--Aluminium	1.5	-	-	1.8	0.6	-	-	-	-	..
--Other	0.2	-	-	0.6	0.2	-	-	9.0	2	..
Agriculture	0.2	93.6	6.3	-	-	39.5	-	-	-	..
Landfills (waste)	0.1	165.2	-	-	-	-	-	-	-	..
Evaporation of solvents	0.1	-	-	-	-	-	42.1	-	-	..
Other process emissions	0.0	5.0	-	0.2	-	-	0.9	-	-	..
Mobile combustion	14.5	3.0	1.1	8.8	182.5	0.5	94.8	639.8	104	8.0
Motor vehicle traffic	8.4	1.6	0.7	3.9	81.2	0.5	75.1	596.2	99	4.6
-Gasoline-driven	5.1	1.5	0.3	1.6	47.1	0.5	70.0	577.3	98	0.7
--Passenger cars	4.8	1.4	0.3	1.5	42.8	0.5	64.5	531.8	91	0.6
--Light commercial vehicles	0.3	0.1	0.0	0.1	3.8	0.0	4.9	39.0	6	0.0
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.5	1	0.0
-Diesel-driven	3.3	0.1	0.4	2.3	34.1	0.0	5.1	18.8	0	3.9
--Passenger cars	0.4	0.0	0.0	0.2	1.3	0.0	0.4	1.5	0	0.6
--Light commercial vehicles	0.4	0.0	0.0	0.3	1.6	0.0	0.6	1.8	0	0.8
--Heavy vehicles	2.5	0.1	0.4	1.7	31.2	0.0	4.1	15.5	0	2.5
Motorcycles, mopeds, scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.6	1	0.0
Motorized tools	0.8	0.1	0.0	0.5	11.9	0.0	1.8	6.1	0	1.5
Railways	0.1	0.0	0.0	0.1	1.5	-	0.1	0.4	0	0.1
Air traffic	1.3	0.0	0.1	0.2	3.6	-	0.6	3.1	2	0.2
Ships and boats	3.9	1.1	0.2	4.1	84.1	-	12.0	20.5	2	1.7
--Coastal traffic, pleasureboats etc.	2.5	0.7	0.2	3.0	52.3	-	10.7	17.7	2	1.1
--Fishing fleet	1.2	0.4	0.1	0.9	27.3	-	1.0	2.5	0	0.5
--Mobile oil rigs etc.	0.2	0.1	0.0	0.1	4.6	-	0.3	0.3	0	0.1

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B5. Emissions[1] to air by county. 1992. 1 000 tonnes unless specified otherwise

	CO_2 Mill. tonnes	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb Tonnes	Par-ticu-lates[2]	Cad-mium kg
Total	34.7	293.0	13.0	48.1	247.4	40.7	279.7	849.9	149	21.1	446
Of this total, aircraft and ships engaged in international traffic	1.4	0.4	0.1	11.0	29.8	-	1.1	2.5	0	0.5	16
Østfold	1.1	12.3	0.6	3.6	6.9	1.9	9.3	46.7	9	1.1	21
Akershus	1.4	17.6	0.4	0.8	11.2	1.5	16.6	87.7	17	1.4	16
Oslo	1.1	2.6	0.1	1.1	8.1	0.0	12.4	55.2	12	0.6	14
Hedmark	0.8	14.7	0.6	0.5	7.0	2.9	8.1	49.6	9	1.5	17
Oppland	0.7	20.7	0.7	0.4	6.1	3.8	7.4	42.9	8	1.1	14
Buskerud	0.9	12.8	0.4	1.4	7.2	1.1	10.0	50.6	10	1.0	16
Vestfold	1.1	9.4	0.3	1.2	6.0	1.0	10.6	40.0	8	0.8	17
Telemark	2.9	9.1	2.9	1.1	7.8	1.0	7.5	47.1	6	0.8	39
Aust-Agder	0.4	7.0	0.1	2.8	2.2	0.5	4.1	49.3	3	0.9	8
Vest-Agder	0.9	10.9	0.2	1.8	3.5	0.9	5.7	25.6	4	0.8	17
Rogaland	2.2	37.7	1.1	2.0	8.9	6.6	14.8	63.2	12	1.3	33
Hordaland	3.2	29.2	0.6	3.9	10.6	2.3	47.2	69.7	11	2.4	41
Sogn og Fjordane	1.1	11.9	0.4	2.4	3.6	2.3	4.1	22.1	3	0.9	42
Møre og Romsdal	0.9	15.5	0.6	0.9	5.3	3.2	8.4	38.6	7	1.0	27
Sør-Trøndelag	1.0	14.5	0.6	3.0	6.3	3.3	7.8	43.0	7	0.9	12
Nord-Trøndelag	0.5	12.6	0.7	0.6	4.1	3.8	5.2	29.4	5	0.9	9
Nordland	1.8	19.9	2.0	3.9	8.1	2.5	7.9	38.9	9	1.0	37
Troms	0.6	9.2	0.2	0.9	3.8	1.1	4.8	24.3	5	0.5	6
Finnmark	0.3	6.6	0.2	0.8	1.9	1.1	2.9	12.7	2	0.3	5
Svalbard	0.1	6.5	0.0	0.4	0.2	0.0	0.1	0.3	0	0.1	8
Continental shelf	11.8	12.4	0.4	14.5	128.4	-	84.6	13.0	1	1.9	49

[1] Does not include emissions in air space higher than 1000 metres.
[2] Emissions are not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B6. Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Total	35876	57504	255302	267020	36199	48281	251323	280010
Of this total, aircraft and ships engaged in international traffic	1977	12137	34465	1337	1840	11080	30976	1218
Østfold	1226	5147	7198	9679	1096	3606	6924	9339
Halden	78	305	659	993	72	74	597	953
Moss	156	1002	724	960	164	699	763	948
Sarpsborg	405	2564	1828	1839	314	1762	1651	1701
Fredrikstad	284	1101	1556	2436	248	930	1478	2349
Hvaler	11	4	66	394	11	4	66	389
Aremark	6	3	57	63	6	3	58	58
Marker	17	9	151	168	16	8	154	166
Rømskog	2	1	16	17	2	1	16	16
Trøgstad	18	10	155	181	18	9	155	178
Spydeberg	17	9	144	185	16	7	143	185
Askim	40	25	229	361	36	15	224	363
Eidsberg	39	21	339	432	38	18	338	414
Skiptvet	8	4	73	90	8	4	73	93
Rakkestad	29	16	236	290	29	15	236	280
Råde	34	16	316	399	35	16	323	394
Rygge	51	40	352	538	48	25	347	535
Våler	15	7	138	154	15	7	139	152
Hobøl	17	9	159	179	17	8	163	165
Akershus	1452	949	11164	16806	1428	840	11154	16569
Vestby	43	21	386	634	43	20	387	611
Ski	63	33	515	781	63	30	515	823
Ås	60	29	545	665	61	28	550	669
Frogn	31	15	228	595	31	14	235	571
Nesodden	25	12	152	743	25	11	151	730
Oppegård	43	23	341	534	42	21	336	548
Bærum	340	140	2281	3193	339	135	2291	3351
Asker	138	70	1105	1915	139	75	1123	1824
Aurskog-Høland	42	22	352	479	41	20	352	469
Sørum	50	23	430	581	50	22	435	546
Fet	27	13	225	299	26	12	223	281
Rælingen	41	161	291	239	36	143	259	232
Enebakk	17	9	137	194	16	7	133	178
Lørenskog	53	33	375	725	49	25	360	675
Skedsmo	145	164	1021	1689	133	105	999	1543
Nittedal	43	22	362	483	42	20	358	454
Gjerdrum	9	5	75	105	9	4	75	98
Ullensaker	115	48	882	1077	116	46	898	1111
Nes	53	28	435	534	52	25	438	532
Eidsvoll	82	61	751	982	83	59	763	988

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Nannestad	22	14	177	237	21	13	177	222
Hurdal	11	5	97	124	10	5	96	114
Oslo	1115	1298	8325	12990	1090	1067	8133	12355
Hedmark	785	547	6971	8342	790	495	7024	8113
Kongsvinger	61	37	541	732	61	34	564	714
Hamar	75	51	528	779	74	45	518	779
Ringsaker	123	94	1018	1374	128	89	1015	1320
Løten	28	18	274	299	29	18	280	297
Stange	87	52	779	907	90	49	779	849
Nord-Odal	15	9	140	186	15	8	142	186
Sør-Odal	40	26	333	369	39	22	335	358
Eidskog	28	22	266	320	27	22	267	318
Grue	25	17	234	281	24	14	231	274
Åsnes	33	19	311	353	34	18	310	345
Våler	21	26	174	213	19	13	168	200
Elverum	63	38	548	677	63	35	555	642
Trysil	31	32	313	379	32	35	320	379
Åmot	21	15	206	219	21	13	209	224
Stor-Elvdal	33	19	342	293	34	19	352	289
Rendalen	16	10	169	156	17	9	173	151
Engerdal	9	5	84	108	9	5	86	103
Tolga	10	9	87	85	9	5	87	84
Tynset	32	23	296	285	31	17	300	278
Alvdal	17	13	167	153	17	12	171	150
Folldal	8	8	75	76	9	8	76	81
Os	9	5	84	99	9	5	85	92
Oppland	688	468	6097	7576	695	445	6138	7424
Lillehammer	66	48	501	807	66	44	497	837
Gjøvik	95	58	773	1107	93	50	760	1035
Dovre	25	20	237	228	25	19	237	221
Lesja	18	13	177	146	18	12	185	135
Skjåk	13	7	127	136	13	7	130	134
Lom	11	6	109	124	12	6	111	120
Vågå	18	13	167	185	18	13	170	189
Nord-Fron	25	19	225	252	26	20	230	237
Sel	30	17	271	300	32	17	272	294
Sør-Fron	14	8	135	147	15	8	140	139
Ringebu	32	18	318	321	33	17	325	312
Øyer	26	14	256	272	27	14	262	282
Gausdal	19	12	174	205	19	11	174	196
Østre Toten	46	52	356	459	47	53	358	453

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Vestre Toten	38	29	311	496	36	20	309	463
Jevnaker	17	11	126	201	17	8	126	210
Lunner	26	28	273	324	26	35	292	339
Gran	41	22	366	461	41	21	366	455
Søndre Land	24	15	205	253	23	12	201	237
Nordre Land	23	13	214	273	23	12	214	266
Sør-Aurdal	15	9	153	159	16	9	155	153
Etnedal	8	4	75	81	8	4	76	85
Nord-Aurdal	30	16	274	326	30	15	274	326
Vestre Slidre	9	5	80	86	9	5	80	85
Øystre Slidre	12	7	113	130	12	7	111	127
Vang	8	5	83	94	8	5	83	93
Buskerud	913	1385	7113	10103	893	1439	7216	9969
Drammen	143	88	1036	1667	134	74	1012	1600
Kongsberg	73	60	542	856	74	57	544	856
Ringerike	105	86	856	1148	99	66	856	1156
Hole	28	13	252	286	28	13	255	280
Flå	13	6	127	139	13	6	127	134
Nes	16	8	143	181	16	8	143	164
Gol	20	11	183	219	20	11	184	210
Hemsedal	13	7	122	128	13	7	124	125
Ål	21	27	166	215	21	26	164	205
Hol	22	12	202	235	23	12	205	233
Sigdal	15	9	139	173	15	9	139	179
Krødsherad	18	9	161	206	18	8	160	192
Modum	38	22	309	446	38	25	310	428
Øvre Eiker	68	48	574	658	68	47	582	647
Nedre Eiker	49	27	333	717	45	22	329	728
Lier	118	155	823	1364	115	145	818	1395
Røyken	32	16	232	391	30	16	227	393
Hurum	85	763	567	676	89	870	689	656
Flesberg	13	7	127	145	13	7	129	139
Rollag	8	4	76	82	8	4	77	81
Nore og Uvdal	14	7	141	171	15	7	142	167
Vestfold	1088	1779	6005	10062	1071	1173	5954	10600
Borre	52	30	394	679	54	34	403	654
Holmestrand	77	26	317	376	80	21	316	366
Tønsberg	379	590	1353	3357	417	597	1606	4124
Sandefjord	123	184	720	1139	97	45	660	1079
Larvik	171	415	1222	1735	156	228	1133	1688
Svelvik	53	181	242	181	48	10	121	165
Sande	78	273	482	540	63	165	445	505
Hof	12	6	103	121	12	6	98	126

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Våle	28	14	256	313	29	14	260	300
Ramnes	10	5	94	112	10	5	92	108
Andebu	12	6	108	146	12	6	105	143
Stokke	35	19	312	375	35	17	313	375
Nøtterøy	35	19	233	555	35	16	230	551
Tjøme	10	4	57	307	10	4	58	296
Lardal	12	6	114	124	12	6	115	120
Telemark	2904	1353	9018	7598	2882	1095	7835	7488
Porsgrunn	1911	869	4984	1288	1919	658	3995	1302
Skien	117	257	823	1301	113	246	795	1233
Notodden	39	21	327	489	40	20	329	487
Siljan	6	3	51	82	6	3	50	72
Bamble	625	20	967	1781	602	20	944	1772
Kragerø	38	55	257	698	37	43	239	695
Drangedal	13	8	123	151	13	8	122	160
Nome	24	37	165	220	22	32	160	223
Bø	13	7	109	153	13	7	109	152
Sauherad	15	7	137	155	15	7	138	156
Tinn	21	25	287	276	18	9	163	259
Hjartdal	9	5	85	99	9	5	86	98
Seljord	14	7	132	173	14	7	133	178
Kviteseid	13	7	124	150	13	7	124	159
Nissedal	7	4	64	74	7	3	66	72
Fyresdal	5	3	48	76	5	3	48	72
Tokke	12	6	121	146	12	7	122	139
Vinje	22	12	211	286	22	11	213	260
Aust-Agder	427	3078	2232	4201	429	2849	2221	4133
Risør	20	17	155	323	20	16	156	322
Grimstad	40	25	306	683	39	22	305	653
Arendal	175	1690	665	1366	171	1599	658	1325
Gjerstad	10	6	96	138	10	5	96	135
Vegårshei	5	3	43	63	5	3	42	64
Tvedestrand	19	11	158	307	19	10	158	303
Froland	11	7	110	134	11	7	112	133
Lillesand	86	1251	230	519	93	1117	220	516
Birkenes	21	42	127	175	22	44	130	181
Åmli	8	5	78	100	8	4	78	100
Iveland	2	1	19	28	2	1	20	27
Evje og Hornnes	12	11	92	140	12	12	93	135
Bygland	7	4	59	82	7	3	60	81
Valle	6	3	53	82	6	3	53	84
Bykle	5	2	40	63	5	3	40	74

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes. CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Vest-Agder	859	2339	3658	5742	874	1754	3543	5735
Kristiansand	278	1524	1580	2106	299	1121	1556	2131
Mandal	28	19	227	477	29	18	230	478
Farsund	185	449	302	391	186	316	234	438
Flekkefjord	27	36	232	404	26	18	196	415
Vennesla	36	217	272	374	34	205	278	355
Songdalen	14	7	123	185	14	7	122	175
Søgne	19	10	159	321	19	10	161	321
Marnardal	6	4	62	69	6	4	62	72
Åseral	2	1	21	27	3	1	23	29
Audnedal	5	3	45	60	5	3	46	59
Lindesnes	16	8	141	486	17	8	142	456
Lyngdal	24	25	181	309	21	11	181	305
Hægebostad	5	3	44	65	5	2	44	66
Kvinesdal	208	27	200	380	203	25	198	348
Sirdal	7	4	69	88	8	4	70	87
Rogaland	2301	2400	9814	14868	2184	2001	8911	14791
Eigersund	83	178	524	487	96	290	525	478
Sandnes	137	80	1161	1628	132	71	1093	1638
Stavanger	248	183	1865	3077	244	182	1880	2973
Haugesund	59	63	561	785	55	63	487	740
Sokndal	29	62	207	172	29	66	115	164
Lund	15	8	146	183	15	8	150	182
Bjerkreim	17	12	159	180	17	8	160	171
Hå	52	52	384	530	47	24	387	518
Klepp	56	57	383	522	53	44	375	543
Time	34	20	277	452	34	17	276	451
Gjesdal	27	20	232	303	26	18	208	319
Sola	285	707	667	2489	287	320	670	2493
Randaberg	14	8	114	197	14	7	113	218
Forsand	5	3	46	61	5	2	47	60
Strand	22	13	147	261	23	13	145	244
Hjelmeland	15	10	143	151	12	6	105	146
Suldal	13	7	121	166	14	7	118	169
Sauda	320	27	619	255	242	20	71	236
Finnøy	14	14	57	117	13	10	56	118
Rennesøy	14	8	103	145	14	7	103	144
Kvitsøy	1	0	4	26	1	0	4	26
Bokn	5	2	45	84	5	2	45	89
Tysvær	352	16	767	1182	317	16	748	1255
Karmøy	457	838	883	1136	464	789	828	1132
Utsira	1	0	2	20	1	0	2	25
Vindafjord	23	12	198	258	24	11	199	257

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Hordaland	2822	3859	9768	40951	3180	3928	10604	47241
Bergen	498	559	4017	6366	494	512	3964	6366
Etne	14	9	124	166	15	9	125	173
Ølen	8	5	71	130	8	5	71	131
Sveio	12	7	114	187	13	6	113	182
Bømlo	14	9	105	298	14	8	102	316
Stord	25	15	182	432	25	14	182	409
Fitjar	6	5	47	118	6	5	47	122
Tysnes	5	3	43	139	5	3	41	135
Kvinnherad	182	316	288	528	190	289	280	498
Jondal	2	1	14	40	2	1	14	40
Odda	415	263	662	380	382	180	586	350
Ullensvang	11	7	109	172	12	7	109	177
Eidfjord	7	4	71	85	7	4	72	87
Ulvik	4	2	33	46	4	2	34	49
Granvin	6	3	59	84	6	3	60	71
Voss	44	27	386	512	45	26	386	520
Kvam	182	812	651	411	177	823	637	418
Fusa	9	5	76	176	9	5	75	164
Samnanger	8	4	78	116	9	4	79	113
Os	26	16	205	385	26	14	202	401
Austevoll	7	5	47	177	7	4	47	156
Sund	7	4	52	133	7	4	51	130
Fjell	34	18	252	467	35	17	250	496
Askøy	50	112	343	445	58	146	355	412
Vaksdal	17	14	140	213	17	11	144	216
Modalen	1	1	6	8	1	1	7	8
Osterøy	12	8	98	197	13	8	97	181
Meland	7	5	56	141	7	4	56	134
Øygarden	74	4	47	22572	91	3	47	28166
Radøy	9	6	71	141	9	6	71	150
Lindås	1110	1603	1213	5466	1475	1797	2195	6243
Austrheim	5	3	38	91	5	3	38	86
Fedje	1	1	3	29	1	1	3	30
Masfjorden	7	4	64	102	7	4	64	110
Sogn og Fjordane	1058	3194	3507	4107	1067	2379	3575	4116
Flora	28	20	198	365	28	18	198	362
Gulen	8	5	64	93	9	6	65	103
Solund	3	2	12	44	4	3	13	44
Hyllestad	5	3	42	79	5	3	42	74
Høyanger	146	187	179	189	146	287	175	186
Vik	7	4	62	99	7	4	61	95
Balestrand	9	6	67	87	9	6	66	85
Leikanger	7	5	62	85	7	4	62	90

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Sogndal	19	13	140	225	18	10	137	208
Aurland	9	5	89	103	9	5	91	99
Lærdal	10	6	90	102	10	6	92	108
Årdal	416	2136	311	170	375	1404	250	165
Luster	13	8	117	173	13	8	118	191
Askvoll	7	5	61	105	8	5	61	119
Fjaler	7	6	65	87	7	6	65	96
Gaular	12	7	117	130	12	7	117	117
Jølster	12	7	111	131	11	6	111	131
Førde	29	21	211	365	29	20	213	366
Naustdal	8	5	74	93	8	4	75	91
Bremanger	204	607	633	275	239	369	739	303
Vågsøy	30	91	174	200	44	155	195	206
Selje	7	5	65	106	7	5	63	109
Eid	18	12	154	230	17	11	152	223
Hornindal	4	2	35	51	4	2	35	53
Gloppen	18	11	155	216	18	11	154	204
Stryn	25	15	222	305	24	14	224	289
Møre og Romsdal	909	1048	5287	8420	927	903	5296	8421
Molde	50	27	417	655	51	26	412	678
Kristiansund	29	17	205	458	29	16	198	460
Ålesund	94	75	744	1470	102	83	736	1451
Vanylven	18	44	130	119	20	45	168	130
Sande	6	4	55	107	7	4	56	106
Herøy	29	72	183	226	38	115	194	236
Ulstein	11	6	87	250	11	6	85	255
Hareid	8	5	70	140	9	5	67	147
Volda	15	8	125	198	15	8	125	211
Ørsta	27	22	251	349	27	19	239	358
Ørskog	9	5	84	100	9	4	86	96
Norddal	7	5	73	74	7	4	58	74
Stranda	14	9	107	183	14	7	106	181
Stordal	3	2	25	70	3	2	25	66
Sykkylven	15	9	117	277	15	8	116	271
Skodje	17	9	146	185	18	9	149	184
Sula	23	54	128	185	14	9	113	183
Giske	13	6	92	161	14	5	92	175
Haram	21	21	150	286	18	9	144	301
Vestnes	21	13	173	278	20	11	173	263
Rauma	33	23	308	374	34	20	319	385
Nesset	12	6	110	144	12	6	111	135
Midsund	4	2	37	74	4	2	37	79
Sandøy	2	1	14	42	2	1	14	49
Aukra	5	3	39	89	5	2	38	82
Fræna	25	15	217	292	25	14	202	284
Eide	9	6	83	106	11	7	117	108

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Averøy	12	8	97	139	13	8	96	135
Frei	8	5	70	121	8	4	69	108
Gjemnes	12	6	116	153	12	6	116	144
Tingvoll	11	6	99	142	11	6	101	134
Sunndal	299	527	343	283	303	406	343	285
Surnadal	18	10	158	275	19	10	158	260
Rindal	7	7	65	84	7	6	65	92
Aure	7	4	59	100	7	3	58	94
Halsa	5	3	43	67	5	3	46	60
Tustna	2	1	20	43	2	1	20	43
Smøla	6	3	46	119	6	3	46	119
Sør-Trøndelag	1096	3765	6391	7969	1032	3045	6269	7818
Trondheim	358	735	1953	3312	330	657	1968	3374
Hemne	178	1027	586	260	168	693	548	241
Snillfjord	7	3	65	86	7	3	65	74
Hitra	11	7	94	130	11	6	92	127
Frøya	10	8	65	141	9	5	62	133
Ørland	15	7	90	126	15	6	88	123
Agdenes	5	3	53	65	5	3	54	62
Rissa	21	11	195	255	21	11	195	242
Bjugn	18	35	140	175	20	44	140	163
Åfjord	11	6	96	140	10	6	96	120
Roan	3	2	31	40	3	2	31	43
Osen	3	2	27	39	3	2	26	36
Oppdal	30	17	280	312	30	16	281	311
Rennebu	19	10	199	195	20	10	204	183
Meldal	13	7	105	156	12	6	105	142
Orkdal	218	1783	712	471	189	1482	605	420
Røros	17	10	147	212	18	9	147	229
Holtålen	8	5	81	93	8	4	79	93
Midtre Gauldal	27	19	289	314	28	15	282	300
Melhus	49	27	479	523	50	27	496	509
Skaun	20	11	189	230	20	10	189	226
Klæbu	7	4	63	90	7	4	62	86
Malvik	33	18	316	407	34	17	321	384
Selbu	11	7	104	154	11	6	101	145
Tydal	3	2	32	43	3	2	32	50
Nord-Trøndelag	551	583	4253	5324	507	562	4143	5241
Steinkjer	74	61	642	887	71	40	643	780
Namsos	30	28	217	361	28	20	212	359
Meråker	77	206	261	154	33	245	139	129
Stjørdal	90	81	613	811	94	78	631	898
Frosta	6	4	54	70	6	4	56	77
Leksvik	9	5	87	157	9	5	88	147

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Levanger	67	59	576	713	66	52	584	705
Verdal	48	46	386	513	49	29	379	485
Mosvik	3	2	27	34	3	2	27	32
Verran	8	6	65	102	9	7	64	104
Namdalseid	9	5	89	106	9	5	88	104
Inderøy	21	17	176	198	22	14	175	203
Snåsa	14	9	153	128	15	9	155	133
Lierne	7	4	66	88	7	4	68	83
Røyrvik	5	3	33	37	4	2	23	38
Namsskogan	11	7	125	87	11	7	125	84
Grong	18	11	193	181	19	11	196	185
Høylandet	8	4	74	85	8	4	75	84
Overhalla	14	8	122	165	14	7	122	162
Fosnes	3	2	25	31	3	2	25	30
Flatanger	3	2	29	46	3	2	29	46
Vikna	8	5	65	117	8	4	64	124
Nærøy	17	10	157	212	16	9	158	206
Leka	2	1	16	41	2	1	17	43
Nordland	1720	4569	8167	7902	1772	3905	8094	7896
Bodø	97	62	587	1064	99	56	591	1025
Narvik	47	31	365	526	47	28	360	512
Bindal	6	4	55	83	6	4	57	76
Sømna	7	4	55	63	6	3	53	64
Brønnøy	18	11	134	176	18	10	133	221
Vega	3	2	23	61	3	2	23	56
Vevelstad	1	1	12	15	1	1	12	15
Herøy	3	2	22	47	3	2	22	46
Alstahaug	19	12	129	190	19	10	128	198
Leirfjord	8	5	69	87	8	4	69	77
Vefsn	284	344	493	440	285	383	466	447
Grane	16	11	184	133	17	10	188	131
Hattfjelldal	8	9	76	100	7	7	72	101
Dønna	4	3	32	55	4	2	32	55
Nesna	4	3	35	42	4	3	36	50
Hemnes	17	11	160	205	18	11	157	196
Rana	410	1813	1270	1051	506	1817	1491	1070
Lurøy	4	3	33	58	4	3	33	58
Træna	1	1	4	16	1	0	4	17
Rødøy	4	2	31	61	4	2	31	61
Meløy	19	51	360	162	20	24	436	157
Gildeskål	9	5	80	111	9	5	80	109
Beiarn	4	3	33	40	3	2	33	40
Saltdal	22	15	216	246	23	15	229	233
Fauske	32	22	296	349	31	18	281	334
Skjerstad	4	2	37	45	4	2	37	47
Sørfold	272	1909	900	279	301	1362	987	307

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Steigen	10	6	77	109	9	5	73	111
Hamarøy	13	7	124	137	13	7	128	128
Tysfjord	184	97	812	72	107	4	401	78
Lødingen	8	5	61	86	8	5	64	81
Tjeldsund	7	4	57	66	7	4	59	68
Evenes	16	7	103	106	16	6	104	109
Ballangen	12	8	121	131	12	7	105	118
Røst	1	1	9	16	1	1	9	17
Værøy	1	1	7	22	1	1	6	18
Flakstad	4	3	31	38	4	2	30	37
Vestvågøy	28	17	218	293	27	15	215	315
Vågan	21	13	154	224	21	11	154	224
Hadsel	21	13	155	203	22	12	155	199
Bø	9	6	78	93	9	5	78	93
Øksnes	11	7	78	95	11	7	76	98
Sortland	27	19	219	293	27	16	220	283
Andøy	23	12	158	194	24	10	162	197
Moskenes	2	1	14	20	2	1	14	20
Troms	609	1247	3764	5100	603	949	3798	4830
Harstad	50	36	356	599	50	33	367	562
Tromsø	136	165	840	1542	124	104	825	1379
Kvæfjord	10	7	88	106	11	6	88	106
Skånland	12	8	108	131	12	7	109	130
Bjarkøy	1	1	10	17	1	1	10	16
Ibestad	4	4	30	45	5	3	30	42
Gratangen	7	4	59	64	7	4	60	64
Lavangen	5	3	42	50	5	3	44	50
Bardu	20	12	147	226	20	12	155	205
Salangen	7	5	58	81	7	4	57	79
Målselv	39	22	270	404	40	20	280	379
Sørreisa	13	9	82	151	13	8	86	131
Dyrøy	3	3	30	42	4	2	30	43
Tranøy	6	5	57	65	6	4	56	65
Torsken	3	2	26	26	3	2	25	26
Berg	4	3	37	36	4	3	35	36
Lenvik	193	898	736	423	196	677	742	431
Balsfjord	32	19	270	318	33	18	272	319
Karlsøy	7	4	56	89	7	4	57	86
Lyngen	9	7	65	94	10	6	66	92
Storfjord	11	6	98	132	11	6	99	122
Kåfjord	10	6	87	113	10	6	87	112
Skjervøy	4	3	28	67	5	3	29	71
Nordreisa	17	11	137	198	17	9	138	203
Kvænangen	6	4	49	80	6	4	51	81

Table B6 (cont.). Emissions to air by municipality. 1991 and 1992. Tonnes, CO_2 in 1000 tonnes

	1991				1992			
	CO_2 1000 tonnes	SO_2	NOx	NMVOC	CO_2 1000 tonnes	SO_2	NOx	NMVOC
Finnmark	320	1093	2002	2865	309	780	1917	2894
Vardø	8	7	35	58	7	5	35	59
Vadsø	28	71	122	200	31	84	128	203
Hammerfest	20	26	104	211	20	25	108	217
Guovdageaidnu-Kautokeino	13	8	117	196	14	8	121	203
Alta	52	36	384	586	46	28	303	592
Loppa	2	2	15	33	2	2	15	34
Hasvik	3	2	17	25	3	2	19	28
Kvalsund	9	5	80	99	10	5	81	99
Måsøy	4	4	21	42	4	4	21	42
Nordkapp	14	29	64	105	9	8	57	94
Porsanger	25	13	161	267	25	11	162	262
Kárášjohka - Karasjok	10	6	85	149	11	6	86	150
Lebesby	5	4	40	63	5	4	41	62
Gamvik	5	4	26	41	4	3	25	46
Berlevåg	4	2	30	46	4	2	30	46
Deatnu - Tana	15	9	125	180	15	9	126	174
Unjárga - Nesseby	7	4	65	87	7	4	66	85
Båtsfjord	6	5	31	48	6	4	31	49
Sør-Varanger	88	856	480	430	84	566	463	449
Other regions	13033	17403	134569	76415	13371	15066	132572	85035
Spitsbergen	102	447	193	127	104	448	188	121
Bjørnøya	0	0	1	0	0	0	1	0
Hopen	0	0	0	0	0	0	0	0
Jan Mayen	0	0	1	0	0	0	1	0
Cont. shelf south of 62°N	10203	13923	101076	74892	10564	12196	101117	83592
Cont. shelf north of 62°N	1357	2868	29556	1117	1252	2276	27307	1027
Air space above 1000 m	1371	165	3743	279	1450	147	3959	295

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B7. International emissions of CO_2 from energy use. Million tonnes CO_2. Emissions per GDP and per capita

	1970	1975	1980	1985	1990	Per unit GDP (tonnes/1000 US$)[1] 1990	Per capita (tonnes/capita) 1990
Whole world	14640	15744	18792	19580	21562	..	4.1
OECD	8848	9321	10150	9694	10361	0.86	12.1
Norway	28	28	32	30	32	0.55	7.5
Denmark	64	56	64	64	56	0.91	12.7
Finland	41	47	60	53	55	0.89	11.4
Sweden	98	85	75	65	56	0.48	6.5
France	443	462	499	395	385	0.49	7.1
Italy	307	342	382	369	411	0.54	7.2
Netherlands	161	175	184	167	183	0.95	12.8
Portugal	16	22	27	28	43	0.63	4.2
United Kingdom	662	614	601	574	598	0.82	10.6
Switzerland	39	39	42	41	44	0.38	6.6
Germany	1018	994	1092	1039	989	..	12.0
Canada	342	402	439	406	437	1.05	16.1
USA	4267	4444	4913	4732	5038	1.12	19.9
Japan	781	912	937	912	1060	0.57	8.7

[1] GDP expressed in 1985 prices.
Sources: OECD 1993a and OECD 1993b

Table B8. Deposition of reduced nitrogen in Norway. 1985-1993*. 1000 tonnes as N. Annual average change in per cent

Emissions from	1985	1988	1989	1990	1991	1992	1993*	Av change 1985-1993*	Av. change[1] 1992-1993*
Norway	16.7	16.8	17.1	16.8	16.8	17.4	15.7	-0.8	-9.8
Sweden	1.4	1.5	0.9	1.1	1.1	1.0	1.3	-0.9	30.0
Finland	0.4	0.2	0.2	0.3	0.2	0.2	0.3	-3.5	50.0
Denmark	3.3	4.0	3.3	3.9	2.9	3.2	2.6	-2.9	-18.8
Netherlands	2.2	2.7	2.0	2.7	2.1	2.0	1.4	-5.5	-30.0
United Kingdom	3.0	3.2	4.4	4.3	3.2	3.3	2.0	-4.9	-39.4
Germany	5.4	6.7	5.2	5.2	4.2	3.8	3.0	-7.1	-21.1
France	2.1	2.0	2.1	2.8	1.3	1.5	1.2	-6.8	-20.0
Belgium	0.6	0.7	0.5	0.8	0.5	0.4	0.3	-8.3	-25.0
CIS	2.3	2.0	1.0	1.3	1.6	0.8	2.4	0.5	200.0
Poland	2.2	3.0	1.8	1.7	2.6	1.3	1.6	-3.9	23.1
Czech./Slov.	0.4	0.4	0.4	0.3	0.5	0.5	0.4	0.0	-20.0
Other countries	1.9	1.3	1.9	2.0	1.3	1.8	1.3	-4.6	-27.8
Unspecified	11.9	10.6	14.6	15.3	12.1	12.9	9.4	-2.9	-27.1
TOTAL	53.8	55.1	55.4	58.5	50.4	50.1	42.9	-2.8	-14.4

[1] For 1992 and 1993 the emissions on which the calculations are based are the same. The changes can therefore be attributed to climatic conditions.
Source: Tuovinen et al. 1994

Table B9. Deposition of oxidized nitrogen in Norway. 1985-1993*. 1000 tonnes as N. Annual average change in per cent

Emissions from	1985	1988	1989	1990	1991	1992	1993*	Av. change 1985-1993*	Av. change[1] 1992-1993*
Norway	5.5	6.2	6.2	5.8	6.2	6.1	5.4	-0.2	-11.5
Sweden	5.3	5.1	3.5	3.9	3.7	3.5	4.8	-1.2	37.1
Finland	1.5	1.0	0.9	1.2	0.9	0.9	1.3	-1.8	44.4
Denmark	2.6	3.5	2.8	3.1	3.3	3.1	2.8	0.9	-9.7
Netherlands	2.4	4.4	3.2	4.5	3.6	3.3	2.4	0.0	-27.3
United Kingdom	14.5	20.0	26.1	26.7	21.6	22.3	14.5	0.0	-35.0
Germany	12.2	18.2	13.8	13.3	13.3	11.7	10.1	-2.3	-13.7
France	2.6	3.9	4.1	6.0	2.8	3.4	2.3	-1.5	-32.4
Belgium	1.1	1.9	1.6	2.1	1.5	1.6	1.1	0.0	-31.3
CIS	2.5	2.4	1.1	1.8	1.7	1.0	2.6	0.5	160.0
Poland	3.0	4.1	2.2	2.1	3.5	1.9	2.3	-3.3	21.1
Czech./Slov.	1.6	1.9	1.4	1.7	2.3	1.7	1.6	0.0	-5.9
Ocean	2.5	3.0	2.9	3.4	2.6	2.6	2.1	-2.2	-19.2
Other countries	2.0	1.4	2.8	3.0	1.5	2.3	1.7	-2.0	-26.1
Unspecified	16.5	15.0	18.9	20.6	16.4	16.1	13.7	-2.3	-14.9
TOTAL	75.8	92.0	91.5	99.2	84.9	81.5	68.7	-1.2	-15.7

[1] For 1992 and 1993 the emissions on which the calculations are based are the same. The changes can therefore be attributed to climatic conditions.
Source: Tuovinen et al. 1994

Table B10. Deposition of oxidized sulphur in Norway. 1985-1993*. 1000 tonnes as S. Annual average change in per cent

Emissions from	1985	1988	1989	1990	1991	1992	1993*	Av. change 1985-1993*	Av. change[1] 1992-1993*
Norway	11.6	8.2	7.0	6.2	5.5	4.9	4.4	-11.4	-10.2
Sweden	5.3	4.3	2.1	1.9	1.6	1.4	1.9	-12.0	35.7
Finland	2.2	1.2	0.8	1.1	0.7	0.6	0.9	-10.6	50.0
Denmark	3.3	3.7	2.4	2.5	3.0	2.8	2.6	-2.9	-7.1
Netherlands	1.2	2.1	1.3	1.6	1.0	0.9	0.6	-8.3	-33.3
United Kingdom	21.6	27.5	35.1	36.2	25.1	24.6	15.4	-4.1	-37.4
Germany	22.2	27.9	19.1	18.6	16.4	11.6	13.0	-6.5	12.1
France	2.4	3.0	2.8	3.7	1.8	1.9	1.4	-6.5	-26.3
Belgium	1.7	2.4	1.8	2.6	1.6	1.1	0.8	-9.0	-27.3
CIS	18.1	13.4	10.6	11.7	11.5	8.8	10.4	-6.7	18.2
Poland	8.0	11.4	6.8	5.1	8.1	4.1	5.4	-4.8	31.7
Czech./Slov.	4.1	4.8	3.3	3.9	4.4	2.8	3.0	-3.8	7.1
Ocean	2.4	3.0	3.0	3.4	2.6	2.6	2.0	-2.3	-23.1
Natural sources[2]	3.1	2.7	3.7	3.6	3.0	3.2	2.1	-4.8	-34.4
Other countries	3.6	2.1	3.9	4.6	2.6	3.0	2.5	-4.5	-16.7
Unspecified	37.0	34.7	43.4	44.8	37.5	39.2	31.2	-2.1	-20.4
TOTAL	147.8	152.4	147.1	151.5	126.4	113.5	97.6	-5.1	-14.0

[1] For 1992 and 1993 the emissions on which the calculations are based are the same. The changes can therefore be attributed to climatic conditions. [2] Emissions from natural sources in marine areas.
Source: Tuovinen et al. 1994

Table B11. Concentration of NO_2 and SO_2 in air. Winter 1993/94 and average for the winters 1988/89 - 1992/93. µg/m³

Measurement site	Location[1]	NO_2 Mean value 88/89-92/93	NO_2 Mean value 93/94	NO_2 Highest 24-hour mean value 93/94	NO_2 No. days with values exceeding the recommended limit[2]	SO_2 Mean value 88/89-92/93	SO_2 Mean value 93/94	SO_2 Highest 24-hour mean value 93/94	SO_2 No. days with values exceeding the recommended limit[2]
Halden	S	34	27	67	-	9	..	..	..
Fredrikstad	S	47	52	105	20	9	8	44	-
Oslo	S	59	53	118	17	15	12	29	-
Lillehammer	S	60	44	111	12	10	..	..	..
Drammen	S	68	75	134	80	11	6	26	-
Skien	S	55	58	105	29	9	7	24	-
Kristiansand	S	31	30	68	-	6	3	41	-
Stavanger	S	59	63	146	45	..	..	..	..
Bergen	S	49	63	204	51	8	..	..	..
Trondheim	S	51	61	135	38	6	5	27	-
Tromsø	S	26	26	55	-	6	..	..	..
Sarpsborg	I	..	..	..	..	42	19	135	1
Øvre Årdal	I	..	..	..	..	28	17	50	-
Pasvik	I	..	..	..	..	21	8	196	2

[1] Location: S = street, I = close to industry.

[2] The recommended limit for the 24-hour average is 75 µg/m³ for NO_2 and 90 µg/m³ for SO_2.

Source: Norwegian Institue for Air Research

Table C1. Stock development of some important fish species. 1976-1994. 1 000 tonnes

Year	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arctic saithe[2]	Greenland halibut[1]	Barents Sea capelin[3]	Norwegian spring-spawning herring[4]	North Sea herring[4]
1976	2570	470	610	130	6790	150	80
1977	2130	310	470	110	5460	300	50
1978	1800	280	460	90	5890	370	60
1979	1490	290	420	120	5560	410	100
1980	1200	250	540	90	6970	470	130
1981	1200	190	530	100	4290	480	200
1982	1010	120	470	100	3750	470	280
1983	750	70	480	120	4230	560	430
1984	870	60	400	110	2860	610	730
1985	1000	160	370	110	820	530	760
1986	1240	270	350	110	120	410	820
1987	1120	250	360	110	100	780	940
1988	830	160	360	110	430	2300	1150
1989	1020	130	330	110	870	2750	1390
1990	1170	120	410	100	5830	2680	1260
1991	1690	150	510	100	7100	2760	1150
1992	2170	230	590	60	5150	2450	990
1993	2620	310	620	70	800	2310	730
1994	2280	290	700	60	200	2520	970

Year	North Sea cod[3]	North Sea haddock[5]	North Sea saithe[3]	North Sea whiting[5]	Plaice[3]	Sole[3]	Blue whiting (northern and southern stock)[5]
1976	550	870	740	1080	450	50	..
1977	760	560	560	750	480	60	..
1978	720	640	460	730	480	60	..
1979	730	650	490	910	470	50	..
1980	900	1220	450	810	490	40	..
1981	680	660	540	610	490	50	5170
1982	770	820	590	470	560	60	4090
1983	600	730	690	500	550	70	3660
1984	670	1450	650	470	560	70	3430
1985	430	830	590	430	550	60	3430
1986	560	650	540	630	650	50	3580
1987	470	1040	400	520	630	60	3040
1988	370	410	360	410	620	70	2660
1989	350	360	380	540	580	100	2570
1990	270	310	340	460	540	120	2550
1991	250	720	390	450	460	110	3500
1992	370	610	430	450	470	110	3040
1993	270	990	400	460	420	100	2600
1994	500	670	460	510	410	100	2560

[1] Fish 3 years old or more. [2] Fish 2 years old or more. [3] Fish 1 year old or more. [4] Spawning stock.
[5] Fish 0 years old or more.
Sources: ICES Working Group reports and Institute of Marine Research, Bergen

Table C2. Norwegian catch by group of fish species. 1986-1994*. 1 000 tonnes

	1986	1987	1988	1989	1990	1991	1992	1993*	1994*
Total	1790	1804	1686	1725	1519	1949	2354	2328	2280
Cod	270	305	252	186	125	164	219	276	375
Haddock	58	75	63	39	23	25	40	45	73
Saithe	131	152	148	145	112	140	167	188	187
Tusk	33	30	23	32	28	27	26	27	20
Ling/blue ling	28	25	24	29	24	23	21	20	19
Greenland halibut	8	7	9	11	24	33	12	15	13
Norway haddock (red-fish)	24	18	25	27	41	56	38	32	26
Others and unspecified	24	34	29	29	30	44	31	32	30
Capelin	273	142	73	108	92	576	807	530	113
Mackerel	157	159	162	143	150	179	207	224	258
Herring	331	347	339	275	208	201	227	351	536
Sprat	5	10	12	5	6	34	33	47	44
Other industrial fish species[1]	450	500	526	696	655	447	526	541	587

[1] Includes lesser silver smelt/greater silver smelt, Norway pout, small sandeel, blue whiting and horse mackerel.
Source: Directorate of Fisheries

Table C3. Use of antibiotics in fish farming. 1981-1994. kg of active agent

Year	Total	Oxytetra-cycline-chloride	Nifura-zolidone	Oxolinic acid	Trimetoprim + sulfadiazine (Tribrissen)	Sulfa-merazine	Flume-quine	Flor-fenikol
1981	3640	3000	-	-	540	100	-	-
1982	6650	4390	1600	-	590	70	-	-
1983	10130	6060	3060	-	910	100	-	-
1984	17770	8260	5500	-	4000	10	-	-
1985	18700	12020	4000	-	2600	80	-	-
1986	18030	15410	1610	-	1000	10	-	-
1987	48570	27130	15840	3700	1900	-	-	-
1988	32470	18220	4190	9390	670	-	-	-
1989	19350	5014	1345	12630	32	-	329	-
1990	37432	6257	118	27659	1439	-	1959	-
1991	26798	5751	131	11400	5679	-	3837	-
1992	27485	4113	-	7687	5852	-	9833	-
1993	6144	583	78	2554	696	-	2177	56
1994	1396	341	-	811	3	-	227	14

Source: Norwegian Medicinal Depot

Table C4. Export of some main groups of fish products. 1981-1994*. 1 000 tonnes

Year	Fresh	Frozen	Fillets	Salted or smoked	Dried	Canned	Meal	Oil
1981	24.6	58.7	74.0	13.6	86.2	15.0	266.5	107.3
1982	46.2	100.2	76.3	14.9	68.8	11.2	228.6	101.1
1983	91.5	62.6	91.6	24.9	59.4	22.4	283.9	128.0
1984	72.9	78.7	98.5	24.6	69.5	22.7	248.9	76.9
1985	74.5	79.5	95.9	20.3	64.6	23.4	173.9	114.3
1986	139.4	98.8	95.2	22.7	62.9	24.4	92.6	38.8
1987	189.6	114.2	105.0	38.0	40.6	24.3	88.3	71.3
1988	212.5	126.7	105.1	36.9	47.0	22.9	68.9	45.6
1989	215.1	159.8	95.2	46.2	48.0	23.2	45.4	39.1
1990	238.8	263.4	71.0	34.6	50.6	23.9	45.3	42.7
1991	249.6	366.9	68.7	48.6	50.3	23.0	110.8	58.5
1992	258.8	351.6	103.2	48.0	57.4	23.9	140.1	53.7
1993	309.1	412.4	141.3	66.4	62.6	23.9	139.6	62.0
1994*	307.8	518.4	195.3	100.2	66.6	26.4	72.0	63.5

Source: Statistics Norway, External Trade Statistics

Table C5. Export of fish and fish products, by important recipient countries. 1983-1994*. Million NOK

Year	Total	EU-countries, total	Of this total: France	Den-mark	United Kingdom	Germany	Other countries, total	Of this total: Japan	Sweden
1983	7367.7	3186.2	568.8	337.2	1022.1	515.0	4181.3	334.5	893.7
1984	7675.2	3233.3	530.3	350.3	1026.7	545.8	4442.1	408.2	908.0
1985	8172.3	3605.0	605.1	377.1	1202.0	632.8	4567.8	463.8	872.5
1986	8749.4	4293.9	781.0	626.9	1014.2	705.5	4455.5	408.8	852.0
1987	9992.3	5597.0	1114.1	926.7	1059.1	754.2	4395.3	501.0	939.4
1988	10693.1	6107.2	1318.6	1115.1	987.2	932.3	4585.9	808.0	889.2
1989	10999.2	6416.1	1305.5	1196.0	1019.5	892.9	4583.1	755.7	918.9
1990	13002.4	8119.2	1617.1	2046.3	868.8	1046.5	4883.3	1067.5	1191.9
1991	14940.4	9114.8	1534.8	2021.9	991.0	1196.1	5825.6	1797.7	1421.5
1992	15385.2	10180.2	1850.7	1794.1	1388.9	1309.3	5205.0	1366.3	1171.1
1993	16619.1	10365.3	1835.9	1690.1	1542.3	1369.2	6253.8	1810.3	1088.4
1994*	19576.8	11734.6	2250.8	1770.1	1496.6	1700.2	7842.2	2003.8	1283.5

Source: Statistics Norway, External Trade Statistics

Table C6. Exports of fresh and frozen reared salmon 1981-1994*. 1 000 tonnes and million NOK

Year	Total		Fresh or cooled		Frozen	
	Quantity 1000 tonnes	Value Mill. NOK	Quantity 1000 tonnes	Value Mill. NOK	Quantity 1000 tonnes	Value Mill. NOK
1981	7.4	292.9	5.5	211.4	1.9	81.5
1982	9.2	395.3	7.9	330.8	1.3	64.5
1983	15.4	709.1	13.0	582.6	2.4	126.5
1984	19.7	944.9	17.3	819.1	2.4	125.8
1985	24.0	1308.3	21.4	1160.6	2.6	147.8
1986	38.9	1663.7	34.4	1458.6	4.5	205.1
1987	43.2	2174.4	39.2	1967.3	4.0	207.1
1988	66.0	3079.7	56.0	2594.9	10.0	484.8
1989	95.5	3486.1	81.1	2954.6	14.4	531.5
1990	130.7	4834.9	92.8	3423.8	37.9	1411.1
1991	126.6	4449.6	91.3	3149.3	35.4	1300.3
1992	122.1	4399.9	107.1	3881.8	15.0	518.1
1993	131.0	4553.2	117.9	4087.4	13.1	466.0
1994*	154.1	5434.2	140.9	4949.3	13.2	484.9

Source: Statistics Norway, External Trade Statistics

Table D1. Forest balance. 1994. Whole country. 1 000 m^3, bark not included

	Total	Spruce	Pine	Deciduous trees
Volume per 1/1	606 777	278 434	197 347	130 997
Total removal	11 389	7 648	2 140	1 601
Of which, total roundwood cut	9 346	6 608	1 711	1 027
Sold timber, excl. fuel wood	8 063	6 248	1 611	204
Fuel wood for sale and private use	1 080	207	57	817
Timber for own use	202	153	43	6
Other removals, sum	2 043	1 040	429	574
Waste from logging	602	396	103	103
Natural losses	1 441	644	327	471
Total increment	20 879	10 725	5 442	4 712
Volume per 31/12	616 267	281 511	200 649	134 108

Source: Statistics Norway

Table D2. Standing cubic mass and annual increment. Whole country and counties. 1994. 1 000 m^3, bark not included

	Standing cubic mass				Annual increment			
	Total	Spruce	Pine	Deciduous trees	Total	Spruce	Pine	Deciduous trees
1933	322635	170960	90002	61673	10447	5835	2535	2077
1967	435121	226168	133972	74981	13200	7131	3364	2706
1990	560303	263859	185824	110620	18524	9702	4890	3932
1994	616267	281511	200649	134108	20879	10725	5442	4712
County								
Østfold	25 910	12 973	9 467	3 470	1 020	570	288	162
Akershus/Oslo	38 121	23 131	8 829	6 162	1 686	1 061	270	355
Hedmark	112 117	56 682	44 637	10 799	4 050	2 238	1 388	424
Oppland	68 751	46 408	13 322	9 022	2 226	1 558	375	294
Buskerud	60 215	29 799	21 977	8 439	1 952	998	594	360
Vestfold	13 098	6 560	2 292	4 246	539	290	54	195
Telemark	52 936	23 279	19 804	9 853	1 667	794	497	376
Aust-Agder	31 982	9 079	16 304	6 599	907	295	414	198
Vest-Agder	23 035	3 961	11 407	7 666	741	233	258	249
Rogaland	9 083	1 402	4 209	3 472	380	118	129	133
Hordaland	19 734	5 254	8 427	6 054	803	382	218	203
Sogn og Fjordane	19 559	4 026	7 390	8 142	671	244	182	245
Møre og Romsdal	20 313	3 806	8 316	8 191	756	273	211	272
Sør-Trøndelag	32 770	16 584	10 856	5 330	877	495	243	139
Nord-Trøndelag	42 213	28 326	6 179	7 708	1 125	765	116	244
Nordland	26 519	9 973	3 148	13 398	836	381	73	382
Troms	17 049	268	1 960	14 821	549	28	64	458
Finnmark	2 864	1	2 124	738	92	0	69	23

Source: Statistics Norway

Table D3. Crown density distributed between 10% classes for spruce. Whole country. 1988-1994. Per cent

Year	Crown density classes										Average	No. trees
	90	80	70	60	50	40	30	20	10	0		
1988	51.9	20.5	10.8	6.6	2.9	2.9	2.2	0.9	0.8	0.3	83.6	2007
1989	57.5	18.7	9.7	5.5	2.7	2.4	1.2	1.1	0.8	0.5	85.1	4399
1990	57.1	17.8	9.7	5.1	3.2	2.4	2.0	1.3	0.8	0.8	84.6	4340
1991	52.6	18.2	10.2	6.2	4.2	3.2	2.6	1.5	0.8	0.5	82.5	4228
1992	47.9	19.2	12.4	7.4	4.4	3.8	2.2	1.4	0.8	0.6	81.6	4065
1993	48.2	21.1	12.2	6.6	3.1	2.8	2.3	1.7	1.3	0.7	81.7	4049
1994	47.6	20.9	11.2	6.8	4.0	3.3	2.6	2.0	1.1	0.5	81.0	3835

Source: Norwegian Institute for Land Inventory

Table D4. Crown density distributed between 10% classes for pine. Whole country. 1988-1994. Per cent

Year	Crown density classes										Average	No. trees
	90	80	70	60	50	40	30	20	10	0		
1988	47.5	25.7	12.4	7.1	1.9	2.2	2.0	0.7	0.3	0.2	83.6	1163
1989	50.7	28.3	12.6	4.6	1.5	0.9	0.5	0.4	0.3	0.2	85.7	3053
1990	51.5	27.7	12.8	4.4	1.2	0.9	0.4	0.4	0.3	0.3	86.0	2998
1991	50.4	29.9	11.6	4.3	1.5	1.1	0.7	0.2	0.1	0.2	86.1	2938
1992	40.3	30.3	16.6	7.4	2.5	1.3	0.8	0.4	0.2	0.2	83.2	2972
1993	39.8	33.8	15.2	5.4	2.3	2.0	0.7	0.4	0.1	0.3	83.5	2908
1994	37.9	33.9	16.5	6.8	2.2	1.1	0.9	0.3	0.2	0.2	83.2	2845

Source: Norwegian Institute for Land Inventory

Table E1. Cultivated agricultural land, by use. Whole country and counties. 1985 and 1994. Decares

	Total cultivated agri-cultural land	Grain and oil seed	Vege-tables, field grown	Potatoes, green fodder and silage	Fully cultivated meadow for mow-ing and pasture	Surface cultivated meadow for mow-ing and pasture	Fertilized grazing	Other culti-vated agri-cultural land	Fallow land
Whole country									
1985	8960715	3176930	46791	574576	4074097	288884	657632	101372	40433
1994	9830284	3400514	49861	563267	4451137	260591	983876	92395	28643
County 01-10									
1985	4592700	2711339	32952	249028	1274817	81633	146173	70877	25882
1994	4985232	2878416	37679	268754	1418203	76220	226654	62719	16587
01 Østfold									
1985	719086	606346	3825	25403	57993	4099	10421	9547	1452
1994	755308	638234	5063	22496	63508	4909	13308	6439	1351
02/03 Akershus/Oslo									
1985	731326	602875	2218	21660	77351	5782	12582	5415	3443
1994	793086	660772	2461	16870	81375	4009	19417	5389	2793
04 Hedmark									
1985	948160	550225	4808	70132	271635	8558	23099	12370	7333
1994	1024511	586473	4676	83927	295509	7569	32726	9788	3843
05 Oppland									
1985	865331	261724	3534	65660	459266	20818	47648	3272	3408
1994	961215	266376	4096	78498	501829	23086	82486	2866	1978
06 Buskerud									
1985	445976	258076	6512	17161	119417	11330	19543	10466	3472
1994	494949	280678	6437	16978	139532	9954	29890	9089	2391
07 Vestfold									
1985	401152	316750	7348	21048	26963	2586	4874	20037	1545
1994	422805	323859	10308	24226	36142	2612	5829	18539	1290
08 Telemark									
1985	217468	92904	1275	11081	83125	11993	8164	5604	3322
1994	237158	102610	832	9964	93685	9919	12321	6047	1780
09 Aust-Agder									
1985	99329	14427	2489	7914	63152	3580	3891	2756	1122
1994	110327	12462	2916	6283	77023	2753	5331	2968	591
10 Vest-Agder									
1985	164874	8013	944	8969	115915	12887	15951	1409	786
1994	185873	6952	890	9512	129600	11409	25346	1594	570
11 Rogaland									
1985	745612	36721	4497	75362	373877	15841	235101	3108	1106
1994	891524	30699	4658	100244	409579	15685	326414	3190	1055

Table E1 (cont.). Cultivated agricultural land, by use. Whole country and counties. 1985 and 1994. Decares

	Total cultivated agricultural land	Grain and oil seed	Vegetables, field grown	Potatoes, green fodder and silage	Fully cultivated meadow for mowing and pasture	Surface cultivated meadow for mowing and pasture	Fertilized grazing	Other cultivated agricultural land	Fallow land
12 Hordaland									
1985	417988	1225	667	10299	253562	58339	80495	12644	756
1994	453185	587	240	6845	263347	55204	114666	11778	518
14 Sogn og Fjordane									
1985	408825	1615	1449	10823	271728	47649	65100	9754	708
1994	457565	1056	1252	6856	293884	38835	106079	8861	742
15 Møre og Romsdal									
1985	545761	19566	1325	22336	435837	21333	41370	1429	2566
1994	589666	17991	375	14578	469171	20006	64132	1627	1786
16 Sør-Trøndelag									
1985	665756	132685	646	47938	445828	12054	23023	919	2663
1994	722734	155832	462	37303	469476	12775	43446	1230	2210
17 Nord-Trøndelag									
1985	774425	269681	3285	90699	374675	10121	20909	1976	3079
1994	852285	312872	3720	71907	416983	10792	30915	1989	3107
18 Nordland									
1985	489187	4012	1285	43895	377502	25067	34667	399	2360
1994	531370	3044	1108	26742	426944	19232	52286	552	1462
19 Troms									
1985	230886	74	590	18050	190465	12435	8507	261	505
1994	251584	17	337	22028	204814	8490	14879	429	590
20 Finnmark									
1985	89575	12	96	6147	75807	4412	2287	8	808
1994	95140	-	30	8010	78736	3352	4405	21	586

Source: Applications for production subsidies, Ministry of Agriculture

Table E2. Area with grain and oil seed by method of soil preparation. Autumn-sown grain. Whole country and selected counties.1989/90, 1992/93 and 1993/94*. Decares

	Grain and oil seed, total	Of this amount, autumn-sown	Autumn-ploughed land	Autumn-harrowed, no autumn ploughing	All soil prepara-tion in spring	Directly sown grain and oil seed	Unspeci-fied soil prepara-tion[1]
Whole country							
1989/90	3649601	110465	2977341	..	..	9335	662970
1992/93	3668456	365735	2070250	140440	1434485	23291	..
1993/94	3643411	367500	2028636	99501	1489411	25862	..
County 01-10							
1989/90	3071938	107853	2563424	..	..	8829	499749
1992/93	3109574	363803	1878226	136557	1073765	21046	..
1993/94	3081343	364136	1725418	92926	1238320	24680	..
01 Østfold							
1989/90	660337	35139	604733	..	..	3371	52212
1992/93	691565	137185	500796	19329	167770	3676	..
1993/94	676580	138400	458915	16036	196322	5308	..
02/03 Akershus/Oslo							
1989/90	699503	25012	626148	..	..	1203	72168
1992/93	684334	94230	448830	28653	203342	3509	..
1993/94	691314	104353	425108	22181	239551	4474	..
04 Hedmark							
1989/90	657356	7082	496208	..	..	470	160710
1992/93	657517	16520	365388	35011	254493	2597	..
1993/94	641123	13628	305895	24477	307236	3515	..
05 Oppland							
1989/90	287309	7548	214449	..	..	1081	71814
1992/93	286823	5103	139748	15165	129509	2410	..
1993/94	283593	3396	131821	8013	140721	3038	..
06 Buskerud							
1989/90	306307	10993	250370	..	..	447	55489
1992/93	307442	32363	158931	14428	130068	4024	..
1993/94	306085	29812	143175	9365	149268	4277	..
07 Vestfold							
1989/90	327163	16923	275099	..	..	2236	49823
1992/93	342658	69091	203902	17589	117067	4111	..
1993/94	350696	62579	204370	8830	134143	3353	..
08 Telemark							
1989/90	107438	4456	79454	..	..	20	27966
1992/93	110681	8404	50061	4894	55470	258	..
1993/94	106313	10189	46186	3264	56691	172	..

Table E2 (cont.). Area with grain and oil seed by method of soil preparation. Autumn-sown grain. Whole country and selected counties.1989/90, 1992/93 and 1993/94*. Decares

	Grain and oil seed, total	Of this amount, autumn-sown	Autumn-ploughed land	Autumn-harrowed, no autumn ploughing	All soil preparation in spring	Directly sown grain and oil seed	Unspecified soil preparation[1]
09 Aust-Agder							
1989/90	16319	700	11812	..	..	-	4511
1992/93	18211	530	7260	1093	9409	461	..
1993/94	16347	813	6710	239	8890	509	..
11 Rogaland							
1989/90	50788	32	4881	..	..	344	45553
1992/93	39235	132	3162	-	35730	345	..
1993/94	39461	692	4434	187	34500	341	..
16 Sør-Trøndelag							
1989/90	165710	111	123439	..	..	105	42183
1992/93	166985	322	54316	2724	109458	478	..
1993/94	168305	376	88993	1906	77246	160	..
17 Nord-Trøndelag							
1989/90	327353	1371	268567	..	..	57	58706
1992/93	328013	1479	130098	980	196021	916	..
1993/94	331523	2296	201515	3794	125676	539	..

[1] Area with grain and oil seed for which annual comparison of soil preparation method is impossible.
Source: Statistics Norway, Sample censuses of agriculture

Table E3. Nutrient balance for agricultural areas in use. Norway. 1985 - 1993. 1000 tonnes

	1000 tonnes nitrogen				1000 tonnes phosphorus		
Year	In manure	NH_3 loss	Commercial fertilizer	Removed in crops	In manure	Commercial fertilizer	Removed in crops
1985	72.03	25.65	110.80	86.01	11.82	24.83	17.90
1986	71.66	25.51	106.01	80.46	11.79	22.75	16.65
1987	70.08	24.95	109.81	83.97	11.58	21.95	17.44
1988	68.55	24.41	111.21	81.86	11.33	19.70	16.72
1989	68.23	24.33	110.14	80.68	11.21	17.38	16.54
1990	69.04	24.30	110.42	96.77	11.36	16.00	19.88
1991	69.33	24.77	110.79	94.99	11.39	15.19	19.38
1992	70.41	25.22	110.88	79.60	11.58	14.82	15.97
1993	69.06	24.24	109.30	92.23	11.34	13.72	18.67

Sources: Statistics Norway, Ministry of Agriculture and the National Agricultural Inspection Service

Table E4. Animal farms with less than 4 decares fully cultivated spreading area per animal manure unit (amu). Surplus amu as per cent of all amu. Whole country and counties. 1985 and 1994

	Farms with less than 4 decares fully cultivated land per amu								Surplus amu
	Total farms		Farms with 1-9 amu		Farms with 10-20 amu		Farms with more than 20 amu		
	No. farms	Per cent of all animal farms	No. farms	Per cent of all farms with 1-9 amu	No. farms	Per cent of all farms with 10-20 amu	No. farms	Per cent of all farms with more than 20 amu	as per cent of all amu
Whole country									
1985	12662	18	4274	11	3353	19	5035	35	11
1994	9148	17	2628	12	2294	15	4226	26	8.3
County 01-10									
1985	1959	8	723	5	550	9	686	16	6
1994	1364	7	362	5	287	5	715	14	5.0
01 Østfold									
1985	123	7	25	3	21	5	77	14	10
1994	107	7	14	3	15	5	78	13	8.4
02/03 Akershus/Oslo									
1985	81	5	25	3	18	5	38	8	6
1994	72	6	21	4	9	4	42	8	5.5
04 Hedmark									
1985	252	6	94	4	56	5	102	10	4
1994	180	6	39	3	27	3	114	10	3.4
05 Oppland									
1985	574	9	165	5	206	9	203	16	3
1994	368	7	89	5	98	5	181	12	3.2
06 Buskerud									
1985	205	8	107	7	60	9	38	15	4
1994	125	7	46	5	35	6	44	13	3.7
07 Vestfold									
1985	83	8	13	2	16	8	54	20	7
1994	86	11	4	1	11	7	71	20	8.2
08 Telemark									
1985	237	12	131	9	52	15	54	39	8
1994	136	9	50	5	30	9	56	31	7.0
09 Aust-Agder									
1985	125	10	53	6	38	15	34	31	7
1994	89	9	24	4	24	9	41	28	7.1
10 Vest-Agder									
1985	279	12	110	7	83	18	86	36	12
1994	201	11	75	8	38	8	88	28	8.0

Table E4. (cont.). Animal farms with less than 4 decares fully cultivated spreading area per animal manure unit (amu). Surplus amu as per cent of all amu. Whole country and counties. 1985 and 1994

	Farms with less than 4 decares fully cultivated land per amu								Surplus amu
	Total farms		Farms with 1-9 amu		Farms with 10-20 amu		Farms with more than 20 amu		
	No. farms	Per cent of all animal farms	No. farms	Per cent of all farms with 1-9 amu	No. farms	Per cent of all farms with 10-20 amu	No. farms	Per cent of all farms with more than 20 amu	as per cent of all amu
11 Rogaland									
1985	4451	64	671	31	970	70	2810	84	30
1994	3496	56	467	30	752	58	2277	68	21.1
12 Hordaland									
1985	2018	30	970	20	555	43	493	70	16
1994	1523	28	748	23	382	29	393	50	11.7
14 Sogn og Fjordane									
1985	2204	33	1049	25	777	43	378	60	13
1994	1462	28	610	22	575	32	277	37	13.7
15 Møre og Romsdal									
1985	743	11	273	7	220	13	250	21	5
1994	459	9	159	7	140	9	160	12	3.5
16 Sør-Trøndelag									
1985	293	6	77	4	92	5	124	9	3
1994	190	5	39	3	46	3	105	7	2.3
17 Nord-Trøndelag									
1985	256	6	43	3	61	4	152	9	3
1994	222	6	32	4	41	4	149	8	3.8
18 Nordland									
1985	398	8	248	8	72	5	78	9	3
1994	236	6	106	6	40	3	90	9	3.1
19 Troms									
1985	255	8	157	8	48	6	50	18	4
1994	147	7	68	7	28	4	51	14	4.1
20 Finnmark									
1985	85	10	63	11	8	5	14	9	5
1994	49	8	37	13	3	2	9	6	3.9

Source: Application for production subsidies, Ministry of Agriculture

Table F1. Inputs of phosphorus (P) and nitrogen (N) to the North Sea[1]. 1990[2]. 1000 tonnes

	P			N		
	Total	Inputs from rivers	Direct inputs	Total	Inputs from rivers	Direct inputs
Total	55	48	7	1451	907	544
Belgium[3]	2.0	2.0	..	30	30	..
Denmark	2.8	1.9	0.9	64	59	5
France	8.4	8.4	..	112	110	2
Netherlands[4]	24.1	21.0	3.1	346	330	16
Norway	1.9	1.1	0.8	58	48	10
Sweden	1.4	1.3	0.1	39	35	4
United Kingdom	2.9	0.8	2.1	187	105	82
Germany[4]	11.1	11.0	0.1	190	190	0
Atmospheric depositions				425	..	425

[1] Including the English Channel, Kattegat and Skagerrak.
[2] 1991 figures for Norway.
[3] Direct inputs insignificant compared with inputs from Scheldt.
[4] Including inputs from upstream countries.
Source: NSTF 1993

Table F2. Municipal waste water treatment plants. Hydraulic capacity (p.u.) and number of plants by size category and purification principle. 1993

		Size category (p.u.)					
Purification principle	Total	50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total p.u.	4837378	24575	176171	306882	791410	1193740	2344600
Mechanical	1281715	10859	93033	104453	318230	411140	344000
Chemical	2685047	950	6263	59894	314740	727600	1575600
Biological	61320	975	16190	35155	9000	-	-
Chemical / biological	752460	1350	31870	102800	136440	55000	425000
Unconventional	48977	10157	28040	2280	8500	-	-
Other / unknown	7859	284	775	2300	4500	-	-
Total number of plants	1822	367	833	339	204	63	16
Mechanical	835	165	443	115	86	23	3
Chemical	219	13	25	59	75	36	11
Biological	133	15	74	40	4	-	-
Chemical / biological	306	21	123	119	37	4	2
Unconventional	319	149	165	4	1	-	-
Other / unknown	10	4	3	2	1	-	-

Source: Statistics Norway

Table F3. Municipal waste water treatment plants. Hydraulic capacity by purification principle. County. 1993. p.u.

County	Total	Mechanical	Chemical	Biological	Chemical biological	Uncon-ventional	Other/ unknown
Whole country	4837378	1281715	2685047	61320	752460	48977	7859
Østfold	349025	3100	325500	3030	17395	-	-
Akershus	1050670	-	1038130	450	11655	60	375
Oslo	351105	-	-	75	350080	950	-
Hedmark	194115	-	82170	2555	109390	-	-
Oppland	247170	1570	123020	550	104950	16686	394
Buskerud	295194	5833	244537	4450	33560	6814	-
Vestfold	202125	50430	136790	280	14470	155	-
Telemark	230430	13000	192000	16150	8680	600	-
Aust-Agder	130858	91640	31250	250	6900	818	-
Vest-Agder	191960	28480	153090	1560	7760	1070	-
Rogaland	426862	168707	250460	1500	1200	495	4500
Hordaland	355715	256321	66290	3925	24930	1949	2300
Sogn og Fjordane	68352	58895	65	4450	1350	3372	220
Møre og Romsdal	85136	60771	20000	580	2740	1045	-
Sør-Trøndelag	383045	348903	7400	4360	19555	2757	70
Nord-Trøndelag	151295	126355	5620	9910	8610	800	-
Nordland	24771	15911	2100	5585	850	325	-
Troms	56120	23200	4550	935	17685	9750	-
Finnmark	43430	28599	2075	725	10700	1331	-

Source: Statistics Norway

Table F4. Number of persons connected to separate waste water treatment plants, by purification principle. Permanent settlement. County. 1993

County	Total	Direct discharge	Sludge separator	Mini treatment plant	Infiltra-tion	Sand trap	Separate sewerage solution	Sealed tank
Whole country	871415	69729	393197	11526	264584	82024	43137	7218
Østfold	34300	2271	17262	1029	1427	3228	9048	35
Akershus	57142	4805	27098	3118	12978	5654	1604	1885
Oslo	1968	-	600	120	30	1218	-	-
Hedmark	72425	2011	8394	445	48635	3835	8536	569
Oppland	66854	451	4564	42	55776	900	5121	-
Buskerud[1]	47477	1014	10905	2256	26847	1300	4822	333
Vestfold	28570	843	18845	515	1349	1688	3377	1953
Telemark	21571	826	7796	730	9824	1494	689	212
Aust-Agder	31423	2512	10032	328	9370	7078	1861	242
Vest-Agder	23659	744	11612	281	8653	1389	920	60
Rogaland[1]	45643	2157	33891	728	5787	1645	1034	401
Hordaland	144129	8368	84124	1083	27463	19491	3132	468
Sogn og Fjordane	33052	2277	12661	50	10369	7695	-	-
Møre og Romsdal[1]	34129	11956	9680	30	6426	4638	1145	254
Sør-Trøndelag[1]	43796	4305	23895	191	9446	4712	1106	141
Nord-Trøndelag	41582	2949	22668	359	5238	9426	470	472
Nordland	74017	9208	46476	170	11859	5913	247	144
Troms[1]	47281	6317	35769	-	4800	370	25	-
Finnmark[1]	22397	6715	6925	51	8307	350	-	49

[1] Figures lacking for 25 municipalities in Møre og Romsdal, 5 in Sør-Trøndelag, 5 in Finnmark, 3 in Rogaland, 1 in Buskerud and 1 in Troms. Source: Statistics Norway

Table F5. Calculated discharges of phosphorus (P) from waste water treatment plants and scattered settlements. County. 1993

County	Discharges in tonnes		Cleaning effect[1] in per cent	
	Waste water treatment plants	Scattered settle-ments	Waste water treatment plants	Scattered settle-ments
Whole country	534	398	72	32
North Sea counties	163	129	87	46
Rest of Norway	371	269	44	21
Østfold	12	15	90	27
Akershus	23	26	95	27
Oslo	12	1	91	17
Hedmark	6	16	93	64
Oppland	8	12	91	70
Buskerud	11	14	90	54
Vestfold	26	13	70	25
Telemark	13	8	80	42
Aust-Agder	20	14	42	31
Vest-Agder	32	10	46	35
Rogaland	74	28	66	18
Hordaland	85	70	42	21
Sogn og Fjordane	18	15	13	29
Møre og Romsdal	24	34	32	33
Sør-Trøndelag	92	24	19	23
Nord-Trøndelag	50	21	26	18
Nordland	10	38	66	16
Troms	9	27	53	12
Finnmark	9	12	43	30

[1] Shows the share of the substance removed from the waste water.
Source: Statistics Norway

Table F6. Municipal sewerage system. Annual cost per subscriber and degree of coverage in the municipalities. County. 1993

County	Annual cost per subscriber[1]. NOK: Arithmetic mean	Annual cost per subscriber[1]. NOK: Weighted[3] mean	Degree of coverage[2]: Arithmetic mean	Degree of coverage[2]: Weighted[3] mean
Whole country	3000	2200	0.69	0.80
North Sea counties	4100	2600	0.61	0.76
Rest of Norway	2200	1600	0.74	0.88
Østfold	3300	2900	0.76	0.90
Akershus/Oslo	3200	2300	0.74	0.74
Hedmark	4500	3300	0.59	0.70
Oppland	4800	3600	0.51	0.66
Buskerud	4200	3100	0.55	0.70
Vestfold	2900	1900	0.75	0.92
Telemark	2900	2200	0.64	0.83
Aust-Agder	5700	2800	0.51	0.79
Vest-Agder	4900	3300	0.46	0.76
Rogaland	2000	1700	0.80	0.74
Hordaland	2400	1500	0.70	1.06
Sogn og Fjordane	2100	1800	0.78	0.83
Møre og Romsdal	1600	1600	0.93	0.77
Sør-Trøndelag	2500	1300	0.68	0.92
Nord-Trøndelag	3900	2500	0.61	0.82
Nordland	2100	1400	0.66	0.84
Troms	2300	1500	0.78	0.87
Finnmark	1200	800	0.71	0.80

[1] Interest = 10 per cent. Depreciation time = 20 years.
[2] Collected charges in the municipalities / annual costs in the municipalities.
[3] Weighted according to the number of subscribers connected to the waste water pipeline network in the municipalities.

Source: SN 1994

Table G1. Municipal waste delivered for recovery of materials, by type of waste and material. Norway. 1992 and 1993. Tonnes

	1992			1993		
	Total	Household waste	Industrial waste	Total	Household waste	Industrial waste
Total	185541	92863	92678	239928	154794	85134
Paper and cardboard	90703	60860	29843	141668	112443	29224
Glass	14613	11682	2931	17335	14573	2761
Plastic	1055	154	901	760	11	749
Rubber and tyres	1861	116	1745	2083	294	1789
Iron and other metals	36711	7143	29568	34153	15562	18591
Food, slaughter and fish waste	9280	1170	8110	9708	1590	8118
Wood waste	5374	603	4771	19596	3109	16487
Textiles	1214	1206	8	5525	5435	90
Other	24731	9929	14802	9100	1775	7325

Source: SN 1994b

Table G2. Municipal waste delivered for recovery of materials, by method of sorting and material. Norway. 1993. Per cent

	Regular collection at source	Sporadic collection at source	Centrally placed container	Container in neighbourhood	Sorted at waste treatment facility
Total	50	6	17	6	21
Paper and cardboard	71	3	12	4	11
Glass	25	1	54	20	0
Plastic	40	60	0	-	-
Rubber and tyres	18	19	0	0	62
Iron and other metals	3	27	17	4	48
Food, slaughter and fish waste	97	-	0	-	3
Wood waste	-	-	11	15	74
Textiles	-	4	81	13	2

Source: SN 1994b

Table G3. Total quantity of municipal waste, by type. Norway. Mill. tonnes and kg per capita

	Mill. tonnes		kg per capita	
	1992	1993	1992	1993
Total	2.22	2.22	517	513
Household waste	1.04	1.10	242	254
Industrial waste	1.09	1.07	253	247
Unknown / mixed	0.09	0.05	22	12

Source: SN 1994b

Table G4 Rates of waste charges, excl. VAT. Weighted average. County. 1993

County	Normal charge NOK per year	Delivered at waste treatment facility NOK per tonne
Whole country	809	391
Østfold	822	401
Akershus	791	556
Oslo	1076	393
Hedmark	742	335
Oppland	855	409
Buskerud	737	306
Vestfold	711	402
Telemark	762	508
Aust-Agder	728	224
Vest-Agder	699	299
Rogaland	685	189
Hordaland	761	291
Sogn og Fjordane	977	466
Møre og Romsdal	929	549
Sør-Trøndelag	1022	449
Nord-Trøndelag	869	382
Nordland	770	390
Troms	969	547
Finnmark	773	444

Source: SN 1994

Table G5. Calculated quantity of production and consumer waste, by sector[1] and material. 1993. Tonnes

Material	Total	Food	Textiles	Wood product	Pulp and paper processing, graphic
Total	2967435	591270	15732	430909	1029143
Paper and cardboard	206756	26809	1749	4553	145297
Plastic	34132	9785	681	2665	9015
Glass	55093	45343	1	241	29
Tyres	400	70	31	168	24
Rubber (excl. tyres)	1228	2	6	20	42
Iron and other metals	180123	3517	716	2631	6164
Food, slaughter, fish waste	446629	441637	3874	24	194
Wood waste	878676	3500	378	379856	476539
Textiles	16320	142	2395	664	67
Stone, gravel and concrete	142760	5141	361	3844	5476
Ash	17631	138	3	3198	12891
Slag	272431	3	-	652	1124
Dust	73814	72	0	22202	1463
Sludge	250177	5657	5	131	230828
Chemicals	18758	1967	15	24	29
Other	214290	13760	2	6508	110082
Mixed, unknown	158218	33728	5516	3529	29879

Material	Chemicals	Minerals manuf.	Metals manuf.	Metal prod., machinery	Other production
Total	100113	134146	454362	208970	2788
Paper and cardboard	8167	3209	1665	14626	681
Plastic	7691	474	742	2841	236
Glass	842	7082	8	1546	2
Tyres	20	29	22	35	0
Rubber (excl. tyres)	10	134	58	956	0
Iron and other metals	7212	1351	39855	118441	235
Food, slaughter, fish waste	169	6	261	403	61
Wood waste	3054	1163	3824	10032	330
Textiles	534	11742	4	763	10
Stone, gravel and concrete	14999	67805	30789	14345	-
Ash	24	3	1357	17	-
Slag	314	6657	263297	382	3
Dust	2786	6336	40658	289	9
Sludge	6584	6240	368	360	5
Chemicals	184	16509	-	26	4
Other	17592	3501	54128	8716	1
Mixed, unknown	29931	1906	17327	35190	1211

[1] See note 1 to table G6.
Source: SN 1994a

Table G6. Calculated quantity of production and consumer waste delivered to external waste treatment facilities, by sector[1] and method of treatment / disposal. 1993. Tonnes

Method of treatment / disposal	Total	Food	Textiles	Wood products	Pulp and paper processing, graphic
Total	1599215	560112	15013	127514	215615
Recycling and/or re-use of materials	795005	420695	1718	44690	152243
Combustion, with utilization of energy	57689	8940	834	37346	4085
Combustion without utilization of energy	1770	147	362	4	-
Biological treatment	49568	45667	-	3270	46
Deposited on landfill	347581	65870	7192	17975	42243
Used as fill material	299004	3967	-	22886	5978
Sorting	46028	14393	4904	1342	11020
Other	2569	433	3	-	-

Method of treatment / disposal	Chemicals	Minerals manuf.	Metals manuf.	Metal prod. and machinery	Other production
Total	66548	83243	322332	206068	2771
Recycling and/or re-use of materials	14753	6029	38332	115742	804
Combustion, with utilization of energy	3727	137	15	2589	15
Combustion without utilization of energy	423	161	661	12	-
Biological treatment	545	28	-	11	-
Deposited on landfill	40624	8456	90663	72668	1889
Used as fill material	1604	65085	192022	7463	-
Sorting	2922	3312	638	7434	62
Other	1949	35	-	150	-

[1]Food - Manuf. of foods, beverages and tobacco products.
Textiles - Manuf. of textile products, apparel, leather and leather products.
Wood products - Manuf. of wooden products.
Pulp and paper processing, graphic - Manuf. of pulp and paper products, printing and publishing.
Chemicals - Manuf. of chemical products and of mineral oil, coal, rubber and plastic products.
Minerals manuf. - Manuf. of mineral products.
Metals manuf. - Manuf. of basic metals.
Metal prod., machinery - Manuf. of fabricated metal products and machinery.
Other production - Other manufacturing industries.

Source: SN 1994a

Table G7. Calculated quantity of production and consumer waste dealt with on own premises, by sector[1] and method of treatment / disposal. 1993. Tonnes

Method of treatment / disposal	Total	Food	Textiles	Wood products	Pulp and paper processing, graphic
Total	1368219	31158	719	303396	813528
Combustion, with utilization of energy	829297	2	156	278086	550828
Combustion, without utilization of energy	2628	435	145	1467	11
Biological treatment	16091	16075	-	6	-
Deposited on landfill	481666	4096	41	15771	261651
Used as fill material	25700	113	1	7404	817
Municipal sewerage	1334	785	15	309	217
Other	11503	9653	361	352	4

	Chemicals	Minerals manuf.	Metals manuf.	Metal prod. and machinery	Other produc-tion
Total	33565	50903	132031	2902	18
Combustion, with utilization of energy	4	15	11	180	14
Combustion without utilization of energy	16	94	-	460	-
Biological treatment	-	-	-	10	-
Deposited on landfill	30830	37156	132019	100	1
Used as fill material	2163	13638	-	1564	-
Municipal sewerage	4	-	-	1	3
Other	548	-	-	586	-

[1] See note 1 to table G6.
Source: SN 1994a

Table G8. Calculated quantity of hazardous waste, by sector[1] and hazardous waste category. 1993. Tonnes

Hazardous waste category	Total	Food	Textiles	Wood products	Pulp and paper processing, graphic
Total	320282	3045	237	824	6132
Waste oil, lubricating oil etc.	11579	464	40	453	524
Oily waste from waste treatment plants	5918	7	0	16	11
Oil-contaminated waste from drilling operations	168	-	-	-	-
Oil emulsions	1778	17	58	4	8
Organic solvents containing halogen	720	56	0	17	19
Organic solvents not containing halogen	20665	94	118	62	122
Paint, glue, varnish and printer's ink	9821	14	9	116	291
Distillation residues and tarry waste	642	2	2	23	6
Waste/batteries containing heavy metals	17292	72	6	60	302
Waste containing cyanide	6006	-	-	-	2
Discarded pesticides	5	1	-	-	-
Waste containing PCBs	26	3	-	2	0
Isocyanates	11	-	0	7	-
Other organic waste	44811	123	0	22	49
Strong acids	175890	191	2	28	3
Strong alkalis	6181	1944	1	7	2019
Other inorganic waste	18666	1	-	7	2762
Aerosol containers	0	-	-	-	-
Laboratory waste	97	56	-	0	15
Mixed / unknown	5	-	-	-	1

Hazardous waste category	Chemicals	Minerals manuf.	Metals manuf.	Metal prod. and machinery	Other production
Total	243900	320	50660	15115	48
Waste oil, lubricating oil etc.	2019	261	2024	5786	8
Oily waste from waste treatment plants	5268	15	188	413	-
Oil-contaminated waste from drilling operations	-	-	-	168	-
Oil emulsions	518	7	190	975	2
Organic solvents containing halogen	516	4	1	106	0
Organic solvents not containing halogen	19945	5	18	298	2
Paint, glue, varnish and printer's ink	8918	10	13	450	0
Distillation residues and tarry waste	594	0	3	13	-
Waste/batteries containing heavy metals	352	13	16116	370	0
Waste containing cyanide	1	-	5964	17	22
Discarded pesticides	4	0	-	0	-
Waste containing PCBs	0	-	19	1	-
Isocyanates	2	1	-	1	-
Other organic waste	32406	2	12057	152	0
Strong acids	164033	2	9439	2191	1
Strong alkalis	6	1	2019	177	8
Other inorganic waste	9293	0	2609	3989	5
Aerosol containers	-	-	0	0	-
Laboratory waste	24	0	1	2	-
Mixed, unknown	-	-	-	4	-

[1] See note 1 to table G6.
Source: SN 1994a

Table G9. Calculated quantity of hazardous waste delivered to an approved treatment facility, by sector[1] and hazardous waste category. 1993. Tonnes

Hazardous waste category	Total	Food	Textiles	Wood products	Pulp and paper processing, graphic
Total	235552	756	125	602	1921
Waste oil, lubricating oil etc.	11174	452	38	431	349
Oily waste from waste treatment plants	4917	7	-	16	11
Oil-contaminated waste from drilling operations	168	-	-	-	-
Oil emulsions	1544	17	48	3	8
Organic solvents containing halogen	641	2	-	7	6
Organic solvents not containing halogen	9800	93	26	49	76
Paint, glue, varnish and printer's ink	5128	4	5	58	213
Distillation residues and tarry waste	366	0	2	2	6
Waste/batteries containing heavy metals	3872	71	6	16	120
Waste containing cyanide	41	-	-	-	2
Discarded pesticides	5	1	-	-	-
Waste containing PCBs	0	-	-	-	-
Isocyanates	3	-	-	-	-
Other organic waste	8718	61	-	14	20
Strong acids	174467	19	-	-	0
Strong alkalis	552	20	-	-	17
Other inorganic waste	14112	1	-	7	1077
Aerosol containers	0	-	-	-	-
Laboratory waste	37	8	-	-	15
Mixed, unknown	5	-	-	-	1

Hazardous waste category	Chemicals	Minerals manuf.	Metals manuf.	Metal prod. and machinery	Other produc-tion
Total	194787	260	25841	11227	33
Waste oil, lubricating oil etc.	1990	218	2000	5690	7
Oily waste from waste treatment plants	4271	15	186	411	-
Oil-contaminated waste from drilling operations	-	-	-	168	-
Oil emulsions	404	-	165	898	1
Organic solvents containing halogen	516	4	1	104	-
Organic solvents not containing halogen	9275	4	18	257	1
Paint, glue, varnish and printer's ink	4458	9	13	368	0
Distillation residues and tarry waste	345	0	-	12	-
Waste/batteries containing heavy metals	190	4	3115	350	0
Waste containing cyanide	1	-	-	17	20
Discarded pesticides	4	0	-	0	-
Waste containing PCBs	0	-	-	-	-
Isocyanates	1	1	-	1	-
Other organic waste	154	2	8319	148	0
Strong acids	164033	2	9439	972	1
Strong alkalis	6	1	353	156	-
Other inorganic waste	9127	-	2231	1667	1
Aerosol containers	-	-	0	0	-
Laboratory waste	11	0	1	2	-
Mixed, unknown	-	-	-	4	-

[1] See note 1 to table G6.

Source: SN 1994a

Table G10. Hazardous waste delivered to the hazardous waste management system, by hazardous waste category. 1991-1994*. Tonnes

Hazardous waste category		1991	1992	1993	1994*
Total		65681	8748	98382	91963
1	Waste oil, lubricating oil etc.	29901	32896	34266	38916
2.1	Oily waste from waste treatment plants	8256	9626	10967	12790
2.2	Oil-contaminated waste from drilling operations	16590	33593	36674	19867
3	Oil emulsions	2095	1747	2051	2813
4.1	Organic solvents containing halogen	228	196	202	1425
4.2	Organic solvents not containing halogen	2150	2290	2820	3440
5	Paint, glue, varnish and printer's ink	2333	2825	2821	2773
6/7	Distillation residues and tarry waste	314	264	407	889
8/9	Waste / batteries containing heavy metals	1099	951	1245	1390
10	Waste containing cyanide	20	9	33	24
11	Discarded pesticides	16	13	45	52
12	Waste containing PCBs	16	13	27	909
13	Isocyanates	5	14	22	38
14	Other organic waste	987	1330	1523	1647
15	Strong acids	588	422	1535	778
16	Strong alkalis	288	173	267	355
17	Other inorganic waste	768	1087	3442	3771
18	Aerosol containers	7	4	6	5
19	Laboratory waste	22	29	25	64
20	Unknown	1	1	3	17

Source: Norsas AS

Table G11. Hazardous waste delivered to the hazardous waste management system[1]. County. 1991-1994*. Tonnes

County	1991	1992	1993	1994*
Total	49091	53890	61709	72090
Østfold	1990	2226	3100	5993
Akershus	3361	4080	4623	4957
Oslo	3261	2987	3744	5597
Hedmark	1010	1155	1230	1534
Oppland	1478	1149	1740	2145
Buskerud	2906	2534	2787	3581
Vestfold	2318	3238	3754	4419
Telemark	2563	2393	2200	2191
Aust-Agder	647	700	655	859
Vest-Agder	2019	1799	2689	2544
Rogaland	5816	8290	9060	10258
Hordaland	10518	10251	10681	12693
Sogn og Fjordane	1383	1822	2901	1989
Møre og Romsdal	2785	3430	4131	4206
Sør-Trøndelag	1761	2125	1985	2248
Nord-Trøndelag	976	1015	1157	1443
Nordland	2395	2539	2994	3133
Troms	1086	1398	1560	1517
Finnmark	789	718	674	747
Svalbard	29	41	42	37

[1] Oil drilling waste not included. Source: Norsas AS

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ISBN 82-537-4147-2
ISSN 0804-3221

NOK 140,00

Statistisk sentralbyrå
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Cover Design: Enzo Finger Design. Photo: Tommy Normann Hansen.