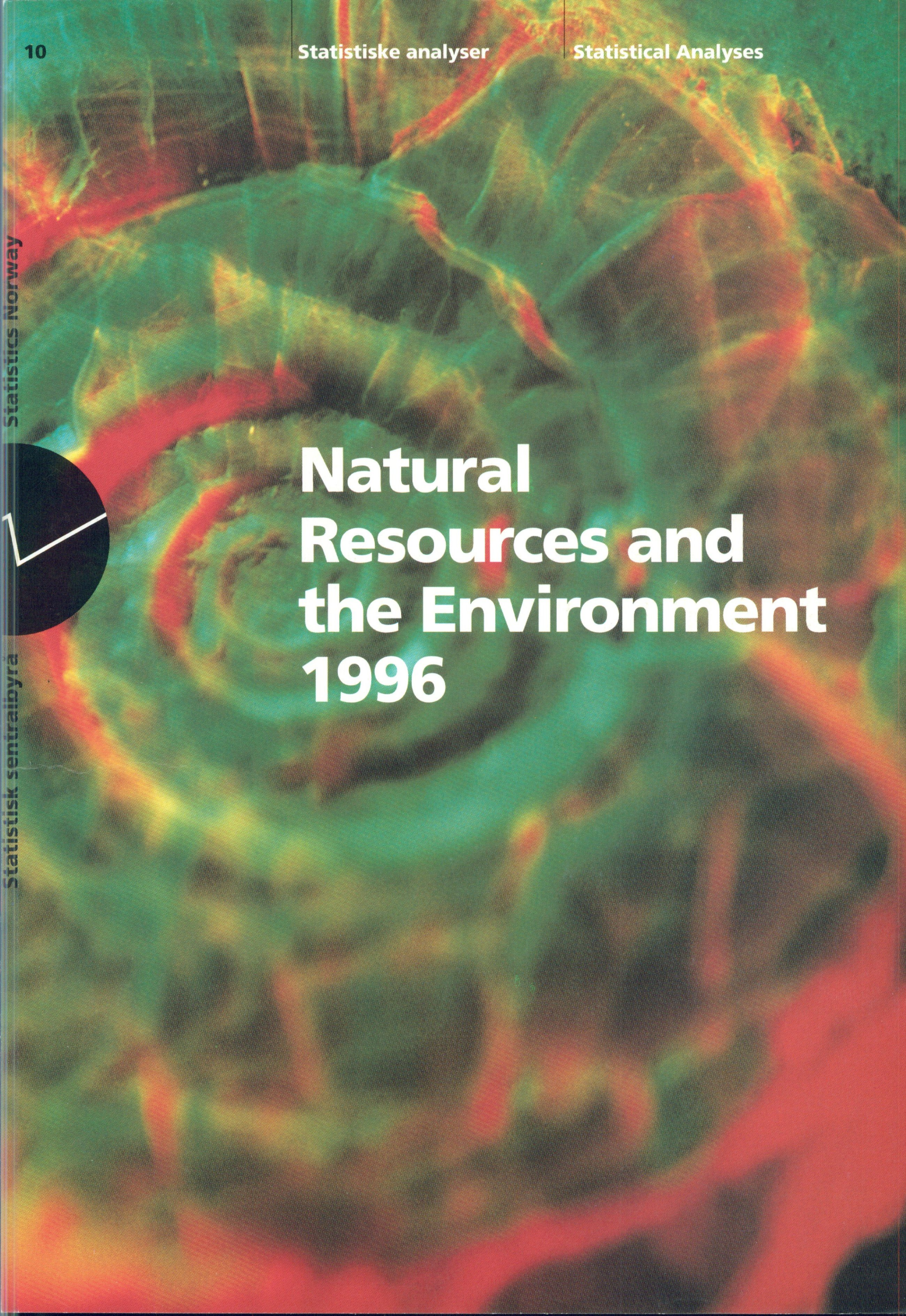

Statistisk sentralbyrå Statistics Norway

Natural Resources and the Environment 1996

Natural Resources and the Environment 1996

Statistisk sentralbyrå • Statistics Norway
Oslo-Kongsvinger 1996

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Preface

Statistics Norway compiles statistics on important natural resources and the state of the environment, and develops methods and models for analysing relationships between the environment, natural resource use and economic developments. The annual publication *Natural Resources and the Environment* gives an overview of this work.

Natural Resources and the Environment 1996 consists of three main parts. Part I contains updated resource accounts for energy and the latest official figures for emissions to air. These are followed by articles and updated statistics on fishing, sealing and whaling, forests and forest damage, agriculture, waste water treatment and waste management. The last chapter describes the results of surveys of how people experience noise and pollution in their local environment and at work. Part II presents results from Statistics Norway's research into resource and environmental economics. The main emphasis is on analyses of the environment and economic growth, management of the environment and natural resources and international analyses. Part III provides more detailed statistics in the form of tables.

Statistics Norway would like to thank the people and institutions who have supplied data for *Natural Resources and the Environment 1996.*

The report is a joint publication by the Division for Environmental Statistics, Department of Economic Statistics, and the Resource and Environmental Economics Division, Research Department, and was edited by Henning Høie. Part II was prepared by an editorial committee consisting of Torstein Bye, Sverre Grepperud and Solfrid Malo. Alison Coulthard (part I, part II, 3.1 and 3.2, and part III) and Janet Aagenæs (rest of part II) have translated the Norwegian version into English.

Statistics Norway
Oslo/Kongsvinger, 15 May 1996

Svein Longva

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Introduction

Natural Resources and the Environment 1996 provides information on important Norwegian natural resources and the natural environment in the form of statistics (*Part I* and *Part III*) and analyses (*Part II*). The information is based mainly on Statistics Norway's own material, but data have also been obtained from other sources.

Part I describes status and trends for a number of important resource and environmental parameters in Norway, with particular emphasis on pollution. *Part II* presents analyses of the relationships between use of resources, the environment and the economy. *Part III* consists of an appendix of tables which provide more detailed statistics on natural resources and environmental conditions in Norway.

The first chapter on *energy* provides updated statistics on resources and the extraction and use of crude oil, natural gas and hydropower in Norway and abroad. Energy use is considered particularly in relation to the energy market and price trends for important energy commodities.

Emissions of pollutants to air may have local, regional or global effects. The chapter on *emissions to air* deals with both emissions and pollution problems at these three levels. One of the most important questions is whether Norway will be able to achieve its national goals and meet its obligations under international agreements on emissions of gases such as CO_2, SO_2, NO_x and volatile organic compounds. Depletion of the ozone layer and climate change, which are global problems, are also discussed.

The chapter on *fishing, sealing and whaling* presents figures on fish stocks, catches and exports, and key figures on fish farming. The chapter on *forest* includes statistics on forestry in Norway and on forest resources and forest damage both in Norway and in the rest of Europe.

Various measures, mainly in the fields of *waste water management* and *agriculture,* have been implemented in order to comply with the requirements of the North Sea Declarations. These include the reduction of discharges of nitrogen and phosphorus to the North Sea by about half by 1995, using 1985 as the base year. *Natural Resources and the Environment 1996* presents the latest statistics and analyses of measures to reduce discharges of nutrients to the North Sea.

The chapter on *waste* presents data from sample surveys of the generation and management of waste and hazardous waste by manufacturing industries and the public sector. The chapter also includes data on the collection and management of municipal waste and annual records of deliveries of hazardous waste for treatment. The publication includes a thorough discussion of economic aspects of waste water treatment and waste management.

Central issues in *Part II* are the impact of economic growth on the natural environment and how natural resources should be managed. In this connection, issues such as changes in energy markets, the effects of the CO_2 tax and projections of various environmental parameters are discussed. The introductory chapter to Part II on page 93 describes its contents in more detail.

Part I. Resource and environmental statistics

1. Energy

Petroleum extraction is currently Norway's most important industry. Norway ranks sixth among the world's crude oil producers, and is the second largest exporter of crude oil after Saudi Arabia. Oil production rose by 7.3 per cent from 1994 to 1995, and gas production by 10.5 per cent. Given the current rate of extraction and the petroleum reserves estimated to exist, Norway's oil reserves will be exhausted in 14 years and its gas reserves in 97 years.

In 1995, electricity production in Norway totalled 123.2 TWh. This is the highest level of production ever recorded, and 8.6 per cent higher than the year before. Ninety-three per cent was used within the country. Electricity's share of total domestic energy use has risen from 40 per cent in 1976 to 48 per cent in 1995.

1.1 Resource base and reserves

Crude oil and natural gas

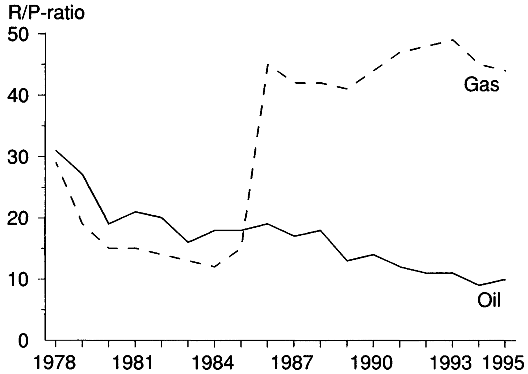
Petroleum reserves are defined as the share of the total proven resources that can profitably be extracted given current prices and technology. At the end of 1995, Norwegian reserves of crude oil in fields that are already developed or where development has been approved totalled 1 374 million tonnes, which is equivalent to 1 599 million Sm^3 o.e., and corresponds to 0.8 per cent of the world's crude oil reserves (table 1.2). Reserves of natural gas in fields that are already developed or where development has been approved totalled 1 352 billion Sm^3 (equivalent to 1 352 million Sm^3 o.e.), or 1.0 per cent of total world reserves. Trends in the estimates of Norwegian reserves are shown in tables A1 and A2 in Part III. Expressed as oil equivalents, these figures give total reserves of 2 951 million Sm^3 o.e. Given the present rate of production and cur-

Table 1.1. World reserves[1] of oil and gas as of 1 January 1996

	Oil		Gas	
	Billion Sm^3o.e.	Per cent	Billion Sm^3o.e.	Per cent
World	160.1	100.0	139.7	100.0
North America	4.3	2.7	6.5	4.7
Latin America	20.5	12.8	7.7	5.5
Western Europe	2.5	1.5	4.8	3.4
Eastern Europe and CIS	9.4	5.9	56.7	40.6
Middle East	104.8	65.5	45.2	32.4
Africa	11.6	7.3	9.5	6.8
Asia and Australasia	7.0	4.4	9.3	6.7
OPEC	123.7	77.2	57.7	41.3
Norway	1.3	0.8	1.3	1.0

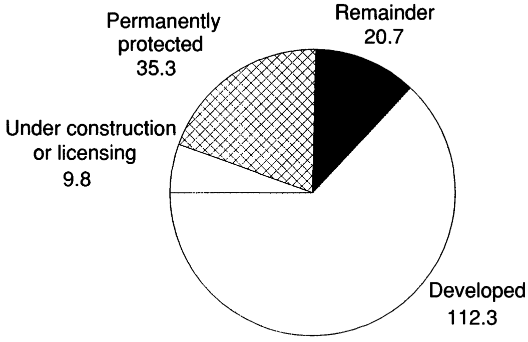
[1]For most countries, the reserves comprise proven resources which can be exploited using current technology and prices
Source: Oil & Gas Journal (1995)

Figure 1.1. Ratio between reserves and production (R/P ratio) for oil and gas. Fields already developed or where development has been approved



Sources: Statistics Norway and Norwegian Petroleum Directorate

Figure 1.2. Hydropower potential as of 1 January 1996



Source: Norwegian Water Resources and Energy Administration (NVE)

rent technology, the oil reserves in fields that are already developed or where development has been approved will be exhausted after 10 years, and the natural gas reserves after 44 years.

The ratio between reserves and production (the R/P ratio) will change with time, depending on the rate of extraction, prices, the discovery of new fields and technological developments. Historical trends in this ratio are shown in figure 1.1. The estimated petroleum reserves in fields where development has not yet been approved are about 600 million tonnes crude oil (including wet gas) and about 1 600 billion Sm^3 natural gas. The R/P ratio, including fields where development has not yet been approved, is 14 years for crude oil and 97 years for natural gas.

As of 1 January 1996, Norway's proven oil reserves were larger than those of any other European country except Russia. Russia also had Europe's largest natural remaining gas reserves, and Norway ranked third, after the Netherlands (Oil & Gas Journal 1995). In Western Europe, 54 per cent of the oil reserves and 28 per cent of the gas reserves are on the Norwegian continental shelf. At the end of 1995, the R/P ratio for the world's petroleum reserves was 45 years for crude oil and 64 years for natural gas.

Hydropower

Hydropower resources are divided into developed reserves, reserves that have been approved for development or are being considered for development, protected river systems and the remainder. As of 1 January 1996, Norway's economically exploitable hydropower reserves totalled 178.1 TWh (expressed as mean annual production capacity, i.e. the production capacity of the power stations in a year with normal precipitation. The reference period for inflow is 1931-60). Of this, 112.3 TWh was already developed and 35.3 TWh permanently protected (figure 1.2). The counties Telemark, Hordaland, Sogn og Fjordane and Nordland account for 45 per cent of Norway's developed reserves, and Nordland also has 20 per cent of the

Table 1.2. Average energy content and efficiency of energy commodities[1]

Energy	Theoretical energy content	Fuel efficiency: Manufacturing and mining	Fuel efficiency: Transport	Fuel efficiency: Other commodity
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 gas	48.6 GJ/tonne	..	..	..
Natural gas (1995)[2]	41.8 GJ/1000 Sm^3	..	..	..
Liqefied propane and butane (LPG)	46.1 GJ/tonne = 23.5 GJ/m^3	0.95	..	0.95
Fuel gas	50.0 GJ/tonne	..	..	..
Petrol	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 fuel oil no. 1 og 2	43.1 GJ/tonne = 36.2 GJ/m^3	0.80	0.30	0.70
Heavy fuel 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/fast m^3	0.65	-	0.65
Wood waste (dry weight)	16.8 GJ/tonne	..	..	..
Black liquor (dry weight)	14.0 GJ/tonne	..	..	..
Waste	10.5 GJ/tonne	..	..	..
Electricity	3.6 GJ/MWh	1.00	0.95	1.00
Uranium	430–688 TJ/tonne			

[1]The theoretical energy content of a particular energy commodity may vary. The figures therefore give mean values.
Sm^3 = standard cubic metre (at 15° C and 1 atmospheric pressure)
Sources: Statistics Norway, Norwegian Petroleum Institute, Norwegian Association of Energy Users and Suppliers, Norwegian Building Research Institute

Energy units

Quantities of both oil and gas have generally been expressed in tonnes oil equivalent (toe). In accordance with a new system introduced by the Norwegian Petroleum Directorate, this chapter instead uses a unit of volume, Sm^3 o.e.[1] (standard cubic metres oil equivalent).[2]

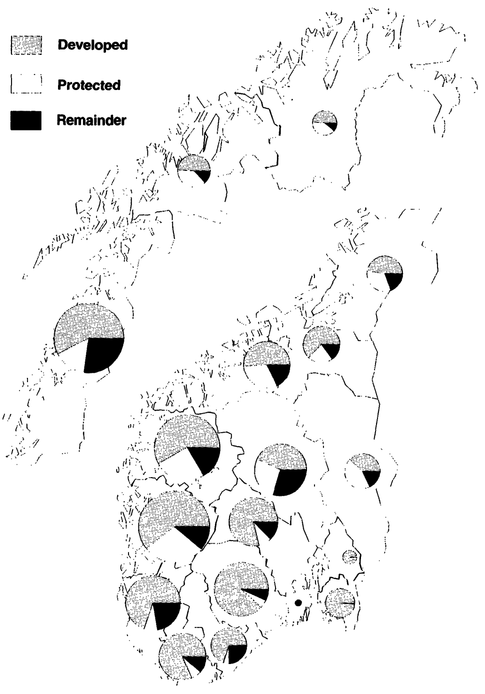
	PJ	TWh	MSm^3 o.e. oil	MSm^3 o.e. gas
1 PJ	1	0.278	0.027	0.024
1 TWh	3.6	1	0.098	0.086
1 MSm^3 o.e. oil	36.6	10.2	1	0.868
1 MSm^3 o.e. gas	41.8	11.6	1.14	1

[1]1 Sm^3 oil = 1 Sm^3 o.e., 1000 Sm^3 gas = 1 Sm^3 o.e
[2]Table A10 in Part III shows figures taken directly from other countries' reports in toe.
Sources: Statistics Norway and Norwegian Petroleum Directorate.

Prefixes

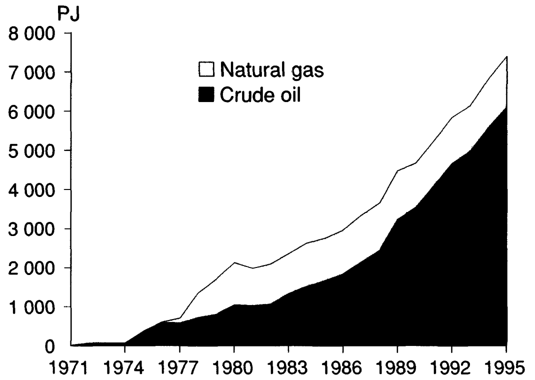
Name	Symbol	Factor
Kilo	k	10^3
Mega	M	10^6
Giga	G	10^9
Tera	T	10^{12}
Peta	P	10^{15}
Exa	E	10^{18}

Figure 1.3. Norway's hydropower reserves by county as of 1 January 1996



Digital base map: Norwegian Mapping Authority
Source: Norwegian Water Resources and Energy Administration

Figure 1.4. Extraction of crude oil and natural gas in Norway



Source: Statistics Norway

country's remaining undeveloped production capacity (figure 1.3).

Coal

At the end of 1995, Norway's proven coal reserves were about 6.1 million tonnes. Trends in the estimate of the reserves are shown in table A3 in Part III. At the current rate of extraction, the coal reserves will be exhausted in 20 years' time. At the end of 1994, the world's exploitable coal reserves were 1 044 billion tonnes. At the current rate of extraction, they will last for 235 years. The largest reserves are found in the USA, the former Soviet Union and China.

1.2 Extraction and production

Crude oil and natural gas

According to production statistics compiled by the Norwegian Petroleum Directorate, net production of crude oil and natural gas totalled 190.8 Sm^3 o.e. in 1995. This is 6.5 per cent more than the year before, continuing the steep growth in the extraction of crude oil and natural gas in Norway (figure 1.4). Oil production rose by 7.3 per cent, and the production of condensate and NGL (wet gas) by 10.5 per cent. The production of marketable natural gas rose by 3.7 per cent. In December 1995, production averaged 3.2 million barrels of oil, NGL and condensate per day, which was a new production record for the Norwegian shelf. According to the *Oil & Gas Journal* (1996), Norway accounted for 4.5 per cent of world production of crude oil and 1.3 per cent of gas production in 1995 (table 1.3). Norway is thus the world's sixth largest producer of crude oil and the second largest in Europe after Russia. According to the production forecasts in the National Budget for 1996, production of oil, NGL and condensate is expected to be maintained at about 3.2 million barrels a day from 1996 to 2000.

Table 1.3. World production of crude oil and natural gas in 1995. Million Sm^3 o.e.

	Oil	Gas
World	3 563.9	2 220.7
North America	483.9	731.5
Latin America	461.5	101.1
Western Europe	340.5	232.2
Eastern Europe and CIS	418.5	739.5
Middle East	1 092.3	131.2
Africa	369.7	75.3
Asia and Australasia	397.5	209.8
OPEC	1 465.3	266.3
Norway	161.5	27.8

Sources: Oil & Gas Journal (1996)

According to the Norwegian Petroleum Directorate, Norway's total production of crude oil (including NGL and condensate) was 163.0 Sm^3 o.e. in 1995, a rise of 7.0 per cent from the year before. The main reasons for this rise were that production started on Troll West and Heidrun, and that Statfjord North and Statfjord East came on stream in January 1995 and October 1994, respectively. In addition, production rose steeply on Draugen (by 79.3 per cent) and Tordis (by 168.1 per cent) in 1995. These fields came on stream in October 1993 and June 1994, respectively. A rise in oil production on Eko-fisk, Brage, Sleipner East and Snorre also added substantially to the overall growth in crude oil production in the course of 1995.

Because several oil fields came on stream in 1995, and production increased on relatively new fields, the share of total oil production obtained from the smaller fields rose from 30.7 per cent in 1994 to 39.1 per cent in 1995. As regards the four large fields (Statfjord, Oseberg, Gullfaks and Ekofisk), production rose by 23.9 per cent on Ekofisk, but dropped on the other three (by 18.3, 0.7 and 9.5 per cent respectively) from 1994 to 1995. According to the operating company Statoil, 1994 will probably prove to have been the peak production year for Gullfaks.

In 1995, Oseberg was for the first time the oil field where production was highest. Total production on the field in 1995 was 28.9 Sm^3 o.e. Gullfaks was close behind, producing 27.6 Sm^3 o.e. On 24 May 1995, accumulated production on Gullfaks since Gullfaks A came on stream in December 1986 reached 1 billion barrels. It is expected that oil production from Gullfaks will continue to be profitable for another 10-15 years. On Statfjord, for several years the field with the highest production on the Norwegian shelf, there was a sharp drop in production in the course of 1995, and it was overtaken by both Oseberg and Gullfaks. Production on Statfjord will probably drop to about one third of the 1994 level during the next four years. Oil production from the four fields that are currently producing most oil will drop steeply towards the end of the century. The small and medium-sized fields are expected to account for a substantially larger proportion of total oil production during the next few years.

According to figures from the Norwegian Petroleum Directorate, gas production in 1995 totalled 27.8 billion Sm^3 o.e. On Sleipner East, which came on stream in 1993, production rose by 31.5 per cent from 1994 to 1995. This was the main reason for the rise in gas production last year. Sleipner East, which produced 5.2 billion Sm^3, ranked second on the Norwegian shelf last year, after Ekofisk (7.9 billion Sm^3). In future, Sleipner East will account for a growing proportion of Norwegian supplies of gas to the continent. Production also rose considerably on Ekofisk (by 10.4 per cent). The new fields, Tordis, Statfjord North and Statfjord East, also contributed to the rise in production. On Statfjord, natural gas production dropped by 6.4 per cent from 1994 to 1995.

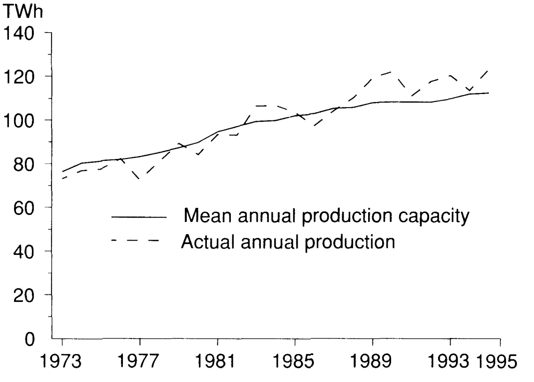
In the Frigg area, production reached only just over half the 1994 level (a reduction of 45.2 per cent). Production ceased on Odin in August 1994, and on North-east Frigg in May 1993. Production on the main field, Frigg, is expected to stop by 1998.

Electricity
Electricity production in Norway in 1995 totalled 123.2 TWh, which was the highest level ever recorded and 8.6 per cent higher than the year before (table A7 in Part III). Of this, 0.7 TWh was thermal power, 0.01 TWh wind power, and the rest hydropower. As a result of high precipitation and thus high inflow to storage reservoirs, the water level in the reservoirs was well above normal in the last six months of 1995.

Hydropower production is determined by the interplay between supply and demand in the power market. The level of demand depends on prices as well as on temperature conditions and the level of economic activity. The inflow of water to the power supply sector, and the producers' assessments of current and future prices are important in determining the electricity supply. The reservoir capacity (which is equivalent to a production of 77.8 TWh) limits the amount of water that can be stored for production at a later date. Both the mean production capacity and actual production have grown steeply since the early 1970s as a result of substantial increases in capacity. In recent years, actual production has been higher than the mean production capacity as a result of very high inflow to the reservoirs (figure 1.5).

Biofuel
Wood, wood waste and black liquor are the three most important biofuels in Norway. Production of these fuels, including production for own use, was estimated to be about 41 PJ in 1994 (this figure is uncertain because the data are incomplete). In 1994, energy equivalent to about 4.5 PJ was generated for district heating by waste incineration, and about 90 per cent of this may be classified as bioenergy. In 1994, methane with an energy content of about 9 PJ was generated in Norwegian landfills. In 1992, 4.3 per cent (0.4 PJ) of this was flared, 1.2 per cent (0.1 PJ) was used for energy purposes, and the rest was released directly to the atmosphere. Only a small proportion of the methane originates from fossil sources such as plastics and other oil-based products.

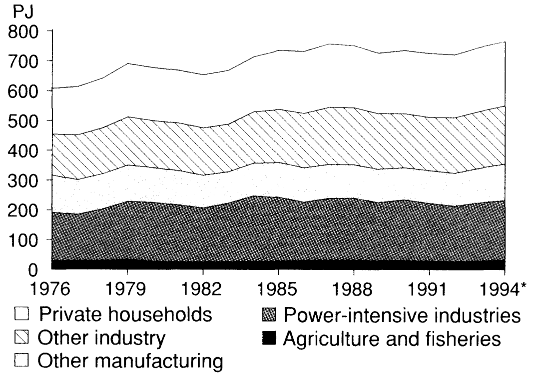
Figure 1.5. Mean annual production capacity[1] and actual hydropower production in Norway



[1]From 1994, a new reference period (1931-1990) for inflow has been used.
Source: Norwegian Water Resources and Energy Administration

Coal
Coal production on Svalbard in 1995 was equivalent to somewhat more than 8 PJ, about the same level as the year before. World coal production in 1994 was about 93 EJ. Europe, China and the USA each produced about one quarter of this total.

Figure 1.6. Domestic energy use by consumer group



Source: Statistics Norway

1.3 Energy use

Total energy use

In 1995, net energy use in the energy sectors (sectors which produce primary and secondary energy carriers) accounted for about 19 per cent of Norway's total energy use, excluding international maritime transport. Energy use in the energy sectors has risen from 34 PJ in 1976 to 189 PJ in 1995 (preliminary figures). The use of natural gas in the extraction of crude oil and natural gas accounted for 12 PJ in 1976 and 140 PJ in 1995 (see table A6 in Part III). In 1995, 99 per cent of the gas was used and the rest was flared. Energy use in the energy sectors has risen so steeply because of the very large increase in the level of activity on the Norwegian continental shelf. Particularly large amounts of energy are needed to generate power on oil platforms and to operate the pipeline systems. However, the amount of energy used per unit of crude oil and natural gas produced has been reduced in the same period.

Excluding the energy sectors and international maritime transport, the total consumption of energy commodities in Norway was 764 PJ in 1994 and 779 PJ in 1995 (preliminary figures), corresponding to a rise of 1.9 per cent (figure 1.6 and table A5 in Part III). The gross domestic product (GDP) in mainland Norway rose by 3.3 per cent and private consumption by 2.7 per cent from 1994 to 1995, showing that the Norwegian economy is becoming steadily less energy-intensive. From 1976 to 1994, energy use rose by an average of 1.3 per cent per year, and GDP by an average of 3.0 per cent.

Oil consumption

Total oil consumption, excluding international maritime transport, has dropped by 18 per cent (preliminary figure) from 1976 to 1995, despite the fact that oil consumption for transport has risen by 39 per cent. Transport now accounts for 79 per cent of total oil consumption, as compared with 47 per cent in 1976. Auto diesel and marine gas oil are the types of transport oils whose consumption has risen most, while the largest drop has been in the consumption of heavy fuel oil. The consumption of oil for stationary purposes has dropped by 68 per cent from 1976 to 1995. In 1978, sales of these oils, expressed as utilized energy, totalled about 31 TWh, whereas in 1995 the corresponding figure was only about 11 TWh (figure 1.7). It is particularly the consumption of heavy fuel oils that has dropped.

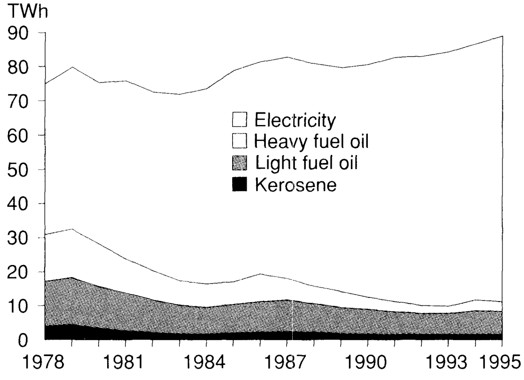
In 1976, electricity accounted for 40 per cent of total domestic energy use, rising to 48 per cent in 1995. During this period, electricity consumption outside power-intensive industries has risen by more than 90 per cent. The changeover from fuel oils to electricity took place mainly in the early 1980s. This was due partly to the high prices of fuel oils at this time, and also to the large investment costs associated with the construction of new oil-based systems and the high maintenance costs of existing systems. From 1993 to 1994, the decline in the stationary consumption of fuel oils was temporarily interrupted;

the consumption of light fuel oils rose by 8.5 per cent and that of heavy fuel oils by 55 per cent. Most of the rise occurred in manufacturing industries. However, preliminary figures for 1995 show a substantial drop in stationary consumption of heavy fuel oils compared with 1994. Sales of fuel oil no. 1 and 2 and of heating kerosene were also lower in the last six months of 1995 than in the same period in 1994. This is partly because the relative prices of fuel oil/kerosene and electricity changed, so that it became cheaper to use electricity.

Electricity consumption
Ample inflow to reservoirs and high production resulted in low spot prices for electricity in 1995, which in turn contributed to growth in domestic consumption and exports. Norway exported 8.6 TWh of electric power last year, or 7 per cent of its total production. This was a rise of 72 per cent from the year before, explained by growing demand abroad as a result of low prices on the exchange market for power exports. Imports totalled 2.2 TWh in 1995, corresponding to 2.1 per cent of net consumption. Imports dropped by 54.5 per cent from the year before.

Net domestic consumption was 106 TWh in 1995. This is a rise of 2.7 per cent from the year before, and 0.6 per cent lower than the growth in GDP for mainland Norway in the same period. Regular power consumption in 1995 totalled 72.1 TWh, an increase of 3.4 per cent from the year before. The percentage increase was the same if regular power consumption was corrected for temperature. Net electricity consumption by power-intensive industries was 28.1 TWh in 1995, a decrease of 0.3 per cent from the year before. The extremely low temperatures experienced throughout the country in December resulted in very high figures for electricity use. At the end of December 1995, load demand

Figure 1.7. Electricity consumption (excluding power-intensive industries) and sales of fuel oils and kerosene



Source: Statistics Norway

in domestic sectors exceeded 20 000 MW for the first time. On 3 January 1996, a new record was reached (20 725 MW). At the same time, there was a net export of 500 MW. Norway's installed load capacity is about 27 000 MW, and the actual demand that can be met is about 3 000 MW lower.

In some industries, such as the pulp and paper industry, it is possible to switch between electricity and oil as power sources for boilers. If the short-term price of electricity relative to the price of oil exceeds a certain level, there is a changeover to the use of oil. The price level at which this happens varies from one type of boiler to another. At today's prices and for boilers that burn light fuel oil, the changeover to oil takes place if the spot price exceeds about NOK 0.19-0.21 per kWh. For boilers that burn heavy fuel oil, the switch takes place at a somewhat lower price, since heavy fuel oil is cheaper. The changeover price for this type of boiler is currently about NOK 0.12-0.14 per kWh.

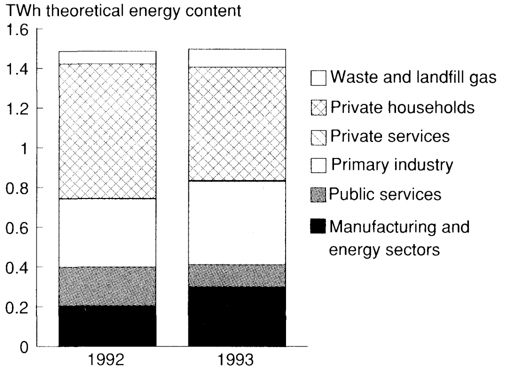
In 1995, total consumption of occasional power in electric boilers was 5.8 TWh, which is an increase of 9.2 per cent from 1994. The steep increase in the consumption of occasional power was explained by the fact that the average spot price for electricity was considerably lower than the year before. In 1995, the average spot price was NOK 0.113 per kWh, whereas the year before it was NOK 0.185 per kWh.

Energy use in the municipalities
Statistics Norway calculates the annual consumption of fossil fuels and biofuels for energy purposes in the municipalities. The figures are split by energy commodity and branch of industry. As an example of this, figure 1.8 shows energy use (theoretical energy content) for stationary combustion in Oslo municipality in 1992 and 1993 (see also table A9 in Part III).

World energy use
In 1993, Norway accounted for somewhat less than 0.28 per cent of total world energy use (table A10 in Part III), and the OECD countries for over half the total. Per capita energy use in Norway is higher than the average for the OECD countries, but lower than in Sweden and Finland. Energy intensity in Norway, measured as energy used per unit of GDP, is somewhat lower than the average for the OECD countries. The energy mix varies between continents, but oil, coal and natural gas are important energy commodities in all continents.

Energy prices
Price trends for fossil energy commodities for stationary purposes, compared with those for electricity, provide a partial explanation of trends in total consumption (figure 1.9). Table A8 in Part III shows the average prices of energy supplied. If all taxes and tariffs are included, the average price of electricity to private households was NOK 0.497 per kWh in 1995. Converted to the price per kWh utilized energy, kerosene cost

Figure 1.8. Energy use for stationary combustion in Oslo, by branch of industry



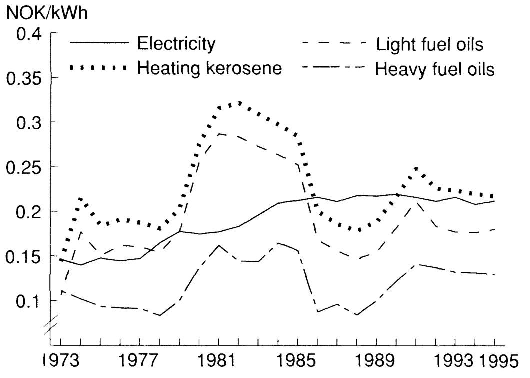
Source: Statistics Norway

NOK 0.510 per kWh and light fuel oil NOK 0.422 per kWh in 1995. This shows that the price of light fuel oil is competitive with that of electricity for heating purposes.

Despite the record levels of electricity consumption at the end of 1995, the spot price remained relatively low compared with the price in the same period in preceding years. The average spot price during the last three months of 1995 was NOK 0.117 per kWh, compared with NOK 0.261 and NOK 0.132 at the same time of year in 1994 and 1993. The low prices at the end of 1995 are explained by high inflow in autumn 1995, when the reservoirs were already well-filled and the weather was milder than normal. As a result, the spot price fell from NOK 0.15 per kWh in week 39 to about NOK 0.05 per kWh in week 45, which is very low for the time of year. The high spot prices in 1994 were a result of the low water level in the reservoirs and low inflow, combined with a cold winter.

There was a steep increase in trade on the spot market in the last few months of 1995. In recent years, sales have averaged between

Figure 1.9. Prices of fuel oils and electricity for heating (as utilized energy), in fixed 1980 prices including all taxes and tariffs



Source: Statistics Norway and Norwegian Petroleum Institute

200 and 400 GWh per week, but from October 1995, they were well above 600 GWh per week. This was partly because production was higher than expected, and also because Statnett Marked reorganized its weekly market, which had been a forward market, as a futures market. This means that buyers and sellers now receive a daily statement of profits and losses based on changes in value from the previous day. Previously, buyers and sellers were unable to alter their terms from the time a contract was signed, and did not receive any settlement for profits or losses until the time when the power was to be supplied. The changeover to a futures market has attracted more customers to both the power exchange and the weekly market. Statnett Marked has reported an increase in trade in both the spot market and the weekly market since the reorganization in September. The weekly market has now become a purely financial speculative market, while actual physical trade in power takes place in the spot market. The fact that Swedish participants now have access to the power exchange also helps to increase sales in the spot market. During the first few weeks of 1996, sales per week were about 700 GWh.

More information may be obtained from Torstein Bye, Lisbet Høgset and Trond Sandmo

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2. Air

Emissions of the greenhouse gas CO_2 rose by 7 per cent from 1989 to 1995, but overall emissions of greenhouse gases changed little from 1989 to 1994. Emissions of NO_x have decreased by 6 per cent since 1987, but there was no decrease in 1995. Emissions of non-methane volatile organic compounds (NMVOCs) rose by 13 per cent from 1989 to 1995, but with little change during the past year. Emissions of SO_2 were reduced by 76 per cent from 1980 to 1994. Sulphur deposition over Norway has dropped by 30 per cent since 1985. Deposition of oxidized and reduced nitrogen compounds totalled 107 000 tonnes in 1994. Nitrogen deposition has tended to decrease during the past decade, but there are large variations from year to year.

Emissions of pollutants to air may have local, regional or global effects. *Locally*, the most important effects are injury to health caused by a variety of substances. Such problems are often associated with towns and built-up areas. The major *regional* problems are acidification of water and soils and damage to vegetation. The *global* effects are depletion of the ozone layer and climate change. The box on page 31 summarizes the adverse effects of various air pollutants.

International environmental agreements

Protocols are the most binding type of agreement. They generally set out specific obligations to be met by individual countries.

Protocols:

Sofia	Stabilization of NO_x emissions at the 1987 level by 1994
Genèva	30 per cent reduction of NMVOC emissions by 1999 using 1989 as the base year. Applies to the mainland and Norway's Economic Zone south of 62°N
Oslo	76 per cent reduction of SO_2 emissions by 2000 using 1980 as the base year

2.1 Trends in national emissions

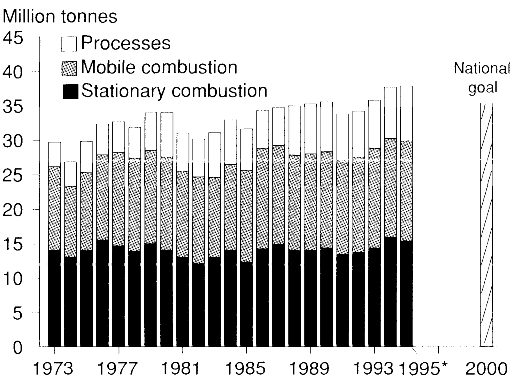
Emissions of the greenhouse gas carbon dioxide (CO_2) are rising, and according to preliminary figures for 1995, totalled 37.7 million tonnes. This is markedly higher than in 1989 and 1990 (figure 2.1 and table B1 in Part III). Emissions were somewhat lower in the intervening years. The main reasons for this were that oil consumption for transport and heating was lower and that process emissions from the metal and cement industries dropped as a result of lower production. However, more recently oil consumption for transport has risen, as has production in the metal and cement industries. Reductions of emissions in 1973-1974, 1979-1980 and 1990-1991 coincided with rises in oil prices.

In recent years, Norway's national goal has been to stabilize emissions at the 1989 level by 2000. This goal will continue to be the basis for the Government's climate policy. However, in Report to the Storting 41 (1994-95), it was estimated that given current CO_2 tax rates, Norway's CO_2 emissions will rise by about 16 per cent from 1989 to 2000. The Government estimates that if carbon taxes are to be the main instrument used, it would be necessary to raise the tax rate to 4-5 times its current level to make it possible to stabilize emissions at their 1989 level in 2000. In the Government's opinion, this is not a practical policy at present. The most important sources of CO_2 emissions today are oil and gas production (28 per cent) and road traffic (22 per cent).

Emissions of sulphur dioxide (SO_2) were reduced by 78 per cent from 1973 to 1994 (figure 2.2), and by 74 per cent from 1980 to 1994. Both the goal set out in the Helsinki Protocol (30 per cent reduction from 1980 to 1993) and Norway's national goal (50 per cent reduction from 1980 to 1993) have thus been achieved. The Helsinki Protocol was renegotiated in summer 1994, and is now known as the Oslo Protocol. In this Protocol, Norway has undertaken to reduce its SO_2 emissions by 76 per cent from 1980 to 2000. The drop in SO_2 emissions from combustion can be explained by a reduction in the sulphur content of oil products, a changeover to the use of lighter oil products and electricity, and the installation of more and better equipment to control emissions. About 59 per cent of Norway's SO_2 emissions in 1994 were generated by industrial processes. The drop in process emissions since the early 1980s has been brought about by requirements to install equipment to control emissions at a number of plants and by the closure of some of the plants that generated most pollution.

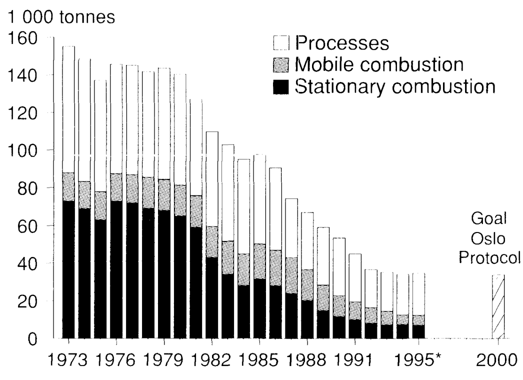
Emissions of nitrogen oxides (NO_x) rose steeply until 1987 (figure 2.3). This was mainly because of the growth in the use of private cars. According to the Sofia Protocol, Norway has undertaken to stabilize its emissions at the 1987 level by 1994. From 1987 to 1994, emissions were reduced by 6.5 per cent (see table B2 in Part III), thus achieving

Figure 2.1. Emissions of CO_2 by source



Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 2.2. Emissions of SO_2 by source



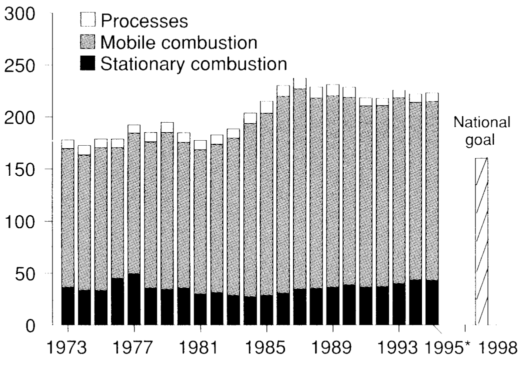
Sources: Statistics Norway and Norwegian Pollution Control Authority

Harmful effects of air pollutants

Component	Symbol	Effects
Carbon dioxide	CO_2	Enhances the greenhouse effect
Methane	CH_4	Enhances the greenhouse effect and contributes to O_3 formation
Nitrous oxide	N_2O	Enhances the greenhouse effect
SSulphur dioxide	SO_2	With other components, increases the risk of respiratory disease. Acidifies soil and water and causes corrosion
Nitrogen oxides	NO_x	Cause respiratory disease (particularly NO_2). Contribute to O_3 formation and corrosion
Ammonia	NH_3	Contributes to acidification of water and soils
Non-methane volatile organic compounds	NMVOC	May include carcinogenic substances. Contribute to O_3 formation
Carbon monoxide	CO	Increases risk of heart problems in people with cardio-vascular diseases
Particulate matter	PM_{10}	Increases risk of respiratory complaints, together with other components
Ozone in the lower atmosphere	O_3	Causes respiratory complaints and vegetation damage
Lead	Pb	No damage to health at concentrations currently found in air in Norway

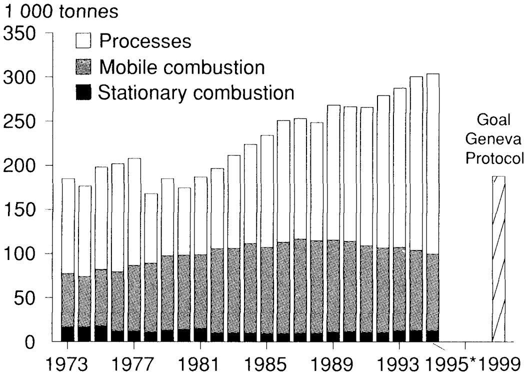
this goal by 1995. The main causes of the drop were a reduction of flaring in the North Sea, lower petrol consumption, an increase in the percentage of cars with three-way catalytic converters, lower fuel consumption by the fishing fleet and other shipping, and lower emissions from industrial processes. In 1993, emissions rose sharply, mainly because of a rise in the consumption of auto diesel oil and marine fuel. Similarly, the reduction from 1993 to 1994 was due to a drop in the consumption of marine fuel and a reduction of emissions from road traffic. In addition to its obligations under international agreements, Norway has established a national goal, which is to reduce emissions by 30 per cent by 1998 compared with the 1986 level. To achieve this goal, fuel consumption for transport purposes must be reduced, the replacement of older cars with cars equipped with three-way catalytic converters must be accelerated, and emissions from shipping must be substantially reduced. In 1994, the most important sources of NO_x emissions in

Figure 2.3. Emissions of NO_x by source



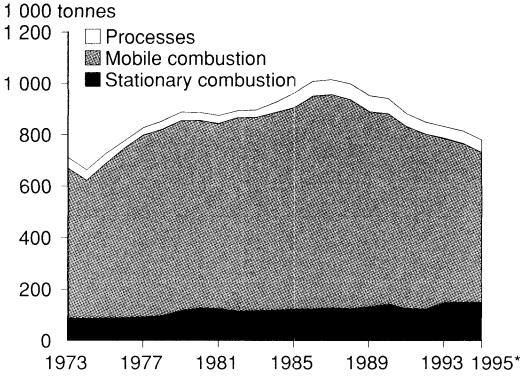
Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 2.4. Emissions of NMVOCs by source



Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 2.5. Emissions of CO by source



Sources: Statistics Norway and Norwegian Pollution Control Authority

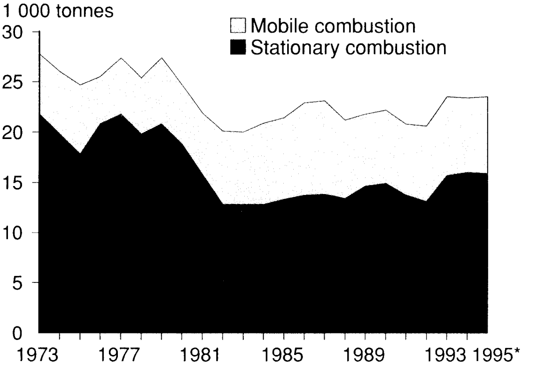
Norway were road traffic (34 per cent) and shipping (35 per cent).

Emissions of non-methane volatile organic compounds (NMVOCs) have risen steeply since the late 1970s (figure 2.4). The most important sources in Norway are evaporation during loading of crude oil (43 per cent) and emissions from petrol engines and petrol distribution (27 per cent). The rise in emissions during this period is a result of the growth in the volume of crude oil transported and also, in the period 1973-1987, an increase in the use of cars with petrol engines. Norway is bound by the Geneva Protocol, which applies to the entire mainland and to Norway's Economic Zone south of 62°N and requires a 30 per cent reduction of emissions by 1999, using 1989 as the base year. Preliminary figures for 1994 show that emissions have risen by 12 per cent since 1989. In order to reduce NMVOC emissions to the required level, further measures must be introduced to reduce emissions from loading of crude oil. The amount of crude oil shipped will probably rise in the years ahead, thus tending to counteract the effects of such measures. The rising proportion of new cars with petrol engines designed to meet stricter emissions standards, together with measures to reduce evaporation of petrol, will help to reduce NMVOC emissions.

Emissions of ammonia (NH_3) and the greenhouse gas methane (CH_4) have remained stable in recent years, and emissions of nitrous oxide (N_2O), another greenhouse gas, have dropped somewhat. The most important sources of CH_4 are biodegradation of waste (56 per cent) and domestic animals and manure (32 per cent). The dominant sources of emissions of N_2O and NH_3 are domestic animals and the use of mineral fertilizer in agriculture. Nitric acid production is another important source of N_2O emissions. However, there is a large degree of uncertainty in estimates of emissions of these components.

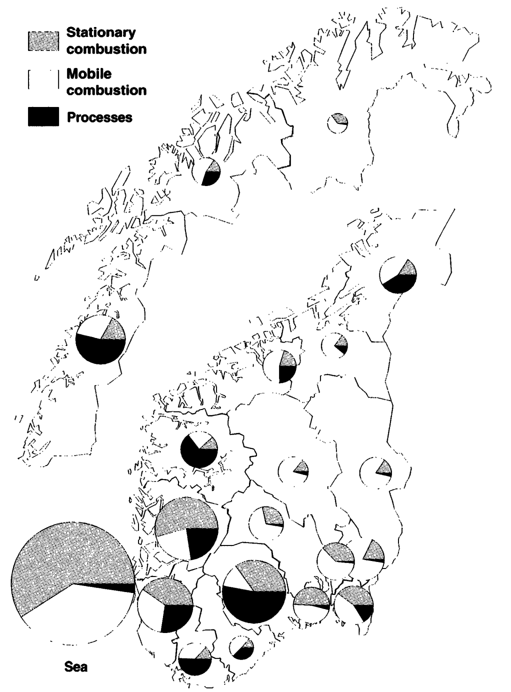
Carbon monoxide (CO) emissions rose from 1973 to the mid-1980s (figure 2.5). However, there has been a marked drop since then, mainly as a result of improvements in technology and lower petrol consumption. The main source of CO emissions is road traffic (71 per cent).

Figure 2.6. Emissions of particulate matter from combustion by source



Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 2.7. CO_2 emissions in 1993 by source and county



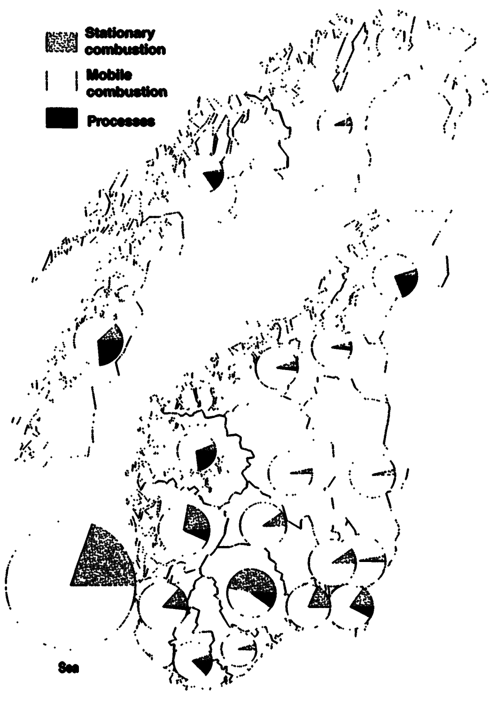
Digital base map: Norwegian Mapping Authority
Sources: Statistics Norway and Norwegian Pollution Control Authority

Emissions of particulate matter from combustion were considerably reduced from 1973 to 1982 (figure 2.6). This can be explained by the drop in the use of heavy fuel oil for heating. During the 1980s, emissions from stationary combustion rose somewhat because wood consumption increased. In 1994, emissions from stationary consumption accounted for 64 per cent of total emissions, and most of this (60 per cent of the total) was generated by the use of wood as fuel. There was a rise in mobile emissions in the period 1973-1987 as a result of the growth in road traffic and shipping. Statistics Norway and the Norwegian Pollution Control Authority do not calculate emissions of particulate matter from processes (e.g. asphalt dust from the use of studded tyres).

Emissions of lead were reduced by more than 97 per cent from 1973 to 1995, and have dropped by about 10 per cent each year compared with the previous year. From 1993 to 1994, emissions dropped by 70 per cent. Leaded petrol accounts for 94 per cent of lead emissions, and almost 83 per cent of the total can be traced back to passenger cars with petrol engines. In 1995, leaded petrol accounted for 7 per cent of total sales. Lead pollution in air is now well below the level believed to cause injury to human health.

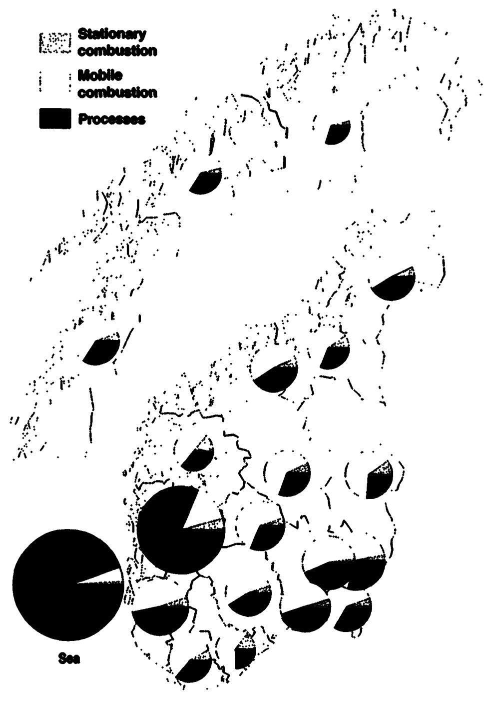
In the OECD countries, there has been a reduction in SO_2 emissions during the past 20 years. Per capita SO_2 emissions in Norway are lower than the average for the OECD countries. Per capita CO_2 emissions are also lower in Norway (see table B7 in Part III). This is mainly because hydropower accounts for a large proportion of energy use in Norway. However, on a world basis, average per capita emissions are only half the

Figure 2.8. NOx emissions in 1993 by source and county



Digital base map: Norwegian Mapping Authority
Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 2.9. NMVOC emissions in 1993 by source and county



Digital base map: Norwegian Mapping Authority
Sources: Statistics Norway and Norwegian Pollution Control Authority

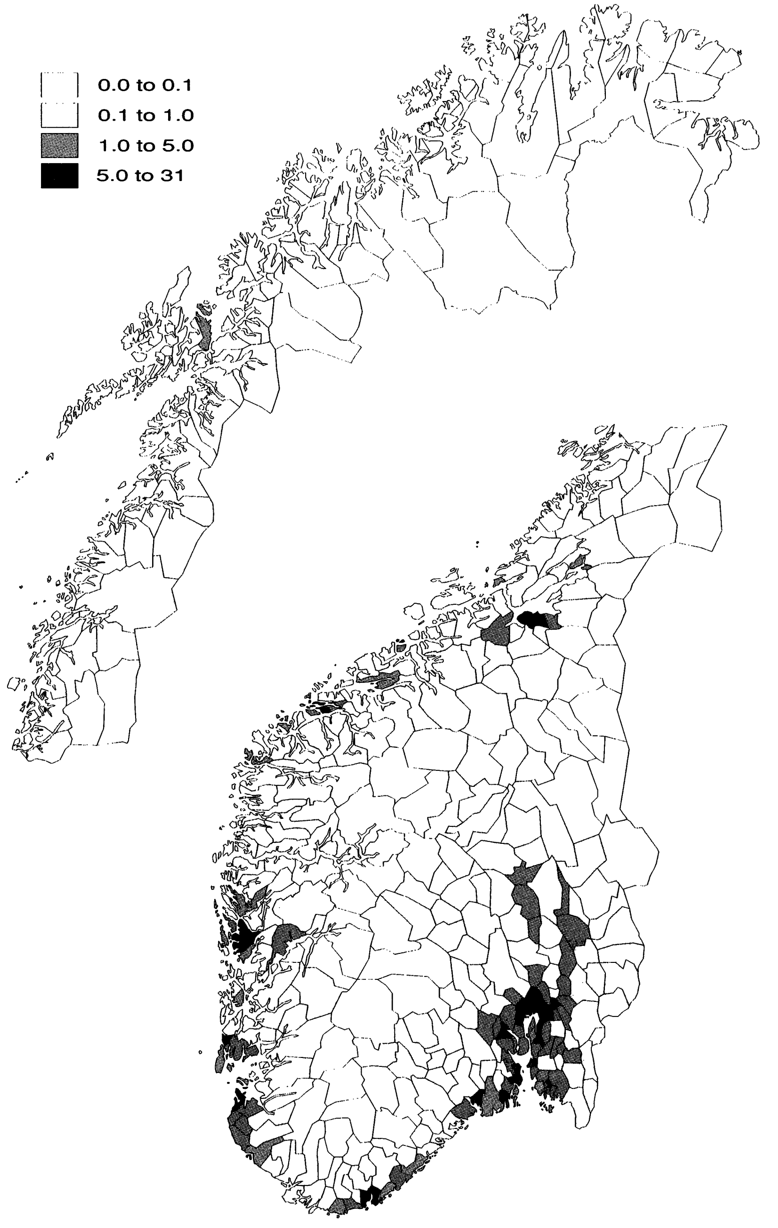
Norwegian level. Per capita NO_x emissions in Norway are higher than the average for the OECD. This is because a high proportion of combustion in Norway takes place in gas turbines, and the country has a large amount of coastal shipping. Both these sources generate high NO_x emissions per unit of energy commodity consumed.

2.2 Emissions by county

Telemark is the county with the highest CO_2 emissions (figure 2.7). CO_2 emissions are also high in Hordaland, Rogaland and Nordland. In all four counties, metal manufacturing accounts for a relatively high proportion of emissions. In addition, fertilizer and cement production and the petrochemical industry are major sources in Telemark. Emissions from oil refineries are highest in Hordaland.

CH_4 and NH_3 emissions are highest in Rogaland. This is mainly because emissions from livestock and manure are twice as high as in most other counties. On Svalbard, the coal mines are a major point source of CH_4 emissions. Process emissions from the manufacture of fertilizer in Telemark and Nordland account for over 40 per cent of the country's total emissions of N_2O.

Figure 2.10. NO_x emissions by municipality in 1993. Tonnes per km^2



Digital base map: Norwegian Mapping Authority
Sources: Statistics Norway and Norwegian Pollution Control Authority

Østfold, Hordaland, Sør-Trøndelag and Nordland account for the largest SO_2 emissions from the mainland (see table B7 in Part III). Refineries, the manufacture of ferro-alloys and chemical industry are the main sources. In all counties, NO_x emissions are dominated by mobile sources (figure 2.8); in Akershus, where NO_x emissions are highest, 96 per cent of the total is generated by mobile sources. As a result of industrial emissions, Rogaland, Telemark and Hordaland are also among the counties with the highest NO_x emissions.

Hordaland alone accounts for 26 per cent of total mainland emissions of NMVOCs (figure 2.9). The main sources are process emissions from loading of crude oil and oil refining.

The main source of CO emissions is road traffic, and emissions are highest in Akershus. Emissions of particulate matter are highest in Hordaland, which is followed by Hedmark, Akershus and Rogaland. The main sources are wood-firing and road traffic.

CO_2 emissions are high at sea, where one third of Norway's total emissions are generated (figure 2.7 and table B7 in Part III). Stationary combustion on oil fields and emissions from shipping account for 59 and 39 per cent respectively of the total. Emissions at sea also make the largest regional contribution to Norwegian emissions of SO_2, NO_x and NMVOCs. Shipping is the main source of SO_2 and NO_x, while loading of crude oil on tankers offshore is the most important source of NMVOC emissions.

2.3 Air quality and local emissions

The concentrations of pollutants in the air are determined by the amounts released, weather conditions and topography. Local emissions usually have most effect on air quality in towns and built-up areas. Long range transport of pollutants is less important (see section 2.4 for a discussion of ozone). In Norway, road traffic is the most important source of local pollution by NO_2, CO and particulate matter. Industrial installations are the most important source of high SO_2 concentrations.

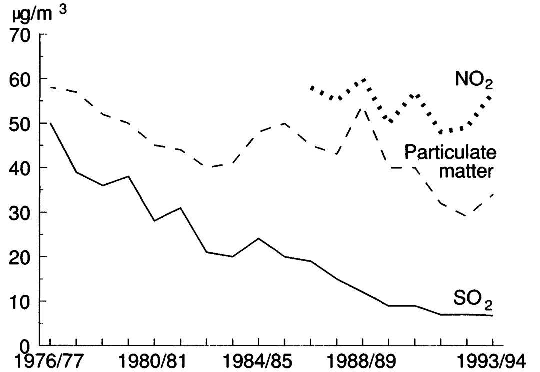
In 1993, the municipalities of Oslo, Porsgrunn and Bergen accounted for the largest NO_x emissions. As a first approximation to an estimate of local air quality, emissions per km^2 can be calculated. If this is done for NO_x emissions, we find the highest values in Porsgrunn and Stavanger (figure 2.10). As a general rule, emissions per km^2 are highest in municipalities with a high population density and where there are national highways. Per capita NO_x emissions were highest in Sørfold, followed by Tysfjord, Lindås and Bremanger; the main source of emissions in these municipalities was manufacturing industry. Per capita NO_x emissions are also high in certain municipalities with few inhabitants where there are national highways. Table B8 in Part III shows emissions to air by municipality.

Most of the measuring stations where air quality is monitored (see figure 2.11) are situated in town streets where traffic is heavy or near industrial enterprises. In winter 1993-94, the 24-hour mean concentration of NO_2 recommended in air quality guidelines was exceeded at eight of eleven measuring stations in towns. At most of

Emissions to air by municipality

These figures include emissions to Norwegian territory from international maritime and air transport and foreign activities in Norway. These activities are not included in the figures for national emissions. The methods used to calculate emissions to air are described in Bang et al. (1993), Rypdal (1993 and 1995) and Daasvatn et al. (1994).

Figure 2.11. Winter mean concentrations of NO_2, particulate matter and SO_2 at eight selected measuring stations[1]



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

these, the mean value was higher than in the preceding winters because of colder weather and poorer dispersion conditions. SO_2 levels were low at most measuring stations, but concentrations above the recommended limits were measured at some localities that are affected by industrial emissions. Corresponding figures for 1994-95 are not yet available.

Concentrations of pollutants in the largest towns have generally followed the same trends as emissions (figure 2.11). The concentration of SO_2 has dropped considerably in recent years, in line with reductions in emissions. Concentrations of particulate matter have not changed greatly. The decrease after 1989 may be related to the mild winters and good dispersion conditions. As a result of weather conditions and a rise in the sales of petrol and auto diesel, concentrations of particulate matter and NO_2 rose in winter 1993-94.

The surveys of living conditions show that exposure of the population to road-traffic pollution is somewhat lower than previously, which is consistent with measurements of air quality (see Chapter 8).

In 1995, calculations of emissions to air per basic unit (the smallest geographical unit used for statistical purposes) were started in four of Norway's largest towns. By January 1996, the municipality of Oslo had an operative model for calculating air quality on the basis of these and other figures. This project is described in more detail in Chapter 3.2 in Part II.

2.4 Long-range transport of air pollutants

Emissions of SO_2 and NO_x are lower in Norway than in most other European countries. Per capita SO_2 emissions are also very low, but per capita NO_x emissions are among the highest in Europe. SO_2 emissions are particularly high in Eastern Europe, the former East Germany and the United Kingdom. A large proportion of European SO_2 emissions is generated by point sources, especially coal- and oil-fired power stations. The hundred largest installations are estimated to account for more than 40 per cent of total European emissions. Of these, 54 are in Eastern Europe, 40 in EU countries (including 12 in the United Kingdom and 12 in Germany), and six in Turkey. The Russian refinery at Nikel, just across the border from Finnmark county, is ranked as number five in this list.

Pollution released to air may be deposited near the source or transported for considerable distances with air currents. Sulphur and nitrogen compounds tend to acidify soils and water, but the extent of the damage depends on the type of soil and vegetation. Lime-rich soil can for example withstand acidification by weathering to release calcium. Many parts of Norway have lime-poor soils and sensitive vegetation, and the impact of acid rain is greater than in many other areas where deposition of acid components is higher.

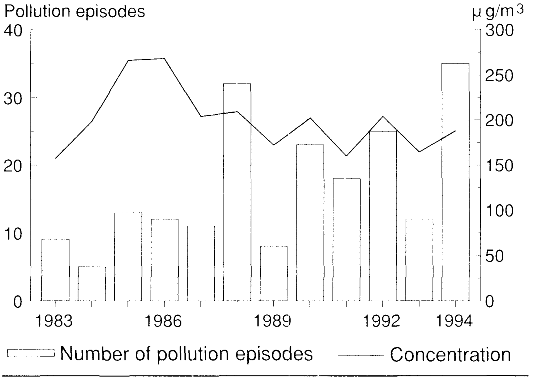
Fresh-water organisms have suffered the most serious damage, and the effects have been observed particularly in Southern Norway, the southern parts of Western Norway, and Eastern Norway. Sør-Varanger municipality in Finnmark suffers the effects of acid rain from sources in Russia.

In 1994, sulphur deposition over Norway totalled 100 000 tonnes (see table B12 in Part III). This is five times as much sulphur as Norway's total emissions. About 3 000 tonnes of the total originates from Norwegian emissions, and 5 000 tonnes from sea water and other natural sources. Other large sources in 1994 were the United Kingdom (about 15 000 tonnes), Germany (17 000 tonnes) and Eastern Europe, Russia and the Baltic states (18 000 tonnes). Of Norway's own sulphur emissions in 1994, a large proportion was deposited over the North Sea and North Atlantic, and some in Sweden and over Norwegian territory. From 1985 to 1994, sulphur deposition over Norway was reduced by about 30 per cent as a result of reductions in emissions in Europe.

Total deposition of oxidized and reduced nitrogen in 1994 was 107 000 tonnes (see tables B10 and B11 in Part III). Of this, 21 per cent originated from Norwegian emissions, and emissions from the United Kingdom and Germany accounted for a further 14 per cent each. Deposition of nitrogen compounds has changed little in recent years.

Tropospheric ozone can also be transported from other parts of Europe to southern Norway with air currents, injuring health and damaging vegetation. Ozone in the lower atmosphere is formed by chemical reactions between oxygen, NO_X and NMVOCs in the presence of sunshine. In periods of high pressure and sunshine during summer, ozone concentrations higher than the recommended threshold values (pollution episodes) are registered both in southern Norway and across most of the rest of Europe. As a result of the EEA Agreement, the Norwegian authorities are now obliged to inform the population when the ozone concentration exceeds 180 $\mu g/m^3$ (the recommended threshold value in Norway is 100 $\mu g/m^3$). No definite trend can be seen in recent years in the number of pollution episodes involving ozone or in the maximum concentrations of ozone measured at Norwegian background stations (figure 2.12). In summer 1994, there was a prolonged period of high pressure across Western Europe, which resulted in very high ozone concentrations both in Central Europe and in the United Kingdom.

Figure 2.12. Tropospheric ozone. Pollution episodes[1] in Norway involving high ozone concentrations, and highest hourly mean concentration



[1]Number of days when one measuring station records a maximum hourly mean concentration of 200 $\mu g/m^3$ or several measuring stations record an hourly mean concentration of more than 120 $\mu g/m^3$.

Source: Norwegian Pollution Control Authority

To avoid episodes when the recommended threshold values for ozone concentrations are exceeded, it will be necessary to reduce emissions of both NMVOCs and NO_X by more than 70 per cent across large parts of Europe. Up till now, emissions of these substances have not been significantly reduced.

2.5 Global environmental problems

Depletion of the ozone layer

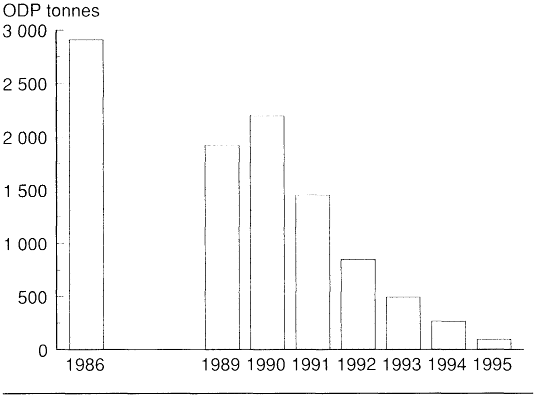
The atmospheric ozone layer prevents harmful ultra-violet (UV) radiation from the sun from reaching the surface of the earth. About 90 per cent of the ozone is found in the stratosphere, 10-40 km above the earth. This region, where there is an elevated concentration of ozone, is usually known as the ozone layer. Ozone is constantly formed and broken down by natural processes in the ozone layer. It is generated above the equator and transported towards the poles. There are natural variations in the ozone content of the stratosphere; in spring, there may be twice as much as in autumn.

For several years, the ozone content of the stratosphere has been very low and the levels of UV radiation reaching the earth have been high above Antarctica. Observations have also shown that the ozone content of the stratosphere above middle latitudes dropped by about 3 per cent in the 1980s (UNEP 1993). The causes of ozone depletion include anthropogenic emissions of chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs), halons and other gases containing chlorine and bromine. These gases are transported by air currents up to the ozone layer in the stratosphere. Under certain meteorological conditions, they can cause chemical degradation of ozone that does not occur naturally. Depletion of the ozone layer increases the amount of UV radiation reaching the earth, and may result in a higher incidence of skin cancer, eye injury and damage to the immune system. In addition, plant growth both on land and in the sea (algae) may be reduced.

Satellite measurements of ozone above Oslo from 1979 to 1994 show that the total amount of ozone has been reduced by 0.37 per cent per year (NILU 1994). The drop was particularly steep in the winter and spring months of 1992 and 1993, when measurements showed 10-20 per cent less ozone than normal above Oslo. This was probably caused by a combination of ozone depletion as a result of anthropogenic emissions of gases containing chlorine and bromine, natural causes such as unfavourable circulation patterns in the atmosphere, and sulphate particles from the eruption of the volcano Mount Pinatubo in 1991. More normal values were registered for much of 1994.

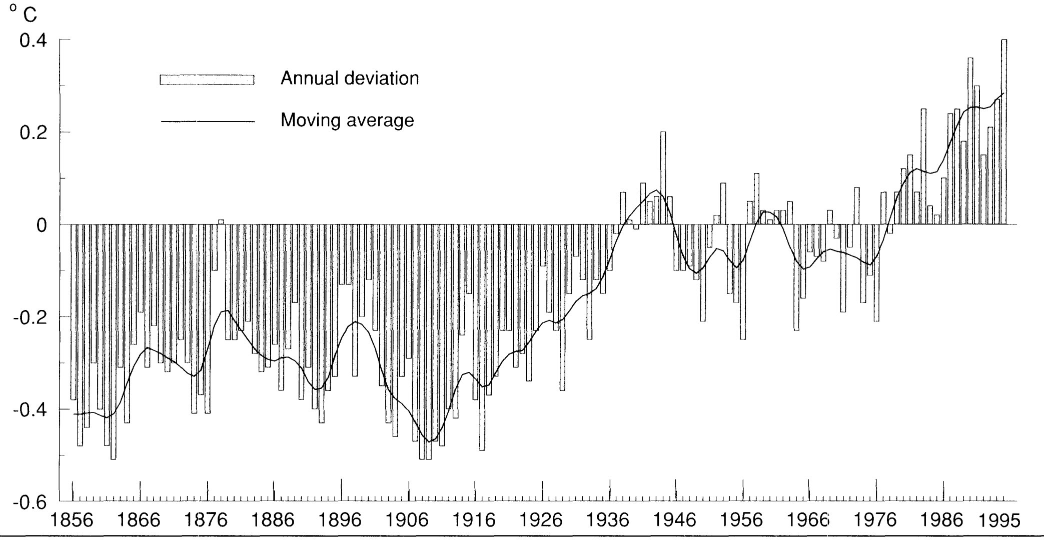
The consumption of ozone-depleting substances in Norway, measured as imports (see figure 2.13) has dropped since the mid-1980s, expressed as CFC-11 equivalents (in ODP tonnes, which takes into account the ozone depletion potential of each substance). Most of these substances are eventually released to air, and only small amounts are destroyed. In accordance with the revised Montreal Protocol, Norway has eliminated consumption of newly-produced halons and CFCs. In addition, Norway has undertaken to keep to a timetable for reductions in consumption or prohibitions against the use of several other substances that

Figure 2.13. Imports of ozone-depleting substances to Norway



Source: Norwegian Pollution Control Authority

Figure 2.14. Changes in global mean temperature 1856-1995, compared with the normal value for 1961-1990. °C



Sources: University of East Anglia and Norwegian Meteorological Institute

deplete the ozone layer. For overview of this and more details about the ozone layer and substances that deplete the ozone layer, see SSB/SFT/DN (1994) and Miljøverndepartementet (1995).

Climate change

The natural greenhouse effect of the atmosphere is an essential condition for life on earth as we know it. Without this effect, the global mean temperature would be about -18°C, not 15 °C as it is now. The heat balance of the atmosphere depends on its chemical composition. Anthropogenic emissions of the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorine-containing gases can alter the composition of the atmosphere more rapidly than natural processes. This in turn may accelerate changes in the global climate system.

During the 1980s, the CO_2 concentration of the atmosphere rose by an average of 0.4 per cent per year, indicating that about half the anthropogenic emissions of CO_2 remained in the atmosphere. The rate of change decreased somewhat in 1991-1993, but rose again in 1994. Analyses of the observed changes in the CO_2 content of the atmosphere (from ice cores and direct measurements) confirm that the observed increase really is caused by emissions from human activities. The concentrations of other greenhouse gases in the atmosphere are also continuing to rise substantially.

The global mean surface temperature has risen by about 0.6 °C during the past 100 years (figure 2.14). This is generally consistent with the trends predicted by climate models on the basis of rising concentrations of greenhouse gases in the atmosphere. Nevertheless, the temperature rise is still within the limits that could be explained by natural variations. In 1995, the global mean temperature was 0.04 °C higher than the previous record from 1990, 0.4 °C higher than the average for 1961-1990 and 0.7 °C higher than the average for 1861-1890 (University of East Anglia). Calculations by the UN Intergovernmental Panel on Climate Change (IPCC) indicate that the global mean temperature may rise by 1.5 - 4.5 °C during the next hundred years. There is great uncertainty associated with the effects of a further temperature rise, but probable effects are changes in precipitation patterns, more frequent occurrence of extreme weather conditions, displacement of climate zones and a further rise in sea level. This could have serious consequences for world agricultural production and for low-lying agricultural areas.

To allow a comparison of the extent to which different gases enhance the greenhouse effect, the concept of Global Warming Potential (GWP) is used. The GWP value of a gas is defined as the cumulative impact on the greenhouse effect of 1 tonne of the gas compared with that of 1 tonne of CO_2 over a specified period of time (usually 100 years). GWP values take account of the different residence times of the substances in the atmosphere and of the fact that they absorb energy at different wavelengths. For greenhouse gases other than methane and nitrous oxide, the uncertainty in the GWP values may be up to 30 per cent. In 1994, emissions of greenhouse gases in Norway totalled 50 million tonnes CO_2 equivalents (see tables B1 and B3 in part III). This is not significantly different from the 1989 level. Emissions of fluorine-containing gases from the magnesium and aluminium industry have been reduced, at the same time as CO_2 emissions from the oil sector and mobile sources have increased.

Norway has signed the UN Convention on Climate Change, according to which all industrial countries undertake to take measures to limit emissions and enhance sinks (e.g. forests) of greenhouse gases. In addition, Norway's national goal in recent years has been to limit Norwegian CO_2 emissions so that they do not exceed the 1989 level in the year 2000. The main policy instrument Norway has used until now as a means of achieving this goal is a CO_2 tax on a large proportion of petroleum consumption. However, in Report to the Storting No. 41 (1994-95), it was estimated that given current CO_2 tax rates, Norway's CO_2 emissions will rise by about 16 per cent from 1989 to 2000. The Government estimates that carbon taxes would probably have to be raised to 4 - 5 times the current level to make it possible to stabilize emissions at their 1989 level in 2000. This is not a practical policy at present, and the tax must therefore be combined with or replaced by other instruments if Norway is to achieve its national goal.

More information may be obtained from Ketil Flugsrud, Tone C. Mykkelbost and Kristin Rypdal

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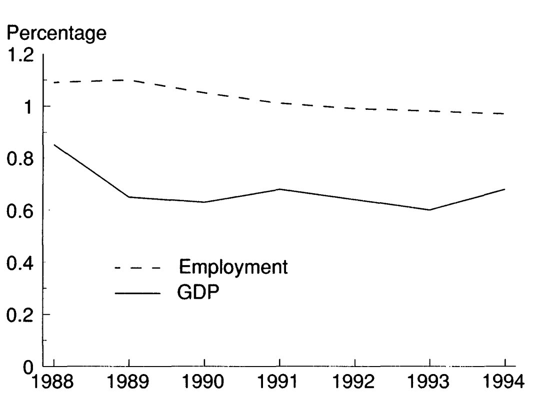
3. Fishing, sealing and whaling

The stock of Norwegian spring-spawning herring is growing strongly. After severe depletion in the 1970s, the spawning stock rose to 3.9 million tonnes in 1995. The total catch in Norwegian fisheries in 1995 was 2.7 million tonnes, with a first-hand value of NOK 8.2 billion. In 1995, the slaughtered quantity of farmed salmon was almost 250 000 tonnes, 40 000 tonnes more than in 1994. The export value of fish in 1995 was more than NOK 20 billion, and farmed fish accounted for almost NOK 7 billion of this.

3.1 The economic importance of the fisheries

According to the national accounts[1], the share of Norway's gross domestic product (GDP) derived from fishing, sealing and whaling decreased from 0.85 per cent in 1988 to 0.68 per cent in 1994. In the same period, the share of total employment decreased from 1.1 per cent to 1.0 per cent (figure 3.1).

Figure 3.1. Fishing, sealing, whaling and fish farming. Proportion of GDP and employment



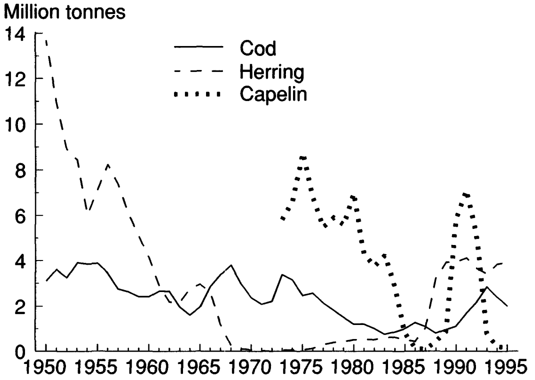
Source: Statistics Norway

3.2 Trends in stocks

Norwegian spring-spawning herring, capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Since the end of the 1960s, all three of these stocks have at some time reached a historical low (figure 3.2). The herring stock was severely depleted by overfishing at the end of the 1960s. The capelin stock collapsed in 1986-87, partly as a result of overfishing, but also from natural causes. The cod stock remained low throughout the 1980s. More recently, the cod and herring stocks have been recovering (see table C1 in Part III). The capelin stock in the Barents Sea recovered rapidly after its collapse, but has now dropped sharply again. The latest development is a result of a significant increase in the natural mortality of both larvae and older capelin. This is explained by predation; cod and marine mammals in particular feed

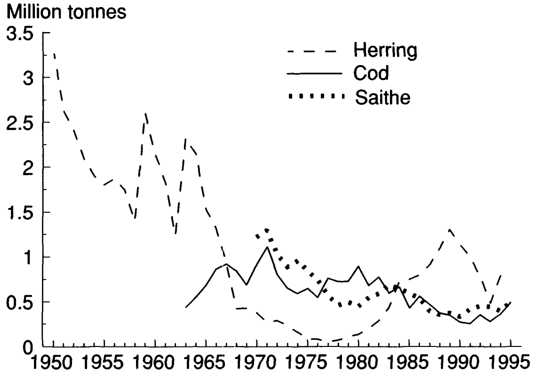
1 The latest general revision of the Norwegian national accounts applies from 1988 onwards.

Figure 3.2. Trends for stocks of North-East Arctic cod[1], Norwegian spring-spawning herring[2] and Barents Sea capelin[3]



[1] Fish aged three years and over [2] Spawning stock [3] Fish aged one year and over
Sources: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research

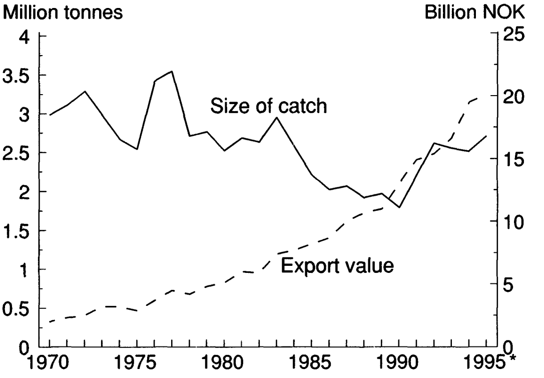
Figure 3.3. Trends for stocks of cod in the North Sea[1], saithe in the North Sea[1] and North Sea herring[2]



[1] Fish aged one year and over [2] Spawning stock
Sources: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research

on adult capelin, and juvenile herring feed on capelin larvae. The capelin stock will remain very low for at least a further two to three years (Havforskningsinstituttet 1995a and 1996).

Figure 3.4. Catches and export value



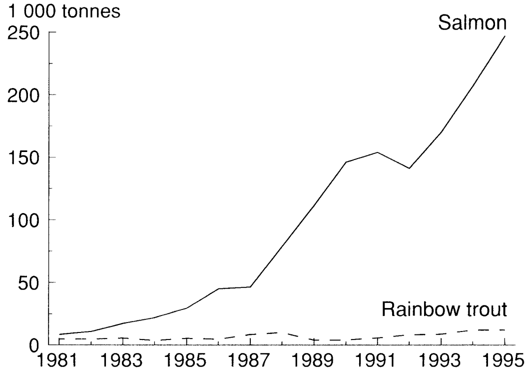
Sources: Statistics Norway and Directorate of Fisheries

The stock of North Sea herring rose steadily from 1980 onwards, but the spawning stock has dropped considerably during the 1990s (figure 3.3 and table C1 in Part III). Stocks of demersal fish in the North Sea are currently at a historical low, so that the natural mor-tality of juvenile herring is probably not as high as would normally be expected. However, substantial amounts of juvenile herring are being caught both in the Skagerrak and in the North Sea, and this fishery must be limited to ensure the growth of the spawning stock. The fishing pressure on adult herring should also be reduced (Havforskningsinstituttet 1995a and 1996).

3.3 Fisheries and fish farming

The total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) in 1995 was 2.7 million tonnes (figure 3.4 and table C2 in Part III), and the first-hand value was NOK 8.2 billion. The total catch was about 200 000 tonnes higher than in 1994, and its value rose by almost NOK 900 million. Catches in the herring and industrial fisheries (Norway pout, blue whiting and sandeel) rose substantially in 1995, while the catch of capelin was further reduced. In

Figure 3.5. Fish farming. Slaughtered quantities of salmon and rainbow trout



Sources: Statistics Norway and Kontali AS

both 1994 and 1995, the capelin fishery in the Barents Sea was closed, and this will be the case in 1996 as well.

The production of farmed fish has risen steeply since the industry was established at the beginning of the 1970s. The slaughtered quantity of farmed salmon rose from about 207 000 tonnes in 1994 to 247 000 tonnes in 1995 (figure 3.5). More than 80 per cent of the farmed salmon is exported. In 1994, Norway accounted for 55 per cent of total world production of farmed Atlantic salmon (Havforskningsinstituttet 1995b). The production of rainbow trout has remained more stable than salmon production, and was about 12 000 tonnes in 1995.

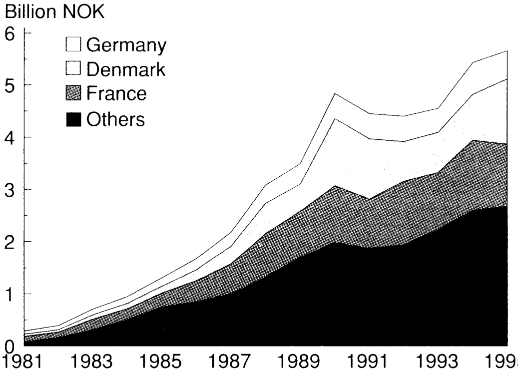
The most important diseases in Norwegian fish farming in recent years have been furunculosis, infectious salmon anaemia (ISA), infectious pancreatic necrosis (IPN) and bacterial kidney disease (BKD) (Havforskningsinstituttet, 1995b). However, the health of farmed fish has now been considerably improved, and the use of medicines by the fish farming industry has been greatly reduced in recent years. New vaccines and improvements in the operation of fish farms are probably the main reasons for this. The consumption of antibacterial agents fell from a peak of nearly 49 tonnes in 1987 to 1.4 tonnes in 1994 and 3.1 tonnes in 1995 (table C3 in Part III). Restrictions on antibiotics and sound routines for their use are important if we are to avoid their transfer to other organisms and the development of resistant forms of bacteria.

3.4 Exports

Preliminary figures show that in 1995, exports of fish and fish products rose to about 1.6 million tonnes, with a value of NOK 20.1 billion (figure 3.4 and tables C4 and C5 in Part III). The value of exports to EU countries was NOK 13.2 billion, or 66 per cent of the total.

Exports of fresh and frozen farmed salmon totalled 189 000 tonnes, with a value of almost NOK 5.7 billion (figure 3.6 and table C6 in Part III). In addition, smoked salmon and salmon fillets to a value of more than NOK 1 billion were exported, so that salmon exports in 1995 had a total value of NOK 6.7 billion. This is equivalent to 33 per cent of

Figure 3.6. Exports of fresh, chilled and frozen farmed salmon to the main purchasing countries

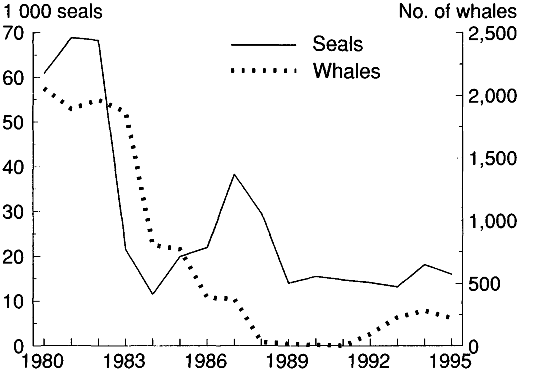


Source: Statistics Norway, External Trade Statistics

all Norwegian fish exports. For many years, France and Denmark have been the most important purchasers of Norwegian farmed salmon. Salmon exports to the USA have dropped sharply since 1990 because of the high import duty imposed on fish products, whereas exports to Japan have risen considerably.

In all, the export value of fish and fish products accounted for 14 per cent of exports of traditional goods from Norway in 1995 (i.e. exports excluding crude oil, natural gas, ships and oil platforms). Between 1978 and 1990, this figure varied between 10 and 13 per cent, while it has been between 14 and 15 per cent in the 1990s.

Figure 3.7. Norwegian catches of seals and small whales[1]



[1]1988-1992: scientific whaling only.
Source: Directorate of Fisheries

3.5 Sealing and whaling

Since 1983, Norwegian sealing has taken place in the West Ice (off Jan Mayen) and in the East Ice (the White Sea). Catches have been small, varying between 10 000 and 40 000 animals per season (figure 3.7). In 1995, the total catch was 15 981 animals (15 048 harp seals and 933 hooded seals). The catch of harp seals included 577 weaned pups taken for research purposes.

Until the early 1980s, the annual value of the seal catch was between NOK 10 and 40 million. In 1995, the value was less than NOK 1 million, but a large proportion of the catch is still not being sold.

Norwegian catches of small whales have consisted mainly of minke whales. The traditional commercial hunt was discontinued after the 1987 season, but was resumed in 1993, when 226 whales were taken. In 1995, 217 minke whales of a total quota of 232 animals were caught. No scientific whaling was carried out in 1995.

In the last two years before the traditional hunt was discontinued, the value of the catch was about NOK 20 million, down from NOK 45 million in 1983. In 1995, the value of the catch was NOK 13 million. The export of whale meat is now prohibited.

More information may be obtained from Frode Brunvoll

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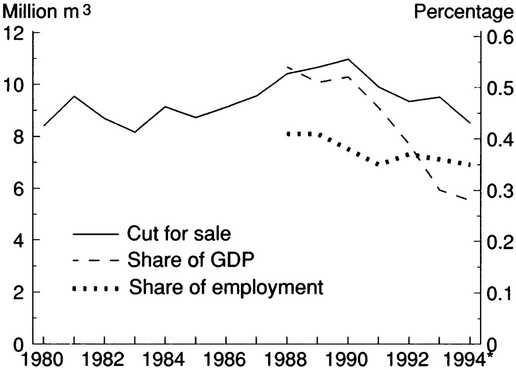
4. Forest

In 1994, forestry accounted for 0.3 per cent of Norway's gross domestic product (GDP) and 0.35 per cent of total employment. In the same year, the total volume of the roundwood cut for sale and industrial production was 8.5 million m^3. The volume of the growing stock rose from 310 million m^3 in 1925 to 616 million m^3 in 1994. Both the area of forest and the volume of the growing stock have also risen substantially in the EU and EFTA countries during the past 30 years. In recent years, the health of Norwegian forests, as measured by changes in crown density, has shown a slight tendency to deteriorate, and this is continuing.

4.1 The economic importance of forestry

According to the national accounts[1], labour input in forestry dropped from 9 400 full-time equivalent persons in 1980 to 6 200 full-time equivalent persons in 1994. This corresponds to 0.35 per cent of total labour input. In 1994, forestry accounted for 0.3 per cent of Norway's GDP, and the total volume of the roundwood cut for sale and industrial production was 8.5 million m^3. This is 10 per cent less than the year before, and the roundwood cut has not been lower since 1983 (figure 4.1). For the country as a whole, the gross value of the roundwood cut dropped by 7.4 per cent from NOK 2.7 billion in 1993 to NOK 2.5 billion in 1994 (current NOK).

Figure 4.1. Forestry: share of employment and GDP. Roundwood cut



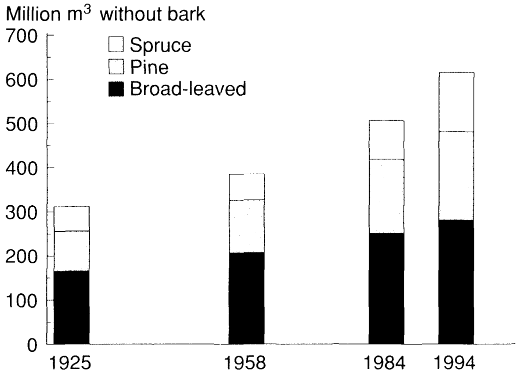
Source: Statistics Norway

4.2 Forest resources

The total area of productive forest in Norway is about 72 000 km^2, divided among 125 000 forest properties. Individuals own 79 per cent of the productive area of forest, and more than half the forest properties are run in combination with agricultural operations. For several hundred years, Norwegian forests have been exploited intensively for exports of roundwood, sawn wood and wood

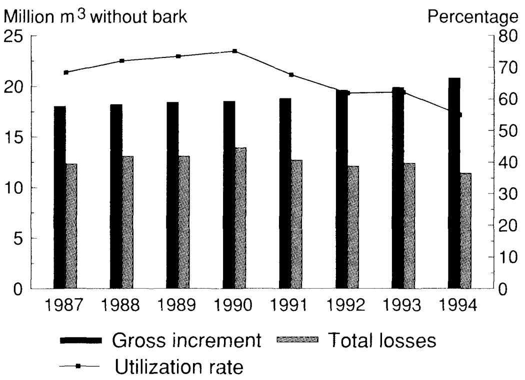
1 The latest general revision of the Norwegian national accounts applies from 1988 onwards.

Figure 4.2. Volume of the growing stock according to forest inventories in 1925, 1958 and 1984. Calculated volume in 1994



Sources: Statistics Norway and National Forest Inventory

Figure 4.3. Gross increment and total losses (in million m^3 without bark). Utilization rate of the growing stock (percentage)



Source: Statistics Norway

tar and for charcoal production. In addition, there is a long tradition of using forests as pasture for livestock and for hunting game. Today, forests are most important in economic terms as a source of raw materials for the sawmilling and pulp and paper industry. However, forests and the biological diversity they contain also have an intrinsic value as an ecological asset and as recreational areas for a more and more urban population.

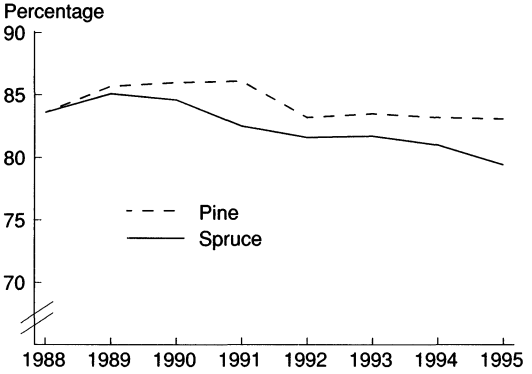
Growing stock

Forest inventories and calculations of volume show that the volume of the growing stock below the coniferous forest line rose by more than 95 per cent from 1925 to 1994 (figure 4.2). The increase was particularly rapid towards the end of the period. Annual figures for the volume of the growing stock, the forest balance, show the calculated figures for the growing stock at the beginning and end of the year. New calculations of the forest balance show that at the end of 1994, the volume of the growing stock, without bark, below the coniferous forest line was 616 million m^3. This total consisted of 46 per cent spruce, 33 per cent pine and 22 per cent broad-leaved trees. In 1994, the *net* increment (annual increment minus roundwood cut and natural losses) in the growing stock was 9.5 million m^3, or 1.5 per cent of the total volume (figure 4.3 and tables D1 and D2 in Part III). The net increment was highest for broad-leaved trees and pine.

The annual utilization rate for forest resources can be calculated as the total annual losses in the volume of the growing stock as a percentage of the gross increment in volume. The utilization rate decreased from 1990 to 1994 and was 55 per cent in 1994.

If the utilization rate is less than 100 per cent, the biomass of the forest is increasing, and more and more CO_2 from the atmosphere is assimilated by forests. In recent years, the net uptake of CO_2 has corresponded to about one third of Norway's anthropogenic CO_2 emissions. This includes CO_2 assimilated in bark, roots and other biomass.

Figure 4.4. Mean crown density of spruce and pine



Source: Norwegian Institute for Land Inventory

4.3 Forest damage

The causes of forest damage are often complex. Unfavourable climate and weather conditions, insect and fungal attacks, forest fires and air pollution are the factors that have the greatest effects on the health of forests. Results from the Norwegian monitoring programme for forest damage (NIJOS 1995) show the current state of health of forests, measured as mean crown density and crown colour for the country as a whole (tables D3 and D4 in part III). The mean crown density for spruce dropped from 85 per cent to just over 79 per cent in the period 1989 to 1995 (figure 4.4). The mean crown density for pine fell from 86 per cent in 1991 to 83 per cent in 1992, and has remained about this level since. The proportion of pine trees in the highest crown density class dropped by 10.1 percentage points between 1991 and 1992. The deterioration in the health of both these tree species has been most serious in the Trøndelag counties and in large parts of the southern half of Norway. In the period 1988 to 1995, the proportion of young spruce and pine trees showing discoloration of the needles remained stable, whereas the proportion of older spruce trees rose significantly.

Birch has been included in the monitoring programme since 1992, and preliminary records of birch trees in coniferous forest were made from 1990 onwards. In the period 1992 to 1995, mean crown density decreased from 73.8 to 70.7 per cent. However, broad-leaved trees respond rapidly to natural stresses such as drought and insect attacks, and observations over several years are needed before the results can be properly evaluated.

An international monitoring programme to study the effects of air pollution on forest was started in 1985. In 1994, 32 countries took part in the programme, and a total of 1.5 million km^2 of forest was surveyed. Pine, spruce, silver fir, beech and oak accounted for about two-thirds of the trees in the programme. Earlier experience has shown that defoliation of up to 20-25 per cent does not necessarily indicate declining health, but can be regarded as normal adaptations to variations in climate and nutrient supply. However, the results from 1994 show more than 25 per cent defoliation for 26 per cent of all the trees surveyed. This is an increase of almost 4 percentage points from 1993. (Bundesministerium für Ernährung, Landwirtschaft und Forsten 1995).

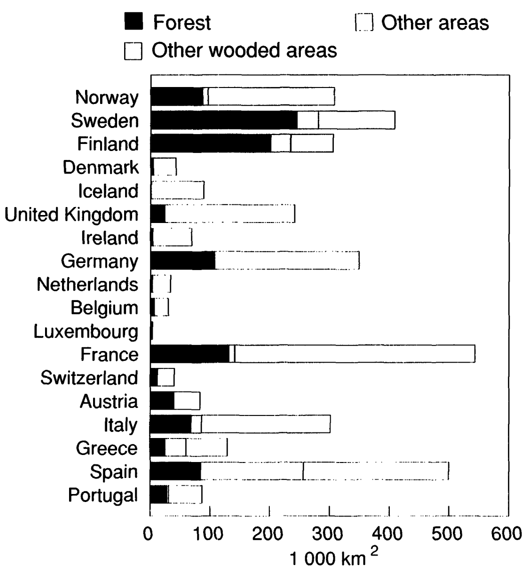
The results for individual countries show that the extent of the damage is greatest in Poland and Czechia. The estimated extent of the damage in the United Kingdom has been sharply reduced after the methodology was harmonized with that of other countries. In Portugal, a prolonged period of drought ended in 1993, and the proportion of trees showing signs of damage dropped from 23 per cent to 7 per cent between 1992 and 1993. (EC-UN/ECE 1994). There are large regional variations in the health of forests in

Europe. In Denmark, more than every third tree observed was reported to show signs of damage in 1994, while the average figure for Germany was only 22 per cent. However, the extent of the damage in Germany increased markedly from west to east. In Austria, the percentage of trees showing signs of damage has dropped from 11 per cent in 1993 to 8 per cent in 1994, and in France it has remained stable at around 7 per cent (Bundesministerium für Ernährung, Landwirtschaft und Forsten 1995).

4.4 Forest resources in Europe

In Europe west of the Urals, the total area of forest and other wooded land is about 3.1 million km^2, or 33 per cent of the total area of land. About 1.2 million km^2 of this lies within the EU and EFTA area. The proportion of wooded land varies from country to country; Iceland is virtually treeless, whereas forests cover 66 per cent of Finland (figure 4.5). Forests have been intensively managed in Western Europe since the Second World War. This has made it possible to meet the growing demand for wood, while at the same time both the area of wooded land and the volume of the growing stock have increased by about 10 per cent during the last 30 years (European Environment Agency 1995). However, in many areas, this form of forest management has resulted in the development of increasingly homogeneous cultivated forests.

Figure 4.5. Area of forest and other wooded areas in EU and EFTA countries in 1990



Source: UN-ECE/FAO 1995

In recent years, interest in international coordination of measures to influence the way forest resources are managed has shown a marked increase. This is exemplified by the resolutions on sustainable use and biodiversity adopted at the Strasbourg conference in 1990 and the Helsinki conference in 1993. The Common Agricultural Policy (CAP) of the EU includes a major programme of tree-planting on agricultural land and a programme for the prevention of forest fires. Apart from this, the EU countries do not at present have a comprehensive common forestry policy. In most European countries, national forestry legislation has been drawn up primarily to ensure adequate timber production. However, in many countries there is now a growing interest in multiple land use, recreation, protection and other objectives for forest management.

Further information may be obtained from Per Schøning and Ketil Flugsrud

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5. Agriculture

In 1994, the agricultural sector accounted for 1.5 per cent of Norway's GDP and 3.7 per cent of total employment. The total area of agricultural land in use in 1995 was 9.9 million decares[1]. The fertilizer surplus, measured as phosphorus, has been more than halved during the past ten years. Tillage of cereal acreage in the autumn has been reduced; in autumn 1994, 40 per cent of this acreage overwintered under straw stubble, as compared with 16 per cent in 1990. However, there was no change from 1993 to 1994. The data show a clear relationship between soil management regimes and the use of pesticides against perennial weeds; during the past three years, an average of 15 per cent of the area ploughed in autumn was sprayed, as against 42 per cent of the area that was not tilled.

5.1 The economic importance of agriculture

According to the national accounts[2], the agricultural sector is becoming steadily less important in economic terms. From 1988 to 1994, the agricultural sector's share of total employment (measured as full-time equivalent persons) sank from 4.8 to 3.7 per cent (figure 5.1). In absolute figures, the drop was from 88 000 to 66 000 full-time equivalent persons. The agricultural sector's share of gross domestic product (GDP) dropped from 1.9 per cent to 1.5 per cent in the same period. Agricultural production expressed as a percentage of food consumption by the population (measured as energy content) rose from 30 to 44 per cent in the period 1970 to 1994 (Statens ernæringsråd 1994).

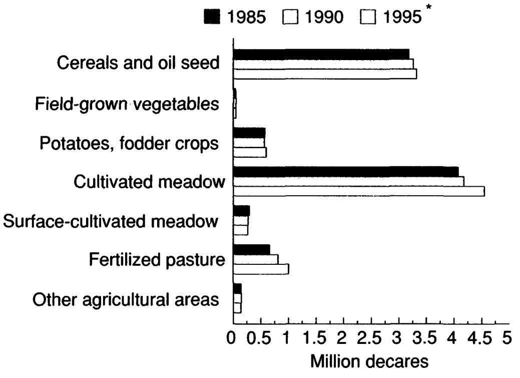
Figure 5.1. Some indicators of the economic importance of the agricultural sector

Sources: Statistics Norway and National Nutrition Council

[1] 1 decare = 0.1 hectare

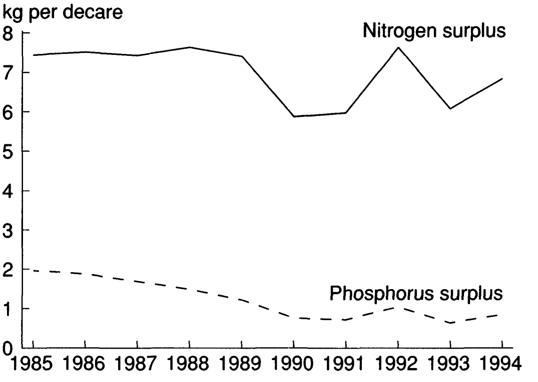
[2] The latest general revision of the Norwegian national accounts applies from 1988 onwards.

Figure 5.2. Use of agricultural areas



Source: Applications for production subsidies, Ministry of Agriculture

Figure 5.3. Surplus of nutrients (nitrogen and phosphorus) on agricultural areas



Sources: Statistics Norway and Statkorn

5.2 Land use

From 1985 to 1995, the agricultural area in use increased by 11 per cent, and was 9.9 million decares in 1995 (table E1 in Part III). Cereal and oil-seed acreage made up 33.5 per cent of this, and cultivated meadow 45.8 per cent. The acreage of cereal crops and cultivated meadow has risen slightly during the past decade, whereas the area of surface-cultivated meadow has dropped (figure 5.2). The area of fertilized pasture has risen by 53 per cent. (The figures are based on applications for production subsidies, and part of the rise may be explained by the fact that a larger proportion of the area is eligible for production subsidies.)

5.3 Environmental impacts

Nutrient balance

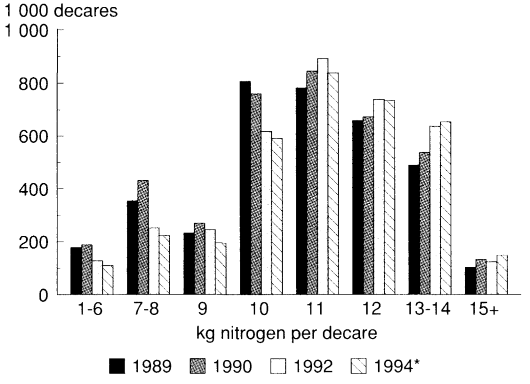
There are two main sources of nutrient discharges from the agricultural sector; point discharges (seepage from manure storage facilities and silos) and diffuse discharges (runoff). Calculations show that runoff accounts for 90 per cent of the total, and point discharges for 10 per cent (JORDFORSK 1989). Heavy applications of fertilizer in relation to the yields obtained may result in a large surplus of nutrients on agricultural areas. Such a surplus raises the risk of loss of nutrients (pollution) from farmland. The size of the surplus can be calculated by means of a nutrient balance.

In this context, the nutrient balance for agricultural areas is defined as the difference between the amount of nutrients added in commercial fertilizer and animal manure, and the amount removed in the form of crops. Figure 5.3 shows changes in the nitrogen and phosphorus balance from 1985 to 1994. The balance has been corrected for nitrogen losses (evaporation of ammonia) from animal manure and for manure from animals grazing on outfield areas.

Surplus nutrients may be stored in the soil, carried off with surplus water, or, in the case of nitrogen, be lost to the air.

Using this method of calculation, we find that in 1985, the surplus per decare of agricultural land was 7.4 kg nitrogen and 2.0 kg phosphorus. By 1994, these figures had

Figure 5.4. Area of cereals and oil seed in relation to fertilizer application (nitrogen in commercial fertilizer)



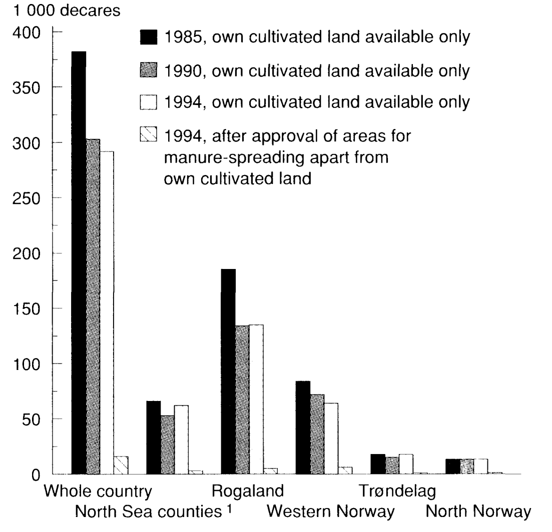
Source: Statistics Norway

dropped to 6.8 kg nitrogen and 0.8 kg phosphorus. The relative reduction was much greater for phosphorus than for nitrogen, mainly because farmers now apply much less phosphorus in the form of commercial fertilizer. Some of the figures on which figure 5.3 is based are given in table E3 in Part III.

Commercial fertilizer

For the country as a whole, sales of phosphorus in commercial fertilizer have dropped by 46 per cent from 1984-1985 to 1994-1995, whereas sales of nitrogen in commercial fertilizer have changed relatively little. Given that the area of agricultural land has increased during this period, this means that the input of phosphorus per decare has decreased substantially, whereas the input of nitrogen has only been marginally reduced. In recent years, the area of meadow that has been either intensively or very lightly fertilized (more than 25 kg or less than 4 kg nitrogen per decare) has steadily decreased. The amount of nitrogen fertilizer applied on cereal acreage has risen in recent years (figure 5.4).

Figure 5.5. Shortfall in areas for manure spreading



[1]Counties to which the North Sea Declarations apply, see page 61.
Sources: Statistics Norway and Ministry of Agriculture

Animal manure

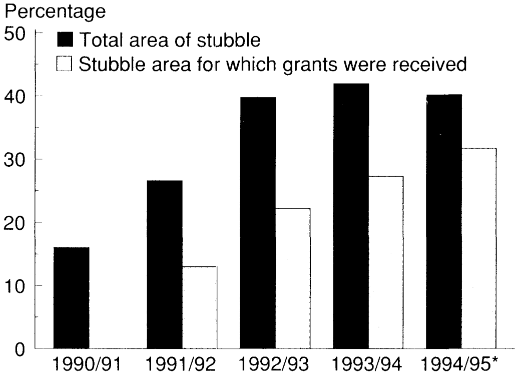
The number of domestic animals, and therefore the amount of manure produced, has changed little since 1985. The proportion of the manure applied during the growing season, expressed as nitrogen, rose from 80 per cent in 1989 to 86 per cent in 1994.

To prevent excess application of manure to agricultural land, the authorities introduced the requirement that a farm must have at least four decares suitable for manure spreading per animal manure unit (per "cow-unit"). If there is too little cultivated land on the farm to meet this requirement, the farmer must fertilize land that is not cultivated, sell manure or use it on other farms. Such areas must be approved by the county agricultural authorities.

Disregarding pasture and any manure used on other types of land, the calculated shortfall of areas suitable for manure spreading in 1994 was 290 000 decares, as compared with 380 000 decares in 1985. From 1994, the shortfall of areas for manure spreading on farms with more than 20 animal manure units has been taxed at a rate of NOK 1 000 per decare, and we now have an overview of the area still required *after* the approval of areas for manure spreading. In 1994, it was estimated that the shortfall was only 15 000 decares (figure 5.5), indicating that farmers have been able to find almost all the extra land needed. There are large variations from one county to another.

Soil management
If the soil is tilled in autumn, it is left without any plant cover that can protect it against rain and melt-water. This may lead to large losses of soil (erosion), thus causing the loss of a valuable resource and resulting in the pollution of nearby water recipients. Erosion can be reduced by restricting tillage in autumn.

Figure 5.6. Cereal acreage with no tillage in autumn (straw stubble) as share of total cereal acreage



Sources: Statistics Norway and Ministry of Agriculture

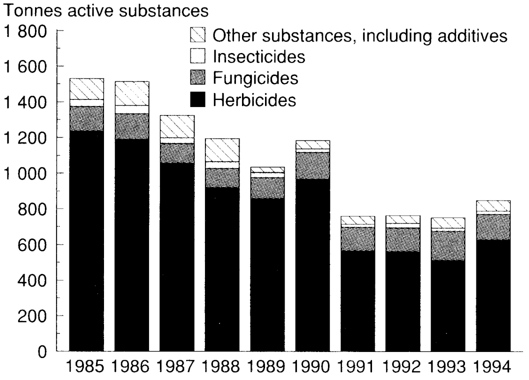
To reduce soil losses, the authorities provide grants for areas that are vulnerable to erosion on condition that the farmers leave them under stubble during the winter, i.e. do not till such areas in autumn. The proportion of such areas which were overwintered under stubble rose from 16 per cent in 1990-91 to 40 per cent in 1994-95. The entire increase took place during the first three years of the period, and there has been no change during the last three (figure 5.6). The proportion of the area under stubble for which support is granted, on the other hand, has risen steadily throughout the period. In 1994-95, there was a slight decrease in the actual area under stubble, despite the fact that the area for which grants were provided rose (figure 5.6). However, a growing proportion of the grants is being provided for areas that are particularly vulnerable to erosion.

The area of autumn-sown cereals rose from 108 000 decares in 1989-90 to 309 000 decares in 1994-95, when it accounted for 9 per cent of the total area under cereals. See also table E2 in Part III.

Use of pesticides
Residues of pesticides in soils, water and food products can cause injury to human health and environmental damage. Thus, there is always a certain risk to health and the environment associated with the use of pesticides.

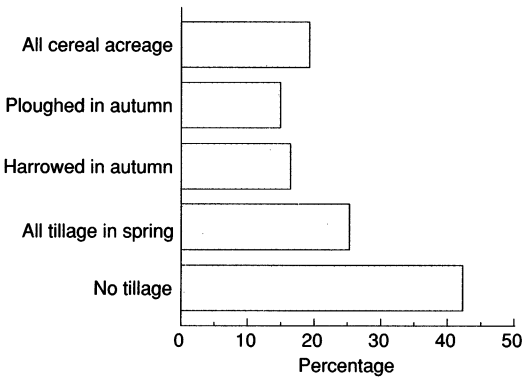
Total consumption of pesticides, expressed as kilograms of the active substances, was greatly reduced from 1985 to 1993 (figure 5.7). The consumption of fungicides has remained fairly constant, but there has been a substantial reduction for other substances. The statistics only show the total amounts used, which include a variety of very different types of substances, and do not show any changes with time in the types of active substances in use. The degradation rates of dif-

Figure 5.7. Sales of pesticides



Source: Norwegian Agricultural Inspection Service

Figure 5.8. Proportion of cereal acreage sprayed against perennial weeds according to soil management regime. Average for for the whole country 1992-93 to 1994-95



Source: Statistics Norway

ferent pesticides vary widely, as do their selectivity and toxicity. Nevertheless, changes in the total consumption of pesticides do give some indication of whether their environmental impact is increasing or decreasing.

During the past three years, an average of 19 per cent of the area under cereals has been sprayed against perennial weeds. Although the extent of the spraying varies widely from year to year depending on conditions during harvesting, there is a clear relationship between the soil management regime and spraying against perennial weeds. The more tillage of the soil is reduced or postponed, the larger the proportion of the area that is sprayed. On average, 42 per cent of the area under cereals that was not tilled at all (sown directly) was sprayed against perennial weeds, as compared with only 15 per cent of the autumn-ploughed area (figure 5.8). This means that the environmental cost of reducing erosion by limiting tillage is greater use of pesticides.

More information may be obtained from Henning Høie

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6. Waste water treatment

In 1994, the total waste water treatment capacity of municipal sewage treatment plants was reported to be 5 million population units (p.u.). Operating and capital costs were calculated at NOK 3.1 billion in both 1993 and 1994, which in 1994 was equivalent to about NOK 2 150 per subscriber, or an average per capita cost of NOK 720. Sewage fees covered 88 per cent of this. Since 1975, gross investments of NOK 26 billion have been made in the municipal waste water treatment sector. In 1994, investments totalled NOK 1.4 billion, and 73 per cent of this was used for laying new sewers and renovation of the existing sewer systems. Waste water treatment plants removed 71 per cent of the phosphorus entering the plants. For the North Sea counties alone, this figure was 88 per cent.

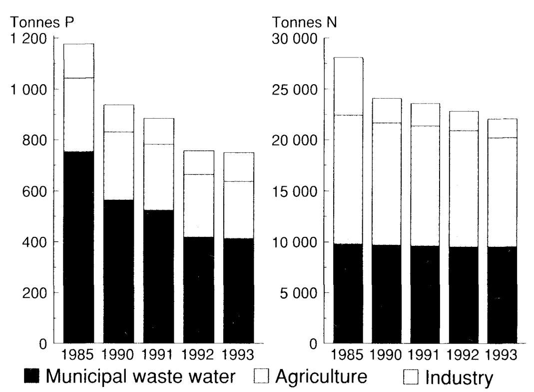
6.1 Introduction

Statistics Norway and the Norwegian Pollution Control Authority together organize the annual registration of data from the waste water treatment sector in all municipalities in Norway. The county departments of environmental affairs are responsible for data collection. In 1994, the computerized data collection system SSB-AVLØP (Statistics Norway 1995) was expanded to include information on scattered settlements and sewer systems, economic figures and complete pollution accounts as well as data from waste water treatment plants.

Discharge figures from SSB-AVLØP are used in calculating the total inputs of phosphorus and nitrogen to coastal waters around Norway. These calculations also use discharge figures for agriculture and industry, and take into account retention in fjords and river systems.

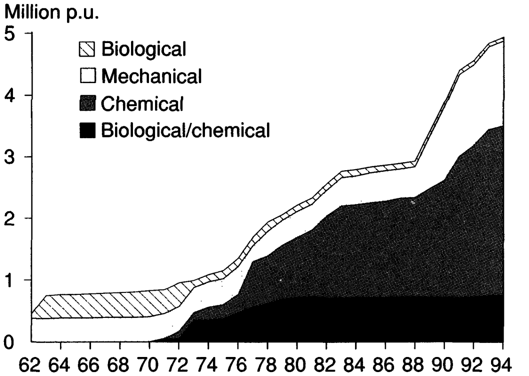
In 1993, total Norwegian anthropogenic inputs of nutrients from activities on land and in the coastal zone were calculated at about 4 700 tonnes of phosphorus and 56 000 ton-

Figure 6.1. Norwegian anthropogenic inputs of phosphorus and nitrogen to the coast from Østfold to Vest-Agder inclusive



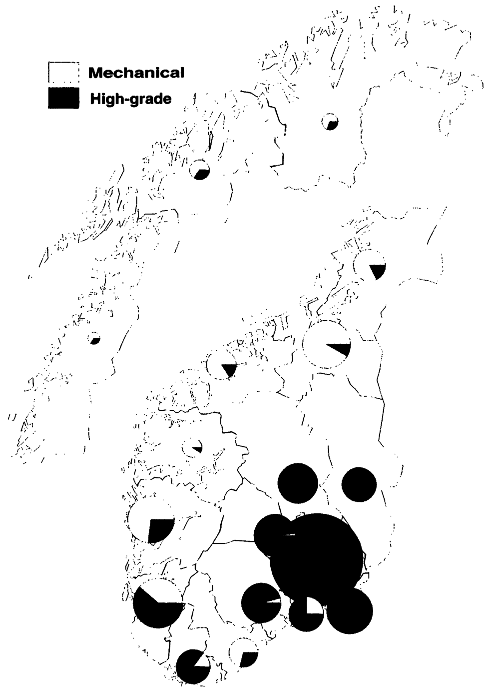
Source: Norwegian Pollution Control Authority

Figure 6.2. Hydraulic capacity by treatment method



Source: Statistics Norway

Figure 6.3. Hydraulic capacity at primary and high-grade treatment plants



Digital base map: Norwegian Mapping Authority
Source: Statistics Norway

nes of nitrogen. The coastline from Østfold to Vest-Agder counties inclusive (the area to which the North Sea Declarations apply, see box) received 16 per cent and 39 per cent respectively of the total inputs of phosphorus and nitrogen (SFT 1996). Norway is implementing the goals of the North Sea Declarations by means of a variety of measures, and discharges of nutrients to this stretch of coastline have been substantially reduced since 1985 (figure 6.1). Inputs of nitrogen and phosphorus from Norway to the North Sea are relatively modest compared with those from other European countries (table F1 in part III).

6.2 Waste water treatment plants

Most waste water treatment plants in Norway have been built within the last 30 years (figure 6.2). The earliest plants provided mechanical or biological treatment of the waste water. However, since the beginning of the 1970s it has become more common to build plants which also include a chemical purification process to remove phosphorus. The main reason for the apparent rise in mechanical treatment capacity from 1988 to 1990 is the inclusion of strainers and sludge separators in this category. Norway has given high priority to the removal of phosphorus to prevent algal growth in fjords and river systems, and substantial resources have therefore been invested in chemical treatment of waste water. Other European countries have considered the removal of organic matter to be more important, and make more use of biological treatment (SFT 1996).

In 1994, 1 934 municipal waste water treatment plants with a treatment capacity of at least 50 p.u. were registered in Norway. In the same year, the total treatment capacity of all types of municipal waste water treatment plants was 5.0 million p.u.. Eighteen of these plants had a treatment capacity of 50 000 p.u. or more, and these treated almost half

Waste water treatment plants (wwtp) are generally divided into three groups according to the type of treatment they provide: mechanical, biological or chemical. Some plants incorporate combinations of these basic types.

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

High-grade waste water treatment plants are those which provide a biological and/or chemical treatment phase. Biological treatment mainly removes readily degradable organic material using microorganisms. The chemical phase involves the addition of various chemicals to remove phosphorus. High-grade plants reduce the amounts of phosphorus and other pollutants in the effluent more effectively than mechanical plants.

Population equivalents (pe) are used to express waste water from industry, institutions, etc as the number of people who would produce the same amount of waste water.

The number of **population units** (p.u.) in an area is given by the sum of the number of permanent residents and the number of population equivalents in the area.

A **subscriber** is one household or 3 population equivalents connected to a municipal waste water treatment plant.

The **hydraulic capacity** of a treatment plant is the amount of waste water it is designed to receive.

The **hydraulic load** is the amount of waste water a treatment plant actually receives.

Separate waste water treatment plants are designed to treat amounts of waste water equivalent in amount or composition to that from up to seven permanent households or holiday homes.

Investments less grants gives the investments which may be included as a basis for calculating municipal fees, and which subscribers are required to pay through fees. Investments in municipal waste water treatment may also be financed in other ways, e.g. by grants from the Ministry of the Environment, other government grants, private grants, repayments pursuant to the Planning and Building Act, and construction grants. Costs which are covered in these ways may not be included in calculating waste water treatment fees.

Capital costs are calculated by assuming a depreciation period of 20 years and an interest charge of 7.5 per cent. This is in accordance with the model used by the municipalities to calculate the basis for their fees.

The **income-to-cost** ratio indicates the proportion of the municipalities' expenditure on waste water treatment that is covered by fees.

The North Sea Declarations were signed by ministers from the countries surrounding the North Sea, and contain various goals for pollution reduction. One of these is a reduction of the order of 50 per cent of inputs of nutrients (nitrogen and phosphorus) in the period 1985 - 1995.

The North Sea counties (or area) are those Norwegian counties to which the North Sea Declarations apply. The area stretches from Østfold to Vest-Agder, and drains almost entirely into the North Sea.

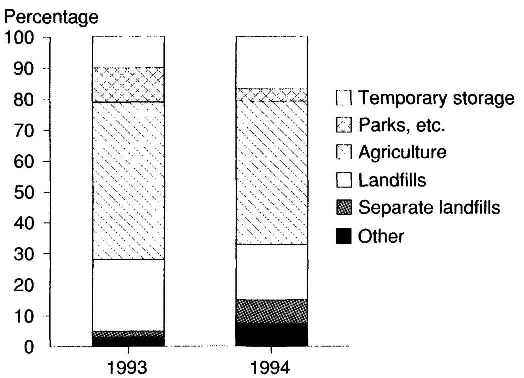
of all municipal waste water. In Eastern and Southern Norway, a large proportion of municipal waste water is treated in high-grade treatment plants (figure 6.3), whereas along the coast from Hordaland county and northwards, most waste water is only mechanically treated.

6.3. Sewage sludge

Sludge is a residual product of waste water treatment plants, and contains both organic matter and plant nutrients that can be used as fertilizer or in integrated plant nutrient management. For 1994, figures for the amounts of sludge produced are available from 528 plants, which accounted for 71 per cent of the total hydraulic load. These produced 86 350 tonnes of sludge (dry weight). Of this, 46 per cent was used directly for agricultural purposes (figure 6.4).

The composition of the sewage sludge produced varies widely from one plant to another. The type of waste water, the type of treatment used and the way the sludge is treated are crucial in determining the content of heavy metals (table 6.1) and nutrients (table 6.2).

Figure 6.4. Disposal of sewage sludge



Source: Statistics Norway

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

	No. of plants	Mean value	Min. value	Max. value	Standard deviation
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 matter in sewage sludge in 1993. Percentage of dry weight

	No. of plants	Mean value	Min value	Max value	Standard deviation
Organic material	79	60.20	4.90	78.62	14.83
Nitrogen	156	2.46	0.03	5.09	0.96
Total phosphorus	100	1.30	0.05	4.02	0.57
Potassium	96	0.23	0.04	1.93	0.29
Calcium	95	3.38	0.01	36.00	6.99

Source: Statistics Norway

6.4 Sewer systems

In 1994, figures were obtained from 347 municipalities, which account for 86 per cent of the population. The total length of the sewer systems in these municipalities was 26 700 km, which corresponds to 7.2 m per inhabitant. In 1994, the total length of new sewers laid was 827 km. Combined sewer systems accounted for 17 per cent of this, waste water sewers for 52 per cent, and storm water sewers for 31 per cent. The data available on types of sewer systems, length, age, materials, overflow and pumping stations is incomplete in both this year's and earlier reports. It is therefore difficult to say anything definite about the current situation and trends.

6.5 Waste water treatment in scattered settlements

Whereas the county governors are responsible for municipal waste water treatment, the municipalities are responsible for control of discharges from scattered settlements. Permits for such discharges must be obtained in accordance with the Regulations relating to discharges from separate waste water treatment plants, which also outline the types of treatment that may be used.

In 1993, just under 300 000 separate waste water treatment plants were registered. About 870 000 people were connected to these. These figures are based on reports for 399 of the country's 439 municipalities (94 per cent of the population). Sludge separators and infiltration are the commonest treatment methods for waste water from scattered settlements (figure 6.5).

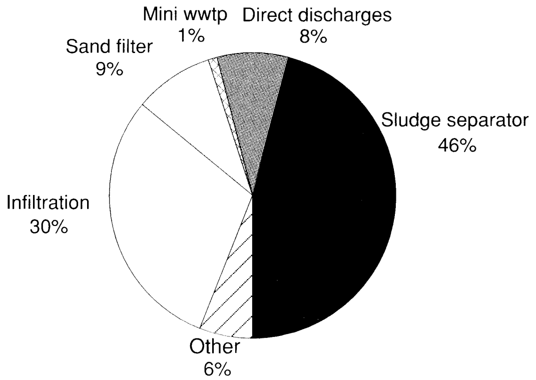
6.6 Discharges of phosphorus from waste water treatment plants

Phosphorus has been chosen as the indicator for amounts discharged and treatment efficiency in the pollution accounts in SSB-AVLØP. In 1994, discharges of phosphorus from municipal treatment plants were calculated to be 578 tonnes. The counties from Østfold to Vest-Agder (the North Sea counties) accounted for only 144 tonnes, or about 25 per cent of the total.

In addition, substantial amounts are lost directly from the sewer systems.

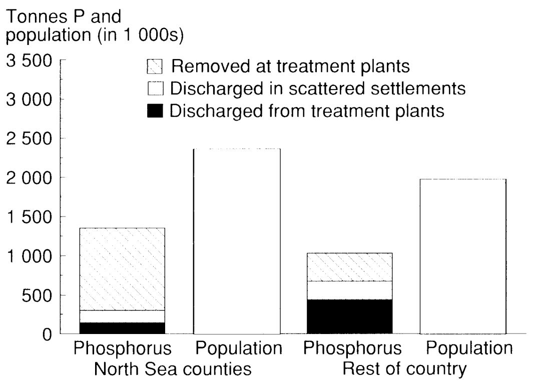
In 1994, average treatment efficiency, i.e. the proportion of the phosphorus removed at waste water treatment plants, was 71 per cent, which is about the same as the previous year. In the North Sea counties, treatment efficiency was 88 per cent, and the corresponding figure for the rest of the country was 43 per cent. This means that, in the country as a whole, treatment plants removed 1 580 tonnes of phosphorus. The figure for the North Sea counties was 1 160 tonnes. Treatment efficiency is high in the North Sea counties because they are served by a number of large high-grade waste water treatment plants. In Norway, scattered settle-

Figure 6.5. Treatment methods for waste water from scattered settlements in 1993



Source: Statistics Norway

Figure 6.6. Phosphorus removed and discharged at municipal treatment plants and discharged in scattered settlements in 1994



Source: Statistics Norway

ments are a major source of phosphorus discharges, and this has become relatively more important as discharges from municipal treatment plants have been reduced (SFT 1996).

6.7 Municipal economy in the waste water treatment sector

Investments

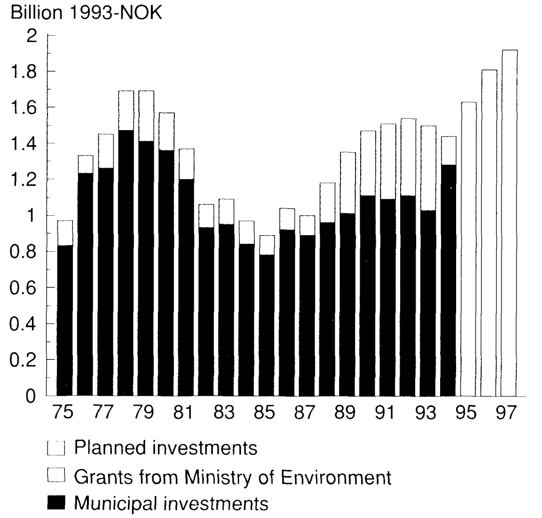
In 1994, gross investments in municipal waste water treatment totalled NOK 1.4 billion. This corresponds to an average of NOK 990 per subscriber. Investments in municipal waste water treatment reached a peak at the end of the 1970s and then dropped during the 1980s, but have since risen again and have remained stable and high during the 1990s. The relatively high level of investments in the 1990s may be related to the implementation of the North Sea Declarations. According to the municipalities' own estimates, total investments in the waste water treatment sector will probably exceed NOK 5 billion for the period 1995-1997.

Figure 6.7 includes grants from the Ministry of the Environment to the municipal waste water sector. The amount granted in 1994 was lower than earlier in the 1990s, and only about one third of the 1993 level.

The amounts invested in 1994 varied substantially from one county to another, depending partly on whether or not a county belongs to the North Sea region. Total investments in the North Sea counties were about NOK 920 million, or about 64 per cent of overall investments in the waste water treatment sector in 1994. Investments were highest in Akershus and Oslo and lowest in Finnmark.

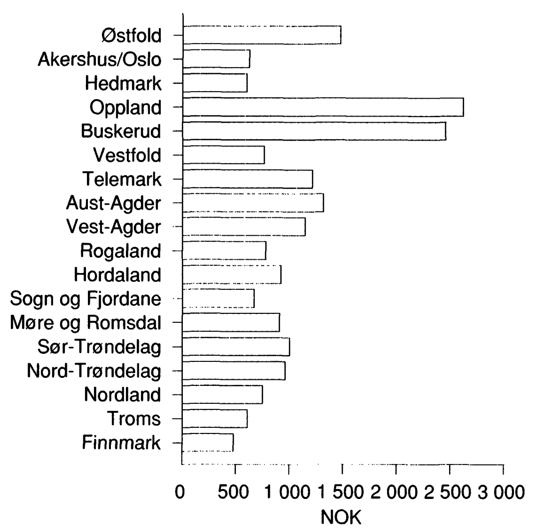
Investments per subscriber were highest (NOK 2 619) in Østfold, and lowest (NOK 477) in Finnmark. The average figure was NOK 1 356 in the North Sea counties, and NOK 786 in the rest of the country.

Figure 6.7. Investments in municipal waste water treatment, 1975-1994. Planned gross investments 1995-1997. Whole country



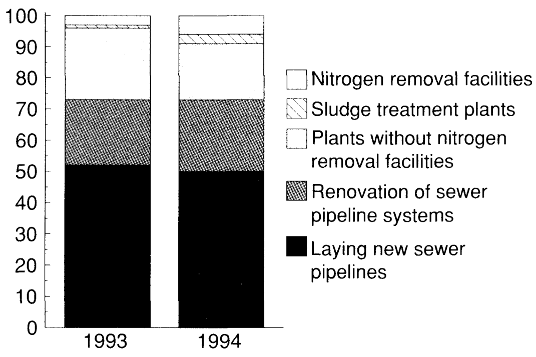
Source: Statistics Norway

Figure 6.8. Gross investments in municipal waste water treatment per subscriber. Weighted averages by county, 1994



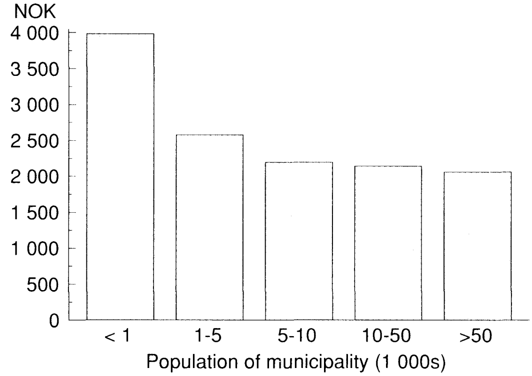
Source: Statistics Norway

Figure 6.9. Gross investments by type



Source: Statistics Norway

Figure 6.10. Average annual costs per subscriber in 1994 according to population of the municipality (weighted averages)



Source: Statistics Norway

In 1994, 73 per cent of the amount invested was used for laying sewer pipelines and renovation of sewer pipelines systems. This is roughly the same as the year before (figure 6.9). Investments in sludge treatment plants rose from 1 per cent of the total in 1993 to 3 per cent in 1994, and investments in nitrogen removal facilities rose from 3 to 6 per cent of the total.

Annual costs in 1994

In 1994, the total costs of municipal waste water treatment were more than NOK 3.1 billion. Operating costs accounted for slightly less than NOK 1.7 billion of the total, and capital costs[1] for slightly more than NOK 1.4 billion. The average annual cost per subscriber was NOK 2 156.

In general, the annual costs were lower in the larger municipalities. This may be connected with economies of scale. However, there were a few exceptions.

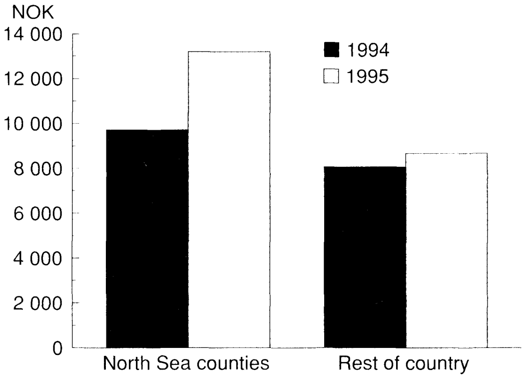
The costs per subscriber were highest in municipalities in the North Sea counties. The weighted mean[2] for the North Sea counties was about NOK 2 588, compared with NOK 1 780 for the rest of the country. Costs per subscriber were highest in Oppland, Aust-Agder and Vest-Agder. The high level of costs in the North Sea counties may be connected with the high treatment standards these counties are required to achieve.

Fees

The municipalities are authorized to levy fees that cover the capital and operating costs of waste water treatment. They do this by charging connection fees and annual fees. In 1994, the municipalities collected a total of almost NOK 2.8 billion in waste water treatment fees, of which annual fees accounted for more than NOK 2.5 billion. Total income in the form of fees covered 88 per cent of the municipalities' total costs. The income-to-cost ratio[3] rose by 8 percentage points from 1993 to 1994.

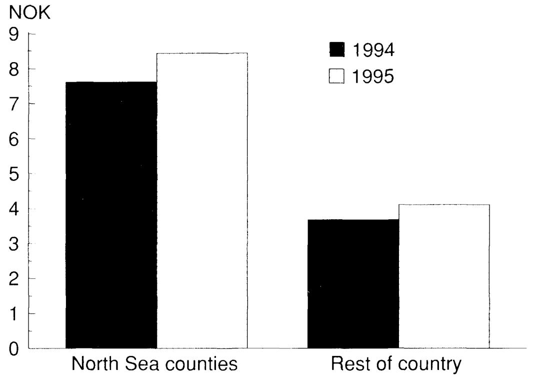
1 Capital costs are calculated on the basis of a depreciation period of 20 years and an annual interest of 7.5 per cent.
2 Weighted according to the number of subscribers in the municipality connected to the sewage system.
3 The income-to-cost ratio is the ratio between income from annual fees and annual costs.

Figure 6.11. Average connection fee



Source: Statistics Norway

Figure 6.12. Average annual fee per m^3 water



Source: Statistics Norway

The average connection fee for the whole country was NOK 10 470 in 1995. This is an increase of about 20 per cent from 1994. Fees rose more steeply in the North Sea counties than elsewhere. The size of the fee varied from NOK 100 to more than NOK 50 000. The average connection fee was highest in the North Sea counties both in 1994 and in 1995. In 1995, the average connection fee in the North Sea counties was NOK 13 195, while the corresponding figure for the rest of the country was NOK 8 663.

In 1995, the annual fee averaged NOK 5.87 per m^3 water. The corresponding figure for 1994 was NOK 5.42, and the average fee thus rose by 8 per cent from 1994 to 1995. The average annual fee per m^3 water was twice as high in the North Sea counties as in the rest of the country both in 1994 and in 1995 (figure 6.12). This is because the required standard of treatment, and therefore the costs, were higher in the North Sea counties.

More information may obtained from Per Schøning, Marianne Vik Dysterud and Andrew Essilfie

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7. Waste

Every Norwegian generated an average of 247 kg household waste in 1994. This is about the same as in the two preceding years, but considerably more than for example in 1974, when the average quantity was 174 kg. The proportion of waste recycled rose to 16 per cent of all household waste in 1994.

In 1993, manufacturing industries generated 3 million tonnes production and consumer waste, of which 29 per cent was recycled. In addition, 320 000 tonnes hazardous waste was generated. About 10 per cent of the waste generated by a sample of public institutions and services was recycled in 1995.

In 1994, almost 440 000 tonnes hazardous waste was generated in Norway. Of this, 20 per cent was collected by the system for hazardous waste management, 28 per cent was treated on-site by industrial enterprises, 38 per cent was treated outside the system for hazardous waste management, 6 per cent was exported and 8 per cent was disposed of illegally.

The number of municipal or intermunicipal waste treatment and disposal plants has dropped from 340 in 1992 to 252 in 1995. The closure of a further 149 plants before 2000 is being considered.

7.1 Introduction

Waste consists of all residual products for which there is no use. It used to be an easy solution to throw away or burn what was not needed, but as the quantities of waste generated have increased, the associated environmental problems have become increasingly obvious. Pollution of water sources, air pollution from incineration plants, the generation of greenhouse gases in landfills, unpleasant smells and hygienic problems are among the most serious of these. At the same time, waste contains valuable resources which can be used by recycling and re-using more waste, and in many cases pollution problems can be eliminated by making better use of the resources in waste.

The strategy being followed by the environmental authorities is first and foremost to minimize waste generation, secondly, to promote re-use, the recovery of useful materials and the extraction of energy from any waste generated, and thirdly, to ensure sound management of the residual waste.

Nationwide official statistics on waste and recycling are needed to provide information on the quantities of waste, to reveal environmental problems and to monitor the effects of any measures introduced. Statistics Norway has cooperated with the Norwegian Pollution Control Authority and other institutions in drawing up waste statistics in their current form.

Several waste streams have still not been described, and some of the data available are unreliable. Current waste statistics do not provide a complete description of the waste generated and how it is disposed of. Statistics Norway is therefore in the process of expanding the statistics to develop *waste accounts* for Norway. The first results of this work will be presented in 1996.

7.2 Waste generation

The statistics on waste generation are based on the sector of society or industry where the waste originates, either through production or consumption. Storage, exports, imports and illegal treatment may result in substantial differences between the amounts of waste generated annually and the amounts registered in the waste statistics.

No complete figures are available for the quantities of waste generated in Norway each year. Household waste is fairly well covered by the statistics. Statistics Norway has collected figures on waste generation from a sample of institutions and enterprises in the private and public sectors.

Statistics Norway has also calculated the amounts of waste that will be generated in the future on the basis of assumptions concerning economic trends, see Part II, Chapter 4.1.

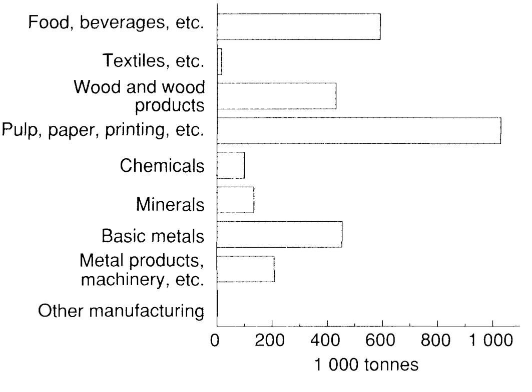
Household waste
There has been a substantial increase in the amount of household waste generated since the early 1970s. In 1974, each person generated an average of 174 kg household waste (Ligård 1982). In 1994, this had risen to 247 kg per capita according to Statistics Norway's figures. The amount of waste generated remained fairly stable in 1992 and 1993 (Statistics Norway 1994b and 1995a,b, table G1 in Part III).

Differences in per capita waste generation have been analysed both in Norway and in other countries. Over time, there has proved to be a relationship between general welfare trends in a country expressed as gross domestic product and per capita waste generation (Halmø 1984). Studies in Norway show that per capita waste generation is higher in urban municipalities than in rural municipalities (Ligård 1982).

Waste from manufacturing industries
Calculations show that in 1993, manufacturing industries generated 3.0 million tonnes production and consumer waste and in addition, 320 000 tonnes of hazardous waste. These figures do not include waste recycled on-site (Statistics Norway 1994a, tables G5-G8 in Part III).

The manufacture of pulp and paper, printing and publishing generated 35 per cent of this

Figure 7.1. Calculated amounts of production and consumer waste generated by manufacturing industries, 1993



Source: Statistics Norway

Terminology and classification

The names of waste categories can be confusing because there are many ways of classifying waste, for instance according to origin, composition or environmental impact. The result is a wide variety of terms, some of which have overlapping meaning.

In the Pollution Control Act, waste is divided into three categories, largely on the basis of its composition. These are consumer waste, production waste and hazardous waste. Statistics Norway classifies waste according to its origin, as household waste or industrial waste. In addition, the term municipal waste has been used for waste treated or administered in the municipal system. Often, waste fractions consisting of particular materials are discussed separately (paper, glass, metal, etc). These may form part of any of the previously mentioned categories. Waste may also be classified according to product type (packaging, electronic products, household appliances, etc). These may also belong to any of the above-mentioned categories.

Other countries use their own terminology, which only rarely coincides with Norwegian usage. This makes it difficult to produce waste statistics covering several countries. Both the EU and the ECE are giving high priority to the development of a joint classification system, but have not yet presented final recommendations.

Consumer waste
Ordinary waste, including large items such as fittings and furnishings from private households, shops, offices, etc.

Production waste
Waste from commercial activities and services which is significantly different in type or amount from consumer waste.

Hazardous waste
Waste which cannot appropriately be treated together with municipal waste because it may cause serious pollution or a risk of injury to people and animals.

Household waste
Waste from normal activities in private households.

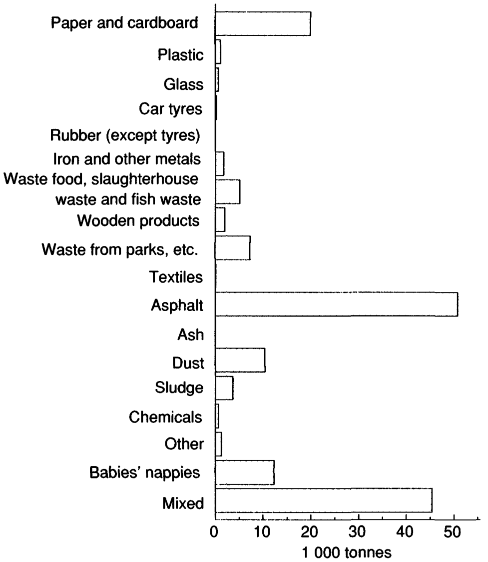
Industrial waste
Waste from economic activities, both private and public. Statistics Norway further subdivides industrial waste according to the branch of industry from which it originates. The degree of aggregation in the classification varies.

waste, the manufacture of food, beverages and tobacco products 20 per cent and the manufacture of basic metals 15 per cent. Other manufacturing industries accounted for the remaining 30 per cent (figure 7.1).

Waste wood accounted for the largest proportion of production and consumer waste from manufacturing industries (30 per cent). Waste food, slaughterhouse waste and fish waste accounted for 15 per cent, paper and cardboard for 7 per cent, and uncontaminated materials such as stones and gravel for 5 per cent.

Packaging made up 5 per cent (151 000 tonnes) of all production and consumer waste.

Figure 7.2. Calculated amounts of production and consumer waste generated by selected public institutions and services in 1994, by material (excluding mineral and hazardous waste)



Source: Statistics Norway

This included 62 000 tonnes paper and cardboard and 41 000 tonnes glass.

Waste from the public sector

In 1995, Statistics Norway carried out a survey of waste from a sample of institutions and services in the public sector (Statistics Norway 1996a, tables G10-G14 in Part III). The survey included technical services in the municipalities, the health and social affairs sector of central government administration, educational institutions (agricultural sector, other colleges and universities), research activities, animal health and veterinary services and social services for the elderly. A total of 9 300 institutions and units are involved in these activities, corresponding to 16 per cent of all institutions and units in the public sector, including private services. A sample of 530 of these was selected, and these reported data on waste to Statistics Norway. On the basis of this, the total amount of waste generated by these activities has been calculated to be 406 000 tonnes. About 1 per cent of this was hazardous waste. About 60 per cent of the remainder was stone, gravel and concrete (mineral waste) generated mainly in connection with road construction by the technical services in the municipalities. Figure 7.2 shows the amounts of waste produced, classified by type of material. Hazardous waste and mineral waste are not included in the figure.

Packaging made up a little more than 3.5 per cent of the waste from the sample. This consisted of 77 per cent paper and cardboard, 7

Table 7.1. Amounts of hazardous waste generated in 1994, by waste category

Category	Tonnes	Percentage
Waste oil	50000	11
Other oil-contaminated waste	25000	6
Stable oil emulsions	4000	1
Waste solvents	20000	5
Paints, glue, varnish and printing ink	5000	1
Distillation residues	400	0
Tars	12000	3
Waste containing mercury or cadmium	1	0
Environmentally hazardous metals	125000	29
Waste containing cyanide	50	0
Pesticides	50	0
Isocyanates, etc	50	0
Acids and alkalis	155000	36
Waste from oil-drilling/ production	20000	5
Other very toxic and environmentally hazardous substances	135003	
Waste containing PCBs	1	0
Photographic chemicals	5000	1
Halons	65	0
CFCs	90	0
Total	435207	100

Source: NORSAS

Waste statistics in Norway

The environmental authorities are giving high priority to the development of official nationwide statistics concerning waste and recycling. Statistics Norway has cooperated with the Norwegian Pollution Control Authority and other institutions in drawing up waste statistics in their current form.

Norwegian waste statistics are satisfactory in a number of areas, but more complete information on all waste streams is needed, and Statistics Norway is therefore in the process of developing national waste accounts that will provide a better overall picture.

Municipal waste management
Since 1992, Statistics Norway has prepared annual statistics on waste and its management through the municipal waste collection system. In 1992, these were based on reports from all municipalities and waste treatment and disposal plants, and in 1993 and 1994 on reports from a sample of 50 municipalities. Figures for 1995 will once again be collected from all municipalities and waste treatment and disposal plants. The results of this survey will be published in autumn 1996.

Waste from commercial activities
In 1994, Statistics Norway carried out an interview-based survey of industrial waste from a selection of enterprises in the following branches: petroleum extraction, mining and quarrying, manufacturing industries and construction.

Waste from the public sector
In 1995, a questionnaire-based survey of waste from a sample of institutions and services in the public sector was carried out. It included technical services in the municipalities, the health and social affairs sector of central government administration, educational institutions (agricultural sector, other colleges and universities), research activities, animal health and veterinary services and social services for the elderly.

Packaging
Statistics Norway is in the process of drawing up statistics for waste packaging. This forms part of agreements between packaging manufacturers and the Ministry of the Environment, the purpose of which is to increase the amount of waste recycled and reduce the quantities of packaging.

Hazardous waste
NORSAS A/S (the Norwegian Resource Centre for Waste Management and Recycling) publishes annual statistics of the amounts of hazardous waste delivered.

Organizations involved in waste management
In 1995, the EU adopted a directive which requires each country to establish a register of organizations involved in waste management. NORSAS has been given this task in Norway, and is to establish the register in the course of 1996. There are also plans to use the register to collect data on waste quantities and management.

per cent plastics and 9 per cent glass, wood, iron and other metals and textiles. The remainder consisted of mixed packaging.

Hazardous waste
The high concentrations of toxic substances in hazardous waste represent a serious

threat to the environment, even though the quantities of hazardous waste generated are relatively small. Calculations show that 435 200 tonnes of hazardous waste was generated in Norway in 1994 (NORSAS 1996b, table 7.1). This is considerably higher than previous calculations have shown. In addition, the implementation of EU legislation concerning hazardous waste will make it necessary to include more types of waste in this category, thus increasing the amount of hazardous waste generated by 137 000 tonnes.

Corrosive substances are the largest category of hazardous waste, and make up 36 per cent of the total. The next largest categories are environmentally hazardous metals (29 per cent) and waste oil (11 per cent). The remaining categories each account for less than 6 per cent of the total amount of hazardous waste generated.

Figures from Statistics Norway show that in 1993, manufacturing industries generated 320 000 tonnes of hazardous waste (Statistics Norway 1994, table G8 in Part III). The manufacture of chemicals accounted for 76 per cent of this. More than half of all hazardous waste consisted of acids, and 93 per cent of this was generated by a single enterprise. Other organic hazardous waste accounted for 14 per cent of the total, and oil-contaminated waste for 6 per cent.

The survey of waste in the public sector showed that the selected institutions and services generated 4 000 tonnes of hazardous waste in 1994 (Statistics Norway 1996a, table G12 in part III). Infectious waste made up 48 per cent of this (1 900 tonnes). Photographic chemicals were the next largest category (950 tonnes), followed by waste oil (850 tonnes).

7.3 Waste management

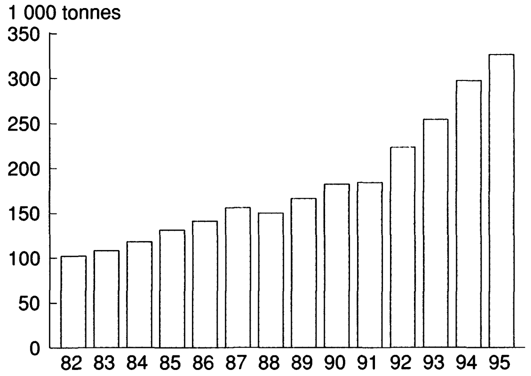
Once waste has been generated, recycling is generally the management strategy that causes least pollution and makes best use of the resources in the waste. Recycling may be divided into re-use, material recovery and energy recovery. Other methods of dealing with waste are landfill and incineration.

Recycling and return schemes

No complete figures for the amount of waste recycled are available, but NORSAS (the Norwegian Resource Centre for Waste Management and Recycling) is setting up routines for regular collection of such information. Because it is difficult to draw a hard-and-fast line between waste and returned raw materials, it is particularly difficult to quantify the amounts of waste recycled on-site by industrial enterprises.

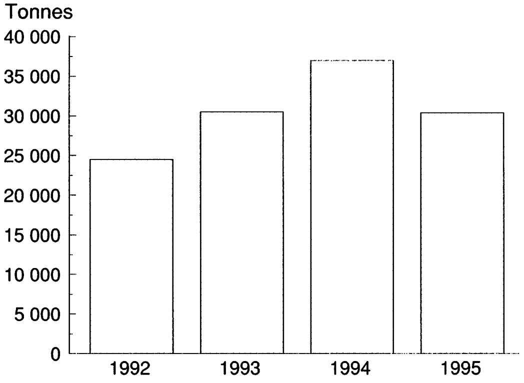
The return scheme for beer, mineral water, wine and spirits bottles is the most important re-use scheme already established in Norway. Between 95 and 100 per cent of all beer and mineral water bottles are returned, and 71 per cent of wine and spirits bottles (Statistics Norway 1995).

Figure 7.3. Amounts of paper and cardboard collected for recycling



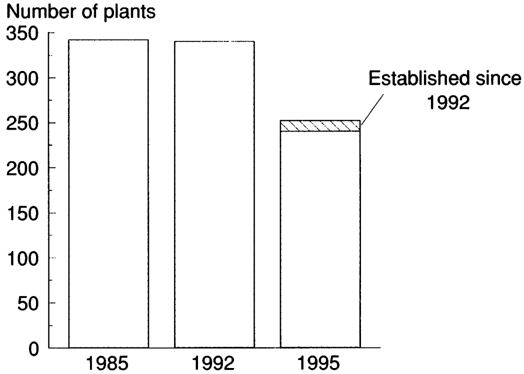
Source: Federation of Norwegian Process and Manufacturing Industries

Figure 7.4. Amounts of glass collected for recycling



Source: Norwegian Glass Recycling A/S

Figure 7.5. Numbers of waste treatment and disposal plants and newly-established plants



Source: Statistics Norway

Regular statistics are compiled for paper and cardboard, and show a substantial increase in the amounts collected during the past ten years (PIL 1996, figure 7.3). The amount collected expressed as a percentage of consumption rose from about 20 per cent in the mid-1980s to 32 per cent in 1993, but fell again to 30 per cent in 1994.

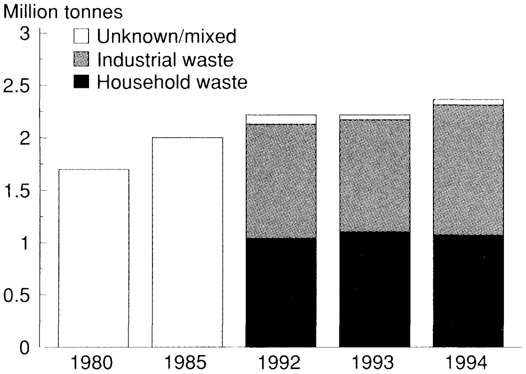
The amount of glass recycled has risen in recent years, but was lower in 1995 than in 1994 (Norwegian Glass Recycling 1996, figure 7.4). This is because breweries and producers of mineral water and soft drinks have switched to plastic packaging for many of their products.

In 1995, about 340 000 tonnes of scrap iron was collected in Norway (Stålverkenes skrapjernkontor 1996). A growing proportion of the scrap iron consists of shredded iron, i.e. scrap iron broken up into very small pieces. In 1993, 20 per cent of this was from scrapped cars and household appliances.

Waste treatment and disposal plants
There has been a substantial drop in the number of municipal and intermunicipal waste treatment and disposal plants in the last few years. In 1992, there were 340 municipal and intermunicipal waste treatment and disposal plants, as compared with 252 in 1995 (Statistics Norway 1996b, table G17 in Part III). This corresponds to a reduction of 29 per cent. During this period, 100 waste treatment and disposal plants were closed and only 12 new ones opened. In addition, the closure of a further 149 plants before 2000 is being considered. These figures include almost all landfills and plants where waste is incinerated or treated biologically, but exclude waste treatment on-site by industry.

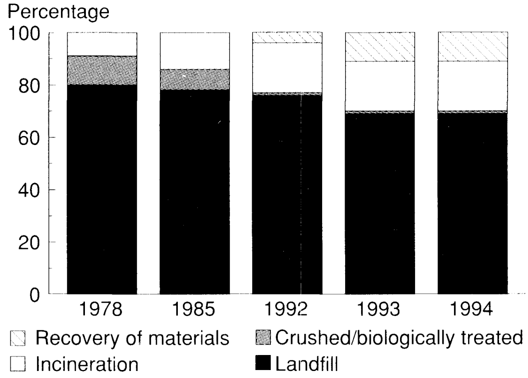
Nordland is the county where the largest number of closures has taken place. Between 1992 and 1995, 19 of the 53 waste treatment and disposal plants in the county were closed. Between 1985 and 1992, the number of waste treatment and disposal plants in Norway remained fairly constant. In 1985, 342 plants were registered, only two more than in 1992.

Figure 7.6. Total quantities of municipal waste



Source: Statistics Norway

Figure 7.7. Municipal waste according to method of treatment



Source: Statistics Norway

Municipal waste management

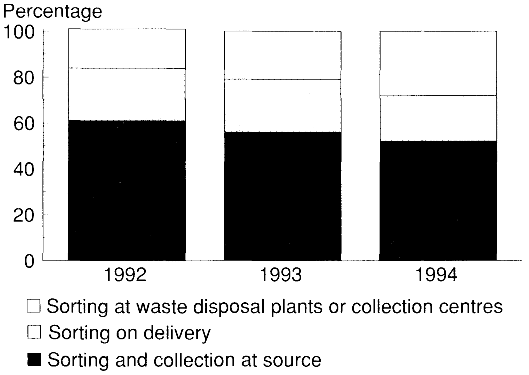
Statistics Norway recorded statistics on waste management by the municipalities for selected years in the 1980s and has done so annually since 1992. These figures include almost all household waste and a large proportion of industrial waste. Waste treated on-site by industrial enterprises is not included. Industrial waste that is recycled is only included in these statistics if the municipalities administer the collection scheme.

In 1994, municipal waste collection systems dealt with 2 365 600 tonnes waste (Statistics Norway 1995a, b, figure 7.6, tables G1-G3 in Part III). This is an increase of about 150 000 tonnes from the two preceding years, which is explained by a rise in the amount of industrial waste. However, since private waste collection systems are not included in these statistics, it is not possible to say whether the total amounts of industrial waste are increasing at the same rate.

Most waste is still disposed of on landfills (figure 7.7). Calculations show that 69 per cent of municipal waste was dumped on landfills in 1994. Of the remainder, 19 per cent was incinerated, 12 per cent recycled and 1 per cent composted.

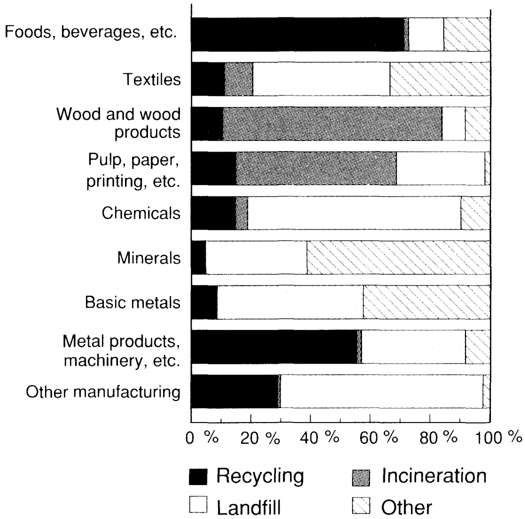
Figures for recent years show a relatively steep increase in the amount of waste recycled. In 1994, 280 000 tonnes municipal waste was delivered for material recovery, 17 per cent more than in 1993. Waste delivered by private households explains the increase; the proportion of household waste recycled has risen from 9 per cent in 1992 to 16 per cent in 1994. The proportion of industrial waste that is recycled has remained stable at about 8 per cent during this three-year period. It is important to remember that the figures only apply to industrial waste handled by municipal waste collection systems. There has been a trend away from sorting waste at source in 1992-1994 (figure 7.8). Throughout the period, sorting and collection at source has been the most widely used system of waste collection for recycling. Nevertheless, the proportion collected in this way has dropped from 61 per cent in 1992 to 52 per cent in 1994. During the same period, the proportion sorted at waste treatment and disposal plants or at collection centres rose from 17 to 28 per cent. The propor-

Figure 7.8. Recovery of materials from municipal waste by sorting method



Source: Statistics Norway

Figure 7.9. Production and consumer waste from manufacturing industries, by branch of industry and method of treatment.[1] 1993



[1]Waste delivered to external facilities and waste dealt with on-site.
Source: Statistics Norway

tion sorted on delivery (i.e waste delivered to special containers, etc) dropped slightly during these three years.

Manufacturing waste
In 1993, 26 per cent of all production and consumer waste from manufacturing industries was delivered for material recovery, 29 per cent was incinerated and 28 per cent was sent to municipal or private landfills (Statistics Norway 1994a, tables G6 and G7 in Part III). The remaining 17 per cent was either biologically treated, used for landscaping or treated in other ways (figure 7.9).

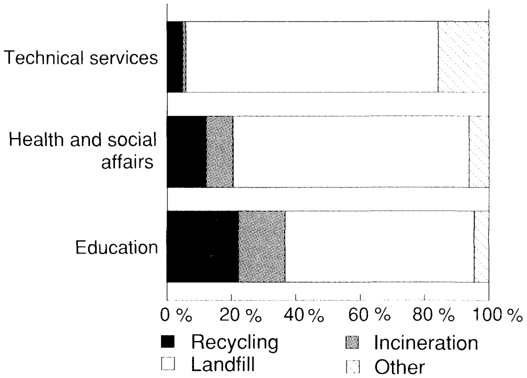
The proportion of waste recycled was highest in the manufacture of food, beverages and tobacco products (71 per cent) and in the manufacture of fabricated metal products, machinery and equipment (55 per cent). In other branches of industry, the proportion recycled varied between 4 and 15 per cent.

In total, 46 per cent of all production and consumer waste from manufacturing industries was disposed of or treated on-site, i.e. landfilled, incinerated or used for landscaping on-site, stored, or washed into the sewer system. In all, 850 000 tonnes of this category of waste was landfilled, and 500 000 tonnes of this went to on-site landfills.

The proportion of iron and other metals recycled was higher than for any other materials; 88 per cent was delivered for recycling in 1993. For paper and cardboard, the proportion delivered for recycling was 75 per cent, while 2 per cent was incinerated and the rest delivered to landfills. For glass, the proportion delivered for recycling was 80 per cent, and for waste food, slaughterhouse waste and fish waste the figure was 81 per cent. Wood waste was largely burnt (81 per cent).

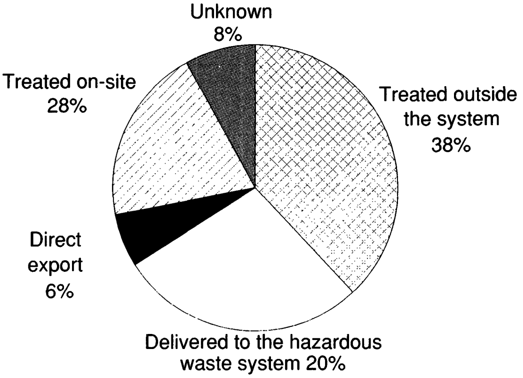
Waste from the public sector
The main method of disposal for waste from the sample of public institutions and services was landfill (Statistics Norway 1996b, figure

Figure 7.10. Production and consumer waste from selected public institutions and services, by sector and method of treatment (excluding mineral waste and hazardous waste). Sum of external and on-site treatment, 1994



Source: Statistics Norway

Figure 7.11. Calculated amounts of hazardous waste by method of treatment. 1994*



Source: NORSAS

7.10, tables G13 and G14 in Part III). The figures show that 55 per cent of the waste (excluding mineral waste) was dumped on landfills (municipal or on-site), while only 10 per cent was delivered for material recovery and 5 per cent was incinerated. Most of the remainder was either used for landscaping (8 per cent) or temporarily stored. In 1994, 25 per cent (40 000 tonnes) of the waste was treated on-site, i.e. landfilled (7 500 tonnes), incinerated (200 tonnes) or used for landscaping on-site (4 000 tonnes), stored (30 000 tonnes) or washed into the sewer system (1 tonne). The category "landfilled on-site" consists mainly of waste from parks, etc and sweepings from streets and pavements which are dumped on temporary landfills by the technical services in the municipalities.

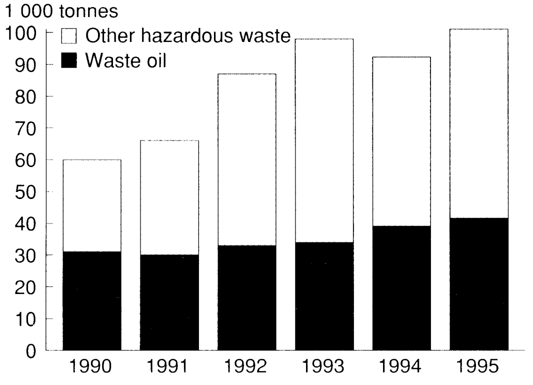
About half of all car tyres and waste glass were returned for material recovery, and the remainder was dumped on landfills. About 30 per cent of the paper and cardboard waste was returned for material recovery, 10 per cent was incinerated, and the rest, together with almost all wood and particle board waste, was landfilled.

Hazardous waste

Calculations from NORSAS show that large amounts of hazardous waste bypass the system of hazardous waste management; some is treated in approved on-site facilities, but the remainder is treated illegally or its fate is unknown (NORSAS 1996b, figure 7.11).

The amount of hazardous waste delivered to the hazardous waste management system has risen considerably in recent years. In 1990, the figure was about 60 000 tonnes, while in 1995 it had risen to almost 102 000 tonnes (figure 7.12, NORSAS 1996a, tables G15 and G16 in Part III). In 1995, various categories of oily waste made up about 60 per cent of the total, waste from oil drilling about 21 per cent, other organic waste 11 per cent and inorganic waste 8 per cent. More than 50 per cent of the total quantity of hazardous waste delivered came from three counties in Western Norway, i.e. Rogaland, Hordaland and Sogn og Fjordane.

Figure 7.12. Hazardous waste delivered



Source: NORSAS

Table 7.2. Exports and imports of hazardous waste

	Exports	Imports
1989	16576	-
1990	21766	-
1991	14643	2419
1992	14533	6262
1993	18208	15222
1994	32811	4358

Source: NORSAS

Exports and imports of waste

Most of the waste generated in Norway is treated within the country's borders. Some household and industrial waste is exported and imported between municipalities on both sides of the borders with Finland and Sweden. However, no figures are available for the overall amounts involved.

There are substantial exports of waste for recycling, including large amounts of waste paper. In 1995, almost 170 000 tonnes of waste paper was exported (PIL 1996). This is more than half of all the waste paper collected. The proportion exported has risen from about one third of the total amount collected in the early 1980s. About 75 per cent of all waste paper exported from Norway was sent to paper manufacturers in Sweden. Denmark, the United Kingdom and France are also important recipients. Substantial amounts of waste paper are also imported; in 1995, the figure was more than 70 000 tonnes. In previous years, Norway has imported roughly 30 000-60 000 tonnes waste paper.

With permission from Norwegian Pollution Control Authority, consignments of hazardous waste have regularly been exported from Norway for treatment in other countries. NORSAS compares information on this with data registered in the hazardous waste management system (NORSAS 1995, table 7.2). The quantities vary widely from year to year. In recent years, lead accumulators have made up about half of total exports. Imports of hazardous waste are registered in the same way as exports. These figures also show considerable variation from year to year. In recent years, a large proportion of the imported waste has consisted of waste oil.

7.4 Municipal economy in the waste sector

Investments

Investments in waste treatment and disposal plants accounted for 48 per cent of the municipalities' total investments in the waste sector in 1994 (Statistics Norway 1995c, figure 7.13). The term waste treatment and disposal plant includes milling, shredding, incineration, composting and rendering plants as well as landfills. Investments in recycling plants accounted for 17 per cent, and collection and transport for 19 per cent.

Costs associated with waste management

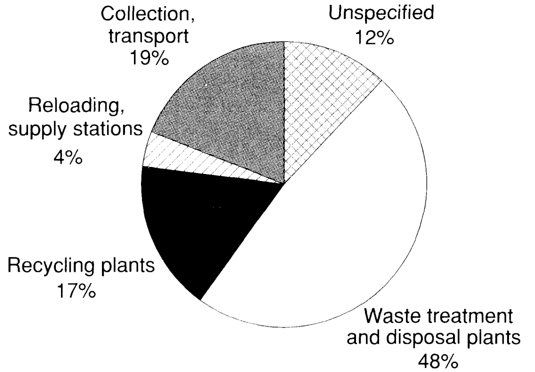
In 1994, the costs incurred by the municipalities in connection with waste management totalled NOK 1.9 billion (table 7.3). This is an increase of about 7 per cent from 1993. The rise is partly explained by the fact that the municipalities have set aside a substantial sum towards an investment fund. Other explanations are costs incurred in upgrading waste treatment and disposal plants and a rise in the amount of municipal waste. The municipalities may also now have more complete information on the real costs of waste management. Municipal waste management costs were equivalent to NOK 440 per person in 1994. The average cost of municipal waste management per tonne in 1994 was NOK 810, the same as in 1993.

Fees

About 97 per cent of all Norwegian households are served by public waste collection systems (Statistics Norway 1994b). A normal subscriber, who has a container or sack that is emptied once a week, paid on average NOK 809 per year in 1993 (SFT 1994, table G4 in Part III). The county average varied from NOK 685 per year in Rogaland to NOK 1 076 per year in Oslo. The average price for delivering refuse directly to a landfill was NOK 390 per tonne. These figures exclude value-added tax.

In general, the fees payable depend on how the waste is treated. Municipalities which have composting plants charge higher fees than those which dump waste on landfills. The fees are also somewhat higher in municipalities which take part in intermunicipal waste collection systems. There is reason to believe that the intermunicipal companies also have a clearer picture of the costs of waste management and are able to include a higher proportion of such costs in the basis for calculating their fees.

Figure 7.13. Investments in the municipal waste sector in 1994, by type



Source: Statistics Norway

Table 7.3. Municipal costs and income in the waste management sector. Million NOK

	1993	1994
+ Operating costs	1632	1716
- Operating income	23	71
+ Capital costs	154	171
+ To investment fund	57	100
- Income from sale of capital	25	1
+ Miscellaneous	0	1
= Net costs	1796	1916

Source: Austbø, T. and A. Essilfie (1995)

From 1995 onwards, the environmental authorities will base their waste management policy on the polluter pays principle. The ultimate objective is to reduce the amounts of waste generated. The Pollution Control Act now requires the municipalities to cover all the costs of waste management through the fees they charge. The Norwegian Pollution Control Authority assumes that until now, very few municipalities have been able to cover the costs of waste management fully through income from fees charged to subscribers. However, it should be realized that the regulations do not currently take into account external costs (e.g. pollution caused by emissions from waste management facilities). Ideally, such costs should also be taken into consideration to achieve more correct pricing of waste management services.

More information may be obtained from Andrew K. Essilfie (economic aspects), Åse Kaurin (industrial waste), Ole Osvald Moss (hazardous waste and waste in general) and Olav Skogesal (municipal waste)

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8. Exposure to noise and air pollution

People perceive road traffic as the main source of noise and pollution in and near their homes. Single parents, people with financial problems and inhabitants of Oslo are more exposed to road-traffic pollution than the average person. However, noise and pollution problems were no worse in 1995 than 15 years earlier, even though the volume of traffic has risen by 50 per cent. There is most road-traffic pollution in Norway's largest towns, and most industrial pollution in medium-sized towns.

Various forms of dust in air were the type of pollution to which Norwegian employees were most commonly exposed in the working environment in 1993. Exposure levels were highest among workers in the manufacture of metal and metal products and wood and wood products. Passive smoking was second in importance, and the degree of exposure was highest among employees in hotels and restaurants. From 1989 to 1993, there was a general increase in levels of pollution in workplaces. The trend was most negative for unskilled employees.

8.1 Introduction

The way people experience pollution and noise at home and at their places of work has been studied in the surveys of level of living and working conditions run by Statistics Norway, see Barstad (1994) and Statistics Norway (1995). These studies are based on how the respondents themselves experience the situation. To avoid too subjective an evaluation, the people interviewed are asked whether they are "exposed to" rather than whether they are "annoyed by" noise or pollution. Nevertheless, the answers will be subjective to some extent. Our perception of environmental conditions is influenced by attitudes, previous experience and knowledge. This must be taken into consideration in making comparisons over a period of time. Since 1980, there has been a much greater focus on "the environment", and it is reasonable to assume that there is now a generally higher level of public awareness of the negative effects of pollution. This in itself may result in an increase in the proportion of people who consider that they are "exposed to" pollution.

The studies do not give any direct information on how harmful such exposure is (see Chapter 3.6 in Part II). In the surveys of working conditions, for example, the toxicity and concentrations of chemicals and the extent to which personal safety equipment is used have not been taken into account. Information on such factors is important in evaluating the risk of injury to health.

8.2 Noise and pollution in the local environment

Surveys of level of living

The surveys of level of living are interview-based studies of a representative sample of the adult population of the entire country, in which various aspects of living conditions and welfare are investigated. Five surveys have been made since 1980, the most recent being in 1995. A net sample of just under 4 000 persons has taken part each time.

The respondents are asked whether they are normally exposed to noise in their homes, pollution near their homes or smells from industry or other sources. Changes in the answers to these questions will be a result of complicated interactions between trends in external stresses (such as growth in traffic and industrial discharges), choice of domicile, the amount of time spent in and near the home, and changes in attitudes and other subjective factors.

Main distribution patterns and changes in environmental problems

The overall impression is that perceived noise and pollution problems in and near the home were about as widespread in 1995 as they were 15 years earlier (tables 8.1 and 8.2). However, there is a weak tendency for somewhat fewer people to be exposed to pollution in 1995 than in 1983 (1983 was the first year when a comparable question was asked about pollution). The proportion of people exposed to pollution sank from 19 to 16 per cent. This decrease may be related to the reduction of certain types of discharges of pollutants (see Chapter 2 in Part I and table B2 in Part III). About one-quarter of the population stated that they were exposed to noise both in 1980 and in 1995.

Throughout the period, road traffic has been the main source of both noise and pollution in the local environment. In 1995, 13 per cent of the population was exposed to road-traffic noise, and 11 per cent was exposed to pollution. Since 1980, the volume of traffic has risen by about 50 per cent (Rideng 1994). Nevertheless, the surveys of level of living indicate that the level of exposure to pollution has dropped somewhat since then, while exposure to noise has remained more or less unchanged. Thus, the level of exposure to noise and pollution has increased less than the volume of road traffic, which may be explained by the fact that emissions from traffic have not increased correspondingly (Statens forurensningstilsyn 1993) and by the construction of noise baffles. Since 1980, noise baffles with a total length of more than 200 km have been built, at a cost of NOK 0.5 - 1 billion at today's prices. Emissions have been reduced by the introduction of more energy-efficient engines, a reduction of the sulphur content of fuel and the introduction of catalytic converters in new cars.

Five per cent of the adult population state that road-traffic noise is so loud that at certain times of day, it is difficult to have a normal conversation inside the home. Three per cent report such difficulties only when the windows are open, one per cent even if they are closed, but only during the rush hour, and one per cent for more than half of the day even if the windows are closed. This

Table 8.1. Proportion of the population exposed to noise from various sources in their homes. Percentages

	1980	1983	1987	1991	1995
Neighbours, stairways, water pipes, etc.	7	6	5	6	7
Road traffic	14	13	12	13	13
Railways	2	2	2	3	3
Aircraft	6	5	6	8	7
Industry or construction	2	2	3	2	3

Source: Statistics Norway, Surveys of level of living

Table 8.2. Proportion of the population exposed to pollution from various sources near their homes. Percentages.

	1983	1987	1991	1995
Dust, smells, exhaust from road traffic	13	12	12	11
Smoke, dust or deposits from industry or other sources	5	6	5	4
Smells from industry or other sources	6	6	5	5
Exposed to only one pollution source	15	14	14	14
Exposed to 2 or 3 pollution sources	4	4	4	3

Source: Statistics Norway, Surveys of level of living

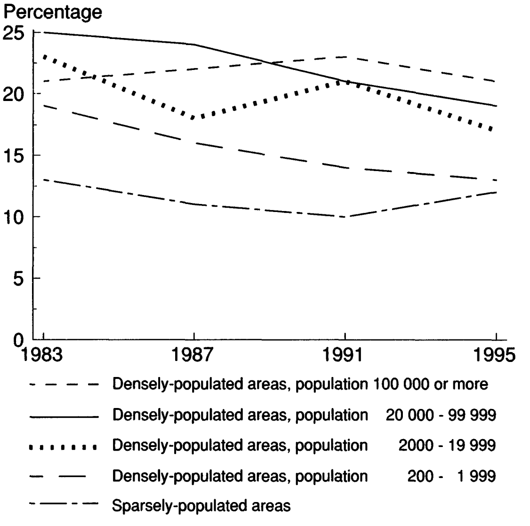
means that, even if the windows are kept closed, about 70 000 people in Norway find it difficult to have a conversation inside their homes because of road-traffic noise.

In all, 8 per cent of the population was exposed to smells or pollution from industry or similar sources in 1995. Barely two per cent of the population was exposed to both road-traffic and industrial pollution.

Geographical distribution of pollution problems
Obvious pollution is largely an urban phenomenon. This pattern has remained more or less unchanged throughout the period covered by the surveys (figure 8.1 and figure 8.2). The level of exposure to pollution has been reduced in medium-sized towns, whereas there has been little change in sparsely-populated areas and in the largest towns.

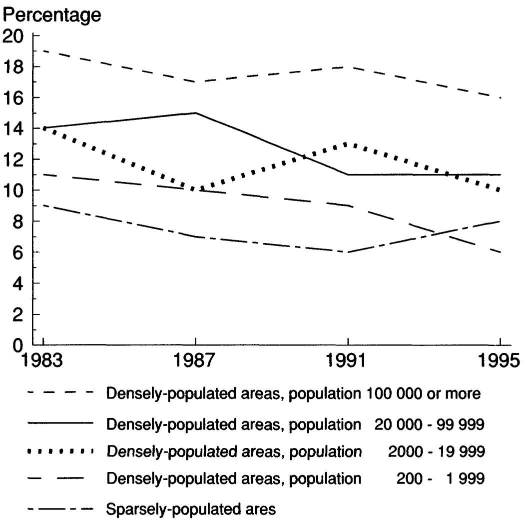
In the largest towns, the proportion of the population exposed to pollution from road traffic decreased, whereas the proportion exposed to industrial pollution rose. This rise is difficult to explain, since the level of industrial activity in towns has in fact decreased in this period. Both random statistical vari-

Figure 8.1. Proportion of the population exposed to both road-traffic and industrial pollution, according to type of residential area



Source: Statistics Norway, Surveys of level of living

Figure 8.2. Proportion of the population exposed to road-traffic pollution, according to type of residential area



Source: Statistics Norway, Surveys of level of living

ations and changes in attitudes are possible explanations.

While the problems related to road-traffic pollution are clearly greatest in the largest towns, industrial pollution is most widespread in urban areas with 20 000 to 100 000 inhabitants. This pattern has been unchanged from 1983 to 1995.

The severity of pollution problems also varies between counties and regions. Oslo and the counties of Western Norway were at opposite extremes in 1995. In Oslo, 25 per cent of the population stated that they were exposed to pollution, whereas in Western Norway the figure was only half this (12 per cent). One in every five people living in Oslo was exposed to road-traffic pollution in 1995, which is almost twice the national average. On the other hand, the proportion of the population exposed to industrial pollution is roughly the same in Oslo as in the rest of the country. People in Oslo are more exposed to noise from various sources than people living in the rest of the country. More than four in 10 people living in Oslo said that they were exposed to noise in 1995.

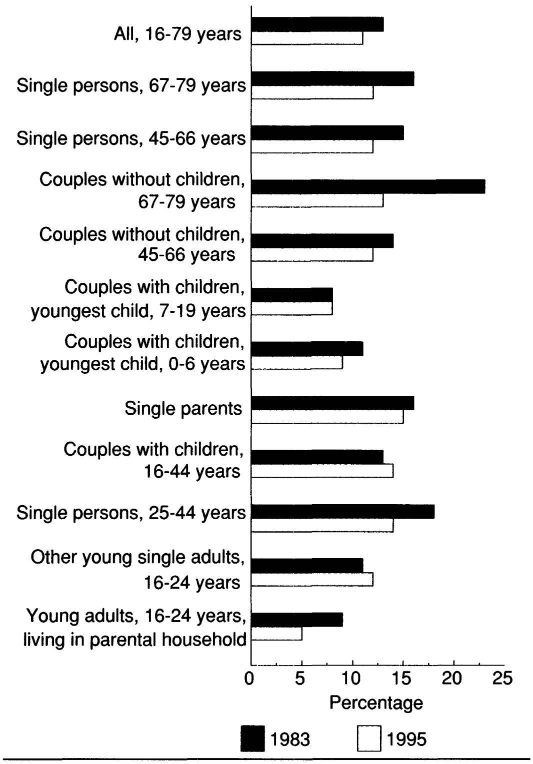
Exposure to industrial pollution was lowest in Western Norway and the Trøndelag counties in 1995. Otherwise, differences between regions were small. These regional differences have also remained almost unchanged from 1983 to 1995.

Pollution problems in different social groups
There are only small differences between the exposure of different types of families to pollution. Single parents were among the groups with the greatest exposure to both road-traffic and industrial pollution in 1995. The level of statistical uncertainty is of course high in such a small group, but single parents have been one of the groups most exposed to pollution in almost all the surveys of level of living.

Pollution from road traffic is very important, since heavy traffic near housing may have particularly adverse effects on living conditions for children and adolescents. About 15 per cent of single parents were exposed to road-traffic pollution in 1995, compared with 8 - 9 per cent of other families with children (figure 8.3). The category least exposed to pollution from road traffic in 1995 was young adults living in the parental household (five per cent).

The most striking change since 1983 is the marked improvement in the situation for old

Figure 8.3. Proportion of the population exposed to road-traffic pollution in 1983 and 1995, by type of family



Source: Statistics Norway, Surveys of level of living

people, particularly older married couples. This may be explained by the substantial improvement in living conditions old people have experienced in financial and material terms (Epland 1993, Opdahl 1993).

Does the level of exposure to pollution vary with the family situation and economy? Single persons and other households without children do not need to take into account living conditions for children and adolescents, and it seems reasonable to assume that they are less interested in spending money on a satisfactory outdoor environment. Young single adults in particular will spend less time in and near their homes than families with children and older people. Single parents are exposed to higher levels of pollution than other families with children, which may be partly explained by their poorer economy. The proportion who experience pollution-related problems is slightly higher among those who also have financial problems. In 1995, 16 per cent of those who often had problems in meeting their current expenses were exposed to road-traffic pollution, as compared with 10 per cent of those who never had financial problems. The corresponding figures for industrial pollution were 10 and 7 per cent, respectively.

The financial problems people experience do not, of course, give a complete picture of a household's economic resources. Earlier analyses of data from the surveys of level of living show that groups with a low household income more frequently live close to roads with heavy traffic than high-income groups, even after correction for type of household, age and other factors (Barstad 1994).

The relationship between geographical and social distribution of pollution problems
Are there differences between towns and less densely populated areas in the relationships between financial problems, the family situation and environmental problems? In households consisting of couples (including young adults living in the parental household) living in densely-populated areas with more than 20 000 inhabitants, a difficult financial situation and pollution problems more often go together than in the same type of household in less urban areas. However, no such relationship exists for single persons.

There is reason to believe that people's financial situation will have a particularly important influence on the environmental quality they can achieve in Oslo, where there is stiff competition in the housing market and an unpolluted residential environment is in short supply. Subject to the considerable statistical uncertainty of the material, the surveys of level of living confirm this hypothesis. Among people in Oslo who had financial problems, 36 per cent were exposed to road-traffic pollution, as compared with only 16 per cent of those who had never had financial problems.

8.3 Noise and pollution in the working environ-ment

Surveys of working conditions
In 1989 and 1993, a sample of employees in all types of Norwegian enterprises and companies in the private and public sectors was interviewed on conditions at their places of work. The interviews included questions on the proportion of working hours during which respondents were exposed to loud noise and various types of pollutants. In the following, the following types of pollution in the working environment will be considered:

- Loud noise, i.e. so loud that people must stand right next to each other in order to be heard.
- Chemicals in contact with skin, e.g. coolants, lubricants, cleaning agents and disinfectants.

- Air pollution in the form of metal dust, fog, mineral dust and organic dust.
- Air pollution in the form of gases and vapours such as ammonia, hydrochloric acid, chlorine, hot water vapour, and various types of solvents.
- Passive smoking.

Noise problems most serious in the manufacture of wood products, food, beverages and tobacco products and metal products
Pollution problems are most serious for workers[1] in manufacturing industries. Employees whose work involves extensive use of machinery are exposed to substantially more noise than employees in companies where there is more automatic control and monitoring of manufacturing processes. In 1993, 42 per cent of employees in companies engaged in the manufacture of wood products were exposed to loud noise for one-quarter or more of the working day. About 35 per cent of employees in the manufacture of food, beverages and tobacco products, metal products, fabricated metal products, machinery and equipment were exposed to loud noise to the same degree. Only 17 per cent of employees in the manufacture of chemicals were equally exposed to noise, the same percentage as for employees in hotels and restaurants.

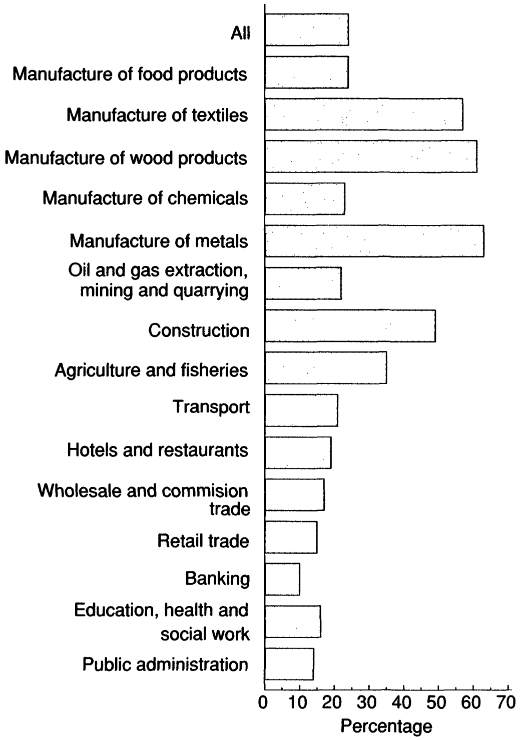
Dust and smoke the commonest pollution problem in the working environment
The most widespread pollution problem in the working environment in general in 1993 was dust, smoke or fog in the air. The situation was worst in the metal industry and in the manufacture of wood products, where more than 60 per cent of all employees were exposed to the problem for at least one-quarter of their working hours.

Dust and smoke were also widespread problems in construction firms, firms manufacturing fabricated metal products, machinery and equipment and in textile manufacturing firms. About half the employees experienced such problems. Employees in the metal manufacturing industry suffer most exposure to gases and hot vapours. About 45 per cent of the workers in this branch of industry were exposed to such pollutants. Skin contact with chemicals was most widespread among employees in hotels and restaurants, where about 42 per cent reported exposure for one-quarter of their working hours or more. This is a logical result of the fact that cleaning is an important part of their work.

Other people's tobacco smoke is a widespread problem in the working environment
Tobacco smoke was the second largest source of pollution in the working environment in 1993. About 22 per cent of all employees were exposed to passive smoking for at least one-quarter of their working hours. The problem was greatest in hotels and restaurants, where 55 per cent of the employees suffered this level of exposure. The problem of passive smoking was least widespread in the primary industries, oil and gas extraction and mining and quarrying, where under 10 per cent of the employees reported the problem. In manufacturing industries, passive smoking was most widespread in the manufacture of metals and fabricated metal products, machinery and equipment, where more than one-third of the employees were exposed to other people's tobacco smoke during working hours.

1 According to the Standard Classification of Socioeconomic Status, workers are employees in agriculture ans forestry, fisheries, mining and blasting, transport and communications, manufacturing industries, building and construction and cleaning. Workers include occupations with the lowest levels of education and occupations requiring training but not involving management tasks. (Statistics Norway 1984)

Figure 8.4. Proportion of employees in selected branches of industry exposed to dust, smoke or fog for one-quarter or more of working hours in 1993



Source: Statistics Norway, Survey of working conditions 1993

In general, there was a clear distinction between workers and salaried employees in the extent to which they were exposed to pollution. This distinction was also found for passive smoking; 29 per cent of unskilled workers were exposed to passive smoking for at least one-quarter of their working hours in 1993, whereas only 14 per cent of higher-level salaried employees suffered the same degree of exposure.

Most polluted working environment in Western and Southern Norway
There was least pollution in the working environment in Oslo and Akershus. Levels of exposure to the various forms of pollution were highest among employees in Western Norway, Vest-Agder, Aust-Agder and Rogaland. This is related to the industrial structure of the various regions of the country. The proportion employed in manufacturing industries is highest in Southern and Western Norway, and lowest in Oslo and North Norway.

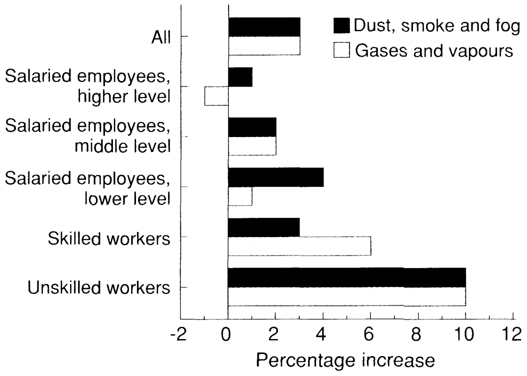
It was only for passive smoking that the level of exposure of employees in Oslo and Akershus was as high as that of employees in other parts of the country. Passive smoking was least widespread in Nord-Trøndelag and Sør-Trøndelag, where only 17 per cent of employees reported exposure for at least one-quarter of their working hours, as compared with 24 per cent in Western Norway.

Slight worsening of pollution in the working environment from 1989 to 1993
There has been an overall slight increase in pollution in the working environment. The increase was greatest for pollution in the form of dust, smoke and fog; the proportion of employees exposed to such pollution for at least one-quarter of their working hours rose from 21 to 24 per cent. The rise was most marked in the pulp and paper industry and in publishing and printing. The proportion of employees exposed to gases and vapours also rose, from 8 to 11 per cent. The most marked increases were for employees in the manufacture of wood products and foods, beverages and tobacco products.

If we consider the various socio-economic groups separately, exposure to pollution rose particularly among unskilled workers in the period 1989-1993 (figure 8.5).

The apparent increase in pollution from 1989 to 1993 coincides with an increase in pressure of work, pressure of time and control in this period (Iversen and Midtlyng

Figure 8.5. Rise in the proportion of employees exposed to air pollution in the working environment from 1989 to 1993



Source: Statistics Norway, Surveys of working conditions

1994, Statistics Norway 1995). This is particularly true for certain branches of manufacturing industry.

In the construction industry, which was particularly hard-hit by the economic slowdown during this period, there was a slight reduction in pollution. The drop in construction activity particularly affected employment levels among unskilled construction workers, who normally suffer most exposure to pollutants on building sites. This is probably an important reason why exposure to pollution has not risen for this sector as a whole.

More information may be obtained from Anders Barstad (surveys of level of living) and Egil Midtlyng (surveys of working conditions)

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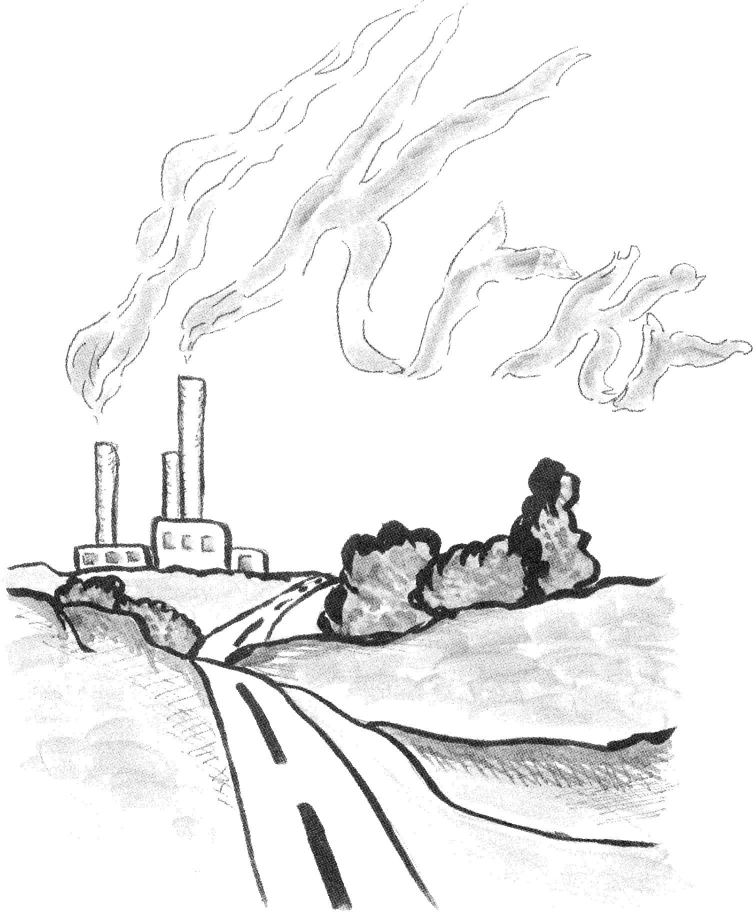
Part II. Economic research on resources and the environment



1. Introduction

Sound utilization of resources and a healthy environment - how can economic analyses contribute?

Norway has an abundance of energy resources. In 1995, total energy production amounted to about 7 600 PJ of hydropower, oil, gas, coal and biofuels, while domestic consumption of energy, excluding the energy sectors, only accounted for 10 per cent of this total. Norway was the world's second largest exporter of oil in 1995, and is also the largest producer of hydropower in Europe.

The value of Norway's energy resources depends on the purchasers' "willingness to pay" in the various markets. It is difficult to quantify these values, however, since the markets for these products are far from perfect. Even though the hydropower sector in Norway has been deregulated, large quantities of energy are still sold on long-term contracts at politically determined prices that are far below the long-term market value of this resource. The value of Norway's hydropower resources depends heavily on how the framework for the sale of electricity to trading partner countries is designed. The Nordic political conditions for trade in electricity are changing constantly. The situation is further complicated in that hydropower closely competes with other power generation technologies, such as nuclear power, gas-generated electricity and other power generation based on fossil energy. For Norway, this means that a relatively limited Nordic market will be decisive when evaluating the profitability of gas and electricity exports.

Norway has been an important exporter of crude oil to the world market for many years. Over time, however, the importance of oil will most likely diminish, whereas gas will probably be facing increasing competition with other major gas suppliers, like Russia and Algeria. The importance of strategic investments in transport solutions for gas will therefore be an important subject of research in the years ahead. The dependence between future gas markets and developments in other energy markets in Europe will figure prominently.

The burning of fossil fuels releases the greenhouse gas CO_2 to the atmosphere. An internationally co-ordinated policy aimed at curbing the greenhouse effect, for example in the form of a harmonization of the EU's energy taxes, will influence the international markets for fossil energy. This, in turn, will have an impact on the value of fossil energy for producer countries. Norway's petroleum wealth may be reduced substantially. An international climate policy will therefore have noticeable distributional effects. A "just" distribution of the burdens which result from reducing the climate problems will therefore be an important subject. In this context, it may also be reasonable to pose the question of how we should respond to the uncertainty surrounding future climate problems which result from the use of fossil fuels.

Emissions of pollutants from various combustion processes will contribute to climate problems, but may also cause various local problems and pollution. This, in turn, will impose economic costs through a decline in labour productivity and a reduced economic lifetime of invested capital. It is important to take account of the magnitude of these costs when making policy decisions about pollution. Analyses of the interaction between economic activity, energy use, pollution and the damages it causes are therefore important. Various pollution components from manufacturing industry have been regulated and have thus, over time, fallen substantially. Stationary emissions have been subject to taxation for several years through taxes on the use of fossil fuels from stationary sources. Greater attention should therefore now be devoted to other major sources of emissions as, for example, emissions from petroleum activities, shipping and other mobile sources. It is thus important to obtain improved data on emissions from these sectors, the technologies on which they depend and the introduction of new technology. The introduction of various types of new car technologies in the Norwegian market has been the subject of research in recent years.

Economic activity also creates environmental problems other than those linked to the use of fossil fuels. Many of the materials used in different production processes are not fully utilized. Packaging and waste products from the household sector create direct waste problems. Waste disposal also results in environmental problems such as extensive land use, run-off from landfills and emissions from waste incineration and treatment. Projections of these emissions will provide an overview of potential waste problems in the future, allowing us to adopt environmental measures well in advance in order to reduce future waste problems. Similar gains can be achieved by calculating changes in other environmental indicators. An overview of the state of the environment will serve as a good supplement to more traditional economic welfare measures.

Norway is one of the largest donors of development aid, relative to its Gross Domestic Product (often channelled through large international organizations or through direct transfers to the various developing countries). Most developing countries are struggling to implement economic reforms to generate higher economic growth and living standards. These reforms often result in a swift depletion of natural resources and greater environmental degradation in these countries. Statistics Norway considers it important that the co-operation with international organizations and the authorities in the various countries contribute to skills enhancement in order to improve the basis for implementing a sustainable economic policy. Statistics Norway has therefore developed integrated economic-environmental models and contributed to increased user competence in a number of countries in Central America, Africa and Asia.

2. Our energy resources in a national and international perspective

2.1 Electric power. Supply and demand in the period to 2020

Investments in power stations and the transmission grid in the electricity generation sector are investments that have a long life, entailing that it is important to have some knowledge about future demand and prices in the power supply market. Furthermore, it takes a long time before a decision to build a power station is transformed into operative productive capacity. Operators in the sector are therefore interested in long-term projections of developments in the electricity market. Regional trends are also important, particularly for network owners and power suppliers in various regions of the country. The Norwegian Power Grid Company (Statnett) has commissioned a project on national and regional projections for important variables in the electricity market.

Statistics Norway's long-term equilibrium model MSG-5 has been used for the projections. The macroeconomic growth projections are largely based on the Government's Long-Term Programme 1994-1997, Report no. 4 (1992-93) to the Storting, with some modifications for the electricity market. Economic growth is highest in the period to the year 2010 and then slows in subsequent years. In the model, the supply of resources (labour) and technical advances are the main determinants of economic growth. The assumptions entail annual net exports of electricity of 4.5 TWh and a reduction of 5 TWh in the metal industry's electricity consumption compared with the current levels. A key assumption relating to the electricity market is the cost of developing new power. The calculations are based on detailed cost estimates from the Norwegian Water Resources and Energy Administration (NVE) for power generation projects in category I and II of the Master Plan[1]. In addition, there are a few projects which already have a licence or do not require a licence. In the calculations, it is assumed that the projects are developed on the basis of rising costs. The calculations also contain a regional dimension. With the help of Statistics Norway's regional models, the demand for electricity has been distributed on regions. The existing and future supply of electricity generation capacity is distributed

1 According to Report no. 60 (1991-92) to the Storting (Master Plan for Water Resources), category I of the Master Plan consist of "*Projects which can be considered for licensing immediately and on a continuous basis to help cover the demand for energy in the years ahead*". Projects that are placed in category II are "*Projects that can be used for power development or other purposes and which cannot be considered for licensing now*".

on the basis of Statistics Norway's data and NVE's project data for new power generation projects, respectively.

According to the calculations, demand growth will slow in the period to 2010 and 2020 as a result of low future growth in GDP and a rising real price of electricity. The relative prices of electricity and oil throughout the projection period move in disfavour of electricity. Changes in the growth in electricity consumption are also influenced by changes in the composition of industry. Activity is shifted from manufacturing to services, i.e. to less electricity-intensive industries. Lower growth is also related to saturation tendencies for some types of energy consumption. For example, there has over time been a sharp rise in both indoor temperature and the share of heated floor space in dwellings and commercial buildings. There has also been a considerable switch from the use of oil to the use of electricity for heating purposes. The high investment costs for oil-based heating installations may be a possible explanation for this shift. Over time, however, the potential for a further switch to electricity will be reduced. Oil heating is used far less extensively today than was the case in the 1970s and 1980s.

According to the calculations, mean potential hydropower production will be 120.1 TWh in the year 2010 and 125.4 TWh in the year 2020. Net consumption, excluding the power-intensive and the pulp and paper sectors, will expand by 1 per cent annually to the year 2010 followed by an annual rise of 0.7 per cent up to the year 2020. Demand growth up to the year 2010 will be highest in service sectors and lowest in private households.

The calculations presuppose market clearance in the Norwegian power supply market. This means that new power generating

Table 2.1.1. Electricity balance 1991, 2010 and 2020

	Levels, TWh			Annual percentage change	
	1991[1]	2010	2020	1991-2010	2010-2020
Mean annual power potential	108.1	120.1	125.4		
Actual production	111.0	120.1	125.4	0.4	0.4
- exports	6.0	10.0	10.0	2.7	0.0
+ imports	3.3	5.6	5.6	2.8	0.0
Domestic consumption	108.2	115.7	121.0	0.4	0.5
-power losses	8.7	8.6	8.6	-0.2	0.0
Domestic consumption, net	99.5	107.1	112.4	0.5	0.5
Power intensive	29.3	24.8	24.8	-0.9	0.0
Pulp and paper	6.5	4.8	4.8	-1.6	0.0
Other industries, excl. pulp and paper	64.1	77.4	82.8	1.0	0.7
Other manufacturing	9.8	11.3	11.9	0.8	0.5
Services	21.0	29.7	31.6	1.9	0.6
Households and agriculture	33.3	36.4	39.3	0.5	0.8

[1]The model's base year and the starting point for the calculations. The column shows observed figures for 1991.
Source: Bye, T., T.A. Johnsen and M.I. Hansen (1995)

capacity is not developed until the price achieved by power producers exceeds the cost of new development. The projects in category I and II of the Master Plan are used as a basis for computing the costs of new power. Based on the assumptions applied, growth in domestic consumption is not sufficient to result in the development of profitable gas-generated power in Norway during the period being analyzed. Growth in demand is exclusively covered by new hydropower. The calculations result in higher real prices for electricity in Norway in the period ahead.

The producer price will be NOK 0.19/kWh (constant 1992-prices) in the year 2010 and

Table 2.1.2. Price of electricity for households. NOK/kWh, constant 1992-prices

	1991*	2010	2020
Producer price	0.16	0.19	0.22
Transmission tariff	0.05	0.05	0.04
Distribution tariff	0.15	0.16	0.17
Electricity tax	0.04	0.05	0.05
Price excl. VAT	0.41	0.45	0.49
Price incl. VAT	0.48	0.55	0.60

*The producer price in 1991 is determined by deducting taxes and estimated transmission rates from the observed purchase price for 1991. Households paid a higher price than the average in 1991. All sectors, excluding power-intensive/pulp and paper, pay the same price in the projection period.
Source: Bye, T., T.A. Johnsen and M.I. Hansen (1995)

NOK 0.22/kWh in the year 2020. Transmission prices and taxes remain approximately unchanged in real terms. For households, this results in an increase in the purchase price, including VAT, of NOK 0.07/kWh in the period to the year 2010 and NOK 0.05/kWh between 2010 and 2020 (real prices). Other sectors, which in 1991 paid lower transport-adjusted prices, will be facing a stronger rise in prices. It must be emphasized that there is considerable uncertainty attached to projections of economic activity, energy prices and demand.

The overall impression based on the regional calculations is that imbalances in regional production and demand for electricity are amplified later in the projection period and that transport between regions increases. The most reasonable power generation projects are found in regions which even today have excess production. Consumption growth is strongest in regions with limited power generation. The calculations for regions were carried out on an ex post basis, and the costs of power transport are therefore assumed to be the same for each group of consumers, irrespective of region.

Project personnel: Torstein Bye, Tor Arnt Johnsen and Mona Irene Hansen

Financing: Statnett SF (The Norwegian Power Grid Company)

Documentation:

Bye, T., T.A. Johnsen and M.I. Hansen (1995): *Tilbud og etterspørsel av elektrisk kraft til 2020. Nasjonale og regionale framskrivninger* (Supply and demand for electric energy to the year 2020. National and regional projections). Reports 95/18, Statistics Norway.

2.2 Flexibility in the Norwegian demand for electricity

In most countries, electricity is produced from natural gas, uranium, coal and other exhaustible resources. In Norway, however, it is possible to exploit large quantities of renewable water resources. Electricity production from Norwegian waterfalls amounts to about 112 TWh a year, and covers total domestic demand. However, even though water is a renewable resource, power from Norwegian waterfalls is a limited resource. A growing shortage of effect and energy makes it necessary to improve the utilization of the existing power system. One way to do this is to give market participants the "right" shortage signals of electricity production.

Gross investment in Norwegian electricity production has fallen steadily over the last decade, from NOK 14 billion in 1980 (1993 prices) to NOK 5 billion in 1992. This represents a reduction of about 65 per cent. During the same period, the domestic demand for electricity increased by about 30 per cent, in addition to which new export agreements with Germany and the Netherlands were signed. Combined, these supply and demand developments have led to an effect shortage in the Norwegian electricity market.

Since the adoption of the new Electricity Act, which liberalized the electricity market in 1991, current electricity prices are given in the spot market. Shortage of effect is reflected in spot price variations over a 24-hour period. In winter, when demand is high, this price variation is substantial. Even though the market value of electricity is determined in the spot market, only a few customers today (under 10 per cent) actually face such variable prices. This is because the majority (over 90 per cent) obtain their electricity under fixed price contracts. It is only when demand is price elastic and shortage signals reach consumers via higher prices that consumers will reduce their electricity usage accordingly. It follows that if more customers had spot price-related contracts with effective shortage signals, there would be less need for further investments in effect capacity.

The flexibility in the Norwegian demand for electricity is analyzed in this project. The peak period (autumn, winter) is compared with the off-peak period (spring, summer) to see if the electricity demand elasticities differ. In the model, prices of electricity and its substitutes, temperature and income are explanatory factors which determine household electricity demand. For industrial customers, the activity level is the relevant variable, rather than income. Customer contract choice behaviour is also modelled.

The data used are from 1993 and consist of monthly observations from 107 industrial electricity customers and 33 households. The choice of contract is a discrete choice. A conditional logit model is therefore used to estimate the choice behaviour. To analyze price flexibility, both a Generalised Leontief (GL) based model and a Cobb Douglas (CD) specification are used.

The limited availability of Norwegian panel data for customers under spot price contracts unfortunately makes it necessary to aggregate data across a diverse set of electricity consumers. This adversely affects the GL estimation. Results from the CD specification, however, are significant. Using this specification, a relatively high direct price elasticity is obtained in both periods, i.e. for both low and high loads. Furthermore, it is found that this elasticity differs between the two periods. The direct price elasticity is greatest in the high load period when the price of energy substitutes, like wood and oil, are near the same level, even if energy is more of a necessity in this period.

The electricity market is constantly changing. An increasing number of customers are choosing spot price-linked contracts. In the period ahead, it is likely that effect and energy will be scarce factors, not least as a result of increasing foreign trade in electricity. In order to achieve an efficient utilization of the existing capacity, customers will gradually be confronted with prices that vary through the day and night. 24-hour hourly pricing of electricity is not used today. This type of pricing, however, will require constant communication between the market participants.

Future studies of flexibility in demand and supply will be of growing interest as the data quality is gradually improved. A broadening of the statistical material will probably make the effects of a liberalized electricity market more visible than was the case for this analysis.

Project personnel: Torstein Bye, Tor Arnt Johnsen and Jan Øyvind Oftedal

Financing: EnFO / The Research Council of Norway through the programme EFFEN-Market

Documentation:
Bye, T.A. Johnsen and J.Ø. Oftedal (1996): *Etterspørsel etter elektrisk kraft i et markedsbasert omsetningssystem* (Flexibility in the Norwegian Demand for Electricity). To be published in the series Reports, Statistics Norway.

2.3 The costs of decommissioning nuclear power stations - The Swedish example

Sweden's nuclear power reactors produce about 70 TWh of electricity annually, which account for about half of Sweden's annual power generation. The Riksdag (Swedish parliament) passed a resolution in 1980 declaring that nuclear power stations in Sweden had to be phased out before the year 2010. The issue of shutting down Sweden's nuclear power stations will again be the subject of debate in the Riksdag in the winter of 1996. In this project, attempts have been made to calculate the total costs for both the Swedish and Nordic energy market as a result of shutting down Sweden's nuclear power stations by taking account of both the supply and demand side in both markets. The present value of total costs for Sweden is estimated at about NOK 77 billion.

Nuclear power accounts for a substantial share of total electricity generation capacity, both in Europe and the rest of the world. Possible consequences of nuclear accidents and problems of waste disposal are discussed frequently and used as arguments for shutting down existing nuclear power stations. The increasing attention being devoted to climate change is also contributing to a greater focus on the value of nuclear power as an alternative to the use of fossil fuels in power generation.

Shutting down Sweden's nuclear power will primarily have the effect of increasing prices. A large part of the 70 TWh that is produced by nuclear power today must then be produced by using other and more costly technologies. This means that costs and prices will rise while the volume sold will be reduced. Both the consumer and producer surplus in Sweden will thus decline. In the other Nordic countries, producer surpluses may rise while consumer surpluses may decline as a result of shutting down Sweden's nuclear power stations.

In 1995, the Riksdag decided to deregulate the Swedish electricity market from 1 January 1996. Furthermore, it was decided to introduce a joint Norwegian-Swedish electricity exchange. Increased international trade in electricity may curb the rise in costs as a result of shutting down Sweden's nuclear power stations if electricity from the other Nordic countries can be imported at costs which are lower than domestically-produced electricity. Higher imports will also result in higher electricity prices in the exporting countries. Producers in the exporting countries will benefit from electricity exports, but consumers will record a loss as a result of higher domestic prices.

A shutdown of Sweden's nuclear power stations will reduce the risk of nuclear accidents, but will also increase the use of fossil energy and thus add to the pollution caused by the burning of fossil fuels. This will make it more difficult to achieve the targets established by Sweden and the other Nordic countries for stabilizing CO_2 emissions in the future. An active tax policy in order to meet specific emission targets will increase the alternative value of Swedish nuclear power. Calculations of the combined discounted costs of shutting down Sweden's nuclear power stations are sensitive to several factors. The assumptions made about alternative power generation technologies are of particular importance. Factors such as the supply, cost and price of coal, natural gas from the North Sea and biofuels are examples of this. Another important factor is the required return on investment in power generation, often expressed by the choice of discount rate. The earlier the various nuclear reactors are decommissioned, the greater the economic losses for Sweden will be.

A Nordic energy market model has been used to calculate the losses for Sweden and the other Nordic countries which result from shutting down Sweden's nuclear power stations. In this model, it is assumed that there is trade in electricity and natural gas between the Nordic countries, with the exception of Iceland. Moreover, it is assumed: i) that there is a world market technology for electricity generation based on fossil fuels, ii) that there is a further specified set of production possibilities based on biofuels and hydropower in the respective countries in the model, iii) that there is a given limited supply of natural gas from the North Sea during the time horizon studied, and iv) that a required return (discount rate) of 7 per cent is used. A phasing out of nuclear reactors after an economic lifetime of 25 years entails that all reactors are shut down by the year 2010.

Given the assumptions used, it is estimated that shutting down Sweden's nuclear power stations will cost Sweden about NOK 77 billion (1995 prices). The loss is distributed as a reduction of NOK 59 billion in the producer surplus and a reduction of NOK 18 billion in the consumer surplus. The loss for the Nordic countries combined will be about the same, i.e. the other Nordic countries combined would neither lose nor win as a result of a shutdown of Sweden's nuclear power stations. Consumers in all countries, except Sweden, record a loss due to higher electricity prices, but this is offset by equivalent gains for power producers in these countries.

Assume that Sweden: i) introduces a tax of NOK 350/tonne CO_2, ii) coal costs rise by 30 per cent, and iii) the discount rate is 5 per cent. The CO_2 tax and coal costs will increase the cost of alternative power generation technologies compared with nuclear power. A lower discount rate will reduce the investment costs of alternative technologies, but the present value of future losses will also be higher. The estimated loss for Sweden based on this assumption is NOK 182 billion. For the Nordic countries combined, the loss now amounts to NOK 117 billion, i.e. all the Nordic countries except Sweden record a gain of NOK 65 billion as a result of Sweden's shutdown of nuclear power. This conclusion depends heavily on the estimated distribution of CO_2 tax revenues.

Project personnel: Finn Roar Aune, Torstein Bye and Tor Arnt Johnsen

Financing: Nordic Council of Ministers and Statistics Norway

Documentation:

Aune, F.R., T. Bye and T.A. Johnsen (1995): The cost of decommissioning nuclear power stations. *Economic Survey*, 1995,4, Statistics Norway.

Aune, F.R. (1995): *Virkninger på de nordiske energimarkedene av en svensk utfasing av kjernekraften* (Effects of phasing out Sweden's nuclear power on Nordic energy markets). Thesis at the Institute of Economics, University of Oslo, and Reports 95/34, Statistics Norway.

Bye, T. and T.A. Johnsen (1995): Prospects for a Common Deregulated Nordic Electricity Market. Discussion papers 144, Statistics Norway.

Bye, T., E. Gjelsvik, T.A. Johnsen, S. Kverndokk and H.T. Mysen (1995): CO_2 emissions and the Nordic electricity market - a model-based analysis. *Tema Nord*: 1995:539, Copenhagen: Nordic Council of Ministers.

2.4 Developments in the European gas market and environmental effects of Norwegian gas sales

Developments in the European oil and gas market will have an important influence on the Norwegian economy. Based on current production levels, Norway has known, recoverable reserves equivalent to about 15 years of oil production and about 100 years of gas production. This means that Norway, early in the next century, will move from being a substantial oil producer to being a major gas producer. Norway's gas exports have received considerable attention by the media the past year, and interest has particularly been focused on the environmental effects of Norwegian gas sales. This study analyzes developments in the European gas market and evaluates the environmental effects of a reduction in Norwegian gas exports to Europe by using the dynamic oligopoly model DYNOPOLY. The results based on this model indicate that a reduction in Norwegian gas sales may have favourable environmental consequences because the reduction will not be replaced by higher exports from Algeria and Russia.

This project has looked at developments in the supply of gas to Europe. Environmental effects, in the form of lower global emissions of CO_2 as a result of a reduction in Norwegian gas exports, have also been studied.

Norway, Algeria and Russia are the dominating suppliers of gas to Europe. The DYNOPOLY model particularly focuses on competition between these few large producers. Norway and Algeria each have a market share of about 10 per cent in Western Europe, while Russia alone has a share of 23 per cent. The Netherlands and the UK, which at the moment are Western Europe's most important gas producers, each have a share of about 22 per cent. Production in the Netherlands and the UK is assumed to be determined exogenously. This simplification can be justified on the grounds that these countries have already implemented most of their heavy investments, and production will decline later in the next century due to limited reserves.

On the continent gas is mostly sold under long-term contracts based on negotiations between a joint Norwegian supply side and European buyers. There are indications, however, that the European gas market will be liberalized and that third-party access (TPA)[2] to the pipeline network will be implemented. DYNOPOLY provides estimates of future prices and the future supply of gas to Western Europe in a liberalized market in which it is assumed that TPA has been implemented.

The supply of gas to Europe is determined in the model as the sum of production in Western Europe, excluding Norway, and the total supply from Norway, Algeria and Russia. Norway, Algeria and Russia are each assumed to have up to three investment projects all of which will expand their production capacity beyond an initial export capacity. Each of the three countries chooses its optimal investment profile, which entails that they maximize the discounted cash flows over a time horizon of 80 years. The model takes account of strategic behaviour among the three producer countries, in that the investments of one producer influence the profitability of the other gas suppliers' investment projects. Strategic investments are motivated by the

2 TPA would provide gas producers with the ability to sell gas directly to large end-users and gas distributors, using transmission companies as transporters.

desire to prevent other producers from implementing their investments.

Norway is assumed to have undertaken commitments to supply 60 billion standard cu.m. a year (bcm/year) from the year 2000. Moreover, Norway can increase production to a total 80 bcm/year by implementing two investment projects, each of which will boost capacity by 10 bcm/year. In the model simulations, Norway has implemented both projects and produces at maximum capacity from the year 2015. Algeria has implemented its investments of 10 bcm and 6 bcm, respectively, and exports 72 bcm/year to Western Europe from the year 2005. Russia is the last to enter the stage with its three large investment projects, which increase capacity from an initial 75 bcm/year in 1995 to a total 165 bcm/year from the year 2020. Total exports from the three countries to Western Europe amount to 317 bcm/year from 2020. As production in Western Europe declines sharply from 2005, due to limited reserves, the region becomes increasing dependent on imports later in the next century.

None of the investments in the model simulations is strategically motivated. One possible interpretation of this result is that the large investments for Norway and Algeria have already been carried out and are included in the initial capacity of the two producers.

A reduction of 10 bcm in Norway's gas exports does not change the behaviour of Algeria and Russia. The supply of gas is thus inelastic in the model. As a result, total gas consumption in Europe will therefore be reduced by 10 bcm, and in isolation will contribute to a reduction in global CO_2 emissions. This analysis, however, only studies supply-side effects. Account has not been taken of effects on demand in the form of shifts in energy consumption towards other forms of energy as a result of price changes. Nor has the study looked at changes in CO_2 emissions in the production and transport system as a result of energy supplies from other sources. Moreover, account has not been taken of environmental and energy policies in the importing countries. Such factors may have a considerable influence on the effects of a reduction in Norwegian gas exports.

One drawback of the DYNOPOLY model is the simplified modelling of the demand side. This is the background for the joint research project started by Statistics Norway and Université Catholique de Louvain (CORE) in Belgium, with the aim of developing a gas market model for Europe. CORE models the demand side, while DYNOPOLY provides the supply side.

The plans call for an analysis of the environmental effects of Norwegian gas sales in which DYNOPOLY is linked to Statistics Norway's energy demand model SEEM (Sectoral European Energy Model). SEEM estimates future demand for solid fuels, oil, gas and electricity in five economic sectors in thirteen West European countries.

Project personnel: Elin Berg and Kjell Arne Brekke

Financing: EU's research programme Joule II and Statistics Norway

Documentation:

Berg, E. (1995): Utviklingen på det europeiske gassmarkedet (Developments in the European gas market), *Økonomiske Analyser* 1995,4, Statistics Norway, 3-12.

Berg, E. (1995): Miljøvirkninger av norsk gassalg - en tilbudssideanalyse (Environmental impact of Norwegian gas sales - a supply-side analysis), *Sosialøkonomen*, 49, 11, 18-25.

2.5 Energy consumption and CO_2 emissions in a changing Western Europe

The Maastricht treaty sets out guidelines and objectives for further economic integration of Western Europe from the turn of the millennium. However, as a result of strong national interests and the economic situation prevailing in each EU member state, it is uncertain whether all parts of the treaty can be implemented. This analysis shows that, with further economic integration of Western Europe, energy consumption using fossil fuels and accompanying CO_2 emissions might increase by a substantially greater margin over the next decades than would be the case with a fragmented Western Europe.

Economic integration has been on the political agenda of the EU for a long time, and considerable institutional, political and judicial changes have taken place in Western Europe in the wake of the integration process. The Maastricht treaty, which was signed by the member states in 1991, contains guidelines and objectives for further integration from the turn of the millennium. There is considerable uncertainty, however, regarding the treaty's consequences for future economic growth and the various markets in Western Europe.

As there is a close relationship between economic growth and energy consumption, Statistics Norway has carried out a study of future energy consumption and CO_2 emissions in a changing Western Europe. The study looks at how continued integration or lack of integration in the EU may influence economic growth and thereby the energy markets and environment in Western Europe. The analysis is based on simulations using the model SEEM (Sectoral European Energy Model)[3].

Using the SEEM model, development paths for the demand for oil, coal and gas are determined in 6 economic sectors in each of altogether 13 West European countries: the 4 major countries (Germany, the UK, France and Italy), Spain, the Netherlands, Belgium, Switzerland, Austria and the 4 Nordic countries (Sweden, Denmark, Finland and Norway). These countries combined account for about 90 per cent of energy consumption in OECD-Europe. In SEEM, the demand for the respective fuels primarily depends on the prices of and taxes on the various types of energy, as well as economic growth. Based on the estimated energy consumption from SEEM, calculations are made of CO_2 emissions in Western Europe. A further description of SEEM is provided in Brubakk, et al. (1995).

In the study, the consequences for future energy consumption and CO_2 emissions are simulated based on two economic scenarios for the EU. The first scenario, called the integration scenario (IS), is based on the assumption that the integration process in the EU will continue in accordance with the plans set out in the Maastricht treaty. The scenario therefore presupposes relatively high annual economic growth of about 2.3 per cent for the entire EU area in the simulation period. Moreover, the import price of coal is assumed to be constant, while the prices of oil and gas are assumed to fall annually by about 0.9 and 0.3 per cent as a result of substantial oil and gas supplies from Russia. The scenario also presupposes that there is a gradual harmonization of energy taxes from the year 2000 to the year 2010 towards the average level of taxes in the four major countries. The other scenario, called the fragmentation scenario (FS), is based on the assumption that national interests will dominate within the EU. As a result of trade barriers

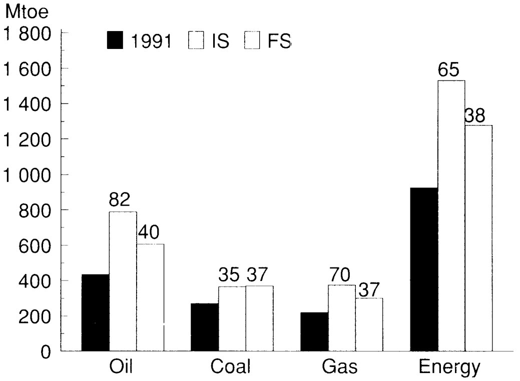
3 The model was originally developed by Statistics Norway and further developed in co-operation with the Netherlands energy research institute ECN (Energieonderzoeck Centrum Netherland)

and market imperfections, this scenario assumes more moderate economic growth of 1.7 per cent annually. Moreover, import prices of oil and gas are assumed to rise by only about 1.1 and 0.7 per cent annually as a result of small oil and gas deliveries from Russia. The import price of coal, on the other hand, is assumed to be constant, as in the integration scenario. No tax harmonization is assumed in the fragmentation scenario.

Figure 2.5.1 illustrates the main results for simulated energy consumption in the year 2020, measured in million tonnes oil equivalents (Mtoe) for the countries combined. In the figure, the columns for "Energy" show the total energy consumption of oil, coal and gas, while the figures referring to the columns for IS and FS show the percentage change in energy consumption from 1991 to 2020. Both scenarios show a growth in total energy consumption in the simulation period. In 2020, energy consumption in IS is 65 per cent higher than energy consumption in 1991, while in FS it is 38 per cent higher. This is equivalent to an annual average growth rate of 1.8 and 1.1 per cent, respectively. The difference in energy consumption growth in the two scenarios is largely ascribable to differences in the estimates of economic growth rates and import prices for the various types of energy. Figure 2.5.1 also shows that oil and gas consumption in IS rises fastest, increasing by 82 and 70 per cent, respectively, from 1991 to 2020. Coal consumption shows moderate growth. The differences in the composition of energy consumption growth in the two scenarios are due to the development paths for import prices which favour the consumption of oil and gas in IS and the consumption of coal in FS.

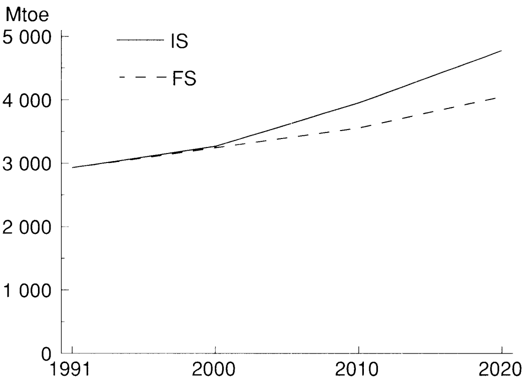
Figure 2.5.2 compares the paths for total CO_2 emissions in IS and FS for all the countries included in the model, measured in million tonnes of CO_2. Since CO_2 emissions are proportional to the consumption of the various fuels, emissions are reflected in the pattern of energy consumption shown in figure 2.5.1. Consequently, CO_2 emissions are 65 per cent higher in 2020 than emissions in 1991 in IS, while the rise in FS is 38 per cent.

Figure 2.5.1. Energy consumption in the integration and fragmentation scenarios in the year 2020



Source: Alfsen et al. (1996)

Figure 2.5.2. CO_2 emissions in the integration and fragmentation scenarios, 1991-2020



Source: Alfsen et at. (1996)

Allowing for the uncertainty associated with the calculations, the above results indicate that, with further economic integration of Western Europe, energy consumption using fossil fuels and accompanying CO_2 emissions may increase by a considerably greater margin over the next decades than would be the case with a fragmented Western Europe. However, the results are largely based on the estimates for economic growth and changes in prices of fossil fuels. More moderate economic growth in both scenarios as well as more limited price differentials for fossil fuels might result in smaller differences in future energy consumption and CO_2 emissions in Western Europe.

Project personnel: Pål Boug, Leif Brubakk, Dag Kolsrud and Morten Aaserud

Financing: Contributions from Statoil, Ministry of Environment and The Netherlands Ministry of Planning, as well as Statistics Norway

Documentation:

Boug, P., L. Brubakk and D. Kolsrud (1996): Impacts of Economic Integration and Tax Harmonization on Energy Demand and CO_2 emissions in Western Europe. To be published in the series Discussion Papers, Statistics Norway.

Alfsen, K.H., P. Boug and D. Kolsrud (1996): *Fragmentation or Integration in Western Europe? Consequences for Energy Demand, Carbon Emissions and Acid Rain*. To be published in the series Reports, Statistics Norway.

References:

Brubakk, L., M. Aaserud, W. Pellekaan and F.V. Ostvoorn (1995): SEEM - *An Energy Demand Model for Western Europe*, Reports 95/24, Statistics Norway.

2.6 CO_2 taxes and the petroleum wealth

An agreement on international CO_2 taxes will probably have a sizeable impact on the markets for fossil fuels. This project focuses on how the petroleum wealth of various producer countries may be influenced. The results indicate that market power is extremely important in the oil market. Given the way OPEC functions today, a global CO_2 tax will probably result in a substantial reduction in OPEC countries' wealth, while the decline for other oil-producing countries will be less.

An increase in the greenhouse effect is today considered one of the most important global threats to the environment. The most important greenhouse gas is CO_2, and attempts are therefore being made in a number of countries to curb emissions of this gas. It is likely that stronger and more global measures will be introduced to reduce the emissions of greenhouse gases as the effects of these emissions emerge more clearly. One possible measure will then be global CO_2 taxes. This will probably have a considerable impact on the global markets for oil, gas and coal. A tax will either result in a lower price for producers or a higher fuel price for consumers. As a rule, both will occur because a higher price for consumers will result in lower demand and, in turn, a lower price for producers. As a result of the substantial oil and gas resources on the Norwegian continental shelf, it is particularly interesting to study the effects of global CO_2 taxes on prices and production of these resources.

A dynamic model was constructed which takes into account that an increase in production today reduces the availability of this resource in the future. Producers take this into account when they make a decision on production in each period. The model thus focuses on the optimal depletion rate over time.

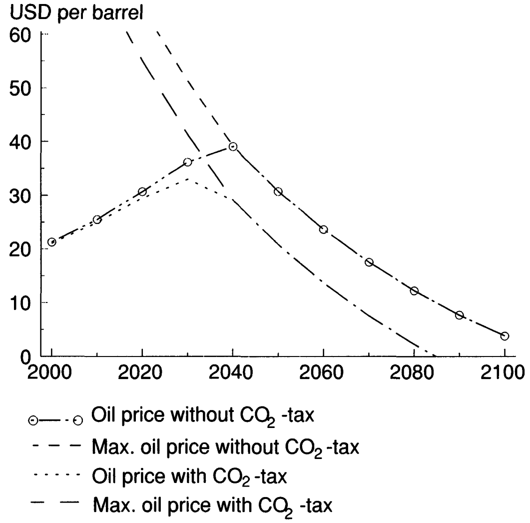
In the model, costs per unit of production rise when the resource is extracted. It has also been taken into account that considerable technological advances are made in extraction, and it is assumed that this is independent of the volume of production. On the demand side, it is assumed that there are certain possibilities for substitution between the various fossil fuels. Changes in one of the markets thereby also has an impact on the other markets. Moreover, it is assumed that a backstop alternative exists, i.e. an alternative carbon-free energy source of which there is an unlimited supply, and which can fully replace all fossil fuels. The backstop alternative is assumed, initially, to be substantially more expensive than fossil fuels, but due to technological advances the price falls over time, entailing that the production of fossil fuels become unprofitable in the long run (see figure 2.6.1).

In the oil market a distinction is made between OPEC and other countries (called the "fringe"). The fringe consists of many small producers which individually look upon the oil price as given. OPEC, on the other hand, has market power in the sense that it can influence the price (more than marginally) by changing the level of production. The model is a Nash-Cournot model, i.e. each of the producers determines its production profile given the production of all other producers.

Transport costs for gas are relatively higher than for oil and coal, and depend on the distance to the markets. The model therefore operates with three separate gas markets: OECD-Europe (including imports from Russia and Algeria), Other-OECD and Non-OECD. These markets are assumed to be competitive for the sake of simplicity. A global competitive market has been modelled for coal.

The calculations indicate that the introduction of a global CO_2 tax equivalent to USD 10 per barrel will first result in a negligible decline in the producer price of oil, cf. figure 2.6.1. Gradually, however, the producer price with the tax rises more slowly than is the case without a tax. The consumer price, however, will change most at the start, entailing that it is the consumers who pay most of the tax the first 40 years. In this period OPEC will reduce its oil production in order to maintain a relatively high price. Production in the fringe actually rises slightly as they move production closer in time, because the price in 2040 is substantially lower than in the reference path. From the year 2040 the consumer price for oil is equal to the price of the backstop alternative, which does not change as a result of a CO_2 tax. This entails that the price paid by consumers is now the same as without a CO_2 tax. However, the maximal producer price (i.e. the price of the backstop alternative less taxes) is reduced by USD 10 per barrel as a result

Figure 2.6.1. Oil price with and without CO_2 tax. 2000-2100



Source: Berg et al. (1996)

of the CO_2 tax (figure 2.6.1). From 2040 it is therefore the producers that must bear the entire tax burden.

Since OPEC finds it optimal to reduce its production to such an extent, the reduction in the fringe's oil wealth as a result of a global CO_2 tax will be only 8 per cent. OPEC's wealth, on the other hand, declines by 22 per cent. The gas wealth of producers in OECD-Europe is reduced by 26 per cent.

The oil market has also been modelled as a competitive market in order to determine the effect of a CO_2 tax in this situation. The fringe's oil wealth in this case was reduced by 39 per cent, while OPEC countries' wealth was reduced by 25 per cent. This corresponds to some extent to the results of earlier calculations (see Kverndokk and Rosendahl 1995) where the oil market was modelled in the same way. A competitive model, however, does not seem to reflect current realities, illustrated by the fact that this model calculates an oil price of about USD 11 at the start (without a CO_2 tax), which makes it optimal for the fringe to postpone production.

If OPEC is dissolved, and all producers act as price-takers, the calculations imply that the fringe's oil wealth will be reduced by as much as 71 per cent. This demonstrates that a break-up of OPEC is a considerably greater threat to Norway's petroleum wealth than international CO_2 taxes.

Project personnel: Snorre Kverndokk, Elin Berg, Knut Einar Rosendahl and Tom Karlsen

Financing: The Research Council of Norway through the Programme for Social Petroleum Research

Documentation:
Berg, E. (1996): Some Results from the Literature on Impacts of Carbon Taxes on Petroleum Wealth. To be published in the series Documents, Statistics Norway.

Berg, E., S. Kverndokk and K.E. Rosendahl (1996): Market Power, International CO_2 Taxation and Petroleum Wealth, Discussion Papers 170, Statistics Norway.

Karlsen, T.W. (1995): Energimarkedet fra 1973 og fram mot 2010 (The energy market from 1973 and up to 2010). Notater 95/58, Statistics Norway.

Kverndokk, S. and K.E. Rosendahl (1995): CO_2 taxes and petroleum wealth, *Økonomiske Analyser* 1995,1, Statistics Norway.

2.7 Just distribution of CO_2 permits

A cost-efficient way of reducing CO_2 emissions is to introduce tradeable emission permits internationally. The initial distribution of permits between countries will then be a key issue. What is the most equitable distribution rule and will this rule be politically feasible? This study looks more closely at such factors, and concludes that a distribution based on population is the most equitable if the principles of various theories of justice are applied.

The greenhouse effect is one of the greatest environmental threats facing the world today, and international negotiations on reducing greenhouse emissions are already under way. Carbon dioxide (CO_2) is the most important greenhouse gas. Negotiations have therefore largely been concentrated on CO_2 emissions. If these negotiations result in agreement on emission limitations, the next question will be how this is to be accomplished. It is well known in economic theory that taxes or tradeable permits can result in the cheapest possible implementation of emission limitations, i.e. the agreement is cost effective. In addition to cost effectiveness, justice will be another criterion for evaluating an international agreement. It is conceivable that if tradeable permits are used to implement an agreement, the requirement of cost effectiveness and justice can be dealt with separately. The reason is that trade in permits in itself will result in a cost-effective distribution irrespective of how the permits are distributed. The allocation rule (the criteria on which the permits are distributed) therefore only determines transfers between countries, and this rule can then be established in such a way that the agreement satisfies the demand for a just agreement.

Justice is important for several reasons. First, justice is an objective in itself. Second, a just agreement is more likely to receive broad support than an agreement which many define as unjust. If all the countries participating in the negotiations perceive justice in the same way, this will facilitate the signing of a binding protocol. The problem is that there is no universal consensus as to what is just. This problem is particularly accentuated in the relationship between industrial countries and developing countries, since each of these groups of countries has a very different starting point with regard to emissions, level of development and population. These disparities entail that the two groups will have very different views on how emission permits should be distributed.

It is difficult to comment on how a benefit should be distributed based on a *theory of global justice*, i.e. a theory of how society should be organized so that its individuals receive a just share of benefits, burdens, obligations and rights. It is not necessarily the case that the chosen allocation rule shall remedy all distortions between countries such as poverty, debt problems and environmental problems. Nevertheless, many of the ideas underlying theories of justice can be transferred to individual distribution problems.

There are several theories of global justice (e.g. utilitarianism and the theories of Rawls (1971) and Nozick (1974)), all of which are based on different principles of how benefits shall be distributed. What principles should be applied if the theories result in conflicting conclusions? One possibility may be to find common features of these theories, and use them in the analysis instead of focusing on each distribution principle.

A basic principle is a rule which is applied to all theories of justice. Two such principles, according to Elster (1990), are ethical individualism and ethical presentism. *Ethical individualism* states that benefits shall be distributed to individuals on the basis of information about individuals, while ethical presentism says that only the existing features of society should be included in an evaluation of justice. Injustice in the past may be relevant, but only to the extent it has left its mark in the present. A third principle in this context is the principle that the distribution of benefits shall not be based on *morally arbitrary factors*. What is then morally arbitrary? External conditions over which we have no control, so-called facts, might be considered morally arbitrary.

The above-mentioned basic principles are used in this project to determine "the most just" allocation rule. The distribution proposals that are most often discussed in the literature serve as the point of departure: Distributions that are proportional to current CO_2 emissions, accumulated emissions, GDP, land area and population. The basic principles are used in an excluding manner, i.e. the various rules are evaluated according to what extent they are in accordance with the principles or not. *Ethical individualism* can exclude a rule based on land area, since area provides little information on individuals. Rules based on CO_2 emissions and GDP can also be excluded on the basis of ethical individualism assuming that economic welfare is based on the utilization of a natural resource. For example, Saudi Arabia's and Kuwait's GDP and emissions will be relatively independent of the size of the population in these countries. The rules can also be discussed on the basis of *ethical presentism*. It is difficult to argue that current CO_2 emissions and economic development are independent of the past. If the high level of development in rich countries is due to the exploitation of other countries' resources at an earlier time, such rules will favour the population in rich countries due to historically unjust acquisitions, and thus violate the principle of ethical presentism. It is, however, the principle of *morally arbitrary factors* which is the essential principle in this analysis. Land area can be considered morally arbitrary to the extent that it cannot be argued that people who live in large countries require more resources to achieve the same level of welfare as others. Rules based on GDP or CO_2 can also be morally arbitrary. It is morally arbitrary which country one is born in. Even if the level of development in rich countries is not due to the exploitation of poorer countries, their inhabitants will receive more quotas since they are born in a richer country. Nationality is a morally arbitrary factor. A distribution rule which provides advantages to one nationality over another can only be defended if there are morally relevant characteristics of all individuals of a nationality which individuals of other nationalities do not possess. Assuming that such characteristics do not exist, a rule based on population will be the only one of the relevant distribution criteria that satisfies all three principles. The conclusion of this analysis is therefore that the most just rule for the distribution of tradeable CO_2 permits is a distribution proportional to the country's population.

There are several reasons why this principle is politically difficult to accept. A starting point of international negotiations is often that no country shall be worse off as a result of participating in the agreement. If this is the case, the agreement will not be signed, and the agreement will therefore not materialize. This disregards the power structure, which may entail that countries are forced to sign an agreement they in isolation would not benefit from. In order to ascertain whether a quota allocation rule is politically feasible, it is thus necessary to identify those countries which will benefit or lose out as a result of the agreement. Fankhauser and Kverndokk (1996) find that both China and the former Soviet Union need side payments for implementing emission reductions of the desired magnitude. A quota allocation rule with such transfers may be politically possible, provided that this still ensures that other regions are better off under an agreement than outside it. The calculations made by Kverndokk (1993) indicate, however, that an allocation based on population will entail transfers to China, while the former Soviet Union would have to buy permits. There are thus many indications that a CO_2 quota distribution based on population will not be politically possible.

Project personnel: Snorre Kverndokk

Financing: Statistics Norway

Documentation:

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Kverndokk, S. (1995): Rettferdighet og politikk - En analyse av omsettbare utslippskvoter med spesiell vekt på fordeling etter folketall (Justice and politics - An analysis of tradeable emission permits with special emphasis on distribution based on population). *Sosialøkonomen*, 49, 7/8, 34-43.

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2.8 How should we respond to an uncertain greenhouse effect?

The greenhouse effect has been recognized as a serious environmental threat even though there is still considerable uncertainty attached to its consequences. This project provides a theoretical overview of the uncertainty surrounding the greenhouse effect and possible ways of dealing with this in economic theory. The focus is on damages caused by the greenhouse effect.

The atmosphere has a certain natural content of greenhouse gases which ensure that the climate on earth is suitable for humans, animals and plants. Without the natural greenhouse effect, the average global temperature would have been -18° C in contrast to the current +15° C (IPCC 1990). The most important greenhouse gas (if steam is disregarded) is carbon dioxide (CO_2) which is responsible for about 50 per cent of the greenhouse effect in the short term, and even more in the long term. Other important greenhouse gases are methane (CH_4), chlorofluorocarbons (CFCs), nitrous oxide (N_20) and ozone (O_3). Man-made increases in the concentration of greenhouse gases in the atmosphere may result in greater global warming, with a rise in the sea level, desertification, reduced access to drinking water and health problems as some of the consequences. It will therefore be very important to limit the increase in the concentration of these gases.

There are many sources of uncertainty a decision-maker must take into account if the aim is to reduce the greenhouse effect. These can be grouped into three categories:

- How great are the damages of the greenhouse effect?
- What will it cost to reduce emissions of greenhouse gases in the future?
- What measures are most effective to combat the greenhouse effect?

This project concentrates on the *damages of the greenhouse effect* since it is here the uncertainty is greatest.

Scientific assessments clearly indicate that man-made emissions of greenhouse gases will result in a substantial increase in their atmospheric concentration (IPCC 1990 and 1992). It is also reasonably certain that an increase in the concentration will result in a rise in the average global temperature, while there is more uncertainty attached to the regional climate effects. The actual consequences of an increase in temperature are also highly uncertain, particularly the effect of this climate change on humans, animals and plants. It may be said that scientists concentrate on calculating climate change and its effects, while economists are primarily attempting to *put a value* on such effects.

The uncertainty concerning the results of the greenhouse effect has several characteristics. The most important are the following:

a) *Long time horizon*
The greenhouse effect must be evaluated in a long-term context. First, CO_2 has a life of about 200 years in the atmosphere. Second, it will also take time before a change in the atmospheric concentration of greenhouse gases results in climate change.

b) *Catastrophic outcome*
Most economic calculations of damages resulting from the greenhouse effect operate with relatively low estimates. The damages resulting from a doubling of the atmospheric CO_2-equivalent concentration[4] compared with the pre-industrial level are estimated to correspond to a reduction of between 1 and 2 per cent of all countries' GDP. This does not mean, however, that a catastrophic outcome can be ruled out even if the probability of such a result is small.

c) *Collective risk*
In contrast to other potential catastrophes, global climate change represents a collective risk. This means that if a catastrophe first occurs, it will have an adverse impact on a large number of people in the same way.

d) *Endogenous risk*
Most economic studies of uncertainty assume exogenous risk. This means that irrespective of what is done, the likelihood of an effect is unchanged. An important characteristic of the greenhouse effect is that the probability of a catastrophic outcome is influenced by human behaviour.

e) *Irreversibility*
The consequences of an uncertain greenhouse effect are often irreversible. If sea levels first rise, this development cannot be reversed within relevant time horizons. Various measures that are introduced to reduce the greenhouse effect may also be irreversible.

Should measures be implemented when there is so much uncertainty concerning the greenhouse effect? *According to the precautionary principle*, environmental investments should be made even if the expected return is small. An alternative view is that investments which reduce the likelihood of catastrophic results of the greenhouse effect must *be evaluated in the same way as all other uncertain investments*. The projects which have the highest expected return should be implemented. Given this criterion, the return on environmental investments may then often be small compared with other investment decisions under uncertainty.

Which strategy should be chosen when decisions under uncertainty are to be made? Is it possible to arrive at a synthesis based on the two above-mentioned principles ?

One often-used criterion for decisions under uncertainty, the *expected utility criterion*, says that the policy which provides maximum expected utility must be adopted. The decision-maker's attitude towards risk will thus have a decisive influence on the choice. In this theory it is assumed that the decision-maker is either risk-averse, risk-neutral or risk-seeking. It can be shown that the differences between the precautionary principle and the principle of evaluating all public projects on

4 All greenhouse gases are converted to a common scale, CO_2-equivalents, in relation to the greenhouse effect they create. See also part III, tables B1 and B3.

an equal footing may be ascribed to differing attitudes towards risk. The *maximin criterion* presupposes an extreme degree of risk aversion.

How can the uncertainty surrounding the damages of the greenhouse effect be reduced? This can be accomplished through *learning* which can assume different forms. The first type of learning is autonomous or exogenous, which means that we acquire knowledge over time without making active efforts to acquire it. The second type is endogenous and can be divided into two categories. Active endogenous learning refers to observations of the state of the economy and climate and the change in these as a result of emission reductions. The second type of endogenous acquisition of knowledge is through purchases. One example is to rely on research and studies.

Little research has been carried out so far on problems relating to uncertainty and the greenhouse effect. True, the questions of catastrophic outcomes, irreversibility and option values have been studied in economic theory earlier, but often not in this context. Nor can earlier results always be directly transferred to the greenhouse problem. As in other analyses concerning uncertainty, it is nevertheless possible to establish that risk and discounting have a considerable influence on which decisions emerge as desirable.

One of the major challenges to research in the period ahead will be to model endogenous disaster probabilities in already existing deterministic models for greenhouse gas emissions and the economy. A first step has already been taken (see e.g. Peck and Teisberg 1994).

Project personnel: Snorre Kverndokk

Financing: Statistics Norway

Documentation:
Kverndokk, S. (1995): Hvordan bør vi forholde oss til en usikker drivhuseffekt? (How should we respond to an uncertain greenhouse effect?). *Sosialøkonomen*, 49, 1, 8-19.

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Intergovernmental Panel on Climate Change (IPCC) (1992): *Climate Change - The Supplementary Report to the IPCC Scientific Assessment*, (Report from Working Group I), Cambridge: Cambridge University Press.

Peck, S.C. and T.J. Teisberg (1994): Note on Optimal CO_2 Control Policy with Temperature Dependent Disaster Probabilities, paper for IPCC Working Group III, Montreux, 3-6 March.

3. Economy and emissions to air in a national perspective

3.1 Emissions to air from domestic shipping

Domestic shipping is a major source of air pollution in Norway. Statistics Norway has developed new methods of calculating both emissions from various categories of ships and their geographical distribution. About one-tenth of emissions are generated by ships in port, and one-third while ships are in transit along the coast. The remaining emissions are released outside the Norwegian territorial sea.

Domestic shipping accounts for a large proportion of Norwegian emissions to air, i.e. 33 per cent of NO_X emissions, 13 per cent of SO_2 emissions and 9 per cent of CO_2 emissions. In this context, the term domestic shipping includes all traffic by Norwegian vessels between Norwegian ports, and also traffic to and around Norwegian oil installations and fishing grounds. These emissions may contribute to the problems of acid rain and to poor air quality in towns and built-up areas which have ports.

Statistics Norway has previously only calculated overall emissions from shipping, not emissions from different types of vessels. However, there is a need to quantify the emissions from various types of vessels and to distinguish better between international maritime transport and domestic shipping. The damage that may be caused by emissions is in many cases dependent on where they take place. The objective of this study has been to develop a method of calculating emissions from different types of vessels and of allocating them to ports and areas of sea.

The emissions have been calculated by linking data on energy use by the various categories of ships with calculated emission factors. The Norwegian Marine Technology Research Institute and Statistics Norway have calculated emission factors on the basis of Norwegian measurements of exhaust emissions, the chemical composition of the fuel and information found in the literature. The data for energy use are based on the available statistics and/or derived by calculation. The Directorate of Public Roads has fuel data for ferries that are part of the national road system. Statistics Norway carries out studies of fuel consumption for cargo vessels. Figures for fuel consumption by naval vessels and vessels belonging to the Coast Directorate have been obtained directly. For fishing vessels, fuel consumption has been calculated on the basis of costs and activity levels. Consumption for other types of ships has generally been calculated. Emissions have been localized by using timetables, log books and other available information. ARC/Info was used for localization and geographical analyses of the data. Routes and traffic zones were digitalized and linked to activity data. Finally, emissions were assigned to municipalities and sea areas and to the 50 x 50 km squares used by EMEP.

Since the mid-1980s, domestic shipping has shown a trend towards the use of lighter types of fuel, which give lower SO_2 emissions, and away from heavy fuel oil. As a result, total emissions of sulphur dioxide have been reduced. The only types of ships in domestic trade which still use large amounts of heavy fuel oil are the largest tankers and dry cargo ships. Emissions of other components to air have remained relatively stable during recent years.

Fishing vessels are the category that use most fuel and therefore generate the largest emissions. This is partly because of their high level of activity and partly because such vessels are energy-intensive. Cargo vessels are also an important source of emissions, particularly of SO_2. Supply and stand-by vessels, dry cargo ships of all sizes and large tankers are all important in this respect. As regards passenger transport, ferries and other vessels in scheduled service account for roughly equal amounts of emissions. The Coastal Express Liner accounts for one quarter of all emissions from scheduled services.

Emissions from fishing vessels take place mainly at sea; about 80 per cent of the total is released outside Norwegian territorial waters. For supply and stand-by vessels, the figure is more than 90 per cent. A larger proportion of emissions from ferries and other scheduled services are generated close to towns and built-up areas. Local air quality will thus mainly be affected by emissions from these types of vessels.

Tysfjord, Kvinnherad, Rennesøy, Stord and Bergen are examples of municipalities where emissions from ferries are high (figure 3.1.1). Emissions from cargo vessels are released mainly while the vessels are in transit along the coast. However, emissions from cargo vessels, and particularly from tugs, may account for a substantial proportion of the total in some ports.

Emissions in port are highest in Stavanger, Oslo and Bergen municipalities. The figures for international maritime transport are included here, and account for a large proportion of the total. Emissions are also high in Ålesund and Tromsø, where fishing vessels account for the largest proportion of the total.

Just over one quarter of all emissions from domestic shipping are generated in the North Sea south of 62°N, and 75 per cent of this is generated by vessels involved in oil and gas extraction (supply and stand-by, offshore loading and mobile rigs). However, CO_2 emissions from stationary combustion on the installations in the North Sea are eight times as large as the total from all domestic shipping in this area, and NO_x emissions are of the same order of magnitude as those from domestic shipping.

In continuing this work, Statistics Norway also wishes to survey emissions from international maritime transport in Norwegian waters.

Project personnel: Kristin Rypdal and Ketil Flugsrud

Financed by: Ministry of the Environment

Publications: a report will be published in spring 1996.

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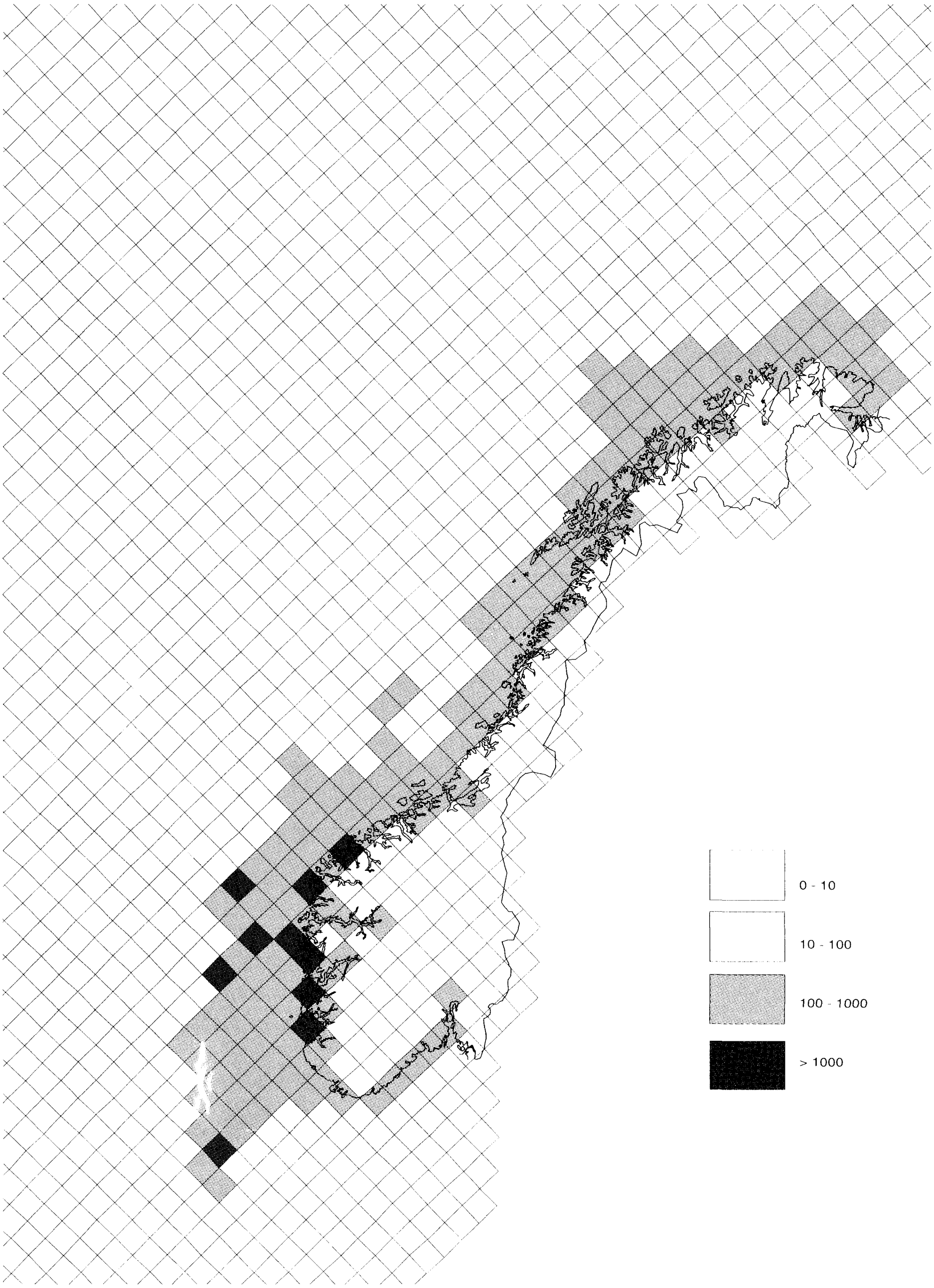
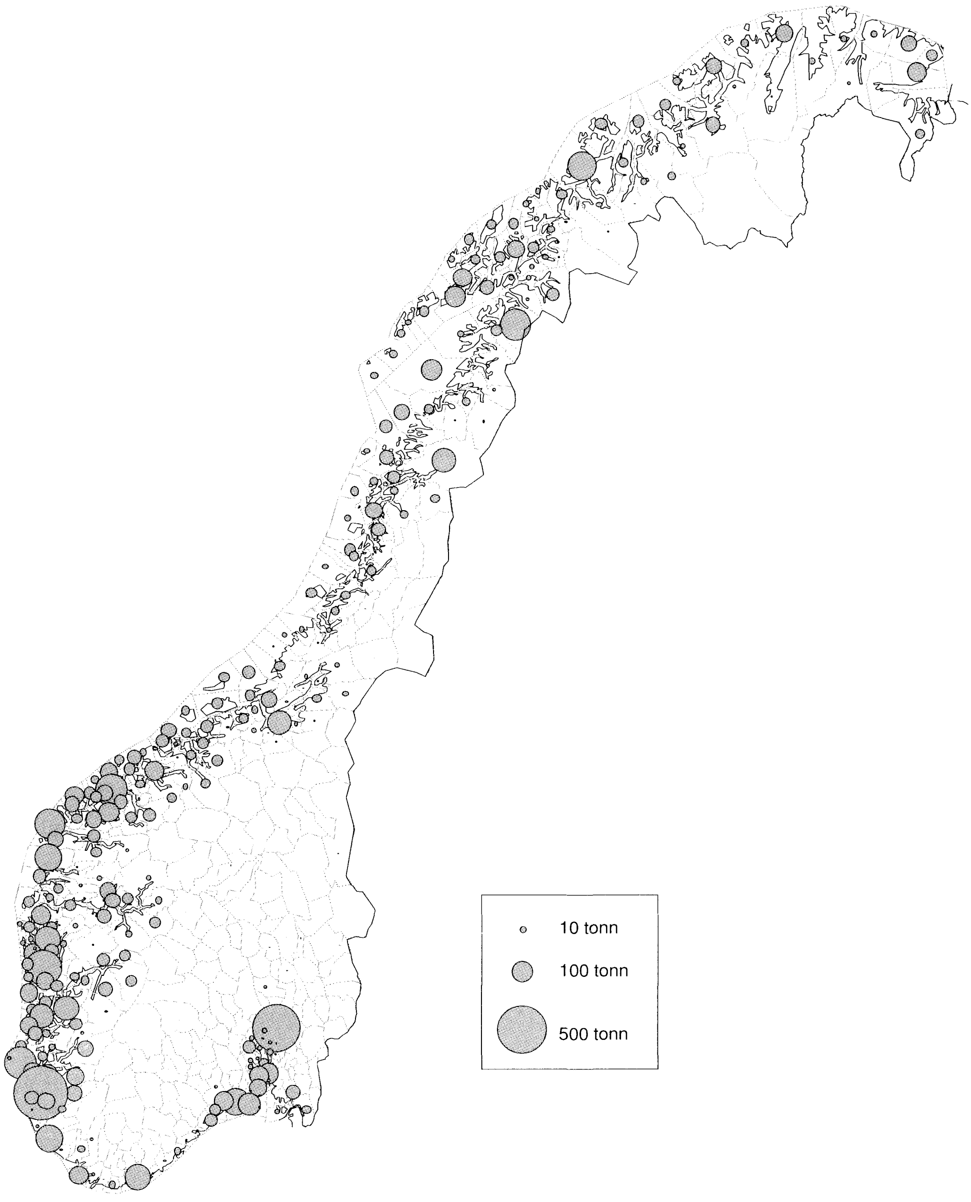
Figure 3.1.1. Emissions of NO_x to air from domestic shipping shown on a 50 km x 50 km grid. 1993. Tonnes



Digital base map: Norwegian Mapping Authority
Source: Statistics Norway

Figure 3.1.2. Emissions of NO_x to air in ports from domestic shipping and international maritime transport, by municipality. 1993



Digital base map: Norwegian Mapping Authority
Source: Statistics Norway

Marintek (1992): Forskrift om avgasskrav til skip. (Regulations relating to emission standards for ships. In Norwegian.) Utredningsprosjekt 1991. MT 22-F92-0039 OR 222109.01.01.92.

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3.2 Emissions to air in districts of towns and basic units

Air quality may be quantified either by direct measurement or by model calculations. In the following, we present a study in which the geographical distribution of emissions to air is calculated by means of a model based on the consumption of energy commodities. This model can be used to monitor air pollution, and to evaluate changes in emissions as a result of local measures to improve environmental quality.

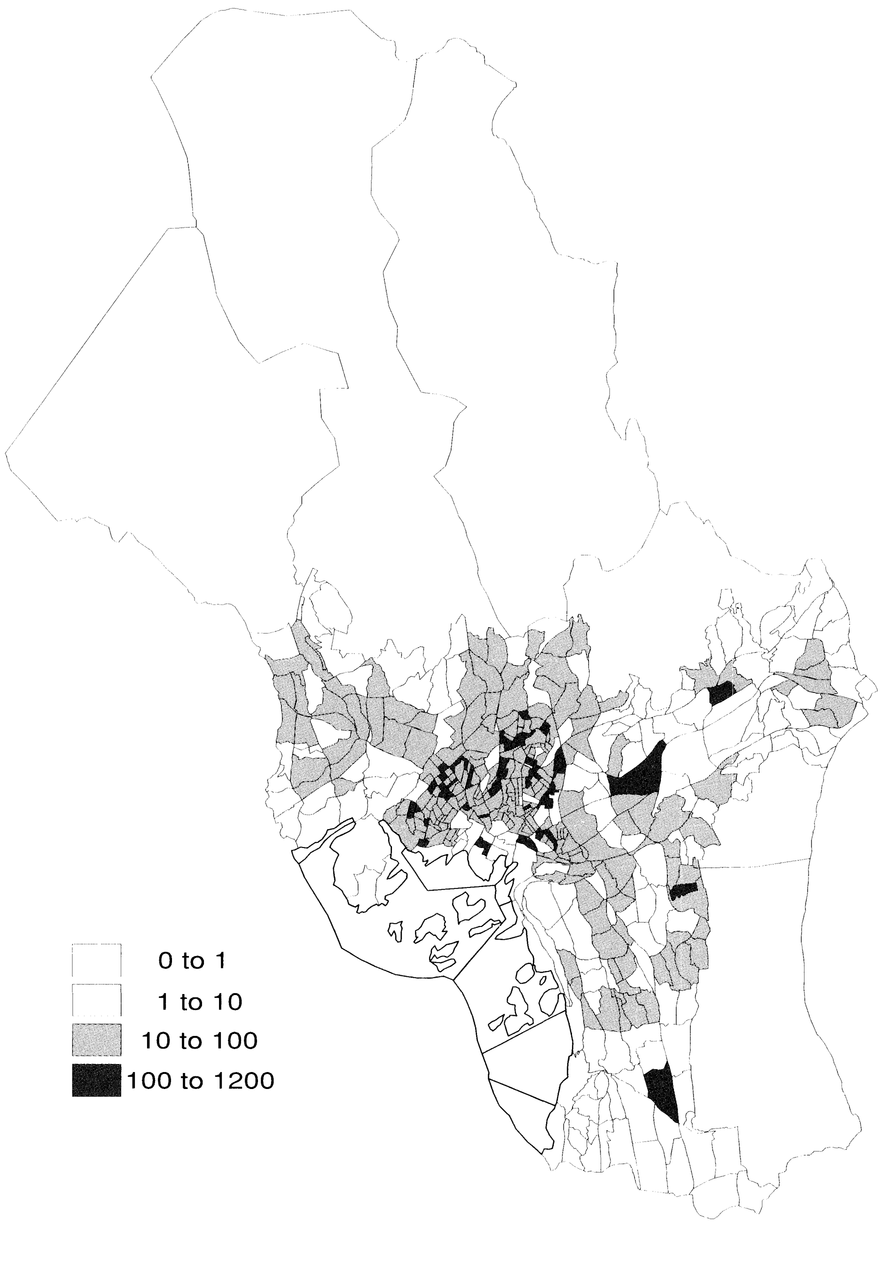
It has been decided to describe air quality by model calculations in the Norwegian Pollution Control Authority's programme for monitoring air quality in towns and built-up areas. In this connection, calculations of emissions to air in basic units (see definition below) and from point sources in selected municipalities were needed. As a first step, calculations have been made for municipalities with large populations, such as Oslo, Drammen, Bergen and Trondheim, but a complete set of calculations is thus far only available for Oslo. The calculations were made for the year 1992.

Basic units are the smallest geographical unit used for statistical purposes, and are defined in such a way that each unit is as stable as possible over time and is uniform as regards building types, industrial base and nature environment. The level of aggregation of basic units is lower than that of municipalities. A number of basic units make up a district, which is the smallest administrative unit in Oslo.

The model calculates emissions to air in each municipality from 31 technical sources and 132 branches of industry, divided between 27 emission carriers and 11 components of pollution. Energy use and emissions of six components (NO_x, SO_2, CO, Pb, Cd and PM_{10}, see Part I, page 31) are allocated to basic units by means of various kinds of activity data. Emissions are allocated to stationary combustion (e.g. oil-fired heating), process emissions (agriculture and industry) and mobile sources (transport). Certain activities associated with process emissions are not included. Three kinds of data are linked to each activity. These are as follows:

- Data on variations between basic units. This is based on information obtained from the GAB register (the official Norwegian register for real estate, addresses and buildings), in which buildings are classified according to type, the activity for which they are used and size, and the locality is identified by means of UTM coordinates. In addition, information on the type of heating is used, together with data on ports, railways and agricultural areas. Large single users (i.e. energy commodity consumption exceeding 100 tonnes/year) are treated separately in each basic unit.
- Data on the amount and type of energy commodities used. This information is obtained from Oslo Energy's register of district heating customers, sales figures from the oil companies, the municipality's own data on energy use, and information directly from large-scale users of energy commodities.
- Data on annual variations in activities. Such data may for example be obtained by means of temperature measurements, records of calls by ships, or direct enquiries.

Figure 3.2.1. Use of wood and fossil fuel for heating housing in Oslo, 1992. MJ per km²



Digital base map: Norwegian Mapping Authority
Source: Statistics Norway

The model calculates that in excess of 25 per cent of the energy used to heat housing in Oslo is obtained from sources other than electricity (oil, wood, coal or district heating based on waste incineration). District heating is the most important of these other sources. District heating plants generate high emissions in the basic units where they are located, but result in low emission figures for the residential areas they supply. Figure 3.2.1 shows how energy use is distributed among basic units in Oslo.

Such data may for example be used in calculating the damage caused by corrosion as a result of air pollution (see the next section, 3.3). In the long term, the model will provide better data for such analyses, and thus help to produce more reliable estimates of the damage caused by corrosion.

In the first instance, the estimates produced by the model calculations are intended to be used by municipalities as input data for model calculations of pollutant concentrations. This is to be used as a tool for municipal pollution monitoring, but can also be used in impact assessment and to plan measures to combat pollution by altering the input data and simulating different scenarios.

There are plans to expand this study to include several municipalities and more pollution components and to extend the period of time to which the calculations apply.

Project personnel: Ola K. Hunnes and Tone C. Mykkelbost

Financed by: Norwegian Pollution Control Authority

Publications:

Flugsrud, K. and O.K. Hunnes (1996): *Metode for fordeling av utslipp på grunnkretser i Oslo, Bergen, Drammen og Trondheim kommuner.* (Method of allocating emissions to basic units in Oslo, Bergen, Drammen and Trondheim municipalities. In Norwegian.) To be published in the series Reports, Statistics Norway.

3.3 Corrosion costs caused by air pollution

Air pollution contains components which contribute to the corrosion of external building materials and vehicles. This project, carried out in cooperation with the Norwegian Institute for Air Research (NILU), calculates the extent of pollution-generated damages to buildings and vehicles and estimates the social costs of such damages.

Air pollution causes damage to external building materials through the corrosion of metals and disintegration of paint, stain, brick and plaster. The primary cause of corrosion damages is sulphur dioxide (SO_2). For some materials, this effect is amplified by exposure to ozone (zinc, galvanized steel, copper). The cost calculations cover 14 materials, including painted or galvanized steel and aluminium, lime, cement and plaster, painted or stained wood, roofing paper, copper, brick and concrete.

A more extensive Nordic analysis of the use of materials in buildings (the MOBAK study) provided a good basis for calculating corrosion costs (Kucera et al. 1993). Data on the exposed quantity of various materials per square metre of floor space were obtained from this study. The use of materials is specified for dwellings (blocks of flats, small houses), industrial buildings and buildings in the service sector.

Buildings are spread throughout areas with varying degrees of exposure to air pollution. The exposure was evaluated in five separate areas: Oslo, other cities, villages south of

Trondheim, villages north of Trondheim and other areas. Data on buildings located in Oslo and other cities were obtained from Statistics Norway's Establishment and Enterprise Register. Buildings located outside Oslo and other cities are distributed on the three remaining areas in relation to population/employment.

Oslo is dealt with in greater detail than other cities and the rest of the country with regard to the identification of exposed buildings. Data on buildings distributed on dwellings (small houses, blocks of flats) and main industries in a detailed grid system were obtained from the Ground Property, Address and Building Register (GAB).

Calculations of the level of pollution in Oslo are based on NILU's dispersion model EPISODE. The model calculates the concentration of SO_2 and NO_2 in a grid system with 44x36 squares each of 500mx500m, in which account is taken of emissions from heating and traffic as well as such factors as wind and temperature. As described in section 3.2, efforts are now being made to obtain an even more precise picture of the geographical distribution of emissions in e.g. Oslo. This will improve the quality of the data applied in the dispersion model. In addition, a regional contribution is included, which is based on measurements outside Oslo. The level of ozone concentration is derived from information on NO_2 concentrations.

The concentration level (excluding the background level from the long-range transport of pollution) is assumed to be proportional to local emissions from all sources. For geographical areas other than Oslo, the same assumption of proportionality between local emissions and concentration is applied.

Corrosion costs for manufacturing industry and service sectors are reflected in a higher depreciation rate for buildings. Higher capital costs have an impact on the entire economy as capital becomes relatively more expensive than other production factors. This leads to a slight reduction in both investments and GDP growth. In the project the relationship between emissions and corrosion is incorporated in a macroeconomic model, and thereby takes account of these allocation costs. This is part of a larger project aimed at integrating additional environmental effects in economic models.

Corrosion costs in 1995 are estimated at NOK 291 million (1995 prices) on a national basis. About a third of these costs are due to allocative losses. The average marginal cost per tonne of SO_2 emissions is about NOK 8 200 on a national basis. There is, however, considerable regional variation. About half of the costs are incurred by private households. Oslo has to bear more than a third of the total cost.

It can thus be estimated that the reduction in SO_2 emissions since 1985 entails annual savings for society amounting to about NOK 500 million.

Project personnel: Solveig Glomsrød and Odd Godal, Statistics Norway, J.E. Henriksen and S. Haagenrud, Norwegian Institute for Air Research and T. Skancke, NORGIT Centre.

Financing: State Pollution Control Authority and Statistics Norway

Documentation: Being prepared

References:

Kucera, V., J. Henriksen, D. Knotkova, and C.H. Sjøstrøm (1993A): Model for calculations of corrosion cost caused by air pollution and its application in three cities.

I: *Progress in the understanding and prevention of corrosion*, 10th European Corrosion Congress, Barcelona, July 1993. Ed. by J.J. Costa and A.D. Mercer. London, Institute of Materials. Vol. 1, pp. 24-32.

3.4 Air pollution, damage to human health and the macroeconomy

As a result of combustion processes and transport, economic activities contribute to air pollution which in turn results in different types of health problems. The harmful effects on human health result in a change in the conditions for economic activity. For example, damage to human health may reduce the growth potential in the long term through a reduction in the supply of labour and labour productivity. Such factors must be taken into account when studying future economic activity and the effects of measures to combat pollution.

Some of the most important damages caused by air pollution are linked to health, diseases and mortality rates. It is well established that exposure to various gases and particulates can result in various respiratory complaints, while there has been more uncertainty linked to the degree of risk. In recent years, however, more knowledge has been acquired in this area due to an array of new studies which have identified the relationship between the level of air pollution and the incidence of diseases and mortality. This knowledge can be used to calculate relationships between economic activity, pollution and effects on health. Some of the effects on health also have an impact on the economy itself, among other things because increased ill health results in a reduction in the labour force and lower labour productivity.

In current macroeconomic projections, emissions of various pollution components to air are calculated in addition to important economic variables. In this project an attempt is made to expand the model used to include relationships between emissions of various components and effects on health, and between health effects and economic activity. As most of the studies of such relationships have been conducted recently, there has not been an established professional consensus concerning which relationships apply. This is in the process of changing to some extent, even though there are still many elements of uncertainty. In this process it has been natural to focus on effects on health which appear to be of greatest importance, and those which can most simply be used to indicate the effect on economic activity. Some of these relationships are presented below.

The studies conducted thus far indicate that the most important pollution component is suspended particulates, which are primarily caused by combustion processes. The relationship which is best documented is that between the daily ambient particulate concentration and mortality rates. Many studies find that a rise in the average concentration level of PM_{10} (i.e. inhalable particulates) of one microgramme per cubic metre ($1\ \mu g/m^3$) results in an increase in the number of premature deaths of about 0.1 per cent of the total number of deaths. By way of comparison, the average concentration level in Oslo on an annual basis is between 20 and 25 $\mu g/m^3$, of which around 15 $\mu g/m^3$ is due to local pollution. This means that about 90 individuals each year experience a premature mortality because of air pollution in Oslo (i.e. 1.5 per cent of the total deaths). It is primarily the elderly and persons with respiratory diseases who die due to air pollution. It is uncertain how long they would have lived if they had not been exposed to pollution, but there are indications that in many cases their lives would have been extended by several years.

Many studies have also been made of the relationship between particulate pollution and various diseases. This project has focused on an extensive study which looked at the effects of short-term sickness absence and other limitations in human activity through variations in particulate concentration. The results of this study are interpreted in such a way that it is possible to indicate how many man-hours are lost in the economy, either as a result of increased sickness absence or reduced efficiency on the job. The study shows that a one unit (1 $\mu g/m^3$) reduction in PM_{10} will increase the effective labour force by 0.1 per thousand through a reduction in sickness absence. Thus, local pollution in Oslo may be responsible for 5-10 per cent of short-term sickness absence.

The most harmful effects on health as a result of air pollution are probably caused by exposure over a *long period*. Such effects, however, are more difficult to demonstrate. Some studies nevertheless suggest relationships between protracted particulate concentration and the incidence of chronic pulmonary diseases. These indicate that a one unit increase in protracted PM_{10} concentration results in an increase of about 1 per cent in the number of people with chronic pulmonary diseases in the population. In addition to the negative effects this has on the individual in question, it results in an increase in sickness absence and a higher number of disability pensioners. A higher incidence of chronic pulmonary diseases will also have an effect on public health expenditure if the standard of treatment for the rest of the population is not to deteriorate.

There is considerable uncertainty attached to the relationships referred to above. Most of the studies have been conducted in the US, while some have been carried out in Europe. No applicable study has been made in Norway. It is thus uncertain to what extent the results can be directly transferred to Norway where the level of pollution is generally lower. One important factor implying that the results are also valid in Norway is that the World Health Organization now appears to be abandoning its recommended threshold values for particulates because harmful effects on health have been observed for very low concentrations.

By applying these relationships to the concentration level of particulate matter in Oslo, it is found that the yearly economic costs of air pollution are about NOK 160 million. This is due to a loss of 400 man-years. In addition, 90 people may each year be affected by a premature death, whereas there may be around 400 new cases of chronic pulmonary diseases each year. These health damages may be valued in economic terms, increasing the total costs to NOK 1.7 billion. The marginal cost related to health damage in Oslo may then be calculated at about NOK 1.8 million (USD 270 000) per tonne of particulate emission.

Project personnel: Solveig Glomsrød and Knut Einar Rosendahl

Financing: Ministry of Environment and Statistics Norway

Documentation:
Rosendahl, K.E. (1996): *Helselvirkninger av luftforurensing og effekter på økonomisk aktivitet* (Effects of air pollution on human health and impacts on economic activity). Reports 96/8, Statistics Norway.

3.5 Structural adjustments in manufacturing industry

Many attempts have been made to calculate the economic effects of introducing environmental taxes. Earlier studies are largely based on long-term calculations that do not take *account of short-term restructuring costs which result from such taxes. In the short run, however, production equipment is determined by earlier investments carried out under different economic circumstances when pollution taxes were neither in effect nor expected. Since the technology has already been chosen and capital costs have been incurred, the effects of taxes on pollution will be less in the short run than in the long run. The costs for firms, on the other hand, will be higher in the short run than in the long run since there are fewer substitution possibilities. The economic effects emerge partly through investment effects, effects on the economic lifetime of capital and price effects.*

Production in manufacturing industry takes place in various factories/machines that were built or introduced at various times and is influenced differently according to the technology chosen in the year of construction. At the time of investment, the firms' decision consists of choosing the technology, from among all the existing technologies, which maximizes the present value of expected profits, given the expected path of all product and factor input prices. Over time, a range of technologies will be chosen, which implies that firms with equipment dating from different years will pollute to varying degrees. In practice it is often the oldest capital equipment which pollutes the most. After an investment has been made, the firm is committed to a production technology which, in turn, determines the use of other factor inputs. The putty-clay model which is used in this analysis is extreme in the sense that it does not take into account that in practice there may be some substitution and modernization possibilities even though the investment has been carried out. It is further assumed that the machines become less efficient as they age and that they are scrapped when they are no longer physically productive or when it is no longer profitable to use them.

The length of time a technology will be used thus depends on changes in depreciation rates, prices and costs. The use of older machines is often, at least from a business point of view, profitable over a long period since the machines are ready for production and the alternative cost is low or non-existent. Usually, a machine will be scrapped when the revenues generated by its production do not cover variable costs even though continued use is still technologically possible. In a model in which there is a desire to study restructuring costs, it is thus necessary that the expected economic lifetime of the capital is determined as a function of product and factor input prices. The product price must be such that the present value of future revenues is sufficient to justify the investment costs incurred in connection with replacement. These last two assumptions yield a putty-clay price model which is very difficult to solve analytically.

The model assumes that there is a sector which produces a product with the help of machinery acquired over several years. The oldest equipment is least efficient, partly because it is run down and partly because it represents an outmoded technology. It is further assumed that a tax on the polluting factor of production is introduced. The expected economic lifetime of old equipment, which requires the intensive use of the factor input that has now become more costly, will decline substantially. As a result, the sector will gradually choose new technologies that are more capital intensive and will also use less of the polluting factor. The expected lifetime of these new machines is longer than for the old technology.

A tax on the polluting factor will immediately reduce the old equipment's share of sectoral production. The product price will also rise since total production costs have risen. This will be immediately followed by another increase in the product price because price formation in the model is based on expectations and is determined by having the present value of the profit from new capital equipment equal to zero.

Investment in the sector will be higher than in the case without a tax on the polluting factor. New equipment will replace the older capital equipment which is scrapped because it cannot cover variable costs. Gradually, however, investments will fall to the same level as before the tax change. Investments determine the model's "vintage" structure, that is the distribution of production over the various years when the equipment was acquired. The use of the polluting factor will eventually decline as the old technology is removed and new technology is applied.

The solution to the model, once the new investment profile has been derived, can be compared with the solution in neo-classical models which are frequently used in analyses of the costs of pollution taxes. The model used here, however, primarily provides a well-grounded explanation for changes in investments and conditions in the period in which the old technology is phased out and the new technology is used.

Project personnel: Petter Frenger

Financing: The Research Council of Norway - the SAMMEN programme

Documentation:

Frenger, P. (1996): Choice of technique and scrapping in a Putty-clay model with endogenous output price. To be published in the series Discussion Papers, Statistics Norway.

3.6 Potential household demand for alternative fuel vehicles

Exhaust gases from car traffic account for a substantial share of CO_2 emissions in Norway. The imposition of a tax on fuels has been a common instrument for curbing the rise in such emissions. It is assumed that this can contribute to a reduction in car traffic, and in the long run result in the use of more energy-efficient car technologies. Several alternative fuel technologies, such as hybrid (dual-fuel), liquid propane gas and electric vehicles, are on the drawing board or at the prototype stage. In this project an analysis is made of how households in Norway will respond to these new fuel technologies when they become available and which attributes are important.

The project is an analysis of the potential demand for alternative fuel vehicles by applying data from a stated preference survey. Based on the data collected, a model was then estimated for the choice between hypothetical vehicles which are characterized by such attributes as purchase price, top speed, fuel consumption and vehicle driving range between recharging/refuelling. The estimated model makes it possible to calculate demand elasticities with regard to price and other attributes and to predict the percentage of persons who, for example, will prefer an electric car with specified attributes over other fuel technologies. In the model, price elasticities (for the choice between technologies, given a purchase) will depend on the values of the attributes. The model can be applied to calculate the willingness to pay for alternative fuel technologies, i.e. the amount that must be added to the purchase price of a specific alternative fuel vehicle to obtain the same value or utility (for the individual) as (for example) a conventional fuel vehicle.

Econometric demand analyses that aim at modelling consumer demand for products that do not exist in the market pose new challenges to the researcher both with regard to econometric method and methodology for collecting data. Traditionally, economists are accustomed to using data based on households' *realized* choices as a basis for carrying out empirical analyses. In this context this is possible only to a limited degree since sales of cars with alternative fuel technologies are very modest.

In the project, the stated preference method was used to collect the data. This entails that individuals are presented with a set of alternatives that are characterized by specific attributes, and they are asked to rank these alternatives, or alternatively only to select the best. In order to analyze the data from this type of hypothetical choice experiment, it is necessary to have a behavioural choice model. Based on the theory of discrete choice, an econometric structural model for individual choice behaviour was developed.

In brief, the point of departure for this theory is as follows: The individual is assumed to have preferences for attributes of the alternatives (in this connection fuel technology alternatives). Some of these attributes may be unobserved by the researcher while they are known to the individual. The individual's preferences over attributes are represented by a utility function (which is not observable), but which depends on the observable attributes of the alternatives. It is assumed that the individual will select the alternative providing the highest utility. While economic theory usually assumes perfect rationality (consistency) in the sense that the individual will make the same choices in various choice experiments under identical conditions, this theory allows for the possibility of inconsistency. This is motivated by the following factors:

- perception and taste may vary from one moment to the next,
- the individual has difficulty in assessing the precise value (for him/her) of each alternative. This means that the individual may choose different alternatives in the various choice situations under identical conditions. In addition, the researcher often does not observe all relevant variables which the individual is aware of and takes into account. In connection with this project the possibility of using stochastic utility theory is particularly appealing since it is reasonable to assume that individuals have difficulty in assessing the value (utility) of alternative fuel vehicles which, at the moment, are purely or partly hypothetical. Based on the data collected, various versions of the model have been estimated.

The estimated model can be used to conduct policy experiments. In Dagsvik et al. (1996), elasticities were calculated with regard to purchase price and willingness to pay for alternative fuel technologies. Data from the survey seem to indicate that those who do not own a car have stronger preferences for alternative fuel technologies than car owners. When the sampling error is taken into account, it is found that there is little correlation between individuals' residential locations and their preferences for alternative fuel technologies. It appears that younger individuals react more strongly to high car prices than older people. Given that the household decides to purchase a (new) car, it appears that the household's income does not have a significant effect on the choice of technology. Women seem to have stronger preferences for alternative fuel technologies than men. The results indicate that older men are particularly reserved towards electric vehicles.

Project personnel: John K. Dagsvik, Dag G. Wetterwald and Rolf Aaberge

Financing: The Research Council of Norway through the programme SAMMEN

Documentation:
Dagsvik, J.K., D.G. Wetterwald and R. Aaberge (1996): Potential demand for alternative fuel vehicles. Discussion Papers 165, Statistics Norway.

3.7 Structure of CO_2 taxes. Theoretical basis and economic consequences

This project deals with CO_2 taxes in a general tax policy context and with the role and structure of these taxes within the framework of national and international targets for the level of CO_2 emissions. Calculations have also been made which illustrate the effects on key economic variables which result from following theoretical recommendations versus the current structure of Norway's CO_2 taxes.

Some people argue that a shift in taxation from general taxes (e.g. the taxation of earned and capital income) to environmental taxes has a favourable impact on the economy beyond the environmental effects (double dividend or double benefit arguments). Empirical literature also exists which discusses whether environmental taxes have favourable effects on the economy independent of the environmental effects. The literature does not provide any clear-cut answer to this question since the total effect depends on which other tax rates are reduced at the same time. This illustrates that taxes are not optimal to begin with and that caution should be exercised when interpreting the results of empirical studies.

Under a national target for the level of Norwegian CO_2 emissions, efficiency considerations imply the same tax on all emissions. CO_2 taxes will come in addition to fiscal-motivated taxes on fossil fuels. With an international agreement where a number of countries cooperate in order to reduce their CO_2 emissions, this agreement may influence emissions in countries that do not participate in the cooperation. In this event, it may be optimal for the cooperating countries to have the same CO_2 tax for all sectors, combined with taxes or subsidies on net imports of all goods and services. If, on the other hand, it is not possible to impose taxes on net imports of goods and services, it may be optimal to differentiate the CO_2 tax across sectors. In practice, however, it is very complicated to calculate the optimal differentiation of the CO_2 tax. In a transitional phase, adjustment cost considerations may to some extent justify this discrimination.

There are often physical links between several emission components, such as emissions of CO_2, NO_x, SO_2 and suspended particulates. In such cases, each emission component must be taxed in such a way that the targets set for each of them can be achieved simultaneously. The relationship between the various components, however, may be complex. In most cases, such a tax rule will result in explicit taxes for each component (additive taxes). In some cases, however, limiting one component will automatically reduce emissions of another component below the established physical limit. In this case, there will be no tax on this last component.

A general conclusion of this theoretical review is that all emission sources should be taxed at the same rate unless an explicit reason is provided for a different approach. A justification for discrimination using different tax rates should be empirically based in order to make it possible to design the system in practice.

A long-term macroeconometric model is used to quantify the effects on some key economic variables which result from a shift from the current tax system, which discriminates between different sources, to a system with the same rate for all sources. In particular, the analysis looks at welfare effects versus more traditional measures such as GDP. One of the conclusions is that real GDP declines slightly as a result of this change in the tax system. The reason is that a change entails higher taxation of the business sector and slightly lower taxation of consumers. A better measure of the welfare effects from such a change, however, is the utility effect for consumers, and the calculations show that this is positive. Positive environmental effects through reduced emissions of SO_2, NO_x and particulates, in addition to lower emissions of CO_2, will contribute further to this conclusion. The effects of a change are small, but will increase with any escalation of taxes. Equalization at a low tax level is thus preferable to equalization at a high tax level.

Project personnel: Michael Hoel (University of Oslo), Torstein Bye and Anne Brendemoen

Financing: Ministry of Finance. The project draws on several studies under The Research Council of Norway's research programme SAMMEN

Documentation:
Brendemoen A., T. Bye and M. Hoel (1995): Utformingen av CO_2 -avgifter. Teoretisk grunnlag og økonomiske konsekvenser (Structure of CO_2 taxes. Theoretical basis and economic consequences). *Norsk Økonomisk Tidsskrift (NØT) 109*, 77-106. Oslo: Norwegian Association of Economists.

3.8 Environmental taxes and long-term economic growth

The long-term macroeconomic effects of a carbon tax can be both positive and negative, depending on whether substitution effects which create efficiency losses in the economy are outweighed by positive terms-of-trade effects. If a tax which results in efficiency losses in the economy already exists, the possibilities for achieving a welfare gain through a further tax increase as a result of terms-of-trade effects will be less the higher the level of the initial tax. With an international carbon tax, the terms-of-trade gain will be smaller and petroleum revenue lower compared with a unilateral tax. For an oil and gas producing economy a unilateral tax will thus result in a smaller welfare loss than an international tax. In this analysis an intertemporal general equilibrium model is used to analyze the long-term welfare effects of introducing a carbon tax in a small, open oil and gas producing economy like Norway.

In addition to the more short-term effects on prices and costs, carbon taxes have long-term welfare effects through changes in the rate of capital accumulation and economic growth. Long-term effects refer to effects on the economy's production potential and the maximum welfare households can achieve within the constraints set by the supply of resources. Intertemporal equilibrium models are thus suitable for analyzing long-term energy and environmental policy problems (see e.g. Jorgenson and Wilcoxen 1993). An intertemporal model assumes that micro-agents make an optimal choice between consumption and saving over time. Consumer behaviour is modelled by means of a representative household with an infinite horizon which decides how much it shall save and consume of consumer goods, given expectations of future prices and wages, and an assumption that the discounted value of net assets (positive/negative) must be equal to zero. This entails that net debt or wealth cannot grow beyond all limits in the long term. The assumption of an infinite horizon can be justified on the assumption that there is an altruistic inheritance motive, i.e. wealth is transferred between generations in the form of inheritance. This is a common assumption in long-term analyses. Using this analytical tool it is possible to analyze the effect of a carbon tax on capital accumulation and thus long-term economic growth. In addition, the model provides a consistent welfare measure in the form of the total discounted utility of consumption. The welfare effects of various tax reform packages can therefore be compared by comparing the effects on total discounted utility.

The model describes a small, open economy, which in addition to petroleum produces another good which is an imperfect substitute for a foreign good. Both the effects of a unilateral and international carbon tax are analyzed. A unilateral carbon tax results in changes in the price of the domestic good in relation to the price of the foreign good. This will lead to changes in both the volume and price of exports and imports (terms-of-trade effects). The terms-of-trade gain is generated by an assumption of differentiated products. A unilateral carbon tax can then be transferred to other countries through cost-determined product prices. This entails that the export price is determined by domestic costs. It may seem unreasonable that a small, open economy can influence its export prices, but recent theory concerning imperfect competition shows that producers in many markets can have market power, see e.g. Helpman and Krugman (1985). The size of the country is then not necessarily of significance. Empirical analyses show that over time Norwegian producers have been able to pass on their cost increases to export prices, see e.g. Lindquist (1993). An international carbon tax results in a decline in the world market price of petroleum products. In this analysis the fall in the price of crude oil does not outweigh the tax imposed on petroleum products so that the domestic price of fossil fuels increases. This results in an increase in the price of the domestic good as a result of higher production costs. The increase in oil product prices is relatively greater than the increase in the price of other competing imports because this good has a lower carbon content. According to studies by the OECD, Burniaux et al. (1992), the terms-of-trade gain through an international carbon tax will be lower for petroleum producing countries than for other countries. With an international carbon tax the terms-of-trade gain will thus be smaller and petroleum revenue lower than with a unilateral tax. This entails that for a petroleum producing economy a unilateral tax can result in a smaller welfare loss than an international tax. The existence of terms-of-trade effects can make it profitable to be "best in the class". It is assumed that tax revenues from the carbon tax are then redistributed through lump-sum transfers. The terms-of-trade effect is thus the only income effect generated by the carbon tax.

A macro commodity is produced in the economy which is used for both consumption and investment. This good, which includes fossil fuels, is a composite good of a domestic and foreign variety. When the price of fossil fuels rises as a result of a carbon tax, it results in substitution towards the domestically-produced macro commodity. With a unilateral tax the price of the foreign variety will remain unchanged, while the domestic good will rise in price. This results in substitution towards the foreign variety. With an international tax the price of the foreign variety will also rise, thereby modifying the substitution away from the domestic variety. In addition, the change in the relative price between the domestic good and fossil fuels will be less, thereby modifying the substitution towards the domestic good. These substitution effects result in efficiency losses in that the prices are shifted as a result of the taxation, and the efficiency loss increases with the tax rate. The positive environmental effects of a carbon tax are disregarded in the analysis.

The total effect on capital accumulation and production depends on whether the negative substitution effects which reduce the demand for the domestically produced good outweigh the positive terms-of-trade effect. Even if the capital stock and, hence, production are reduced, the welfare effect can be positive as a result of the improvement in the terms of trade. This is particularly true if there is no tax initially. A tax increase which is passed on to other countries may then actually result in an increase in income which is sufficient to outweigh the negative effects. However, the higher the initial tax, the greater the initial efficiency loss will be, thereby offsetting the positive terms-of-trade effects so that welfare is reduced if the tax is further increased.

Project personnel: Brita Bye

Financing: The Research Council of Norway through the project SAMMEN

Documentation:
Bye, B. (1995): A dynamic equilibrium analysis of a carbon tax. Discussion Papers 145, Statistics Norway.

References:
Burniaux, J.M., J.P. Martin, G. Nicoletti and J. Oliveira Martins (1992): The costs of reducing CO_2-emissions: Evidence from GREEN, Working Papers 115, OECD.

Helpman, E. and P.R. Krugman (1985): *Market Structure and Foreign Trade; increasing returns, imperfect competition and the international economy*, Hertfordshire: Harvester Press.

Jorgenson, D. and P.J. Wilcoxen (1993): "Energy, the Environment, and Economic Growth" in A.V. Kneese and J.L. Sweeney (eds.): *Handbook of Natural Resource and Energy Economics*, Elsevier Science Publisher, 1267-1350.

Lindquist, K.G. (1993): *Empirical Modelling of Exports of Manufactures: Norway 1962-1987*. Reports 93/18, Statistics Norway.

4. Other environmental issues

4.1 Projections of waste

Economic activity generates considerable waste quantities through production and consumption. This in turn creates environmental problems in the form of storage, seepage from waste disposal sites, air pollution as a result of waste treatment etc. Large quantities of waste also have re-use value, and therefore represent a squandering of these resources. Ratios between various economic activities and generated waste quantities are established in this analysis. Along with projections of economic activity, these ratios are used to project waste quantities in the period to 2010. Waste quantities in this period are estimated to rise by 35-60 per cent, depending on waste components. These results, which provide an indication of future developments with an unchanged waste policy, can serve as important background information when drawing up measures to combat waste problems.

Municipal waste, delivered hazardous waste and waste generated in industrial activities are studied in this analysis. Municipal waste is waste registered at municipal waste collection sites. Delivered hazardous waste is hazardous waste from all industries registered by Norsas AS (the Norwegian centre for waste and recycling). Furthermore, projections have been made for hazardous waste and production and consumption waste generated in industrial activities, i.e. quantities created (not delivered), and only for manufacturing (not all industries). The projections are based on data from Statistics Norway and Norsas AS on waste quantities in Norway (see also part I, chapter 7. Waste). Estimates for key economic variables in the Norwegian economy in the years to 2010 were derived from the macroeconomic equilibrium model MSG-EE, a version of the model used by the Ministry of Finance for its long-term calculations in the Long-Term Programme for 1994-1997. Much of the waste is related to the use of material inputs; intermediate goods that are not included in the product become waste. Some technological change is assumed over time, i.e. that sectors in the economy use material inputs more efficiently as new technology is applied. This contributes to a reduced use of material inputs and thus reduced waste per unit of output.

In spite of projected technological advances of about 1 per cent annually in the production sectors, waste quantities increase at a faster pace than output in the projections. The reason is that material inputs are expected to be cheaper relative to labour and energy over time. The change in relative prices entails that it is profitable to use less of the factor inputs that become more expensive and more material inputs which become relatively cheaper. The substitution effect in the calculations is greater than the contribution from technological change, thereby resulting in an increase in waste quantities. Technological change curbs the effect on prices, but for most types of waste the price effect is strongest.

Production and consumption waste that are generated in manufacturing activities cover a number of different types of waste involving a varying degree of risk, ranging from stones and gravel to chemicals. In order to examine future environmental effects of waste quantities, it is thus necessary to look at changes in the various types of waste.

Table 4.1 shows the growth in various waste categories in the period to 2010. There is a considerable difference in the growth of the various categories of waste. The growth in production and consumption waste generated in industrial activities is influenced by the fact that manufacturing industries expand faster than other sectors in the economy. This waste category shows the highest rise of 60 per cent. Delivered hazardous waste covers hazardous waste from all industries in the economy. The growth in delivered hazardous waste is smaller than the growth in hazardous waste generated in manufacturing, 36 compared with 49 per cent. This is because delivered hazardous waste comprises the oil sector, and this sector is expected to record slow economic growth - thereby resulting in a small increase in waste quantities - in this period. Oil-contaminated and oil drilling waste delivered from the oil sector account for the highest share of delivered hazardous waste. Municipal waste shows a rise of 44 per cent. Household waste accounts for about half of municipal waste. Here, growth in consumption was used to explain changes in waste quantities, and household waste shows a rise of 31 per cent.

Table 4.1.1. Projections of waste quantities in Norway. Base year[1, 2, 3] and 2010. 1 000 tonnes and percentage change

	Base year	2010	Growth 1994-2010
Municipal waste[1]	2 222	3 208	44
Delivered hazardous waste[2]	91	124	36
Hazardous waste generated in manufacturing[3]	320	506	49
Production and consumption waste generated in manufacturing[3]	2 967	4 898	58

[1]Base year 1992. Source: Statistics Norway (1994)
[2]Base year 1994. Source: Norsas (1995a)
[3]Base year 1993. Source: Kaurin, Å (1993)
Source: Bruvoll and Ibenholt (1995)

The projections show that waste problems may be substantial after the turn of the century. An analysis will be made of the economic effects of economic policy measures to combat waste problems in the next phase of the project.

Project personnel: Annegrete Bruvoll and Karin Ibenholt

Financing: Ministry of Environment and Statistics Norway

Documentation:

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

Bruvoll, A. (1995): Skadeverknader ved forbrenning av kommunalt avfall (Harmful effects of municipal waste incineration). Report to The Research Council of Norway.

Bruvoll, A. and K. Ibenholt (1995): *Norske avfallsmengder etter årtusenskiftet* (Waste quantities in Norway after the turn of the millennium). Reports 31/95, Statistics Norway.

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Sources:
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4.2 Projections of environmental indicators

A set of environmental indicators is being developed to provide an overall picture of the state of the environment in Norway. By linking these indicators to macroeconomic models, it is possible to gain an impression of the relationship between the state of the environment and economic development. The model can also be used to make projections of the state of the environment. The factor which determines whether a national macroeconomic model can be used for projections of environmental indicators is the nature of the problem the indicator is intended to elucidate. Many environmental problems are ascribable to factors which depend very little on economic developments and which therefore cannot be projected in a meaningful manner using macroeconomic models. Moreover, within this framework it is not possible to project indicators for global problems or problems that are due to other countries' emissions. The projections are therefore limited to four issues: eutrophication of lakes and watercourses, the urban environment, waste and forests.

An environmental indicator is defined as a number which provides information on the state of a further defined environmental problem. Since it is too complicated to describe even the smallest ecosystems by means of just a few figures, a set of indicators (many indicators) for Norway will only provide a very rough estimation of the state of the environment. However, even a rough indication is better than no information, and too extensive information is difficult to comprehend.

In 1991 the Ministry of Environment appointed a national reference group with the task of proposing a set of environmental indicators for Norway. At the same time, efforts have been made to establish a set of environmental indicators under the auspices of the OECD and the Nordic Council of Ministers. In order to facilitate comparisons of the state of the environment in different countries, attempts are being made to coordinate the proposals for environmental indicators. This is a very time-consuming process, and the first official set of environmental indicators for the Nordic countries is scheduled to be presented in the autumn of 1996. For a further description of the work on environmental indicators, see Statistics Norway (1995).

The Nordic cooperation has resulted in the development of a state-of-the-environment indicator for each problem, indicating the current state of the environment, a pressure indicator which sheds light on important causes of changes in the state-of-the-environment indicator, as well as a response indicator which shows the measures introduced to improve the problem. The projections in this analysis look at the state-of-the environment or pressure indicator and are based on the proposals for environmental indicators as presented in Statistics Norway (1995). The proposal encompasses indicators for altogether eleven issues, but the projections here only look at five of them.

The projections are based on the assumption that the economic growth path is similar to the reference path presented in the Long-Term Programme 1994-1997. Not all environmental indicators can be projected in this way. Some of the indicators are linked to international conditions, and a national model is then unsuitable. This applies to the following areas: climate change, atmospheric ozone and acid rain resulting from the long-range transport of air pollution. Some problems are national, but cannot be dealt with in a macroeconomic model (MSG) because it is not possible to shed sufficient light on the key variables in the model. This particularly applies to issues related to land use: Biological diversity and changes in the cultural and natural landscape. The exclusion of these variables from the model reflects the fact that the model has not been developed to analyze such conditions, but also that some of the problems depend on variables of limited macroeconomic importance. For example, the draining of marshes is of marginal importance in a macroeconomic context, but is extremely important for wetlands, which in turn are important to biodiversity.

A number of environmental problems for which there is a close relationship to economic activity have been the subject of extensive analyses as e.g. emissions to air and waste generation. These problems are described elsewhere in this report. This leaves projections of indicators for three issues: eutrophication, the urban environment (noise) and forests. Except for noise, the development paths have been derived from the assumptions used in the analyses, and are thus not calculated by the model.

Eutrophication results in increased algal growth in fjords and lakes. This can result in a deterioration in water quality and cause changes in plant and animal life. Light penetration in selected lakes has been proposed as the state-of-the-environment indicator for this problem. An important source of eutrophication is excessive use of fertilizer (surplus nitrogen and phosphorus) from agriculture, which has therefore been proposed as the pressure indicator. There are many factors which influence the supply of surplus fertilizer, and most of them cannot be described using existing macroeconomic models. It is reasonable to assume, however, that if special measures to combat eutrophication are not introduced, changes in the level of output in the sector will indicate changes in surplus fertilizer. In the long-term calculations presented in the Long-Term Programme 1994-1997, agricultural production is expected to rise slightly from 1994 to 1996 and then decline in the period to the year 2000, to a level that is 10 per cent lower than in 1994. This indicates that the problem of eutrophication may be reduced in the period ahead.

Increased traffic density results in higher emissions of health-threatening gases and more noise. These problems are most serious in urban areas where pollution affects areas with a high population concentration. In the proposed set of indicators, the state-of-the-environment indicator here is the number of persons exposed to road traffic noise in the capital. This indicator is influenced by total road transport, which can be computed in a model derived from the macroeconomic model. In a development path which is consistent with that presented in the Long-Term Programme, total road transport will rise by 20 per cent from 1994 to 2004. The local environmental authorities in Oslo have then estimated that this will result in a 2 per cent increase in the number of people exposed to noise over the same period, based on assumptions entailing the same road network and traffic pattern, the same level of noise per car, no new noise baffles and an unchanged relationship between residential areas and the road network.

The set of indicators also indicates the state of important natural resources such as forests and fish. For forests, it is considered desirable to measure the standing volume as a resource, while other environmental aspects of forests are partly elucidated by other indicators. The model-based calculations are based on assumptions concerning production trends in forestry. Since timber is the resource for which an indicator will be devised, it has been decided to project resource rent in forestry, i.e. the additional yield in forestry which can be ascribed to the resource. The projection shows a steady growth in the period from 1991 to 2010, with a growth of 66 per cent for the period as a whole.

The change in the spawning stock of the key species herring has been selected as an indicator for fish resources. Even though the macroeconomic calculations are based on assumptions concerning developments in the fisheries industry, changes in the herring stock are only marginally linked to these assumptions. It has therefore been decided not to project this indicator.

The analysis shows that several of the indicators have a limited relationship to general economic trends. This is because the environmental indicators depend on global conditions or conditions that are poorly described in the model. Some environmental problems are also due to factors that have little influence on general economic developments, and in such cases remedial measures to improve the environment would have a limited negative effect on economic growth.

Project personnel: Hilde Lurås and Arne Jakobsen

Financing: The Research Council of Norway, Methodology programme under Economics and ecology

Documentation:

Lurås, H. (1995): *Framskrivning av miljøindikatorer* (Projections of environmental indicators). Reports 95/25, Statistics Norway.

References:

Statistics Norway (1995): *Natural Resources and the Environment 1995*. Statistical Analyses 7.

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Ministry of Finance (1993): Langtidsprogrammet 1994-1997, St. meld nr. 4 (1992-1993) (Report no. 4 (1992-93) to the Storting: Long-Term Programme 1994-1977). (Parts of the report are available in English)

4.3 National income and global sustainability

Estimates of a country's resource wealth (e.g. petroleum wealth) show the market value of these resources. The contribution of resource extraction to national income is defined as the highest sustainable consumption which the resource wealth can finance. This contribution can be both higher or lower than the return to the wealth, depending on expected interest rate movements. If the nation does not con-

sume more than its income, the nation's future generations may maintain the same level of consumption as our generation. In this context it is irrelevant whether the nation saves in the form of petroleum on the seabed or places funds in foreign banks. The calculation presupposes that the oil required by the nation in the future can be bought on the world market. But what happens to the world's future resource requirements if everyone adopts the same approach? The answer is that all countries must become increasingly richer to compensate for the constant reduction in natural resources.

Calculations of national wealth are described in earlier issues of Natural Resources and the Environment (Statistics Norway 1993, 1995). In these calculations it is assumed that Norwegian production and consumption constitute such a small share of the world market that it does not influence international prices and interest rates. The calculations are further simplified by assuming that there are no limits to saving and borrowing, at given interest rates, as long as one is able to repay in the long run. National wealth is then defined as the present value of the nation's net future income flows. The resource wealth is part of the national wealth and is defined as the present value of resource rent, i.e. the share of income from resource-based activities which exceeds the normal return on capital.

If the future were certain, and we could save or borrow unlimited amounts as long as we had the ability to repay, resource wealth could finance all consumption paths which the flow of annual resource rent can finance. Wealth can then be looked upon as a bank deposit. Hicksian income, which corresponds to this wealth, is the highest everlasting consumption that the wealth can finance. If interest rates had been constant forever, and we only lived off interest income, we would then be able to maintain consumption over time. In this case, Hicksian income will be equal to the return on the wealth. If, on the other hand, interest rates fall over time, wealth must increase if interest payments are to be kept at a constant level. Hicksian income is then smaller than the return.

This approach applies for a small country, but is not valid for the world as a whole. Even though some countries borrow and some save, the sum of saving and borrowing must be equal to zero. For the world as a whole, there are no possibilities for saving or borrowing at a given interest rate. Similarly, some countries import resources and others export them, but the sum of exports must be equal to the sum of imports. If the world's resources are depleted, it is not possible to buy more of the resource. How may consumption then be maintained? There is no general answer to this question, but the key issue is to what extent man-made capital can replace natural resources, e.g. by compensating for a reduction in oil production through more efficient car engines or the development of alternative energy sources. If the possibilities for compensating for a reduced supply of natural resources by using better technology are sufficient, it is possible to find a sustainable level of consumption, i.e. a level of consumption which can be maintained forever. The next question is to what extent the current level of consumption is higher than this sustainable level.

It is not possible to provide a general answer to this question either, but some special cases have been analyzed. One result known as Hartwick's rule, from Hartwick (1977), is that if all countries plan on maintaining a constant level of consumption, and the prices of natural resources today reflect the scarcity of these resources, the sum of all investments must be equal to zero. Investment is interpreted here in a broad sense, and includes investments in human capital through education, and the negative investment associated with the extraction of natural resources. In Hartwick's model, the entire resource rent is a negative investment, and if the sum of all investments is to be equal to zero, it means that the entire resource rent must be invested in another form of capital; nothing can be consumed. This is to all appearances at variance with earlier calculations for Norway in which it was found that oil production results in a considerable contribution to Hicksian income, i.e. to sustainable consumption.

The two conclusions, however, are only seemingly contradictory. Hartwick's rule says that if the world's total consumption is to remain constant, investments in other capital must be just as high as the world's total resource rents, including Norway's petroleum rent. This does not mean, however, that Norway must necessarily save its resource rent to allow Norway to maintain its consumption. All countries must thus increase their investment in order to compensate for resource extraction, not only the resource-rich countries, see Asheim (1986).

The explanation of how Hartwick's rule is related to wealth calculations is found in interest rate movements in Hartwick's model. It was seen above that if interest rates fall over time, all countries must increase their wealth to maintain consumption. The interest rate reflects the return that can be obtained on investments, and when there are fewer resources left this will contribute to making the investments less profitable, thereby pushing down interest rates, at least under the assumptions required to derive Hartwick's rule. If all countries increase their wealth to compensate for expected lower interest rates in the long term, all nations will save. If all nations' plans combined entail that the global level of consumption is constant, it follows that when we add up the saving of all nations the final result will be equal to the sum of the resource rent of all nations.

Project personnel: Kjell Arne Brekke

Financing: The Research Council of Norway. Methodology programme under Economics and ecology

Documentation:
Brekke, K.A. (1996): Economic Growth and the Environment, On the measurement of income and welfare. To be published, London: Edward Elgar.

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4.4 Some Norwegian politicians' use of cost-benefit analysis

The transport sector is the only Norwegian public sector where cost-benefit analysis has been used in a systematic manner. Doubt has been raised, however, as to whether politicians in practice take account of the analytical results. This project presents some findings from interviews with members of the Norwegian Parliament. Attitudes towards the cost-benefit ratio varied according to political affiliation, with the parties on the left the most sceptical.

None of the politicians looked upon the cost-benefit ratio as a final evaluation in terms of which projects should be given priority. Some of them used it, however, as an "alarm signal" to indicate which projects should be looked at more closely.

Figure 4.4.1. An index of attitudes towards cost-benefit analysis. 0 = most negative, 12 = most positive.

0	1	2	3	4	5	6	7	8	9	10	11	12
SL		La		Ce	La	La	Co	Co	PP		Co	
SL		La					Co					
		La					La					
		CD					PP					

SL = Socialist Left Party
La = Labour
CD = Christian Democratic Party
Ce = Centre
Co = Conservative
PP = Party of Progress

The survey described here (Nyborg and Spangen 1995) was a joint project with the Institute of Transport Economics, carried out in the spring and summer of 1995. All of the 16 representatives who were members of the Norwegian Parliament's Standing Committee on Transport and Communications in the spring of 1993 were interviewed, and the subject of the interviews was the debate on the Norwegian Road and Road Traffic Plan 1994-1997 (Ministry of Transport and Communications 1993). It is not possible to draw definitive conclusions as to how politicians generally feel about cost-benefit analyses on the basis of this survey, but the results may provide some understanding of how such information is used in the political process.

The road plan consists of a vast number of projects, and is the subject of extensive deliberations in the county councils, the Directorate of Public Roads and the Ministry of Transport and Communications before it reaches Parliament. For a member of Parliament, it will probably be natural to focus on the largest projects as well as those projects where there are indications the cases are somewhat special. In this event the type of signal that functions in this way will be of considerable importance.

A large majority of the politicians appeared to interpret the cost-benefit ratio as an indicator which could be used to sort out projects they ought to take a closer look at. Phrases such as "alarm signal", "a rough selection", and "starting point for questions" were used to describe this. Such an interpretation does not necessarily imply acceptance of the normative implications of cost-benefit analysis, but is more like a screening mechanism. Respondents seemed to use somewhat different strategies regarding *when* they reacted to cost-benefit ratios. It was not necessarily essential whether it was above or below 1 (which marks the limit for when a project is defined as socially profitable in the methodology used by the Directorate of Public Roads in 1993). For the majority of those interviewed, it further appeared that *indications of conflicts* in connection with a project figured far more prominently as an indicator for determining which projects should be scrutinized further.

Respondents who looked upon the cost-benefit ratio as a screening device differed quite substantially in their attitudes towards this device. Several were extremely sceptical, to the extent that it is unlikely that they attached much significance to the cost-benefit ratio.

None of the respondents appeared to use the cost-benefit ratio as a final evaluation of projects in the sense that they automatically ranked projects in accordance with the cost-benefit ratio. As several of them pointed out: if decisions were to be made that way, politicians would be redundant. People expect a politician to participate more actively in the evaluation process than simply adhering to the results of a mathematical calculation.

A few respondents did not appear to place any emphasis on the cost-benefit ratio at all.

An *index* was constructed to provide a rough summary of politicians' attitudes towards cost-benefit analysis. Responses to each question used in the index were given a particular score, and each respondent's scores were added up to yield a final score for each. In this way the respondents were ranked on a scale from 0 to 12, with 12 points reflecting the most positive attitude possible. The questions and scores are presented in Nyborg and Spangen (1995). The results are shown in figure 4.4.1, which also indicates the respondents' political party. The weighting implied by this procedure is somewhat arbitrary, and important nuances may have been neglected. An attempt was also made to code the data in other ways, but this did not materially change the picture which emerged.

The overall impression is that politicians' attitudes towards cost-benefit analysis largely follow a traditional left-right political axis, with the Socialist Left Party representatives as the most critical, followed by some Labour Party representatives and the Christian Democratic Party. The representatives from the Conservative Party and Party of Progress were the most positive.

Nyborg (1995) shows that if a person is concerned about distribution issues or factors other than individual well-being (e.g. nature's intrinsic value, religious considerations, fundamental rights and duties) the normative assumptions inherent in a cost-benefit analysis will not be in close accord with the person's own judgement. It seems reasonable to assume that the Socialist Left Party, the Christian Democratic Party and parts of the Labour Party are more concerned about distribution, and perhaps also intrinsic value variables, than the Conservative Party and Party of Progress. The fact that attitudes towards cost-benefit analysis largely follow the left-right political axis seems to be consistent with the hypothesis that politicians use the information provided in a rational way, pursuing their subjective perceptions of social welfare or political goals. It is therefore not certain that greater importance will be attached to cost-benefit analysis if the politicians' understanding of them is improved.

It was not possible, based on these interviews, to establish with any certainty whether the politicians had a sufficient understanding of the methodology involved. However, it was also impossible to identify respondents who had clearly misunderstood major features of the method. A few respondents demonstrated a considerable insight, including some who were sceptical, and appeared not to use the cost-benefit ratio to any extent in their practical evaluations.

Project personnel: Karine Nyborg, Statistics Norway and Inger Spangen, Institute of Transport Economics

Financing: The Research Council of Norway financed Statistics Norway's part of the project through the Methodology programme under the Economics and ecology programme

Documentation:

Nyborg, K. and I. Spangen (1996): *Politiske beslutninger om investeringer i veger* (Political decisions on investments in roads). Interviews with the Storting's Transport Committee. TØI (Institute of Transport Economics) notat 1026/1996.

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Ministry of Transport and Communications (1993): Norsk Veg og vegtrafikkplan 1994-97. St. meld. nr. 34 (1992-93) (Report no. 34 (1992-93) to the Storting: Norwegian Road and Road Traffic Plan 1994-97).

5. Aid-related projects

5.1 Agricultural productivity and economic growth: A study of Ghana

A successful agricultural policy is an important precondition for economic growth in developing countries. Higher yields, however, may result in soil degradation which in turn threatens agricultural production and economic growth in the long run. The economic importance of productivity losses in agriculture in Ghana is analyzed in this project.

Agriculture accounts for about 40 per cent of gross domestic product (GDP), 60 per cent of export earnings and 70 per cent of employment in Ghana. Developments in agriculture are therefore very important for further economic growth. A decade of economic reforms has lifted the average annual growth rate in Ghana to 5 per cent. This is encouraging for an African country south of Sahara, but the average poor person will still remain below the poverty line for many decades if this growth rate prevails. An acceleration of economic growth is therefore desirable.

Agriculture in Ghana is dominated by low input - low output technology, i.e. labour and land intensive. There is thus a risk of soil degradation when soil nutrients in crop removal are not replaced by chemical fertilizers. In the long term this will reduce productivity in the most important economic sector in Ghana. In this connection there are particularly two questions worth posing:

- What are the costs of soil degradation for Ghana?
- How, and at what costs, can productivity losses in agriculture be reduced?

In studies of this type it is important to include the links between agriculture and other economic sectors. This can be studied in an integrated macroeconomic model with a detailed dynamic modelling of the nutrients balance in agriculture. In the soil sub-model the supply of nutrients helps to determine the size of the crop on a given land area. The crop size will in turn influence the loss of soil from the land (erosion) as well as the quantity of nutrients that are extracted by crop removal. Land productivity will therefore vary over time and will depend on the use of fertilizer, crop type and crop size. The integration of the soil sub-model in a general economic core model influences the prices of agricultural products, and hence prices of other goods and services in the economy. A number of illustrative model simulations were carried out with the integrated macroeconomic model to shed light on the effects of various policy measures in the agricultural sector.

The importance of agricultural productivity losses can be illustrated by simulating a baseline scenario in which the soil model is included, and comparing this with a corresponding economic growth path where the productivity effects from the soil model are excluded.

With base year factor use kept constant, the soil model alone predicts annual soil productivity losses of between 2 and 3 per cent in Ghana. When the soil model is integrated in the economic core model, it is found that the average annual GDP growth rate is only reduced by about 0.6 percentage point, adding up to a total decline in (real) GDP of a little less than 5 per cent in the year 2000. One reason for the relatively small decline in the growth rate is that the direct reduction in soil productivity is offset by a greater use of factor inputs like fertilizer, labour and land. An increased use of land, however, may encounter barriers in the future, partly due to the efforts aimed at preserving the remaining rain forests in West Africa.

Furthermore, an analysis was made of the effect of a 50 per cent subsidy on the use of fertilizers in agriculture in order to compensate for the decline in soil productivity and also reduce the pressure on land. The use of fertilizer and pesticides is very low in Ghana. Estimates indicate that the cost share of fertilizer is less than 0.3 per cent. There may be several reasons why farmers do not use these products more intensively. Prices may be too high or there may be hidden costs associated with their use due to poorly functioning credit markets or poor roads. Farmers may also lack knowledge about the real productive effect of fertilizers and other chemicals.

There are several ways of financing a fertilizer subsidy. This can be done through reduced saving and thereby reduced investments, through transfers from abroad or through various taxes. In the following, a simulation is described in which the fertilizer subsidy is financed by imposing a tax on agricultural products. This proves to have a favourable impact on economic growth in Ghana.

A 50 per cent fertilizer subsidy increases the use of fertilizer in agriculture by about 70 per cent. Since the initial use was rather low, however, the magnitude of fertilizer use following the introduction of the subsidy remains low. Soil productivity is thus only about 2 per cent higher than the level without the subsidy in the year 2000. GDP growth, on the other hand, rises from a baseline level of 7 per cent a year (with the soil model) to 8.8 per cent a year in the scenario with the fertilizer subsidy and a tax on agricultural products. Higher productivity in agriculture thus proves to have considerable positive effects on the rest of the economy. Moreover, land use is 17 per cent lower than in the baseline scenario at the end of the simulation period. This helps to alleviate the pressure on, for example, exposed rain forests.

All in all, the analysis indicates that soil degradation and erosion represent relatively high costs for the Ghanaian economy. The results also suggest, however, that policy measures could be adopted to offset the effect of soil productivity losses, without these measures having ruinous effects on public finances and economic growth.

Project personnel: Knut H. Alfsen, Torstein Bye, Solveig Glomsrød and Henrik Wiig

Financing: The Environment Department of The World Bank

Documentation:
Alfsen, K.H., T. Bye, S. Glomsrød and H. Wiig (1995): Integration assessment of soil degradation and economic growth in Ghana. Documents 95/8, Statistics Norway.

5.2 Structural adjustments, soil degradation and economic growth in Tanzania

As part of an economic stabilization and structural adjustment policy, many developing countries have reduced government expenditure, including fertilizer subsidies. For African countries in particular, the question has been raised as to whether the elimination of fertilizer subsidies has a negative effect on economic growth and food security. Food production may fall due to increased soil degradation as the nutrient content declines. Erosion also increases when very little fertilizer is added to the soil on primary land.

In cooperation with the Agricultural College of Norway a model for soil productivity was integrated with an economic model for Tanzania to analyze relationships between soil productivity and changes in fertilizer subsidies or the introduction of other economic reforms.

Soil degradation depends on the type of crop and management method. For example, the nutrients balance in soil depends on the extent to which biological substances are removed from the soil during harvesting. Moreover, the size of the crop has an influence on soil erosion. A large crop from good-sized plants provides better protection against severe tropical rains and consequently helps to curb soil erosion.

Soil productivity increases through the direct use of fertilizer, but the crop per unit of land will in itself influence soil productivity in subsequent years due to less soil erosion and a greater quantity of nutrients from plant residues. This means that each factor input, whether it be labour or pesticides, which influences the size of the crop in one year indirectly also increases soil productivity the next few years (any negative effects of herbicides on the environment are disregarded here). There may be a self-reinforcing positive trend in an intensification of agriculture, such as in Tanzania and in many other countries in Africa where agriculture is almost exclusively based on the use of labour and land. Higher agricultural productivity is also of importance to the environment beyond the degradation of arable land. Higher productivity in agriculture can curb the pressure on forests which in turn helps to preserve the local climate (prevent drought), curb erosion and preserve biodiversity.

Activities in the agriculture sector are modelled in detail. A model for changes in soil productivity is linked to each sector (crop) (Aune and Lal 1995). The first results from an integrated modelling of land productivity and the economy as a whole indicate that the level of Tanzania's GDP around the year 2000 will be overestimated by nearly 1 per cent if account is not taken of soil degradation. This applies after farmers have compensated for lower soil productivity by using more labour and other factor inputs. With the removal of subsidies on fertilizers and pesticides, economic growth is further reduced. GDP is 2.7 per cent lower in the year 2000 than in the baseline scenario if subsidies are gradually reduced to 0 by 1995. The effect of reduced land productivity is also reflected in this growth decline.

For the maize sector, soil degradation entails an annual reduction in productivity of 1.8 per cent. Maize is a basic commodity, and the productivity loss here will be of considerable importance inasmuch as food will become scarcer and more expensive, and costs in domestic production will be kept at a high level, which in turn reduces the country's competitiveness. Most other types of crops generate an annual decline in land productivity of 0.2-0.3 per cent. This indicates that a change in the pattern of cultivation in itself may result in substantial economic gains.

Wage formation may determine the magnitude of the effects. A constant real wage will mean that GDP and private consumption may be considerably higher than the baseline scenario in the year 2000. An overall evaluation of the economic reforms which are included in the structural adjustment programme will be essentially different depending on how the labour market functions.

Project personnel: Solveig Glomsrød and Henrik Wiig

Financing: The Research Council of Norway through the programme Economy and ecology

Documentation:
Documentation is being prepared.

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Sources:

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Balsvik, R. and A. Brendemoen (1994): *A Computable General Equilibrium Model for Tanzania. Documentation of the Model, the 1990 - Social Accounting Matrix and Calibration*. Reports 94/20, Statistics Norway.

5.3 Structural adjustments and deforestation in Nicaragua

Following the years of civil war in the 1980s, the forests in Nicaragua again became available to people. Economic decline and high unemployment have been reflected in a wave of migration towards subsistence agriculture in the forest reserves. Poverty is thus threatening the rain forests in Nicaragua today. Economic policy can alter this trend in a more favourable direction.

The pressure on forests in Nicaragua primarily comes from smallholders who clear land and produce food without any other factor input except their own labour. Considerable distances from roads, and hence the market, preclude the extensive use of chemical fertilizers and pesticides. The vulnerable soil in forests is quickly being degraded and becoming unsuitable for cultivation after just a few years. Thus even a small population concentration in the colonized areas can exert considerable pressures on forests.

In a general equilibrium model for Nicaragua, the expanding self-sufficient agricultural sector in the rain forest areas is modelled as a separate sector which produces the basic food commodities maize, beans and rice. The technology in the sector, as well as the extent of migration to these areas in the base year, were obtained from studies by the research institute CIPRES and the Nicaraguan Ministry of Environment (GTZ/MARENA 1992). The production system is further described in Monge (1995).

In the model, the degree to which the urban sector will attract labour from rural areas depends on the level of wages and unemployment in the cities. Higher unemployment in urban areas makes (the secure) level of income in rural areas relatively more attractive, and the pressure on both arable land and forests will increase. The population that will remain in rural areas is distributed on traditional agricultural areas and colonized areas based on assessments of income levels in the two scenarios. The extent of annual deforestation is determined on the basis of migration to forests as well as the need for land clearing by those who already live there.

The authorities need to increase tax revenues to reduce the government deficit, or alternatively to raise expenditure on health and education. One way of increasing tax revenues is to broaden the tax base e.g. by collecting taxes from agriculture. This will have an effect on income levels in cities and in rural areas, and will influence migration flows and deforestation.

The stabilization policy includes measures aimed at reducing the balance-of-payments deficit. Moreover, development aid to Nicaragua is expected to be reduced in the years ahead. This may reduce investment and general economic growth, which in turn will have an impact on employment and the level of income. A conceivable outcome is that the foreign debt is reduced by draining natural resource capital in the form of tropical rain forests.

The effects of these potential economic reforms are calculated on the basis of different assumptions about changes in real wages. So far the urban labour market has been characterized by a strong trade union movement and little change in real wages in connection with economic reforms. An assumption of constant real wages has therefore been applied in one scenario. Since unemployment is high, however, it is conceivable that the economy may move towards a new equilibrium with a low trade union profile and flexible real wages. A study has therefore also been made of to what extent a shift in wage formation will influence the distribution of income, migration and deforestation.

The government can contribute to increasing saving, and hence total investment, either by reducing its consumption or by reducing the private economy through higher taxes. An increase in total domestic saving will stimulate investment particularly in manufacturing industry and services which are more capital intensive than agriculture, and thus result in the greatest economic growth in urban sectors. More people will be employed in the cities, and the pressure on land resources will decline. The extent of deforestation is reduced and GDP increases. Net real disposable income per worker for smallholders and urban workers remains approximately unchanged, while total profits fall. A larger share of society's total income thereby accrues to the labour force. In the urban sector, employment rises while it falls in rural areas.

Project personnel: Solveig Glomsrød and Haakon Vennemo

Financing: The Research Council of Norway

Documentation:
Documentation is being prepared

References:
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5.4 Environmental model for Indonesia

Statistics Norway and the Ministry of Environment in Indonesia have worked on a joint project to develop an economic model for Indonesia which includes environmental variables. The model was completed at the end of 1995 and is operative for the Ministry of Environment in Indonesia. The first version of the model contains the use of energy in physical units and emissions of the greenhouse gas CO_2. The model contains behavioural mechanisms which entail that it is possible to reduce the use of energy per unit produced by using environmental taxes.

The project was initiated in the wake of the report presented by the World Commission on Environment and Development (Brundtland Report). This report emphasized the need for analytical tools which included the interrelationships between traditional economic policy and its effects on the environment, and the effects of environmental policy on conditions which traditionally were considered to be within the sphere of economic policy. The Ministry of Environment in Norway, and later the Directorate for Natural Resource Management, administers this and other co-projects between Norwegian research institutions and institutions in Indonesia. The most important objective of this project is to transfer know-how on the construction and use of such models to the central administration in Indonesia. Even though the first version of the model has now been completed, more experience with the practical application of the model is required before this model can really be beneficial. A final decision on a continuation of the project has not yet been taken.

The model, called MEMLI, an acronym for (in Indonesian) *M*akro*E*konomik *M*odel *L*inkungan *I*ndonesia - a macroeconomic environmental model for Indonesia - is constructed around a set of data for 1985, calculated by the Central Bureau of Statistics in Indonesia. This set of data comprises an input-out matrix which describes deliveries of goods (including different types of energy) between the 29 production sectors in the model. Emphasis was placed on distinguishing between sectors according to the quantity of energy used. Moreover, the model includes a complete description of income flows between 5 institutional sectors in Indonesia (rural and urban households, general government, the corporate sector and the foreign sector). A number of behavioural equations for firms and households are included. The composition of household consumption of energy goods and the other goods specified in the model depends on the level of income and relative prices of these goods. The corporate sector's use of labour, electricity, oil and other intermediate inputs is determined by the relative prices of these factor inputs. The model also includes relationships between excise tax rates on some goods, e.g. on fossil fuels, and the market prices of these goods. The introduction of an environmental tax on fossil fuels changes not only the prices of energy, but also goods and services in which energy is directly or indirectly included in the production process. The model also computes the effects of a rise in tax rates on government tax revenues.

The behavioural equations in MEMLI are dynamic, i.e. it takes time before changes in prices fully feed through to demand in the same manner as in traditional macroeconomic models such as Statistics Norway's MODAG model for the Norwegian economy.

The model also contains long-term relationships similar to the type applied in general equilibrium models like Statistics Norway's MSG model. MEMLI thus contains elements from both these traditions.

MEMLI can be used to project energy use and emissions of CO_2 under given assumptions. Key assumptions which must be determined exogenously are population, exports and productivity. According to the model, demand for energy-intensive products increases at a higher rate than GDP in an economic growth process. This indicates a sharp rise in energy use and CO_2 emissions in the period ahead. Historically, however, there has been a trend towards higher energy efficiency, and a continuation of this trend would point to lower growth in emissions than in GDP.

MEMLI will also be very suitable for analyzing the environmental and economic effects of e.g. the introduction of a tax on fossil fuels. An analysis was recently completed of energy use, CO_2 emissions and economic growth for Indonesia in which the model was used as a tool. The analysis suggests e.g. that Indonesia's CO_2 emissions will rise sharply the next 25 years.

Table 5.4.1. Simulated effects of increasing the fuel tax by 20 per cent. Per cent difference from reference simulation

	Year after change			
Variablw	1	5	10	25
GDP	-0.8	-0.5	-0.4	-0.4
Consumer prices	1.5	1.9	2.1	2.2
Consumer price for fuel	16.5	16.6	17.0	1.4
Government saving[1]	0.9	0.9	0.8	0.8
Current account[1]	0.3	0.4	0.4	0.4
CO_2 emission	-5.3	-8.7	-10.6	-11.5

[1] Percentage points of GDP at current prices.

Table 5.4.1 illustrates some key features of the model. The results cannot be interpreted as a forecast of how the Indonesian economy will react to an environmental tax. This is partly because there are several important variables in the Indonesian economy which are not specified, and partly because there may be detailed sectoral conditions which a macroeconomic model can never capture.

The introduction of a CO_2 tax immediately results in an increase in fuel prices and consequently the average price level. With unchanged nominal wages, this undermines purchasing power and reduces domestic demand. GDP thus declines. In the short run it is difficult for firms and households to replace energy with other factor inputs. After a few years, however, the change in production technology and pattern of consumption in a less energy-intensive direction becomes more apparent. After one year emissions are reduced by 5 per cent, while the decline is more than 11 per cent in the long term when all adjustments to the new price level for energy have taken place. The negative effects on GDP are also smaller in the long run because by then firms have succeeded in reducing fuel use by restructuring production. Higher tax revenues result in higher government saving, whereas lower GDP results in lower imports and thereby a higher current-account surplus.

Project personnel: Einar Bowitz, Nils Ø. Mæhle, Rune Johansen

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Bowitz, E., N.Ø. Mæhle, V.S. Sasmitawidjaja and S.B. Widoyono (1995): MEMLI. An

Environmental Model for Indonesia. Technical Documentation of Data Programs and Procedures. Documents 95/7, Statistics Norway.

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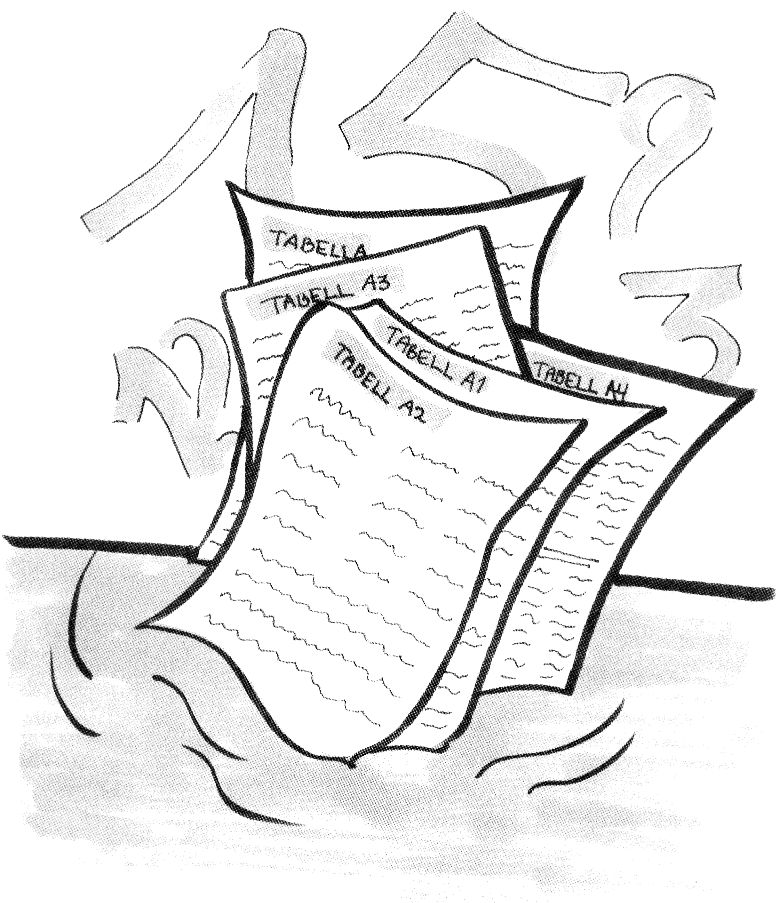
Part III. Appendix of tables



References in tables refer to the reference lists in the corresponding chapters in Part I.

Table A1. Reserve accounts for crude oil. Fields already developed or where development has been approved. 1988-1995. Million tonnes

	1988	1989	1990	1991	1992	1993	1994	1995
Reserves as of 1.1	855	1000	982	1111	1112	1222	1209	1216
New fields	143	-	103	93	94	4	28	109
Re-evaluation	58	56	108	2	123	97	109	190
Extraction	-56	-74	-82	-93	-107	-114	-129	-141
Reserves as of 31.12	1000	982	1111	1112	1222	1209	1216	1374
R/P ratio	18	13	14	12	11	11	9	10

Sources: Norwegian Petroleum Directorate and Statistics Norway

Table A2. Reserve accounts for natural gas. Fields already developed or where development has been approved. 1988-1995. Billion Sm^3

	1988	1989	1990	1991	1992	1993	1994	1995
Reserves as of 1.1	1247	1265	1261	1233	1274	1381	1356	1346
New fields	10	-	15	54	138	1	2	32
Re-evaluation	38	27	-15	14	-2	2	17	5
Extraction	-30	-31	-28	-27	-29	-28	-30	-31
Reserves as of 31.12	1265	1261	1233	1274	1381	1356	1346	1352
R/P ratio	42	41	44	47	48	49	45	44

Sources: Norwegian Petroleum Directorate and Statistics Norway

Table A3. Reserve accounts for coal. 1988-1995. Million tonnes

	1988	1989	1990	1991	1992	1993	1994	1995
Reserves as of 1.1	13.1	13.6	13.3	13.0	4.5	4.1	4.0	6.1
Re-evaluations	0.7	0.1	-	-8.2	-	0.2	2.4	0.3
Extraction	-0.3	-0.3	-0.3	-0.3	-0.4	-0.3	-0.3	-0.3
Reserves as of 31.12	13.6	13.3	13.0	4.5	4.1	4.0	6.1	6.1
R/P ratio	68	33	43	15	11	15	20	20

Source: Store Norske Spitsbergen Kulkompani

Table A4. Extraction, conversion and use[1] of energy commodities. 1994*. PJ. Percentage change

	Coal and coke	Wood, wood waste, black liquor, waste	Crude oil	Natural gas	Petroleum products[2]	Electricity	District heating	Total	Average annual change, per cent 1976-1994	1993-1994
Extraction of energy commodities	8	-	5338	1255	194[3]	406	-	7202		
Energy use in extraction sectors	-	-	-	-137[4]	-13	-10	-	-160		
Imports and Norwegian purchases abroad	50	0	45	-	264	17	-	377		
Exports and foreign purchases in Norway	-9	0	-4787	-1133	-556	-18	-	-6504		
Stocks (+decrease,–decrease)	0	.	-11	.	-8	.	.	-19		
Primary supplies	48	0	585	-15	-118	396	-	896		
Oil refineries	7	-	-603	-	566	-2	-	-31		
Other energy sectors or supplies	-1	41	-	-	17	1	6	64		
Registered losses, statistical errors	-1	-	18	15	-39	-30	-2	-38		
Registered use outside energy sectors	54	41	-	0	427	365	4	891	0.4	1.9
Domestic use	54	41	-	0	300	365	4	764	1.3	2.3
Agriculture and fisheries	0	-	-	-	26	6	0	32	0.4	6.7
Power-intensive industries	41	-	-	0	56	102	0	200	1.2	2.6
Other manufacturing and mining	13	19	-	-	32	59	0	123	0	5.1
Other industry	-	-	-	-	115	78	2	195	1.9	2.1
Private households	0	22	-	-	72	119	1	215	1.9	0.5
International maritime transport	-	-	-	-	127	-	-	127	-2.9	0.8

[1] Includes energy commodities used as raw materials.
[2] Includes liquefied petroleum gas, refinery gas, fuel gas and methane. Petrol coke is included in coke.
[3] Natural gas liquids and condensate from Kårstø.
[4] Includes the gas terminal.
Source: Statistics Norway

Table A5. Use of energy commodities outside the energy sectors and international maritime transport. 1976-1995*. PJ. Percentage change

Energy commodity	1976	1980	1985	1989	1990	1991	1992	1993	1994*	1995*	Average annual change, per cent 1976-1994	1994-1995
Total	607	679	737	727	736	725	721	747	764	779	1.3	1.9
Electricity	241	269	329	340	349	356	358	363	365	376	2.3	3.1
Firm power	232	265	312	320	324	330	330	335	348	355	2.3	1.9
Occasional power	9	4	17	20	24	27	28	28	16	21	3.4	27.4
Oil, total	300	294	263	255	245	236	233	239	248	248	-1.0	-0.2
Oil other than for transport	159	138	80	65	58	51	45	46	55	51	-5.7	-7.7
Petrol	9	3	0	0	0	0	0	0	0	0	.	-
Kerosene	17	16	9	8	7	7	7	7	7	7	-4.7	-1.3
Middle distillates	66	63	43	38	36	31	28	28	31	31	-4.1	-0.9
Heavy fuel oil	66	56	28	18	15	13	10	11	17	13	-7.3	-23.0
Oil for transport	141	156	183	190	187	186	187	194	192	196	1.8	2.0
Petrol, aviation fuel, jet fuel	74	81	92	103	100	97	96	97	98	97	1.6	-1.1
Middle distillates	64	70	83	82	84	87	90	96	94	99	2.2	5.0
Heavy fuel oil	3	5	7	5	4	2	1	1	0	1	-11.4	26.9
Gas[1]	1	41	52	43	52	47	47	54	52	52	21.9	-0.4
District heating	-	-	2	3	3	4	4	4	4	4	.	-
Solid fuel	65	74	91	87	88	81	80	88	95	99	2.1	4.4
Coal, coke	47	48	57	51	50	45	45	48	54	58	0.8	7.1
Wood, wood waste, black liquor, waste	18	26	34	36	38	36	34	39	41	41	4.6	0.7

[1] Includes liquefied natural gas, and from 1990 also fuel gas and landfill gas.
Source: Statistics Norway

Table A6. Net use[1] of energy in the energy sectors. 1976-1995*. PJ

	1976	1980	1983	1985	1987	1989	1990	1991	1992	1993	1994*	1995*
Total	34	65	66	75	82	96	122	154	164	172	189	189
Of this:												
Electricity	4	6	6	8	7	7	7	8	8	8	12	14
Natural gas	12	30	43	45	55	68	79	113	118	125	137	140

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

Table A7. Electricity balance[1]. 1975-1995*. TWh. Percentage change

	1975	1980	1985	1990	1993	1994*	1995*	Average annual change, per cent 1975-1985	1985-1995
Production	77.5	84.1	103.3	121.8	120.1	113.5	123.2	2.9	1.8
+ Imports	0.1	2.0	4.1	0.3	0.6	4.8	2.2	47.6	-6.0
– Exports	5.7	2.5	4.6	16.2	8.5	5.0	8.6	-2.1	6.3
= Gross domestic consumption	71.9	83.6	102.7	105.9	112.2	113.4	116.8	3.6	1.3
– Consumption in pumped storage power stations	0.1	0.5	0.8	0.3	0.6	1.5	1.7	20.8	7.8
– Consumption in power stations, losses and statistical differences	7.1	8.0	10.0	7.9	9.7	8.6	9.1	3.6	-0.9
= Net domestic consumption	64.7	75.1	91.9	97.7	101.9	103.2	106.0	3.6	1.4
– Occasional power	3.2	1.2	4.8	6.7	7.9	5.3	5.8	4.0	1.9
= Net firm power consumption	61.4	73.9	87.1	91.0	94.1	97.9	100.2	3.6	1.4
– Power-intensive industries	26.2	27.9	30.0	29.6	27.4	28.2	28.1	1.4	-0.6
= Regular power consumption	35.2	46.0	57.1	61.5	66.6	69.7	72.1	4.9	2.4
Regular power consumption, corrected for temperature	36.3	45.1	54.6	65.4	66.9	70.1	72.5	4.2	2.9

[1] Statistics Norway's electricity statistics have been used up to and including 1993. For 1994 and 1995, figures from the Norwegian Water Resources and Energy Administration have been used, but we have adjusted the import and export figures for 1995 in accordance with Statistics Norway's figures for external trade. Temperature correction according to figures from the Norwegian Water Resources and Energy Administration from 1993 onwards.
Sources: Statistics Norway and Norwegian Water Resources and Energy Administration

Table A8. Average prices[1] for electricity[2] and some selected oil products. Energy supplied. 1985-1995*

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*	1995*
Heating products:					Price in øre[3]/kWh						
Electricity	32.7	35.6	37.9	41.7	43.5	45.7	46.5	46.6	48.7	47.5	49.7
Heating kerosene	32.8	24.8	25.0	25.7	28.3	33.9	40.1	37.4	37.8	37.6	38.2
Fuel oil no. 1	27.2	19.4	19.6	19.7	21.6	26.6	31.9	28.3	28.0	28.2	29.6
Fuel oil no. 2	25.7	18.1	18.3	18.8	20.7	25.7	30.8	27.2	26.9	27.1	28.1
Heavy fuel oil	18.4	10.9	13.1	12.3	15.2	19.4	23.2	23.0	22.4	22.5	22.8
Transport products:					Price in øre[3]/litre						
Petrol											
leaded, high octane	512.8	476.0	510.0	536.0	578.5	642.8	741.0	795.0	836.2	851.0	893.0
unleaded, 98 octane	-	-	-	-	-	622.1	705.0	747.0	787.1	791.0	838.0
unleaded, 95 octane	-	457.0	489.0	503.0	540.5	594.4	677.0	717.0	757.4	761.0	807.0
Auto diesel	282.0	207.6	210.0	214.0	233.0	285.9	341.0	326.0	402.5	649.0	701.0

[1]Including all taxes. [2]Households and agriculture. [3]100 øre = 1 NOK.
Sources: Statistics Norway, Norwegian Water Resources and Energy Administration, Norwegian Petroleum Institute

Table A9. Consumption of energy commodities for combustion. Oslo, 1992 and 1993. MWh theoretical energy content

	1992		1993	
	Fossil energy	Bioenergy	Fossil energy	Bioenergy
Total	3 782 618	142 291	3 811 691	184 765
Stationary combustion	1 343 153	142 291	1 311 825	184 765
Manufacturing and energy sectors	188 781	14 604	283 250	16 368
Public services	194 349	-	111 753	-
Private services	343 347	36	419 884	36
Primary industries	3 917	-	4 372	-
Private households	606 336	69 838	483 488	86 660
Waste and landfill gas	6 424	57 813	9 078	81 701
Mobile combustion	2 439 465	-	2 499 866	-
Road traffic	2 327 720	-	2 397 543	-
-Private households	714 082	-	761 686	-
-Public transport	163 885	-	170 477	-
-Other transport	1 449 753	-	1 465 381	-
Motorized equipment and tractors	92 538	-	82 856	-
-Private households	3 777	-	3 777	-
-Other sectors	88 761	-	79 078	-
Railways	10 765	-	11 283	-
Shipping in port	8 442	-	8 184	-
Ships in international trade, in port[1]	14 1362	-	124 123	-

[1] Ships in international trade are not included in the total.
Source: Statistics Norway

Table A10. Total primary energy supply. Whole world and selected countries, 1970-1993. Million toe

	1970 Mtoe	1980 Mtoe	1990 Mtoe	1991 Mtoe	1992 Mtoe	1993 Mtoe	Per unit GDP (1993) (toe/1000 USD)	Per capita (1993) (toe/capita)
Whole world	4860.9	6584.1	7928.4	8002.7	7996.5	8075.1	..	..
OECD	3062.4	3808.2	4212.5	4298.4	4317.4	4389.6	0.25	4.56
Norway	13.9	18.9	21.5	22.1	21.9	22.3	0.19	5.16
Denmark	20.2	19.5	18.3	20.2	19.4	19.8	0.15	3.81
Finland	18.1	25.0	28.5	28.9	27.6	28.9	0.24	5.71
Sweden	38.0	41.0	47.8	49.3	47.0	47.1	0.22	5.41
France	147.3	190.7	221.2	232.5	228.8	233.8	0.19	4.05
United Kingdom	207.7	201.2	212.2	217.8	214.4	217.0	0.22	3.75
Germany	304.6	359.2	355.1	347.3	340.7	337.2	0.20	4.15
Turkey	12.2	31.3	53.2	54.2	55.5	59.2	0.34	0.99
Canada	139.6	193.2	210.2	209.7	214.0	220.7	0.38	7.68
USA	1545.9	1801.0	1920.6	1959.4	1973.6	2028.6	0.35	7.88
Japan	257.8	347.1	432.6	443.0	453.1	457.4	0.15	3.67
Ethiopia	0.6	0.6	1.1	1.1	1.1	1.1	0.19	0.02
Guatemala	0.8	1.4	1.4	1.5	1.6	1.9	0.21	0.18
India	63.0	93.9	184.0	193.4	205.0	211.9	0.66	0.24
Bangladesh	1.3	2.8	6.4	6.0	6.5	7.2	0.29	0.06

Sources: OECD/IEA (1995a and b)

Table B1. Emissions of greenhouse gases to air. 1973-1995*

	CO_2	CH_4	N_2O	HFC 125	HFC 134	HFC 152	CF_4 and C_2F_6	SF_6	CO_2-equivalents
	Mtonnes	ktonnes	ktonnes	tonnes	tonnes	tonnes	tonnes	tonnes	Mtonnes
GWP	1	21	310	2800	1300	140	6500[1]	23900	..
1973	30	216[2]	12[2]	..	..	..	..	..	..
1974	27	..	..	..	..	..	..	..	..
1975	30	..	..	..	..	..	..	..	..
1976	32	..	..	..	..	..	..	..	..
1977	33	..	..	..	..	..	..	..	..
1978	32	..	..	..	..	..	..	..	..
1979	34	..	..	..	..	..	..	..	..
1980	34	264	14	..	..	..	..	..	..
1981	31	..	..	..	..	..	..	..	..
1982	30	..	..	..	..	..	..	..	..
1983	31	..	..	..	..	..	..	..	..
1984	33	..	..	..	..	..	..	..	..
1985	32	275	14	0	0	0	428	199	49
1986	34	278	15	0	0	0	418	240	53
1987	35	281	15	0	0	0	405	240	54
1988	35	281	15	0	0	0	388	223	53
1989	35	287	15	0	0	3	376	107	51
1990	36	290	15	0	0	3	385	92	51
1991	34	289	15	0	1	3	327	86	49
1992	34	293	13	0	2	3	253	29	47
1993	36	293	14	0	31	1	266	31	49
1994*	38	297	14	11	40	1	241	36	51
1995*	38	..	..	..	..	..	..	..	..

[1] GWP value of CF_4 is used to estimate total CO_2 equivalents of CF_4 and C_2F_6.
[2] 1970 figure.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B2. Emissions to air, 1973-1995*. 1 000 tonnes unless otherwise specified

	SO_2	NO_x	NH_3	Acid equi-valents[1]	Heavy metals Pb	Cd	NMVOCs	Particu-lates[2]
					Tonnes	kg		
1973	155	178	..	..	886	..	185	28
1974	149	173	..	..	831	..	176	26
1975	137	179	..	..	924	..	198	25
1976	146	178	..	..	760	..	202	26
1977	145	192	..	..	762	..	208	27
1978	142	185	..	..	784	..	168	25
1979	144	195	..	..	827	..	185	27
1980	141	185	..	..	776	..	174	25
1981	127	177	..	..	574	..	187	22
1982	110	183	..	..	648	..	197	20
1983	103	188	..	..	557	..	211	20
1984	95	204	..	..	401	..	224	21
1985	97	215	..	..	416	1143	234	21
1986	91	230	..	..	351	..	251	23
1987	74	237	..	..	301	..	253	23
1988	67	229	21	8.3	302	..	249	21
1989	59	231	22	8.2	277	1212	269	22
1990	53	229	22	7.9	230	1193	267	22
1991	45	219	23	7.5	182	1226	266	21
1992	37	218	24	7.3	148	1121	279	21
1993	35	226	23	7.4	105	1168	287	24
1994*	34	222	23	7.3	28	669	300	23
1995*	35	223	24	7.4	14	..	304	23

[1] Total emissions of SO_2, NO_x and NH_3 weighted as acid equivalents.
[2] Emissions not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B3. Emissions of greenhouse gases to air by sector, 1993. Tonnes unless otherwise specified

	CO_2	CH_4	N_2O	HFC 125[3]	HFC 134[3,4]	HFC 152[3,4]	CF_4	C_2F_6	SF_6	CO_2 equi-valents
	Mtonnes	ktonnes	ktonnes							Mtonnes
Total	35.7	292.6	13.5	-	31.20	1.00	254.3	11.2	30.1	48.5
Energy sectors	10.7	17.7	0.3	-	-	-	-	-	2.4	11.2
Extraction of oil and gas[1]	8.5	12.6	0.1	-	-	-	-	-	-	8.8
Extraction of coal	0.0	4.8	0.0	-	-	-	-	-	-	0.1
Oil refining	2.0	0.2	0.1	-	-	-	-	-	-	2.1
Electricity supplies[2]	0.2	0.1	0.0	-	-	-	-	-	2.4	0.3
Manufacturing and mining	9.6	1.4	5.8	-	0.31	0.01	254.3	11.2	27.8	13.9
Oil drilling	0.3	0.1	0.0	-	-	-	-	-	-	0.3
Manufacture of pulp and paper	0.3	0.2	0.3	-	-	-	-	-	-	0.4
Manufacture of chemical raw materials	2.4	0.9	5.1	-	-	-	-	-	-	4.0
Manufacture of minerals	1.7	0.0	0.1	-	-	-	-	-	-	1.7
Manufacture of iron, steel and ferro-alloys	2.1	0.0	0.0	-	-	-	-	-	-	2.1
Manufacture of other metals	1.8	0.0	0.0	-	-	-	254.3	11.2	27.6	4.2
Manufacture of metal goods, boats, ships and platforms	0.3	0.0	0.0	-	-	-	-	-	0.2	0.3
Manufacture of wood, plastic, rubber, and chemical goods, printing	0.2	0.1	0.1	-	0.31	0.01	-	-	-	0.2
Manufacture of consumer goods	0.5	0.0	0.1	-	-	-	-	-	-	0.6
Other	15.3	273.5	7.5	-	30.89	0.99	-	-	-	23.4
Construction	0.5	0.0	0.0	-	-	-	-	-	-	0.5
Agriculture and forestry	0.7	93.7	6.1	-	-	-	-	-	-	4.6
Fishing, whaling and sealing	1.3	0.4	0.1	-	-	-	-	-	-	1.3
Land transport, domestic	2.8	0.1	0.3	-	-	-	-	-	-	2.9
Sea transport, domestic	1.2	0.3	0.1	-	-	-	-	-	-	1.2
Air transport, domestic	1.1	0.0	0.1	-	-	-	-	-	-	1.1
Other private services	1.9	0.3	0.2	-	30.89	0.99	-	-	-	2.0
Public sector, municipal[5]	0.3	165.4	0.0	-	-	-	-	-	-	3.8
Public sector, state	0.4	0.1	0.0	-	-	-	-	-	-	0.4
Private households	5.2	13.2	0.6	-	-	-	-	-	-	5.7

[1] Includes gas terminal, transport and supply ships.
[2] Includes emissions from waste incineration plants.
[3] Imports only, not emissions. Includes raw material imports only, not imports in products.
[4] Distribution by source uncertain, will be improved.
[5] Includes water supplies.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B4. Emissions to air by sector, 1993. 1 000 tonnes unless otherwise specified

	SO_2	NO_x	NH_3	Acid equi-valents	Heavy metals Pb	Heavy metals Cd	Particu-lates[3]	NM-VOCs	CO
					Tonnes	kg			
Total	35.2	225.6	23.0	7.4	105.2	1167.1	23.5	287.1	831.6
Energy sectors	3.7	43.9	0.0	1.1	1.5	37.4	0.6	128.9	8.5
Extraction of oil and gas[1]	0.8	39.5	-	0.9	0.0	6.2	0.3	119.4	6.6
Extraction of coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil refining	2.2	3.1	0.0	0.1	0.0	0.1	0.1	9.0	0.0
Electricity supplies[2]	0.7	1.3	0.0	0.1	1.5	31.0	0.2	0.5	1.9
Manufacturing and mining	23.5	25.1	0.3	1.3	0.7	932.6	1.8	21.5	55.2
Oil drilling	0.1	4.8	-	0.1	0.0	2.0	0.1	0.4	0.4
Manufacture of pulp and paper	1.6	1.2	0.0	0.1	0.1	18.1	0.4	0.6	1.9
Manufacture of chemical raw materials	7.8	4.3	0.3	0.4	0.0	4.1	0.0	2.6	35.3
Manufacture of minerals	2.2	5.8	0.0	0.2	0.1	57.8	0.2	1.5	0.5
Manufacture of iron, steel and ferro-alloys	7.5	4.2	0.0	0.3	0.0	12.3	0.0	1.4	0.0
Manufacture of other metals	2.8	1.2	0.0	0.1	0.0	801.9	0.1	0.0	9.1
Manufacture of metal goods, boats, ships and platforms	0.2	0.9	0.0	0.0	0.2	1.9	0.1	3.7	1.1
Manufacture of wood, plastic, rubber, and chemical goods, printing	0.3	0.8	0.0	0.0	0.1	30.0	0.7	9.7	5.1
Manufacture of consumer goods	1.0	1.9	0.0	0.1	0.2	4.6	0.2	1.6	1.8
Other	8.0	156.6	22.7	5.0	103.0	197.1	21.1	136.6	767.8
Construction	0.3	5.2	0.0	0.1	0.7	2.7	0.5	11.8	6.0
Agriculture and forestry	0.4	7.4	22.2	1.5	0.8	3.8	1.0	4.5	8.7
Fishing, whaling and sealing	0.9	27.4	0.0	0.6	0.3	11.7	0.5	1.0	2.7
Land transport, domestic	1.9	30.0	0.0	0.7	1.4	16.9	3.1	5.9	23.1
Sea transport, domestic	1.3	25.5	-	0.6	0.1	11.1	0.4	1.5	1.8
Air transport, domestic	0.1	3.1	-	0.1	1.7	-	0.1	1.8	2.6
Other private services	0.8	14.3	0.1	0.3	18.2	5.8	0.5	24.4	108.8
Public sector, municipal[4]	0.2	0.5	0.0	0.0	0.1	7.7	0.1	0.5	0.6
Public sector, state	0.2	4.3	0.0	0.1	0.2	2.0	0.1	1.3	1.6
Private households	1.9	39.0	0.4	0.9	79.6	135.4	14.8	83.9	611.8

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

Table B5. Emissions to air by source[1]. 1993. 1 000 tonnes unless otherwise specified

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOCs	CO	Pb	Particulates[2]
	Mtonnes								Tonnes	
Total	35.7	292.6	13.6	35.3	225.9	23.0	287.1	831.7	105	23.5
Stationary combustion	14.5	15.1	1.4	7.3	39.9	-	12.4	147.1	2	15.7
Oil extraction	7.1	2.5	0.1	0.2	24.9	-	1.0	5.3	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	-	4.3	-	0.1	0.6	-	-
Gas terminal and oil refineries	2.4	0.3	0.1	0.1	3.5	-	0.9	0.3	0	0.1
Other industry	2.9	0.4	0.7	5.0	8.2	-	0.8	7.0	0	1.5
Dwellings, offices, etc.	1.8	11.8	0.5	1.7	2.4	-	9.4	134.2	0	13.9
Waste incineration	0.1	0.1	0.0	0.3	0.9	-	0.3	0.3	1	0.0
Process emissions	7.0	274.6	11.1	20.7	7.6	22.5	180.2	44.2	-	..
Oil and gas sector	0.4	9.9	-	2.1	-	-	126.0	-	-	..
--Venting, leaks, etc.	0.0	5.4	-	-	-	-	3.1	-	-	..
--Oil loading	0.4	4.0	-	-	-	-	114.0	-	-	..
--Gas terminal and oil refineries	0.0	0.5	-	2.1	-	-	8.9	-	-	..
Petrol distribution	0.0	-	-	-	-	-	8.8	-	-	..
Manufacture of pulp and paper	-	-	-	0.6	-	-	-	-	..	
Manufacture of chemicals	1.1	0.9	5.0	4.9	1.2	0.3	1.0	35.2	-	..
Manufacture of cement and other minerals	0.8	-	-	0.7	-	-	-	-	..	
Manufacture of metals	4.2	-	-	12.2	6.4	-	1.4	9.0	-	..
--Ferro alloys	2.0	-	-	9.6	5.5	-	1.2	-	-	..
--Aluminium	1.4	-	-	1.8	0.6	-	-	-	-	..
--Other metals	0.7	-	-	0.7	0.3	-	0.2	9.0	-	..
Agriculture	0.2	93.6	6.0	-	-	22.2	-	-	-	..
Landfills	0.1	165.2	-	-	-	-	-	-	..	
Solvents	0.1	-	-	-	-	-	42.1	-	-	..
Other process emissions	0.0	5.0	-	0.2	-	-	0.9	-	-	..
Mobile combustion	14.3	2.9	1.1	7.3	178.4	0.5	94.6	640.4	104	7.8
Motor vehicles	8.5	1.6	0.7	3.3	82.3	0.5	75.1	597.3	98	4.6
-Petrol engines	5.1	1.5	0.3	1.0	47.1	0.5	69.9	577.8	98	0.7
--Light vehicles	5.1	1.5	0.3	1.0	46.5	0.5	69.2	570.5	97	0.7
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.7	7.3	1	0.0
-Diesel engines	3.4	0.1	0.4	2.3	35.2	0.0	5.2	19.4	0	4.0
--Light vehicles	0.8	0.0	0.0	0.5	2.8	0.0	0.9	3.2	0	1.3
--Heavy vehicles	2.6	0.1	0.4	1.8	32.4	0.0	4.3	16.2	0	2.6
Motorcycles, mopeds, snow scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.8	1	0.0
Motorized equipment	0.7	0.1	0.0	0.5	10.7	0.0	1.7	5.6	0	1.3
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
Shipping	3.5	1.0	0.2	3.1	75.5	-	11.5	19.9	2	1.5
--Coastal traffic, small boats, etc.	2.3	0.7	0.1	2.2	48.3	-	10.5	17.4	2	1.1
--Fishing vessels	1.2	0.4	0.1	0.9	27.3	-	1.0	2.5	0	0.5
--Mobile oil rigs, etc.	0.2	0.0	0.0	0.1	4.6	-	0.3	0.3	0	0.1

[1]Does not include international maritime and air transport. [2]Emissions not calculated for processes.

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B6. Emissions to air by source[1]. 1994*. 1 000 tonnes unless otherwise specified

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOCs	CO	Pb	Particulates[2]
	Mtonnes								Tonnes	
Total	37.6	296.8	14.1	34.0	222.1	23.4	300.5	815.0	28.4	23.4
Stationary combustion	15.9	15.3	1.6	7.5	43.6	-	12.6	148.0	1.8	16.0
Oil extraction	7.5	2.6	0.1	0.2	27.4	-	1.2	5.6	0.0	0.1
--Natural gas	6.2	2.4	0.1	-	16.5	-	0.6	4.5	-	-
--Diesel combustion	0.4	0.1	0.0	0.2	6.3	-	0.4	0.5	0.0	0.1
--Flaring	1.0	0.1	0.0	-	4.5	-	0.1	0.6	-	-
Gas terminal and oil refineries	2.6	0.4	0.1	0.1	3.4	-	0.9	0.5	0.0	0.1
Other industry	3.7	0.4	0.9	5.4	9.4	-	0.9	7.4	0.4	1.8
Dwellings, offices, etc.	2.0	11.8	0.5	1.5	2.5	-	9.4	134.3	0.1	13.9
Waste incineration	0.1	0.1	0.0	0.4	0.9	-	0.3	0.3	1.3	0.0
Process emissions	7.5	278.7	11.4	21.4	8.3	22.7	196.8	48.4	-	..
Oil and gas sector	0.5	10.6	-	1.7	-	-	143.0	-	-	..
--Venting, leaks, etc.	0.0	5.4	-	-	-	-	3.1	-	-	..
--Oil loading	0.4	4.6	-	-	-	-	130.1	-	-	..
--Gas terminal and oil refineries	0.0	0.6	-	1.7	-	-	9.7	-	-	..
Petrol distribution	0.0	-	-	-	-	-	8.5	-	-	..
Manufacture of pulp and paper	-	-	-	1.1	-	-	-	-	-	..
Manufacture of chemicals	1.0	1.0	5.4	5.3	1.2	0.3	0.7	39.4	-	..
Manufacture of cement and other minerals	0.9	-	-	0.8	-	-	-	-	-	..
Manufacture of metals	4.7	-	-	12.4	7.1	-	1.6	9.0	-	..
--Ferro alloys	2.4	-	-	10.0	6.3	-	1.4	-	-	..
--Aluminium	1.5	-	-	1.6	0.6	-	-	-	-	..
--Other metals	0.8	-	-	0.8	0.2	-	0.3	9.0	-	..
Agriculture	0.2	95.1	6.0	-	-	22.4	-	-	-	..
Landfills	0.1	166.4	-	-	-	-	-	-	-	..
Solvents	0.1	-	-	-	-	-	42.1	-	-	..
Other process emissions	0.0	5.6	-	0.2	-	-	0.9	-	-	..
Mobile combustions	14.3	2.8	1.1	5.1	170.2	0.7	91.1	618.6	26.6	7.4
Motor vehicles	8.4	1.6	0.7	2.4	76.6	0.7	71.8	575.1	23.9	4.3
-Petrol engines	5.1	1.5	0.3	1.0	44.6	0.6	67.1	557.9	23.8	0.6
--Light vehicles	5.1	1.5	0.3	1.0	44.1	0.6	66.5	551.0	23.6	0.6
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.9	0.2	0.0
-Diesel engines	3.2	0.1	0.4	1.4	31.9	0.0	4.7	17.2	0.1	3.6
--Light vehicles	0.9	0.0	0.0	0.4	3.2	0.0	1.0	3.5	0.0	1.4
--Heavy vehicles	2.4	0.0	0.3	1.1	28.7	0.0	3.7	13.6	0.1	2.3
Motorcycles, mopeds, snow scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.2	14.0	0.3	0.0
Motorized equipment	0.7	0.1	0.0	0.3	10.5	0.0	1.6	5.4	0.1	1.3
Railways	0.1	0.0	0.0	0.0	1.6	-	0.1	0.4	0.0	0.1
Air traffic	1.5	0.0	0.1	0.2	4.3	-	0.7	3.6	1.7	0.2
Shipping	3.6	1.0	0.2	2.2	77.3	-	11.7	20.0	0.6	1.6
--Coastal traffic, small boats, etc.	2.1	0.6	0.1	1.4	44.5	-	10.4	17.2	0.5	1.0
--Fishing vessels	1.3	0.4	0.1	0.7	28.7	-	1.1	2.6	0.1	0.5
--Mobile oil rigs, etc.	0.2	0.0	0.0	0.1	4.1	-	0.3	0.3	0.0	0.1

[1]Does not include international maritime and air transport. [2]Emissions not calculated for processes.

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B7. Emissions to air[1] by county, 1993. 1 000 tonnes unless otherwise specified

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb	Particu-lates[2]	Cd
	Mtonnes								Tonnes		kg
Total	37.5	293.0	13.7	44.8	253.6	23.0	288.3	834.6	105.5	24.0	1182
Of this, international maritime and air transport	1.3	0.3	0.1	9.6	26.5	-	1.1	2.6	0.2	0.5	14
Østfold	1.2	12.3	0.5	4.8	7.0	1.4	9.3	44.6	6.5	1.1	19
Akershus	1.5	17.7	0.4	0.8	11.4	1.3	16.6	84.3	12.3	1.5	14
Oslo	1.1	2.7	0.1	1.0	7.9	0.1	12.2	51.6	8.8	0.7	16
Hedmark	0.8	14.9	0.6	0.5	7.2	1.8	8.2	49.2	6.0	1.8	23
Oppland	0.7	20.7	0.6	0.4	6.2	1.7	7.5	41.7	5.5	1.3	16
Buskerud	1.0	12.9	0.4	1.0	7.3	0.8	9.4	49.7	7.0	1.2	20
Vestfold	1.1	9.5	0.3	1.2	6.1	0.8	10.4	39.0	5.6	0.9	20
Telemark	3.2	9.2	3.5	1.2	8.8	0.7	7.3	41.2	4.3	0.9	43
Aust-Agder	0.5	7.2	0.1	2.7	2.3	0.3	4.1	52.4	2.4	1.1	11
Vest-Agder	0.9	11.0	0.2	1.7	3.7	0.5	5.7	26.8	3.2	0.9	18
Rogaland	2.4	37.6	1.1	1.7	9.3	3.3	15.0	60.7	8.4	1.5	38
Hordaland	3.1	29.5	0.5	3.5	10.5	1.2	50.3	70.6	7.8	2.8	737
Sogn og Fjordane	1.1	11.8	0.4	1.6	3.6	1.1	4.2	22.7	2.3	1.0	43
Møre og Romsdal	0.9	15.5	0.5	0.8	5.3	1.1	8.3	37.9	5.0	1.2	26
Sør-Trøndelag	1.1	14.5	0.5	3.4	6.3	1.5	7.8	43.1	4.9	1.1	14
Nord-Trøndelag	0.5	12.7	0.6	0.6	4.2	1.6	5.2	29.2	3.5	1.1	11
Nordland	1.9	19.9	2.2	3.7	8.6	1.4	7.8	37.8	5.0	1.1	49
Troms	0.6	9.1	0.2	1.2	4.0	0.8	4.7	23.1	3.3	0.5	7
Finnmark	0.3	6.5	0.2	0.6	2.1	1.7	3.1	13.3	1.8	0.3	5
Svalbard	0.1	4.8	0.0	0.4	0.3	0.0	0.2	0.7	0.1	0.1	8
Continental shelf	12.1	13.0	0.4	11.9	127.4	0.0	90.6	13.1	0.5	1.8	47

[1] Does not include emissions in air space above 1 000 m.
[2] Emissions not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B8. Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Total	36085	47339	248706	280347	37490	44945	253612	288252
Of this international maritime and air transport	1877	10659	31149	1263	1802	9666	27891	1168
Østfold	1091	3602	6802	9307	1219	4794	7030	9333
Halden	71	74	592	945	93	60	602	996
Moss	163	699	713	936	162	545	738	904
Sarpsborg	313	1761	1606	1687	399	3156	1776	1666
Fredrikstad	248	929	1471	2352	256	896	1451	2372
Hvaler	11	4	65	389	11	4	67	380
Aremark	6	3	57	58	6	3	58	58
Marker	16	8	153	165	18	8	157	157
Rømskog	2	1	16	16	2	1	16	16
Trøgstad	18	9	154	177	19	9	155	176
Spydeberg	16	7	142	183	17	7	143	180
Askim	36	15	222	375	39	14	229	410
Eidsberg	38	18	336	411	41	18	344	412
Skiptvet	8	4	73	92	9	4	75	86
Rakkestad	29	15	235	281	30	14	237	286
Råde	35	16	321	393	37	16	327	390
Rygge	48	24	345	533	49	24	349	528
Våler	15	7	138	151	16	7	141	156
Hobøl	17	8	161	164	18	8	166	160
Akershus	1414	822	11129	16630	1495	796	11386	16553
Vestby	42	19	383	608	45	19	397	604
Ski	62	30	512	818	63	28	524	727
Ås	60	27	547	666	63	27	564	644
Frogn	31	14	233	568	32	14	242	592
Nesodden	24	10	148	727	25	11	155	737
Oppegård	41	20	333	544	44	20	343	537
Bærum	345	132	2351	3500	362	130	2370	3477
Asker	137	73	1115	1814	143	70	1149	1821
Aurskog-Høland	40	19	348	471	42	19	353	466
Sørum	49	22	430	543	49	21	443	503
Fet	26	12	220	279	27	12	225	280
Rælingen	35	142	256	224	50	131	303	221
Enebakk	15	7	131	176	16	7	135	173
Lørenskog	47	24	343	658	50	24	350	688
Skedsmo	131	104	996	1532	140	108	1022	1575
Nittedal	42	20	354	451	45	20	371	518
Gjerdrum	9	4	74	98	10	4	78	105
Ullensaker	115	45	894	1107	120	55	913	1113
Nes	51	24	433	528	52	23	435	526
Eidsvoll	81	59	757	985	84	42	736	912

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Nannestad	21	11	175	220	22	10	179	226
Hurdal	10	5	96	113	11	5	98	112
Oslo	1104	1047	8125	12391	1114	995	7928	12152
Hedmark	785	489	6976	8118	816	470	7173	8182
Kongsvinger	61	34	558	754	64	38	557	756
Hamar	73	45	514	774	74	38	528	790
Ringsaker	127	89	1008	1311	129	69	1025	1299
Løten	29	18	278	295	30	16	282	281
Stange	89	49	774	845	93	46	808	841
Nord-Odal	15	8	141	185	15	8	141	179
Sør-Odal	39	21	334	358	42	22	338	357
Eidskog	26	22	265	317	28	28	285	333
Grue	24	14	230	273	25	13	235	269
Åsnes	33	18	308	344	35	17	311	355
Våler	19	13	167	199	21	11	167	199
Elverum	63	34	552	638	66	34	569	651
Trysil	31	32	317	377	32	33	330	422
Åmot	21	13	208	223	23	20	219	213
Stor-Elvdal	34	19	351	289	35	18	365	279
Rendalen	17	9	172	150	18	9	177	150
Engerdal	9	5	85	103	9	11	102	126
Tolga	9	5	87	84	9	4	86	99
Tynset	31	17	298	276	32	16	310	277
Alvdal	17	11	170	150	18	10	177	147
Folldal	8	8	76	80	9	5	76	77
Os	9	5	84	91	9	5	86	83
Oppland	689	441	6094	7350	717	392	6222	7536
Lillehammer	66	44	498	823	68	39	512	858
Gjøvik	93	50	757	1021	101	55	775	1065
Dovre	25	19	235	220	26	16	243	206
Lesja	18	12	184	134	18	9	190	129
Skjåk	13	7	129	133	13	7	132	131
Lom	12	6	110	119	12	6	113	118
Vågå	18	13	169	189	19	9	172	175
Nord-Fron	25	20	226	234	27	17	233	238
Sel	32	17	270	293	33	16	276	292
Sør-Fron	14	8	139	139	16	8	142	168
Ringebu	33	17	322	311	35	16	331	305
Øyer	27	14	261	281	30	14	271	357
Gausdal	19	11	173	194	20	10	171	195
Østre Toten	46	51	353	444	42	22	348	445
Vestre Toten	35	20	306	461	37	18	312	461

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Jevnaker	16	8	125	209	17	7	127	204
Lunner	25	35	290	338	27	38	308	358
Gran	41	21	361	448	43	20	370	454
Søndre Land	23	12	200	236	24	12	204	254
Nordre Land	23	12	212	257	24	11	212	259
Sør-Aurdal	15	8	153	152	16	8	155	161
Etnedal	8	4	76	84	8	4	77	76
Nord-Aurdal	30	15	272	325	32	15	276	334
Vestre Slidre	9	5	80	85	9	4	78	85
Øystre Slidre	12	7	110	127	13	6	110	123
Vang	8	5	82	92	9	4	83	84
Buskerud	896	1412	7185	10243	951	1014	7333	9420
Drammen	138	74	1049	1663	166	69	1065	1591
Kongsberg	73	57	541	852	77	60	552	816
Ringerike	105	70	926	1205	110	73	949	1239
Hole	27	13	254	279	29	13	262	280
Flå	13	6	126	134	13	6	131	130
Nes	15	8	142	163	16	8	145	175
Gol	20	11	183	209	21	10	187	216
Hemsedal	13	7	123	125	14	7	125	108
Ål	21	26	162	219	21	25	165	229
Hol	23	11	204	233	24	11	209	229
Sigdal	15	8	138	178	15	7	137	167
Krødsherad	18	8	159	187	19	8	165	183
Modum	38	24	308	426	40	24	314	423
Øvre Eiker	68	46	577	650	74	60	592	648
Nedre Eiker	45	22	326	901	46	20	334	680
Lier	111	118	810	1389	114	105	822	1122
Røyken	30	16	225	390	31	14	229	378
Hurum	89	870	590	655	82	476	605	421
Flesberg	13	7	127	138	13	6	127	135
Rollag	8	4	76	81	8	4	77	78
Nore og Uvdal	15	7	141	166	15	7	141	171
Vestfold	1073	1167	5965	10636	1062	1186	6101	10351
Borre	53	33	390	647	54	31	393	613
Holmestrand	80	20	314	361	81	17	322	355
Tønsberg	418	594	1604	4111	411	646	1621	3938
Sandefjord	102	47	712	1121	121	58	728	1073
Larvik	155	226	1120	1691	156	198	1173	1644
Svelvik	48	10	120	163	14	10	93	165
Sande	63	164	443	534	62	155	479	535
Hof	12	6	97	126	13	6	100	120
Våle	29	13	258	298	30	13	266	294

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Ramnes	10	5	92	107	10	4	92	102
Andebu	12	6	105	142	12	5	105	134
Stokke	35	17	312	373	37	16	321	369
Nøtterøy	35	16	228	548	36	15	233	558
Tjøme	10	4	58	295	10	4	58	300
Lardal	12	6	114	120	13	6	118	151
Telemark	2878	1086	7780	7465	3172	1236	8805	7348
Porsgrunn	1918	651	3981	1296	2179	804	4804	1275
Skien	112	245	775	1226	113	249	791	1261
Notodden	40	20	326	490	40	18	331	464
Siljan	6	3	49	71	6	3	51	75
Bamble	602	20	942	1769	626	18	1105	1715
Kragerø	37	43	237	693	38	47	241	681
Drangedal	13	8	121	165	13	8	122	145
Nome	22	31	159	222	22	26	159	221
Bø	13	7	108	149	13	6	108	147
Sauherad	15	7	137	155	15	7	137	160
Tinn	18	9	160	254	19	9	162	253
Hjartdal	9	5	85	98	9	5	85	106
Seljord	14	7	132	177	14	7	135	164
Kviteseid	13	7	124	159	14	6	124	151
Nissedal	7	3	66	72	7	3	66	70
Fyresdal	5	3	48	72	5	2	48	68
Tokke	12	7	120	138	13	6	121	138
Vinje	22	11	212	259	23	11	216	253
Aust-Agder	427	2846	2208	4118	456	2666	2280	4135
Risør	20	16	156	320	21	14	158	324
Grimstad	39	22	303	657	41	22	314	655
Arendal	170	1599	654	1317	185	1377	676	1321
Gjerstad	10	5	95	135	11	5	97	133
Vegårshei	4	3	41	63	5	3	44	66
Tvedestrand	19	10	157	301	19	10	159	302
Froland	11	7	111	133	12	7	113	136
Lillesand	93	1117	219	513	102	1184	233	494
Birkenes	22	44	129	180	21	16	127	180
Åmli	8	4	78	99	8	10	90	118
Iveland	2	1	20	26	2	1	20	28
Evje og Hornnes	11	9	91	134	11	8	93	139
Bygland	7	3	60	81	7	3	62	80
Valle	6	3	54	85	6	3	53	84
Bykle	6	3	41	74	6	3	41	74

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Vest-Agder	889	1752	3678	5874	854	1737	3749	5695
Kristiansand	316	1121	1720	2295	317	1187	1735	2211
Mandal	29	18	228	472	30	18	238	461
Farsund	186	316	233	437	157	316	230	385
Flekkefjord	25	17	194	408	26	17	198	382
Vennesla	34	205	261	352	42	126	280	392
Songdalen	14	7	121	174	15	7	125	169
Søgne	19	10	160	320	20	10	166	305
Marnardal	6	4	61	72	6	3	62	79
Åseral	3	1	23	29	3	1	24	27
Audnedal	5	3	46	59	5	2	47	61
Lindesnes	17	8	142	455	19	9	147	418
Lyngdal	21	11	180	303	21	10	183	304
Hægebostad	5	2	44	66	5	2	44	61
Kvinesdal	202	25	197	347	181	25	200	345
Sirdal	8	4	70	87	8	4	70	94
Rogaland	2188	1993	8845	14687	2412	1747	9264	14967
Eigersund	96	292	533	470	86	213	515	519
Sandnes	131	70	1085	1616	136	66	1112	1576
Stavanger	245	183	1897	2986	252	157	1921	3057
Haugesund	55	63	481	746	56	59	472	767
Sokndal	29	66	114	161	32	62	243	174
Lund	15	8	149	179	17	8	156	180
Bjerkreim	17	8	159	169	17	7	161	178
Hå	47	24	385	516	50	22	393	521
Klepp	52	36	372	540	53	29	372	513
Time	33	16	273	449	35	16	275	432
Gjesdal	26	18	208	307	25	13	211	271
Sola	287	320	668	2490	318	324	808	2626
Randaberg	14	7	114	217	14	6	115	179
Forsand	5	2	46	60	5	2	45	60
Strand	22	13	141	240	24	12	146	270
Hjelmeland	12	6	104	145	13	6	107	139
Suldal	14	7	117	169	15	7	136	171
Sauda	242	20	70	235	292	15	72	276
Finnøy	13	10	55	118	12	7	53	118
Rennesøy	14	7	102	144	14	6	102	151
Kvitsøy	1	0	4	26	1	0	4	26
Bokn	5	2	45	89	5	2	45	88
Tysvær	330	16	747	1254	446	15	796	1350
Karmøy	459	787	775	1081	471	680	802	1052
Utsira	1	0	2	25	0	0	2	22
Vindafjord	24	11	198	257	24	10	198	250

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Hordaland	3173	3903	10542	47165	3141	3461	10511	50275
Bergen	491	494	3935	6372	490	449	3895	6377
Etne	15	9	124	172	16	9	127	176
Ølen	8	5	70	131	10	5	74	133
Sveio	12	6	112	181	13	6	114	187
Bømlo	14	8	101	313	14	8	105	329
Stord	24	14	179	406	26	14	189	487
Fitjar	6	4	46	121	6	4	49	135
Tysnes	5	3	40	134	6	3	42	154
Kvinnherad	189	289	279	494	155	278	271	497
Jondal	2	1	14	40	2	1	14	43
Odda	382	178	582	349	333	137	524	356
Ullensvang	12	7	109	176	12	6	111	163
Eidfjord	7	4	71	86	8	4	74	87
Ulvik	4	2	34	48	4	2	35	54
Granvin	6	3	60	71	6	3	61	72
Voss	45	26	384	515	46	24	392	518
Kvam	178	823	638	416	187	922	653	418
Fusa	9	5	74	163	9	5	75	172
Samnanger	8	4	78	109	9	4	80	109
Os	25	14	200	395	27	15	208	392
Austevoll	7	4	48	153	6	4	47	158
Sund	7	4	51	135	7	4	53	130
Fjell	35	17	249	492	35	16	255	517
Askøy	57	145	348	406	53	116	342	439
Vaksdal	17	10	143	193	18	9	146	186
Modalen	1	1	6	8	1	0	6	10
Osterøy	12	8	96	169	13	8	99	183
Meland	7	4	55	132	8	4	57	145
Øygarden	91	3	47	28165	100	3	48	30886
Radøy	9	6	70	147	10	5	71	177
Lindås	1475	1795	2194	6244	1499	1381	2188	6357
Austrheim	5	3	37	86	5	3	37	96
Fedje	1	1	3	30	1	1	4	29
Masfjorden	7	4	65	110	7	4	66	104
Sogn og Fjordane	1065	2379	3564	4080	1064	1562	3590	4168
Flora	28	19	199	359	29	18	199	355
Gulen	9	5	65	102	9	6	66	95
Solund	4	3	13	44	2	1	11	44
Hyllestad	5	3	42	74	5	3	42	74
Høyanger	146	287	174	185	135	190	179	181
Vik	7	4	60	95	7	4	65	99
Balestrand	9	6	66	85	10	5	67	83
Leikanger	7	4	61	89	7	4	59	83
Sogndal	18	10	136	207	18	9	140	267

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Aurland	9	5	90	98	10	5	94	99
Lærdal	10	6	91	107	11	6	93	107
Årdal	374	1403	249	164	395	447	258	146
Luster	13	8	118	191	13	8	118	157
Askvoll	7	5	61	118	7	4	60	111
Fjaler	7	6	65	93	7	6	65	87
Gaular	12	6	116	116	12	6	118	129
Jølster	11	6	111	130	12	6	112	135
Førde	28	20	212	366	30	19	211	381
Naustdal	8	4	74	91	8	4	75	106
Bremanger	239	369	738	302	221	627	730	319
Vågsøy	44	156	199	203	42	142	192	217
Selje	7	5	62	103	7	4	63	103
Eid	17	11	151	218	18	10	155	208
Hornindal	4	2	35	53	4	2	35	53
Gloppen	18	10	153	203	18	10	155	226
Stryn	24	14	223	284	26	14	226	304
Møre og Romsdal	923	909	5268	8291	872	848	5302	8347
Molde	51	26	411	672	53	25	412	793
Kristiansund	29	17	199	455	30	17	204	429
Ålesund	102	84	733	1433	106	78	729	1464
Vanylven	20	45	164	126	20	52	134	128
Sande	7	4	56	105	7	3	56	98
Herøy	38	114	191	227	33	84	185	214
Ulstein	11	6	85	254	12	5	89	221
Hareid	9	5	66	145	9	5	67	144
Volda	15	8	123	206	15	7	124	200
Ørsta	27	23	247	357	28	25	251	358
Ørskog	9	4	85	95	9	4	89	97
Norddal	7	4	57	71	7	4	68	70
Stranda	14	7	105	173	14	7	106	171
Stordal	3	2	25	66	3	1	25	65
Sykkylven	15	8	115	268	14	7	116	257
Skodje	18	9	148	183	18	8	152	177
Sula	14	8	112	168	15	13	116	186
Giske	14	5	91	174	14	5	91	174
Haram	18	9	144	291	19	9	147	294
Vestnes	20	11	172	259	21	10	179	245
Rauma	34	20	317	370	36	19	329	325
Nesset	12	6	110	134	12	7	111	136
Midsund	4	2	37	78	5	2	37	69
Sandøy	2	1	13	48	2	1	13	51
Aukra	5	2	37	82	5	2	39	85
Fræna	25	14	201	283	25	12	210	292
Eide	11	7	113	104	10	5	90	112
Averøy	13	8	97	134	15	8	100	145

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Frei	8	4	69	106	9	4	72	109
Gjemnes	12	6	115	143	13	6	118	140
Tingvoll	11	6	100	130	11	6	104	126
Sunndal	302	406	341	284	237	382	346	290
Surnadal	19	10	157	259	19	9	158	266
Rindal	7	6	65	92	7	3	64	87
Aure	6	3	57	94	7	3	58	97
Halsa	5	3	45	60	5	3	46	67
Tustna	2	1	20	43	2	1	20	41
Smøla	6	3	46	119	6	3	46	121
Sør-Trøndelag	1027	3042	6224	7772	1080	3441	6340	7813
Trondheim	328	657	1954	3360	330	613	1871	3279
Hemne	168	693	547	240	176	898	597	252
Snillfjord	7	3	65	73	7	3	65	76
Hitra	11	6	91	126	11	5	92	146
Frøya	9	5	60	131	9	5	61	138
Ørland	15	6	87	121	14	6	83	125
Agdenes	5	3	53	62	5	3	51	65
Rissa	21	11	193	241	23	11	197	243
Bjugn	20	43	137	162	20	37	139	178
Åfjord	10	6	95	120	11	5	96	133
Roan	3	2	31	43	3	2	32	43
Osen	3	2	26	36	3	2	28	37
Oppdal	30	16	279	310	31	15	289	304
Rennebu	20	10	202	182	21	10	207	182
Meldal	12	6	104	141	13	6	105	136
Orkdal	189	1481	603	418	220	1731	685	453
Røros	17	9	146	227	18	9	149	255
Holtålen	8	4	79	91	8	4	79	86
Midtre Gauldal	28	15	281	298	29	15	287	291
Melhus	50	27	493	504	52	26	509	490
Skaun	20	10	189	225	21	10	193	226
Klæbu	7	4	62	85	7	4	63	87
Malvik	33	17	317	381	35	16	330	391
Selbu	10	6	99	143	11	5	100	157
Tydal	3	2	31	50	3	2	31	40
Nord-Trøndelag	504	561	4113	5228	528	628	4239	5224
Steinkjer	70	39	635	775	73	42	649	777
Namsos	28	20	210	357	28	20	213	344
Meråker	32	245	139	129	46	300	158	135
Stjørdal	93	78	629	896	92	77	628	896
Frosta	6	4	56	77	6	4	55	78
Leksvik	9	5	87	147	9	5	89	152

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Levanger	66	53	583	713	67	42	589	675
Verdal	48	28	376	483	46	25	382	517
Mosvik	3	2	26	32	3	1	26	34
Verran	9	7	63	103	9	6	64	112
Namdalseid	9	5	88	103	9	4	89	101
Inderøy	22	14	173	201	27	44	224	202
Snåsa	14	9	154	133	15	8	159	124
Lierne	7	4	67	82	7	4	67	78
Røyrvik	4	2	23	38	4	2	25	41
Namsskogan	11	6	124	83	12	6	131	84
Grong	19	11	195	185	19	10	201	169
Høylandet	8	4	75	84	8	4	76	88
Overhalla	14	7	121	162	15	7	122	171
Fosnes	3	2	25	29	3	2	25	30
Flatanger	3	2	29	46	3	2	29	47
Vikna	8	4	63	123	8	4	64	121
Nærøy	16	9	156	205	17	9	158	207
Leka	2	1	16	42	2	1	16	43
Nordland	1766	3903	8041	7842	1939	3652	8629	7826
Bodø	98	56	589	1019	96	50	598	1057
Narvik	46	29	358	509	48	28	388	484
Bindal	6	4	56	75	6	3	56	75
Sømna	6	3	52	64	6	3	51	64
Brønnøy	18	10	132	220	18	9	133	191
Vega	3	2	23	56	3	2	23	59
Vevelstad	1	1	12	15	1	1	12	15
Herøy	3	2	21	45	3	2	22	46
Alstahaug	19	10	127	196	19	10	129	206
Leirfjord	8	4	69	76	8	4	69	78
Vefsn	284	383	463	439	270	375	470	440
Grane	17	10	187	131	18	10	195	128
Hattfjelldal	7	7	72	101	8	7	76	97
Dønna	4	2	31	55	4	2	31	54
Nesna	4	3	35	49	4	2	37	40
Hemnes	17	11	156	196	18	10	171	195
Rana	506	1816	1482	1064	421	1338	1282	1020
Lurøy	4	3	32	57	4	2	33	59
Træna	1	0	4	17	1	0	4	17
Rødøy	4	2	30	61	4	2	31	58
Meløy	20	24	434	154	19	41	546	154
Gildeskål	9	5	79	108	9	5	81	102
Beiarn	3	2	32	40	3	2	32	39
Saltdal	23	14	228	232	24	14	239	239
Fauske	31	18	279	332	33	18	290	332
Skjerstad	4	2	37	47	4	2	37	45
Sørfold	301	1362	986	307	312	1475	1099	309

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Steigen	9	5	73	110	9	5	74	115
Hamarøy	13	7	126	127	14	7	132	126
Tysfjord	107	4	400	78	357	121	825	79
Lødingen	8	5	63	81	8	5	67	120
Tjeldsund	7	4	58	67	7	4	60	63
Evenes	16	6	103	108	15	5	101	113
Ballangen	12	7	104	118	13	10	105	119
Røst	1	1	9	17	1	1	9	18
Værøy	1	1	6	18	1	1	6	19
Flakstad	4	2	30	37	4	2	31	37
Vestvågøy	27	15	214	314	28	14	218	293
Vågan	21	11	153	222	22	11	158	234
Hadsel	21	12	153	196	21	11	156	207
Bø	9	5	77	92	9	5	78	93
Øksnes	11	6	74	97	12	6	77	97
Sortland	27	16	218	281	28	18	223	286
Andøy	23	10	160	196	22	10	158	188
Moskenes	2	1	13	19	2	1	14	19
Troms	599	949	3773	4801	627	1165	3978	4702
Harstad	50	33	363	563	52	31	375	572
Tromsø	123	106	832	1368	126	93	851	1323
Kvæfjord	10	6	88	106	11	6	89	98
Skånland	12	7	108	129	12	7	109	122
Bjarkøy	1	1	9	16	1	1	9	13
Ibestad	4	3	29	41	5	3	30	45
Gratangen	7	4	60	63	7	4	62	63
Lavangen	5	3	43	50	5	3	44	45
Bardu	20	12	154	205	20	11	160	201
Salangen	7	4	57	79	7	4	58	77
Målselv	39	20	278	377	40	19	281	381
Sørreisa	13	8	86	130	13	7	85	123
Dyrøy	3	2	30	43	4	2	30	44
Tranøy	6	4	55	65	6	4	56	61
Torsken	3	2	23	26	3	2	22	23
Berg	4	3	33	35	5	3	38	36
Lenvik	195	677	739	427	210	915	876	450
Balsfjord	33	18	270	318	33	17	273	306
Karlsøy	6	4	55	85	7	4	57	75
Lyngen	9	6	64	92	9	6	66	92
Storfjord	11	6	98	122	11	5	100	117
Kåfjord	10	6	87	110	10	5	88	107
Skjervøy	5	3	28	69	6	4	30	55
Nordreisa	16	9	137	201	17	9	138	199
Kvænangen	6	4	50	80	6	3	51	73

Table B8 (cont.). Emissions to air by municipality, 1992 and 1993. Tonnes, CO_2 in 1 000 tonnes

	1992				1993			
	CO_2 ktonnes	SO_2	NOx	NM-VOCs	CO_2 ktonnes	SO_2	NOx	NM-VOCs
Finnmark	321	784	2025	3019	327	626	2058	3119
Vardø	7	5	33	58	7	4	35	61
Vadsø	31	84	134	201	28	59	139	213
Hammerfest	20	25	107	216	20	23	109	236
Guovdageaidnu - Kautokeino	14	8	119	202	15	8	129	177
Alta	60	33	421	729	63	32	424	795
Loppa	2	2	15	34	2	2	15	33
Hasvik	3	2	16	27	3	2	17	28
Kvalsund	9	5	80	99	10	5	82	97
Måsøy	4	4	19	42	4	3	19	43
Nordkapp	9	8	58	92	10	8	61	97
Porsanger	24	11	161	261	23	11	158	261
Karasjohka - Karasjok	10	6	85	150	11	6	89	143
Lebesby	5	4	39	61	5	3	40	61
Gamvik	4	3	24	46	4	3	24	49
Berlevåg	4	2	29	46	4	2	30	48
Deatnu - Tana	15	9	124	174	16	8	129	177
Unjarga - Nesseby	7	4	65	84	8	4	67	83
Båtsfjord	6	4	28	49	7	4	31	54
Sør-Varanger	84	566	466	448	87	441	459	461
Other regions	13273	14252	130365	85331	13644	12530	131693	91104
Spitsbergen	109	450	235	153	99	423	268	188
Bjørnøya	0	0	0	0	0	0	0	0
Hopen	0	0	0	0	0	0	0	0
Jan Mayen	0	0	1	0	0	0	1	0
Continental shelf								
- south of 62°N	10285	11355	94965	83711	10533	9977	94495	89220
- north of 62°N	1430	2299	31205	1172	1537	1943	32903	1395
Air space above 1000 m	1450	147	3959	295	1475	187	4027	300

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table B9. International emissions of CO_2 from energy use[1]. Million tonnes CO_2. Emissions per GDP and per capita

	1970	1975	1980	1985	1990	1991	Per unit GDP (kg/1000 USD) 1991	Per capita (tonnes per capita) 1991
Whole world	14640	15744	18792	19580	21562	..	..	4.1[2]
OECD	8848	9321	10150	9694	10361	10439	692	12.4
Norway	28	28	32	30	32	32	438	7.5
Denmark	64	56	64	64	56	65	714	12.6
Finland	41	47	60	53	55	57	731	11.3
Sweden	98	85	75	65	56	56	389	6.5
France	443	462	499	395	385	406	385	7.1
Italy	307	342	382	369	411	419	422	7.3
Netherlands	161	175	184	167	183	193	772	12.8
Portugal	16	22	27	28	43	44	468	4.2
United Kingdom	662	614	601	574	598	608	670	10.5
Switzerland	39	39	42	41	44	45	306	6.6
Germany	1018	994	1092	1039	989	957	..	12.0
Canada	342	402	439	409	437	435	821	16.1
USA	4267	4444	4913	4732	5038	5035	886	19.9
Japan	781	912	937	912	1060	1079	468	8.7

[1] The figures for Norway according to these data from the OECD differ somewhat from more recent Norwegian calculations of emissions. [2] 1990 figure.
Sources: OECD (1993), OECD (1994)

Table B10. Deposition of reduced nitrogen in Norway, 1980-1994*. 1 000 tonnes as N

Emissions from	1980	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*	Percentage change 1980-1993
Norway	16.7	16.6	16.5	16.7	16.8	17.6	17.3	17.4	18.5	16.7	16.5	0
Sweden	1.5	1.6	1.8	1.8	1.7	1.1	1.3	1.3	1.1	1.2	1.3	-20
Finland	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.2	0.1	0.3	0.2	0
Denmark	3.0	2.5	4.6	2.9	3.0	2.5	3.1	2.3	2.4	1.9	2.9	-37
Netherlands	1.7	1.8	2.7	0.9	1.9	1.4	1.8	1.6	1.1	0.7	1.1	-59
United Kingdom	3.4	3.1	4.9	2.7	3.3	4.5	4.3	3.3	3.3	2.1	2.6	-38
Germany	4.8	4.5	8.7	3.2	5.4	4.1	4.1	3.5	3.0	2.3	4.4	-52
France	1.0	1.3	1.5	0.6	1.1	1.2	1.5	0.7	0.8	0.7	0.8	-30
Belgium	0.4	0.4	0.5	0.2	0.5	0.4	0.6	0.4	0.3	0.2	0.3	-50
CIS	0.9	1.3	1.0	1.0	1.0	0.6	0.7	0.8	0.3	1.2	0.8	33
Poland	2.1	1.9	3.7	1.6	2.6	1.5	1.4	2.3	1.1	1.1	1.6	-48
Czechia, Slovakia	0.4	0.4	0.8	0.3	0.4	0.3	0.3	0.4	0.4	0.3	0.4	-25
Other countries	1.3	1.5	1.8	1.1	0.6	1.5	1.3	1.0	1.0	0.8	0.9	-38
Unspecified	11.5	11.3	13.2	10.2	10.0	14.0	14.5	11.6	12.3	8.6	9.3	-25
TOTAL	48.9	48.8	62.1	43.7	48.7	50.9	52.5	46.6	46.1	38.2	43.3	-22

Source: EMEP/MSC-W (1995)

Table B11. Deposition of oxidized nitrogen in Norway, 1980-1994*. 1 000 tonnes as N

Emissions from	1980	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*	Percentage change 1980-1993
Norway	5.3	6.1	6.3	7.2	7.0	6.4	6.1	6.8	6.5	6.4	6.2	21
Sweden	4.3	4.8	4.8	5.5	4.7	3.1	3.4	3.4	3.1	4.5	4.3	5
Finland	1.0	1.3	1.0	1.3	0.9	0.8	1.0	0.8	0.7	1.0	0.9	0
Denmark	2.8	2.3	4.2	3.4	3.1	2.6	2.7	3.0	2.6	2.2	2.9	-21
Netherlands	3.1	2.3	4.1	2.2	4.2	2.9	4.1	3.2	3.2	2.1	2.4	-32
United Kingdom	15.3	12.5	19.6	13.0	17.0	21.9	22.3	17.8	18.0	10.7	12.1	-30
Germany	11.9	9.8	17.7	8.9	14.1	11.0	10.5	10.5	9.1	7.8	10.2	-34
France	2.7	1.9	3.4	1.7	2.8	3.1	4.0	1.8	2.2	1.4	1.6	-48
Belgium	1.6	1.1	1.4	0.8	1.6	1.5	1.8	1.3	1.2	0.9	0.9	-44
CIS	1.5	2.1	1.8	1.9	1.9	1.0	1.5	1.4	0.9	2.1	1.9	40
Poland	2.9	2.6	4.5	2.6	3.4	1.9	1.8	2.9	1.6	2.0	2.6	-31
Czechia, Slovakia	1.8	1.3	2.6	1.3	1.6	1.1	1.3	1.8	1.4	1.1	1.4	-39
Ocean	2.4	2.2	2.9	2.0	2.6	2.5	2.8	2.2	2.5	1.8	2.2	-25
Other countries	1.4	1.1	1.6	1.7	1.0	2.3	2.3	1.2	1.5	0.9	1.0	-36
Unspecified	14.9	14.8	16.1	13.9	13.4	17.1	18.3	14.9	14.6	12.2	13.2	-28
TOTAL	72.7	66.3	92.3	67.7	79.2	79.2	84.0	73.3	69.2	57.6	63.9	-21

Source: EMEP/MSC-W (1995)

Table B12. Deposition of oxidized sulphur in Norway, 1980-1994*. 1 000 tonnes as S

Emissions from	1980	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*	Percentage change 1980-1993
Norway	13.2	9.0	8.4	7.1	6.5	5.7	5.2	4.4	3.6	3.1	3.2	-77
Sweden	8.3	5.0	5.0	4.8	4.1	2.0	1.8	1.6	1.3	1.7	1.7	-80
Finland	2.5	2.2	1.6	1.8	1.2	0.8	1.0	0.7	0.4	0.6	0.5	-76
Denmark	5.9	3.1	5.0	3.7	3.4	2.5	2.4	3.0	2.1	1.6	2.3	-73
Netherlands	2.4	1.1	1.8	0.9	1.6	1.0	1.3	0.9	0.8	0.5	0.6	-79
United Kingdom	33.4	21.5	32.5	21.7	26.8	34.6	34.8	24.4	23.3	14.5	15.4	-57
Germany	27.0	22.6	45.1	20.0	25.8	18.2	16.6	15.7	10.3	11.3	17.4	-58
France	5.4	2.4	3.0	1.5	2.3	2.5	3.0	1.6	1.7	1.2	1.5	-78
Belgium	3.1	1.5	1.8	0.9	1.7	1.4	1.5	1.1	1.0	0.7	0.9	-77
CIS	16.5	19.2	14.8	17.3	13.4	9.4	10.1	10.9	7.3	8.9	7.2	-46
Poland	8.4	7.9	12.9	7.4	10.9	6.5	4.9	6.8	4.0	5.2	6.8	-38
Czechia, Slovakia	5.6	4.3	9.4	4.3	5.2	3.1	3.9	4.1	3.2	2.8	4.4	-50
Ocean	2.6	2.3	3.0	2.3	2.7	2.8	2.9	2.4	2.5	2.0	2.4	-23
Natural emissions[1]	3.2	3.3	3.9	2.9	2.8	3.9	3.8	3.2	3.3	2.2	2.5	-31
Other countries	4.4	3.8	3.9	3.0	1.7	3.4	4.2	1.9	2.7	1.8	2.8	-59
Unspecified	35.8	35.6	39.5	32.6	32.7	41.7	42.9	36.0	37.5	29.0	30.6	-19
TOTAL	177.6	145.1	192.1	132.5	142.9	139.7	140.5	118.9	105.1	87.6	100.1	-51

[1] Emissions from natural sources in oceans.
Source: EMEP/MSC-W (1995)

Table C1. Stock trends for some important fish species, 1977-1995. 1 000 tonnes

	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arcti saithe[2]	Greenland halibut[1]	Barents Sea capelin[3,6]	Norwegian spring-spawning herring[4]	North Sea herring[4]
1977	2130	240	480	120	5460	300	50
1978	1800	270	470	100	5890	390	70
1979	1490	320	480	130	5560	430	110
1980	1210	250	540	100	6970	510	140
1981	1200	190	530	110	4290	530	200
1982	1010	110	480	110	3750	520	280
1983	750	70	480	120	4230	600	440
1984	870	50	400	110	2860	640	730
1985	1000	150	370	110	820	530	750
1986	1270	250	350	120	120	430	800
1987	1100	250	370	110	100	1010	910
1988	800	160	360	110	430	3220	1100
1989	960	130	330	110	870	3930	1300
1990	1110	130	400	100	5830	3940	1140
1991	1690	160	480	100	7100	4110	990
1992	2170	240	610	70	5150	3660	780
1993	2840	430	620	70	800	3400	480
1994	2410	460	600	60	200	3840	790
1995	2000	430	590	60	190	3910	760

	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]
1977	760	550	560	750	480	60	..
1978	720	640	460	730	480	60	..
1979	730	650	500	910	480	50	..
1980	900	1220	450	810	490	40	..
1981	680	660	540	610	490	50	5350
1982	770	820	590	470	560	60	4230
1983	600	730	690	500	550	70	3750
1984	670	1450	650	470	560	70	3490
1985	430	830	590	430	550	60	3510
1986	560	650	540	630	660	50	3690
1987	470	1040	390	520	640	60	3190
1988	370	410	360	410	630	70	2850
1989	350	370	370	540	590	100	2820
1990	270	310	330	460	560	120	2840
1991	250	740	420	440	470	110	3900
1992	350	610	450	410	480	110	3360
1993	280	860	450	400	420	110	2490
1994	360	490	400	410	360	100	2050
1995	490	1070	500	400	360	90	..

[1] Fish aged 3 years and over. [2] Fish aged 2 years and over. [3] Fish aged 1 year and over. [4] Spawning stock.
[5] Fish aged 0 years and over. [6] As of 1 October.
Sources: ICES working group reports and Institute of Marine Research

Table C2. Norwegian catches by groups of fish species, 1986-1995*. 1 000 tonnes

	1986	1987	1988	1989	1990	1991	1992	1993*	1994*	1995*
Total	1790	1804	1686	1725	1519	1949	2372	2326	2285	2472
Cod	270	305	252	186	125	164	219	275	372	368
Haddock	58	75	63	39	23	25	40	44	73	81
Saithe	131	152	148	145	112	140	168	188	188	221
Tusk	33	30	23	32	28	27	26	27	20	19
Ling/blue ling	28	25	24	29	24	23	22	20	19	19
Greenland halibut	8	7	9	11	24	33	11	15	13	14
Redfish	24	18	25	27	41	56	38	32	27	23
Others and unspecified	24	34	29	29	30	44	43	33	29	26
Capelin	273	142	73	108	92	576	811	530	113	28
Mackerel	157	159	162	143	150	179	207	224	260	202
Herring	331	347	339	275	208	201	227	350	539	685
Sprat	5	10	12	5	6	34	33	47	44	41
Other industrial fisheries[1]	450	500	526	696	655	447	527	541	587	746

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

Table C3. Consumption of antibacterial agents in fish farming, 1981-1995. kg active substance

	Total	Oxytetra-cycline chloride	Nifura-zolidone	Oxolinic-acid	Trimetoprim + sulfadiazine (Tribrissen)	Sulfa-merazine	Flume-quin	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
1995	3116	70	-	2800	-	-	182	64

Source: Norwegian Medicinal Depot

Table C4. Exports of some main groups of fish products, 1981-1995*. 1 000 tonnes

	Fresh	Frozen whole	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	307.4	518.2	195.2	100.1	66.5	26.4	72.0	63.5
1995*	344.1	578.9	211.0	94.9	70.6	20.6	66.1	85.6

Source: Statistics Norway, External Trade Statistics

Table C5. Exports of fish and fish products by important recipient country, 1993-1995*. Million NOK

			Of this					Of this	
	Total	EU-countries total	France	Den-mark	United King-dom	Germany	Other countries total	Japan	USA
1983	7367.7	3186.2	568.8	337.2	1022.1	515.0	4181.3	334.5	747.6
1984	7675.2	3233.3	530.3	350.3	1026.7	545.8	4442.1	408.2	920.1
1985	8172.3	3605.0	605.1	377.1	1202.0	632.8	4567.8	463.8	1129.2
1986	8749.4	4293.9	781.0	626.9	1014.2	705.5	4455.5	408.8	1194.7
1987	9992.3	5597.0	1114.1	926.7	1059.1	754.2	4395.3	501.0	1397.9
1988	10693.1	6107.2	1318.6	1115.1	987.2	932.3	4585.9	808.0	1059.6
1989	10999.2	6416.1	1305.5	1196.0	1019.5	892.9	4583.1	755.7	996.1
1990	13002.4	8119.2	1617.1	2046.3	868.8	1046.5	4883.3	1067.5	754.7
1991	14940.4	9114.8	1534.8	2021.9	991.0	1196.1	5825.6	1797.7	436.4
1992	15385.2	10180.2	1850.7	1794.1	1388.9	1309.3	5205.0	1366.3	400.0
1993	16619.1	10365.3	1835.9	1690.1	1542.3	1369.2	6253.8	1810.3	565.7
1994	19540.2	11709.4	2250.3	1767.8	1484.5	1698.3	7830.8	1999.2	723.1
1995*	20113.0	13186.1	2140.4	2195.0	1591.1	1606.4	6926.9	1988.9	803.9

Source: Statistics Norway, External Trade Statistics

Table C6. Exports of fresh and frozen farmed salmon, 1981-1995*. 1 000 tonnes and million NOK

	Total		Fresh or chilled		Frozen	
	Quantity 1000 tonnes	Value Million NOK	Quantity 1000 tonnes	Value Million NOK	Quantity 1000 tonnes	Value Million 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	153.8	5425.3	140.7	4942.2	13.1	483.1
1995*	188.9	5654.6	169.2	4999.4	19.7	655.3

Source: Statistics Norway, External Trade Statistics

Table D1. Forest balance 1994. 1 000 m^3, without bark

	Total	Spruce	Pine	Broad-leaved trees
Growing stock on 1.1	606777	278434	197347	130997
Total losses	11369	7652	2118	1600
Of which total roundwood cut	9329	6612	1691	1026
Sales, excl. fuelwood	8046	6250	1592	204
Fuelwood, sales and private	1081	208	56	816
Own use	202	154	43	6
Other losses	2041	1040	427	573
Logging waste	601	397	101	103
Natural losses	1440	644	326	470
Total increment	20859	10725	5430	4704
Growing stock on 31.12	616267	281507	200659	134102

Source: Statistics Norway

Table D2. Growing stock and annual increment, excluding bark. Whole country and counties 1994. 1 000m^3 without bark

	Growing stock				Annual increment			
	Total	Spruce	Pine	Broad-leaved trees	Total	Spruce	Pine	Broad-leaved 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	281507	200659	134102	20859	10725	5430	4704
County								
Østfold	25910	12973	9467	3470	1020	570	288	162
Akershus and Oslo	38122	23131	8829	6162	1686	1061	270	355
Hedmark	112136	56681	44656	10799	4050	2238	1389	424
Oppland	68751	46408	13322	9022	2226	1558	375	294
Buskerud	60215	29799	21977	8439	1952	998	594	360
Vestfold	13098	6560	2292	4246	539	290	54	195
Telemark	52936	23279	19804	9853	1667	794	497	376
Aust-Agder	31982	9076	16307	6599	907	294	414	198
Vest-Agder	23034	3961	11407	7666	741	233	258	249
Rogaland	9083	1402	4209	3472	380	118	129	133
Hordaland	19734	5254	8427	6054	803	382	218	203
Sogn og Fjordane	19558	4025	7390	8143	671	244	182	245
Møre og Romsdal	20313	3806	8316	8191	756	273	211	272
Sør-Trøndelag	32770	16584	10856	5330	877	495	243	139
Nord-Trøndelag	42213	28326	6179	7708	1125	765	116	244
Nordland	26519	9973	3148	13398	836	381	73	382
Troms	17049	268	1960	14821	549	28	64	458
Finnmark	2845	1	2112	732	71	0	56	15

Source: Statistics Norway

Table D3. Crown density by 10% classes for spruce. Whole country. 1988-1995. Percentages

Year	Crown density class										Average	No.
	90	80	70	60	50	40	30	20	10	0		trees
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
1995	42.6	22.0	12.6	7.9	4.5	3.1	2.6	2.2	1.7	0.6	79.4	3794

Source: Norwegian Institue for Land Inventory (1996)

Table D4. Crown density by 10% classes for pine. Whole country. 1988-1995. Percentages

Year	Crown density class										Average	No.
	90	80	70	60	50	40	30	20	10	0		trees
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
1995	36.8	34.3	17.5	6.5	2.4	1.1	0.7	0.4	0.2	0.2	83.1	2869

Source: Norwegian Institute for Land Inventory (1996)

Table E1. Agricultural area in use by type of production. Whole country and counties, 1985 and 1995*. Decares[1]

	Agricultural area in use, total	Cereals and oil seed	Vegetables, field-grown	Potatoes, green fodder and silage	Cultivated meadow	Surface-cultivated meadow	Fertilized pasture	Other agricultural areas, fallow
Whole country								
1985	8960715	3176930	46791	574576	4074097	288884	657632	141805
1995*	9921430	3319415	50497	597590	4545732	265102	1005637	137457
Counties 01-10								
1985	4592700	2711339	32952	249028	1274817	81633	146173	96759
1995*	5032189	2820053	38459	292219	1472980	79632	232910	95936
01 Østfold								
1985	719086	606346	3825	25403	57993	4099	10421	10999
1995*	751082	626546	4821	24000	68011	5000	13313	9391
02/03 Akershus/Oslo								
1985	731326	602875	2218	21660	77351	5782	12582	8858
1995*	798070	651973	2337	19374	88423	4951	20194	10818
04 Hedmark								
1985	948160	550225	4808	70132	271635	8558	23099	19703
1995*	1048054	585138	5180	92949	306845	8137	33767	16038
05 Oppland								
1985	865331	261724	3534	65660	459266	20818	47648	6680
1995*	971159	254497	4481	82937	515414	23471	84076	6283
06 Buskerud								
1985	445976	258076	6512	17161	119417	11330	19543	13938
1995*	495307	271813	6581	18692	144248	10203	31347	12423
07 Vestfold								
1985	401152	316750	7348	21048	26963	2586	4874	21582
1995*	426097	313766	10403	27577	39765	2887	5999	25720
08 Telemark								
1985	217468	92904	1275	11081	83125	11993	8164	8926
1995*	241234	98420	876	10987	98862	10547	12595	8947
09 Aust-Agder								
1985	99329	14427	2489	7914	63152	3580	3891	3878
1995*	112022	11130	2740	6528	79102	2913	5510	4099
10 Vest-Agder								
1985	164874	8013	944	8969	115915	12887	15951	2195
1995*	189164	6770	1040	9195	132310	11523	26109	2217
11 Rogaland								
1985	745612	36721	4497	75362	373877	15841	235101	4214
1995*	897313	31919	4926	90258	420648	16167	329248	4147

Table E1 (cont.). Agricultural area in use by type of production. Whole country and counties, 1985 and 1995*. Decares[1]

	Agri-cultural area in use, total	Cereals and oil seed	Vege-tables, field-grown	Potatoes, green fodder and silage	Culti-vated meadow	Surface-culti-vated meadow	Fertilized pasture	Other agri-cultural areas, fallow
12 Hordaland								
1985	417988	1225	667	10299	253562	58339	80495	13400
1995*	456068	591	221	6812	264129	55089	117132	12094
14 Sogn og Fjordane								
1985	408825	1615	1449	10823	271728	47649	65100	10462
1995*	460071	1015	982	6287	296505	38267	107606	9409
15 Møre og Romsdal								
1985	545761	19566	1325	22336	435837	21333	41370	3995
1995*	594284	15415	302	13382	476090	20219	65646	3230
16 Sør-Trøndelag								
1985	665756	132685	646	47938	445828	12054	23023	3582
1995*	730521	148596	487	39184	480028	13628	44813	3785
17 Nord-Trøndelag								
1985	774425	269681	3285	90699	374675	10121	20909	5055
1995*	858863	299154	3868	72565	432383	11375	34536	4982
18 Nordland								
1985	489187	4012	1285	43895	377502	25067	34667	2759
1995*	538011	2672	938	36272	422415	19428	53898	2388
19 Troms								
1985	230886	74	590	18050	190465	12435	8507	766
1995*	257994	-	290	32924	200303	8248	15198	1031
20 Finnmark								
1985	89575	12	96	6147	75807	4412	2287	816
1995*	96116	-	24	7687	80251	3049	4650	455

[1] 1 decare = 0.1 hectare

Source: Applications for production subsidies, Ministry of Agriculture

Table E2. Cereal and oil seed acreage by type of tillage. Autumn-sown cereals. Whole country and selected counties. 1989-90, 1993-94 and 1994-95*. Decares[1]

	Total	Autumn-sown	Autumn-ploughed	Autumn-harrowed, no autumn ploughing	All tillage in spring	No tillage	Unspecified tillage[2]
Whole country							
1989/90	3649601	110465	2977341	..	..	9335	662970
1993/94	3602586	359093	1992564	97949	1487077	24996	..
1994/95*	3517856	309041	1986404	118012	1383322	30118	..
Counties 01-10							
1989/90	3071938	107853	2563424	..	..	8829	499749
1993/94	3052993	355060	1701708	91510	1235943	23832	..
1994/95*	3011290	307220	1706031	115170	1162291	27797	..
01 Østfold							
1989/90	660337	35139	604733	..	..	3371	52212
1993/94	675553	136625	457429	15949	196900	5274	..
1994/95*	661950	130423	422654	19996	212214	7087	..
02/03 Akershus/Oslo							
1989/90	699503	25012	626148	..	..	1203	72168
1993/94	679540	101251	414560	21489	238799	4692	..
1994/95*	679695	95428	417177	23587	232277	6654	..
04 Hedmark							
1989/90	657356	7082	496208	..	..	470	160710
1993/94	641250	13552	305136	24503	308136	3476	..
1994/95*	641079	14784	368468	36563	232499	3549	..
05 Oppland							
1989/90	287309	7548	214449	..	..	1081	71814
1993/94	281613	3368	130596	8034	139993	2989	..
1994/95*	266274	4935	143622	13829	105546	3278	..
06 Buskerud							
1989/90	306307	10993	250370	..	..	447	55489
1993/94	304567	29500	141408	9268	149643	4248	..
1994/95*	293322	24280	127319	10901	152866	2236	..
07 Vestfold							
1989/90	327163	16923	275099	..	..	2236	49823
1993/94	336691	58166	195174	8245	130873	2400	..
1994/95*	338183	30773	170725	6965	157614	2879	..
08 Telemark							
1989/90	107438	4456	79454	..	..	20	27966
1993/94	107415	10820	47012	3268	56966	170	..
1994/95*	108897	5778	46969	2775	57647	1506	..

Table E2 (cont.). Cereal and oil seed acreage by type of tillage. Autumn-sown cereals. Whole country and selected counties. 1989-90, 1993-94 and 1994-95*. Decares[1]

	Total	Autumn-sown	Autumn-ploughed	Autumn-harrowed, no autumn ploughing	All tillage in spring	No tillage	Unspecified tillage[2]
09 Aust-Agder							
1989/90	16319	700	11812	..	..	-	4511
1993/94	16512	813	6772	239	8992	509	..
1994/95*	13688	227	6710	226	6182	570	..
11 Rogaland							
1989/90	50788	32	4881	..	..	344	45553
1993/94	39578	684	4399	186	34658	335	..
1994/95*	34733	213	4023	31	30679	-	..
16 Sør-Trøndelag							
1989/90	165710	111	123439	..	..	105	42183
1993/94	160195	1097	82007	1881	76148	159	..
1994/95*	154537	718	84465	506	68654	911	..
17 Nord-Trøndelag							
1989/90	327353	1371	268567	..	..	57	58706
1993/94	326342	2252	196296	3664	125851	530	..
1994/95*	297548	717	184165	1958	110059	1365	..

[1] 1 decare = 0.1 hectare
[2] Cereal and oil seed acreage where annual comparison of type of tillage is not possible.
Source: Statistics Norway (1996a)

Table E3. Nutrient balance for agricultural areas. Norway. 1985-1994. 1 000 tonnes

	Nitrogen				Phosphorus		
	In manure	NH_3 losses	Commercial fertilizer	Removed in crops	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	24.59	109.30	92.23	11.34	13.72	18.67
1994	70.10	25.61	108.29	83.13	11.52	13.69	16.65

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

Table F1. Inputs of phosphorus (P) and nitrogen (N) to the North Sea[1]. 1990[2]. 1 000 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 deposition	.	.	.	425	..	425

[1] Including the English Channel, the Kattegat and the Skagerrak.
[2] 1991 figures for Norway.
[3] Direct inputs insignificant compared with inputs via river Scheldt.
[4] Including inputs from countries upstream.
Source: North Sea Task Force (1993)

Table F2. Municipal waste water treatment. Hydraulic capacity (p.u.) and number of plants by size categories and treatment methods. 1994

Treatment method	Total	Size category (p.u.)					
		50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total p.u.	5008710	25100	189358	335352	754965	1212240	2491695
Mechanical	1382769	11001	101605	121143	291185	463140	394695
Chemical	2740540	1088	6418	63494	303440	694100	1672000
Biological	57170	1095	16020	33555	6500	-	-
Chemical/biological	762250	1400	32380	108130	140340	55000	425000
Unconventional	49762	10162	28820	2280	8500	-	-
Other/unknown	16219	354	4115	6750	5000	-	-
No. of plants, total	1934	375	909	372	195	65	18
Mechanical	909	168	498	134	79	26	4
Chemical	226	15	27	64	73	35	12
Biological	128	16	71	38	3	-	-
Chemical/biological	317	22	127	124	38	4	2
Unconventional	323	149	169	4	1	-	-
Other/unknown	31	5	17	8	1	-	-

Source: Statistics Norway

Table F3. Municipal waste water treatment plants. Hydraulic capacity (p.u.) by treatment method. County. 1994

County	Total	Treatment method					
		Mechanical	Chemical	Biological	Chemical/ biological	Uncon- ventional	Other/ unknown
Whole country	5008710	1382769	2740540	57170	762250	49762	16219
01 Østfold	346375	2250	323400	530	20195	-	-
02 Akershus[1]	1044670	0	1032130	450	11655	60	375
03 Oslo[1]	351105	0	0	75	350080	950	-
04 Hedmark	193115	0	81170	2555	109390	-	-
05 Oppland	278744	1570	154614	450	105150	16566	394
06 Buskerud	295194	5833	244537	4450	33560	6814	-
07 Vestfold	202125	50430	136790	280	14470	155	-
08 Telemark	256980	10500	218400	14850	12630	600	-
09 Aust-Agder	140978	98980	33050	350	7680	918	-
10 Vest-Agder	191960	28480	153090	1560	7760	1070	-
11 Rogaland	412777	158822	250460	1800	1200	495	-
12 Hordaland	361017	260138	66590	3755	24880	2194	3460
14 Sogn og Fjordane	70628	60755	129	4450	1350	3724	220
15 Møre og Romsdal	159145	122980	20000	580	2840	1045	11700
16 Sør-Trøndelag	386166	351606	7535	4360	19555	3040	70
17 Nord-Trøndelag	172415	141645	9920	10180	9870	800	-
18 Nordland	24771	15911	2100	5585	850	325	-
19 Troms	75730	42960	4550	785	17685	9750	-
20 Finnmark	44815	29909	2075	125	11450	1256	-

[1] Intermunicipal plants.
Source: Statistics Norway

Table F4. Municipal waste water treatment. Number of people[1] connected to separate waste water treatment plants in scattered settlements, by type of treatment. County[2]. 1994

County	Total	Type of treatment							
		Direct discharge	Sludge separator	Mini wwtp without precipitation	Mini wwtp with precipitation	Infiltration	Sand trap	Separate toilet systems	Sealed tank
Whole country	737083	56770	333071	4498	4814	223257	70744	32873	11056
01 Østfold	33806	1687	21705	186	743	905	2164	6265	151
02 Akershus	55154	4446	25568	2957	169	12945	5691	1708	1670
03 Oslo	1968	-	600	-	120	30	1218	-	-
04 Hedmark	77518	989	17614	-	438	44477	5410	8334	256
05 Oppland	34130	-	3284	-	19	25126	37	4554	1110
06 Buskerud	44571	978	10082	84	652	27246	3024	2195	310
07 Vestfold	42825	3513	30558	378	511	2367	2621	698	2179
08 Telemark	33840	434	19443	188	81	7787	2322	643	2942
09 Aust-Agder	33555	3162	9105	136	152	13009	6768	687	536
10 Vest-Agder	19464	492	5790	-	183	8644	1218	2722	415
11 Rogaland	48371	2128	35011	150	493	6650	2723	1034	182
12 Hordaland	99502	7338	47389	267	922	25385	15956	1594	651
14 Sogn og Fjordane	30469	3076	10184	50	3	9633	7523	-	-
15 Møre og Romsdal	61607	16372	32755	25	29	6056	5693	398	279
16 Sør-Trøndelag	49401	3221	23505	76	290	12450	7628	2001	230
17 Nord-Trøndelag	2934	88	1077	1	-	999	627	20	122
18 Nordland	-	-	-	-	-	-	-	-	-
19 Troms	54010	7980	34825	-	5	11131	29	20	20
20 Finnmark	13958	866	4576	-	4	8417	92	-	3

[1]Permanent residents. [2]Figures lacking from 109 municipalities in 1994.
Source: Statistics Norway

Tabell F5. Phosphorus (P) from waste water treatment plants and scattered settlements[1]. 1993 and 1994

County	Phosphorus (total P)					
	Discharges		Removed by treatment		Treatment efficiency[2]	
	Waste water treatment plants	Scattered settlements	Waste water treatment plants	Scattered settlements	Waste water treatment plants	Scattered settlements
	Tonnes				Percentage	
Whole country						
1993	534	367	1373	173	72	32
1994	578	388	1415	166	71	30
Counties 01-10 (N. Sea counties)						
1993	163	129	1091	110	87	46
1994	144	151	1056	105	88	41
Counties 11-20						
1993	371	238	292	63	44	21
1994	433	237	327	63	43	21

[1]Differences in calculated discharge figures for 1993 and 1994 may be partly due to changes in the quality of the data on which the calculations are based. [2]Shows the proportion of the substance removed from the waste water.
Source: Statistics Norway

Table F6. Annual cost per subscriber and income-to-cost ratio[2]. County. 1993 and 1994

	Annual cost per subscriber[1]. NOK				Income-to-cost ratio[2]			
	Arithmetic mean		Weighted mean[3]		Arithmetic mean		Weighted mean[3]	
	1993	1994	1993	1994	1993	1994	1993	1994
Whole country	3000	2768	2200	2156	0.69	0.73	0.80	0.88
N. Sea counties	4100	3699	2600	2588	0.61	0.67	0.76	0.84
Rest of country	2200	2127	1600	1780	0.74	0.77	0.88	0.96
Østfold	3300	2992	2900	2556	0.76	0.77	0.90	0.88
Akershus/Oslo	3200	2935	2300	2381	0.74	0.80	0.74	0.90
Hedmark	4500	3547	3300	2787	0.59	0.68	0.70	0.79
Oppland	4800	4805	3600	3621	0.51	0.55	0.66	0.67
Buskerud	4200	3691	3100	2972	0.55	0.63	0.70	0.76
Vestfold	2900	3032	1900	1982	0.75	0.89	0.92	1.12
Telemark	2900	3213	2200	2512	0.64	0.67	0.83	0.64
Aust-Agder	5700	4466	2800	3523	0.51	0.56	0.79	0.80
Vest-Agder	4900	4511	3300	2796	0.46	0.54	0.76	0.76
Rogaland	2000	2294	1700	1996	0.80	0.74	0.74	0.84
Hordaland	2400	2233	1500	1791	0.70	0.70	1.06	1.16
Sogn og Fjordane	2100	2319	1800	1690	0.78	0.81	0.83	0.88
Møre og Romsdal	1600	2050	1600	1654	0.93	0.92	0.77	0.84
Sør-Trøndelag	2500	2465	1300	1211	0.68	0.66	0.92	0.96
Nord-Trøndelag	3900	2846	2500	2076	0.61	0.82	0.82	1.02
Nordland	2100	1741	1400	1184	0.66	0.74	0.84	0.95
Troms	2300	1903	1500	1172	0.78	0.69	0.87	1.13
Finnmark	1200	1424	800	1091	0.71	0.86	0.80	0.82

[1] Capital costs are calculated on the basis of a depreciation period of 20 years and an annual interest of 10 per cent in 1993 and 7.5 per cent in 1994.
[2] Ratio between income from fees and annual costs in the municipalities.
[3] Weighted according to the number of subscribers in the municipality connected to the sewage system.
Source: Statistics Norway

Table G1. Municipal waste, 1992-1994. Whole country. Tonnes in total and kg per capita

	Tonnes			kg per capita		
	1992	1993	1994	1992	1993	1994
Total	2222779	2216924	2365600	517	513	547
Household waste	1041591	1097301	1069486	242	254	247
Industrial waste	1087615	1066150	1243003	253	247	287
Unknown/mixed	93573	53472	53111	22	12	12

Source: Statistics Norway (1995a,b)

Table G2. Household waste delivered for material recovery, by material. Whole country, 1992-1994. Tonnes

	1992	1993	1994
Total	92864	154794	175834
Paper and cardboard	60860	112443	124156
Glas	11682	14573	15004
Plastic	154	11	92
Rubber and tyres	116	294	745
Iron and other metals	7143	15562	16492
Food, slaughterhouse waste and fish waste	1170	1590	3274
Wood waste	603	3109	7676
Textiles	1206	5435	7503
Other	9929	1775	892

Source: Statistics Norway (1995a,b)

Table G3. Municipal waste delivered for material recovery, by sorting method. 1992-1994. Percentages

	1992	1993	1994
Sorting and collection at source	61	56	52
Sorting on delivery	23	23	20
Sorting at waste treatment and disposal plants/collection centres	17	21	28

Source: Statistics Norway (1995a,b)

Table G4. Fees for waste treatment, excluding VAT. Weighted mean, by county. 1993 and 1994

County	Ordinary subscriber NOK per year		Delivery at waste treatment and disposal plants NOK per tonne	
	1993	1994	1993	1994
Whole country	809	831	391	411
Østfold	822	815	401	326
Akershus	791	773	556	562
Oslo	1076	1098	393	400
Hedmark	742	771	335	388
Oppland	855	882	409	426
Buskerud	737	794	306	355
Vestfold	711	769	402	433
Telemark	762	848	508	483
Aust-Agder	728	744	224	281
Vest-Agder	699	761	299	306
Rogaland	685	711	189	200
Hordaland	761	813	291	297
Sogn og Fjordane	977	1060	466	472
Møre og Romsdal	929	942	549	556
Sør-Trøndelag	1022	950	449	483
Nord-Trøndelag	869	907	382	507
Nordland	770	666	390	418
Troms	969	1085	547	689
Finnmark	773	846	444	468

Source: Norwegian Pollution Control Authority (1994)

Table G5. Calculated quantities of production and consumer waste from manufacturing industries, by branch[1] and material. 1993. Tonnes

Material	Total	Food	Textiles	Wood	Pulp and paper, printing
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 (except tyres)	1228	2	6	20	42
Iron and other metals	180123	3517	716	2631	6164
Food, slaughterhouse waste and 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	Cemical	Mineral	Metals	Machinery	Other
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 (except tyres)	10	134	58	956	0
Iron and other metals	7212	1351	39855	118441	235
Food, slaughterhouse waste and 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 to Table G6.

Source: Statistics Norway (1994a)

Table G6. Calculated amounts of production and consumer waste from manufacturing industries delivered to external waste treatment and disposal plants, by branch[1] and method of treatment. 1993. Tonnes

Treatment method	Total	Food	Textiles	Wood	Pulp and paper, printing
Total	1599215	560112	15013	127514	215615
Material recovery and/or re-use	795005	420695	1718	44690	152243
Incineration with energy recovery	57689	8940	834	37346	4085
Incineration without energy recovery	1770	147	362	4	-
Biological treatment	49568	45667	-	3270	46
Landfill	347581	65870	7192	17975	42243
Used for landscaping	299004	3967	-	22886	5978
Sorted	46028	14393	4904	1342	11020
Other	2569	433	3	-	-

Treatment method	Chemical	Mineral	Metals	Machinery	Other
Total	66548	83243	322332	206068	2771
Material recovery and/or re-use	14753	6029	38332	115742	804
Incineration with energy recovery	3727	137	15	2589	15
Incineration without energy recovery	423	161	661	12	-
Biological treatment	545	28	-	11	-
Landfill	40624	8456	90663	72668	1889
Used for landscaping	1604	65085	192022	7463	-
Sorted	2922	3312	638	7434	62
Other	1949	35	-	150	-

[1]Food - Manufacture of foods, beverages and tobacco products.
Textiles - Manufacture of textiles, wearing apparel, leather and leather products.
Wood - Manufacture of wood and wood products, including furniture.
Pulp and paper, printing - Manufacture of pulp and paper products, printing and publishing.
Chemical - Manufacture of chemicals and of chemical petroleum, coal, rubber and plastic products.
Mineral - Manufacture of mineral products.
Metals - Manufacture of basic metals.
Machinery - Manufacture of fabricated metal products, machinery and equipment.
Other - Other manufacturing industries.

Source: Statistics Norway (1994a)

Table G7. Calculated amounts of production and consumer waste from manufacturing industries treated on-site, by branch[1] and method of treatment. 1993. Tonnes

Treatment method	Total	Food	Textiles	Wood	Pulp and paper, printing
Total	1368219	31158	719	303396	813528
Incineration with energy recovery	829297	2	156	278086	550828
Incineration without energy recovery	2628	435	145	1467	11
Biological treatment	16091	16075	-	6	-
Landfill	481666	4096	41	15771	261651
Used for landscaping	25700	113	1	7404	817
To municipal sewage system	1334	785	15	309	217
Other	11503	9653	361	352	4

Treatment method	Chemical	Mineral	Metals	Machinery	Other
Total	33565	50903	132031	2902	18
Incineration with energy recovery	4	15	11	180	14
Incineration without energy recovery	16	94	-	460	-
Biological treatment	-	-	-	10	-
Landfill	30830	37156	132019	100	1
Used for landscaping	2163	13638	-	1564	-
To municipal sewage system	4	-	-	1	3
Other	548	-	-	586	-

[1] See note to Table G6.
Source: Statistics Norway (1994a)

Table G8. Calculated amounts of hazardous waste from manufacturing industries, by branch[1] and category of hazardous waste. 1993. Tonnes

Category of hazardous waste	Total	Food	Textiles	Wood	Pulp and paper, printing
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 oil drilling operations	168	-	-	-	-
Oil emulsions	1778	17	58	4	8
Organic solvents containing halogens	720	56	0	17	19
Organic solvents not containing halogens	20665	94	118	62	122
Paints, glue, varnish and printing 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
Pesticides	5	1	-	-	-
Waste containing PCBs	26	3	-	2	0
Isocyanates, etc.	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

Category of hazardous waste	Chemical	Mineral	Metals	Machinery	Other
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 oil drilling operation	-	-	-	168	-
Oil emulsions	518	7	190	975	2
Organic solvents containing halogens	516	4	1	106	0
Organic solvents not containing halogens	19945	5	18	298	2
Paints, glue, varnish and printing 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
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 to Table G6. Source: Statistics Norway (1994a)

Table G9. Calculated amounts of hazardous waste from manufacturing industries delivered to approved treatment facilities, by branch[1] and category of hazardous waste. 1993. Tonnes

Category of hazardous waste	Total	Food	Textiles	Wood	Pulp and paper, printing
Total	235552	756	125	602	1921
Waste oil, lubricating oil, etc.	11174	452	38	431	349
Oil waste from waste treatment plants	4917	7	-	16	11
Oil-contaminated waste from oil drilling operations	168	-	-	-	-
Oil emulsions	1544	17	48	3	8
Organic solvents containing halogens	641	2	-	7	6
Organic solvents not containing halogens	9800	93	26	49	76
Paints, glue, varnish and printing 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
Pesticides	5	1	-	-	-
Waste containing PCBs	0	-	-	-	-
Isocyanates, etc.	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

Category of hazardous waste	Chemical	Mineral	Metals	Machinery	Other
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 oil drilling operations	-	-	-	168	-
Oil emulsions	404	-	165	898	1
Organic solvents containing halogens	516	4	1	104	-
Organic solvents not containing halogens	9275	4	18	257	1
Paints, glue, varnish and printing 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
Pesticides	4	0	-	0	-
Waste containing PCBs	0	-	-	-	-
Isocyanates, etc.	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 to Table G6. Source: Statistics Norway (1994a)

Table G10. Calculated amounts of production and consumer waste generated by the public sector, by type of activity[1] and material. 1994. Tonnes[2]

Material	Total	Technical	Health, veterinary, social services	Education and research
Total[2]	402447	327484	66753	8210
Mixed paper and cardboard	2596	77	2105	415
Paper	13856	3774	8414	1668
Cardboard	3525	424	2872	229
Plastic	1115	223	617	275
Glass	601	164	420	17
Car tyres	217	201	14	2
Rubber (except tyres)	26	7	19	-
Iron and other metals	1688	1054	301	333
Waste food, slaughterhouse waste and fish waste	5078	45	4730	303
Wooden products, particle board	1965	1624	152	188
Waste from parks, etc (not stone, gravel, soil)	7257	6581	584	93
Textiles	75	4	70	2
Mineral waste	240020	238775	563	682
Asphalt	50858	50854	0	4
Ash	47	1	46	0
Dust (e.g. from filters, coal dust)	10393	10289	11	93
Sludge, in tonnes dry matter	3635	3635	0	1
Chemicals	607	18	19	570
Other	1254	1060	193	1
Babies' nappies	12243	-	12243	-
Mixed	45391	8677	33380	3334

[1]See note 1 to Table G12.
[2]The figures are rounded off to the nearest whole number, and the totals may therefore not correspond to the sum of the individual figures in the table.
Source: Statistics Norway (1996a)

Table G11. Calculated amounts of packaging waste generated by the public sector, by type of activity[1] and material. 1994. Tonnes

Material	Total	Technical	Health, veterinary, social services	Education and research
Total	5676	602	4530	544
Paper	1055	152	797	106
Cardboard	3297	135	2998	164
Plastic (incl. polystyrene)	386	62	322	1
Glass	276	77	195	4
Wood (incl. wood fibre)	191	80	109	3
Textiles	2	-	2	-
Iron and other metals	44	38	6	-
Other	-	-	-	-
Mixed	425	58	101	266

[1]See note 1 to Table G12. Source: Statistics Norway (1996a)

Table G12. Calculated amounts of hazardous waste generated by the public sector, by type of activity[1] and category of hazardous waste. 1994. kg

Category of waste	Total	Technical	Health, veterinary, social services	Education and research
Total[2]	3951879	524141	3083746	343993
Waste oil, lubricating oil, etc.	443420	402736	17538	23145
Oily waste from waste treatment plants	15920	11920	1109	2891
Oil emulsion	4559	1862	161	2536
Organic solvents containing halogens	17274	1435	2544	13295
Organic solvents not containing halogens	42184	7561	12944	21679
Paint, glue, varnish and printing ink	14138	9873	3033	1232
Distillation residues and tarry waste	4904	2484	122	2298
Waste/batteries containing heavy metals	73182	27777	26491	18913
Waste containing cyanide	1584	-	1434	150
Pesticides	322	162	119	42
Isocyanates	1	-	-	1
Other organic waste	15254	-	6256	8998
Strong acids	13011	38	11541	1432
Strong alkalis	3193	1314	1310	569
Other inorganic waste	31310	840	29842	628
Waste containing PCBs	5744	1000	326	4417
Photographic chemicals	958769	50	936546	22173
Radioactive waste	8996	-	621	8375
Asbestos	54374	54138	234	3
Infectious waste	1906437	-	1697985	208452
Pathological waste, cytostatica, etc.	285321	-	283979	1342
Other	51982	950	49609	1423

[1]Technical - technical services in the municipalities. Health, veterinary, social services - central government administration, health and social affairs sector, animal health and veterinary services, old people's homes. Education and research - educational institutions (agricultural sector, other colleges and universities), research activities.
[2] The figures are rounded off to the nearest whole number, and the totals may therefore not correspond to the sum of the individual figures in the table.
Source: Statistics Norway (1996a)

Table G13. Calculated amounts of production and consumer waste from the public sector treated on-site, by type of activity[1] and method of treatment. 1994. Tonnes

Treatment method	Total	Technical	Health, veterinary, social services	Education and research
Total[2]	139094	138395	565	134
Incineration with energy recovery	26	-	26	-
Incineration without energy recovery	178	28	150	0
Biological treatment	2592	2438	126	29
Landfill	44610	44441	156	12
Used for landscaping	12751	12577	82	92
Washed into sewers	1	-	1	-
Other	78937	78912	25	-

[1] See note 1 to Table G12.
[2] The figures are rounded off to the nearest whole number, and the totals may therefore not correspond to the sum of the individual figures in the table.
Source: Statistics Norway (1996a)

Table G14. Calculated amounts of production and consumer waste from the public sector delivered to external waste treatment and disposal plants, by type of activity[1] and method of treatment. 1994. Tonnes

Treatment method	Total	Technical	Health, veterinary, social services	Education and research
Total[2]	263353	189089	66188	8076
Material recovery and/or re-use	16360	8771	6119	1470
Incineration with energy recovery	8280	2008	5190	1083
Incineration without energy recovery	482	21	371	90
Sent for sorting	2440	243	1879	318
Biological treatment	388	231	13	145
Landfill	201574	148263	48564	4747
Used for landscaping	26847	26835	11	1
Other	6982	2718	4041	223

[1] See note 1 to Table G12.
[2] The figures are rounded of to the nearest whole number, and the totals may therefore not correspond to the sum of the individual figures in the table.
Source: Statistics Norway (1996a)

Table G15. Hazardous waste delivered to the system for hazardous waste management, by category of waste. 1990-1995*. Tonnes

Category of hazardous waste	1990	1991	1992	1993	1994	1995*
Total	59643	65629	87542	98369	92211	101756
1 Waste oil	31203	29921	32896	34261	39115	41637
2 Other oil-contaminated waste	17512	8259	9625	10967	12808	16676
3 Stable oil emulsions	4003	2095	1747	2051	2813	2002
4 Waste solvents	1530	2379	2485	3022	4884	4319
5 Paints, glue, varnish and printing ink	2047	2308	2849	2820	2782	3580
6 Distillation residues	141	259	287	389	668	207
7 Tars	1	31	0	17	220	253
8 Waste containing mercury (Hg) or cadmium (Cd)	881	1099	950	1244	1371	346
9 High-priority metals or metal compounds that constitute a health or environmental hazard	-	-	-	-	19	1883
10 Waste containing cyanide	6	19	8	33	22	13
11 Pesticides	16	16	12	45	52	72
12 Isocyanates and other very reactive substances	8	4	14	22	37	55
13 Corrosive substances and products	1439	1343	1264	2473	1896	2554
14 Waste brought ashore from oil-drilling/production	-	16590	33592	36673	19867	21296
15 Other very toxic, toxic or environmental hazardous substances	808	948	1240	2739	1978	2865
21 Waste containing PCBs	16	16	13	27	911	123
22 Photographic chemicals	8	312	527	1554	2682	3838
23 Halons	-	-	-	-	-	3
24 CFCs	-	-	-	-	-	0
99 Other unspecified waste	24	30	33	32	86	34

Source: NORSAS (Norwegian Resource Centre for Waste Management and Recycling) (1996a)

Table G16. Hazardous waste delivered to the system for hazardous waste management, by county. 1991-1995. Tonnes

	1991[1]	1992[1]	1993[1]	1994[1]	1995*
Total	49 091	53 890	61 709	72 090	101 766
Østfold	1 990	2 226	3 100	5 993	5 998
Akershus	3 361	4 080	4 623	4 957	4 845
Oslo	3 261	2 987	3 744	5 597	5 532
Hedmark	1 010	1 155	1 230	1 534	1 401
Oppland	1 478	1 149	1 740	2 145	2 221
Buskerud	2 906	2 534	2 787	3 581	3 890
Vestfold	2 318	3 238	3 754	4 419	4 890
Telemark	2 563	2 393	2 200	2 191	3 428
Aust-Agder	647	700	655	859	960
Vest-Agder	2 019	1 799	2 689	2 544	1 959
Rogaland	5 816	8 290	9 060	10 258	14 095
Hordaland	10 518	10 251	10 681	12 693	26 571
Sogn og Fjordane	1 383	1 822	2 901	1 989	11 639
Møre og Romsdal	2 785	3 430	4 131	4 206	4 534
Sør-Trøndelag	1 761	2 125	1 985	2 248	2 616
Nord-Trøndelag	976	1 015	1 157	1 443	1 370
Nordland	2 395	2 539	2 994	3 133	3 366
Troms	1 086	1 398	1 560	1 517	1 756
Finnmark	789	718	674	747	656
Svalbard and Jan Mayen	29	41	42	37	40

[1] Oil-drilling waste not included.
Source: NORSAS (Norwegian Resource Centre for Waste Management and Recycling) (1996a)

Table G17. Number of waste treatment and disposal plants. Number closed and established, by county. 1985, 1992 and 1995

County	1985	1992	1995	Closed 1992-95	Established 1992-95
Whole country	342	340	252	100	12
Østfold	13	9	6	3	0
Akershus	14	13	7	6	0
Oslo	3	3	3	0	0
Hedmark	22	17	15	2	0
Oppland	15	14	12	3	1
Buskerud	18	18	16	2	0
Vestfold	5	5	5	0	0
Telemark	16	19	14	8	3
Aust-Agder	12	10	8	2	0
Vest-Agder	13	12	13	0	1
Rogaland	17	16	12	6	2
Hordaland	16	13	11	3	1
Sogn og Fjordane	25	23	19	4	0
Møre og Romsdal	21	27	23	5	1
Sør-Trøndelag	23	22	20	2	0
Nord-Trøndelag	24	22	9	13	0
Nordland	38	53	36	19	2
Troms	21	23	12	12	1
Finmark	26	21	11	10	0

Source: Statistics Norway (1996b)

Table H1. Percentage of employees who are exposed to various types of pollution for 1/4 or more of their working hours, by branch of industry. 1989 and 1993

	Loud noise		Skin contact with chemicals		Dust, smoke or fog		Gases or vapours		Others' tobacco smoke		Number of respondents	
	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993
Total	13	15	17	17	21	24	8	11	20	22	4458	3682
Manufacture of[1]												
Food	29	36	18	28	23	24	11	21	19	23	171	139
Textiles	26	13	10	7	56	57	13	10	18	30	39	30
Wood	32	42	11	10	47	61	3	17	13	22	89	56
Pulp and paper, printing	19	23	9	11	17	30	7	13	17	28	191	151
Chemicals	14	17	21	17	14	23	14	20	14	20	28	35
Metals	33	35	18	28	57	63	45	45	40	39	106	101
Machinery	30	36	29	26	41	48	17	19	22	34	271	253
Other activities												
Agriculture and fisheries	13	10	7	36	9	35	6	32	9	8	21	44
Oil and gas extraction and mining	14	12	17	26	39	22	0	3	12	7	31	38
Electricity and water supplies	16	17	30	11	11	8	7	3	24	17	42	33
Construction	28	24	21	15	58	49	11	14	35	33	301	200
Wholesale and commission trade	7	8	8	6	13	17	3	4	22	26	298	237
Retail trade	5	9	16	18	14	15	4	8	16	20	359	254
Hotels and restaurants	25	17	42	42	10	19	16	9	58	55	113	90
Transport	17	17	14	20	19	21	5	7	25	26	197	164
Post and tele-communication	8	4	8	9	13	19	3	4	23	19	114	100
Banking	1	3	4	2	7	10	0	0	12	10	163	115

Table H1 (cont.). Percentage of employees who are exposed to various types of pollution for 1/4 or more of their working hours, by branch of industry. 1989 and 1993

	Loud noise		Skin contact with chemicals		Dust, smoke or fog		Gases or vapours		Others' tobacco smoke		Number of respondents	
	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993
Insurance	4	0	4	0	11	8	7	0	7	23	26	25
Business activities	4	5	5	7	10	5	2	4	25	22	192	148
Public administration	7	5	10	10	13	14	5	6	17	25	432	303
Cleaning and refuse disposal	0	29	56	46	26	46	17	21	33	38	24	24
Education, health and social work	6	8	21	17	11	16	5	6	12	11	1142	1052
Cultural activities and entertainment	12	9	8	11	33	21	8	18	33	28	22	30
Service activities	36	38	57	69	35	46	22	46	22	29	63	49

[1] Food - Manufacture of food, beverages and tobacco products
Textiles - Manufacture of textiles, wearing apparel, leather and leather products
Wood - Manufacture of wood and wood products, including furniture
Pulp and paper, printing - Manufacture of pulp and paper products, printing and publishing
Chemical - Manufacture of chemicals and of chemical petroleum, coal, rubber and plastic products
Mineral - Manufacture of mineral products
Metals - Manufacture of basic metals
Machinery - Manufacture of fabricated metal products, machinery and equipment
Other - Other manufacturing industries
Sources: Surveys of working conditions 1989 and 1993

Table H2. Percentage of employees who are exposed to various types of pollution for 1/4 or more of their working hours, by socio-economic status. 1989 and 1993

	Loud noise		Skin contact with chemicals		Dust, smoke or fog		Gases or vapours		Others' tobacco smoke	
	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993
Total	13	15	17	17	21	24	8	11	20	22
Unskilled workers	29	36	28	29	45	55	13	23	23	29
Skilled workers	29	32	35	40	43	46	17	23	28	28
Salaried employees, lower level	7	7	19	18	10	14	5	6	19	23
Salaried employees, middle level	7	7	6	8	11	13	3	5	19	20
Salaried employees, higher level	4	3	5	5	8	9	5	4	12	14

Source: Surveys of working conditions 1989 and 1993

Table H3. Percentage of employees who are exposed to various types of pollution for 1/4 or more of their working hours, by region. 1989 and 1993

	Loud noise		Skin contact with chemicals		Dust, smoke or fog		Gases or vapours		Others' tobacco smoke	
	1989	1993	1989	1993	1989	1993	1989	1993	1989	1993
Total	13	15	17	17	21	24	8	11	20	22
Akershus and Oslo	11	10	12	12	19	18	5	9	21	22
Eastern Norway, rest	15	15	20	19	23	24	9	10	20	21
Aust-Agder, Vest-Agder, Rogaland	11	16	18	21	22	27	11	11	20	24
Western Norway	14	17	19	20	20	28	9	14	20	23
Sør- and Nord-Trøndelag	17	16	20	18	23	25	7	11	14	17
North Norway	15	15	18	15	19	17	4	6	21	23

Source: Surveys of working conditions 1989 and 1993

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22/95 Avfallsbehandling koster 440 kroner pr. innbygger. *(Waste management costs NOK 440 per capita)*

22/95 Vi leverer 41 kg avfall til gjenvinning. *(We deliver 41 kg of waste each for recycling)*

23/95 Bærum flinkest med avfall. *(Bærum municipality best at waste management)*

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