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Statistisk sentralbyrå

Natural Resources and the Environment 1997

Natural Resources and the Environment 1997

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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 1997 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 transport, waste management, waste water treatment, agriculture, forests and forest damage, and fishing, sealing and whaling. 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 1997.*

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 Snorre Kverndokk, Runa Nesbakken and Tone Veiby. Alison Coulthard (part I, part II 4.4 and 7.4-7.6, and part III) and Janet Aagenæs (rest of part II) have translated the Norwegian version into English.

Statistics Norway
Oslo/Kongsvinger 2 May 1997

Svein Longva

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Part I Resource and environmental statistics

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Introduction

Natural Resources and the Environment 1997 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 the impact of human activities on the environment through pollution and the use of natural resources. *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 also considered in relation to the energy market and price trends for important energy commodities.

According to surveys of living conditions, road traffic is the most important cause of perceived exposure to pollution. The second chapter quantifies the huge growth in *passenger and goods transport* in Norway during the past 50 years. Energy use and emissions of pollutants from various modes of transport are also compared.

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 carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and volatile organic compounds (NMVOCs). Depletion of the ozone layer and climate change, which are global problems, are also discussed.

The chapter on *waste* presents new and more extensive figures on the collection and treatment of household waste and other municipal waste. Annual records of deliveries of hazardous waste for treatment are also discussed.

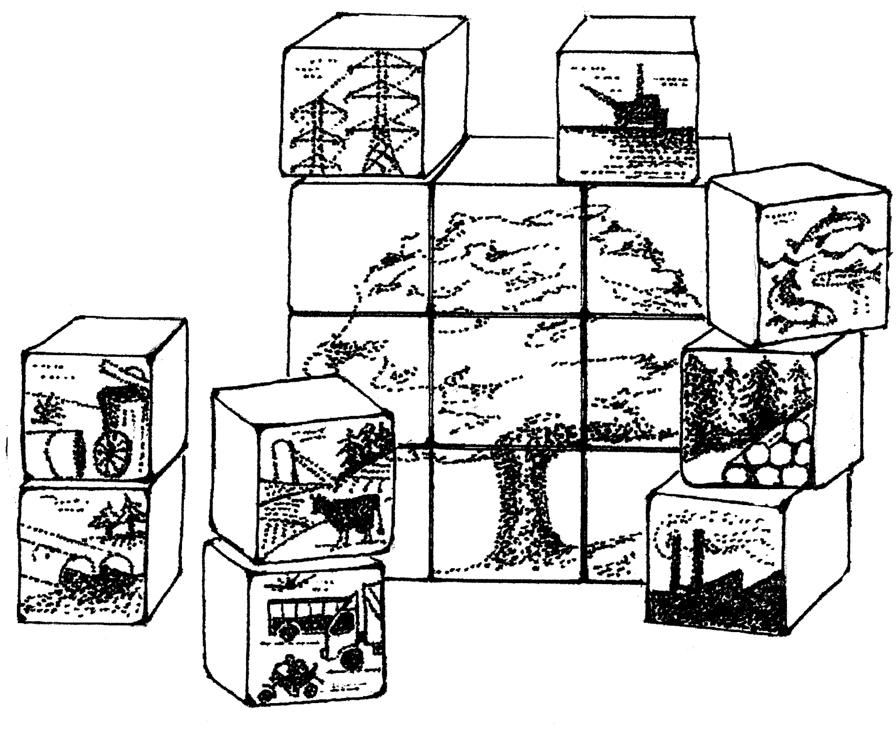
According to the North Sea Declarations, Norway was required to reduce discharges of nitrogen and phosphorus to the North Sea by about half by 1995, using 1985 as the base year. These goals have not quite been achieved, but various measures, mainly in the fields of *waste water management* and *agriculture*, have been implemented to reduce discharges. *Natural Resources and the Environment 1997* presents the latest statistics and analyses of measures to reduce discharges of nutrients to the North Sea.

The publication also includes a thorough treatment of economic aspects of the waste water treatment and waste management sectors.

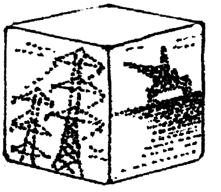
The chapter on *forests* includes statistics on forestry in Norway and on forest resources and forest damage both in Norway and in the rest of Europe. The chapter on *fishing, sealing and whaling* presents figures on trends in fish stocks, catches and exports, and key figures on fish farming.

Central issues in *Part II* are the impact of economic development on the natural environment and how natural resources should be managed. In this connection, issues such as changes in energy markets, the effects of CO_2 taxes and projections of various environmental parameters are discussed. The introductory chapter to Part II on page 95 describes its contents in more detail.

Part I. Resource and environmental statistics



1. Energy



Petroleum extraction is Norway's most important industry, and accounted for 14 per cent of GDP and 38 per cent of export income in 1996. Norway ranks sixth among the world's crude oil producers. Oil production rose by 11.6 per cent from 1995 to 1996, and gas production by 34.5 per cent. Given the current rate of extraction and the petroleum reserves estimated to exist, Norway's oil reserves will be exhausted in 13 years and its gas reserves in 66 years.

In 1996, electricity production in Norway totalled 104.8 TWh. This is 15 per cent lower than the year before, and the lowest level of production since 1987. The net import of electricity in 1996 was 9 TWh, the highest figure ever recorded.

Consumption of fuel oils rose by 27 per cent from 1995 to 1996.

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 1996, Norwegian reserves of crude oil in fields that are already developed or where development has been approved totalled 1 795 million Sm^3 o.e. (standard cubic metres oil equivalents), and corresponded to 1.1 per cent of the world's crude oil reserves (table 1.1). Reserves of natural gas in fields that are already developed or where development has been approved totalled 1 479 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. Given the present rate of production and current technology, the oil reserves in fields on the Norwegian continental shelf that are already developed or where development has been approved will be exhausted after 10 years, and the natural gas reserves after 36 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 540 million Sm^3 o.e. crude oil (including wet gas) and 1 210 million Sm^3 o.e. natural gas. The R/P ratio, including fields where development has not yet been approved, is 13 years for crude oil and 66 years for natural gas.

As of 1 January 1997, Norway's proven oil reserves were larger than those of any other

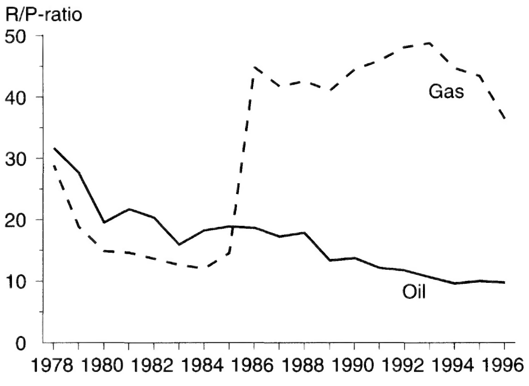
Table 1.1. **World reserves[1] of oil and gas as of 1 January 1997, in billion Sm^3 o.e.**

	Oil		Gas	
	Sm^3 o.e.	Percentage	Sm^3 o.e.	Percentage
World	162.0	100.0	140.0	100.0
North America	4.3	2.7	6.6	4.7
Latin America	20.3	12.6	7.8	5.6
Western Europe	2.9	1.8	4.7	3.3
Eastern Europe and CIS	9.4	5.8	56.7	40.5
Middle East	107.5	66.4	45.8	32.7
Africa	10.7	6.6	9.3	6.6
Asia and Australasia	6.7	4.2	9.1	6.5
OPEC	125.4	77.4	58.1	41.5
Norway	1.8	1.1	1.4	1.0

[1]For most countries, the reserves comprise proven resources which can be exploited using current technology and prices

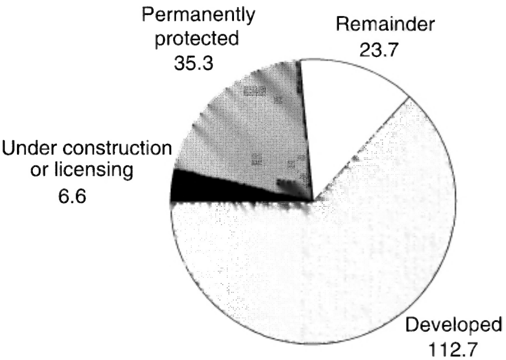
Source: Oil & Gas Journal (1996)

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



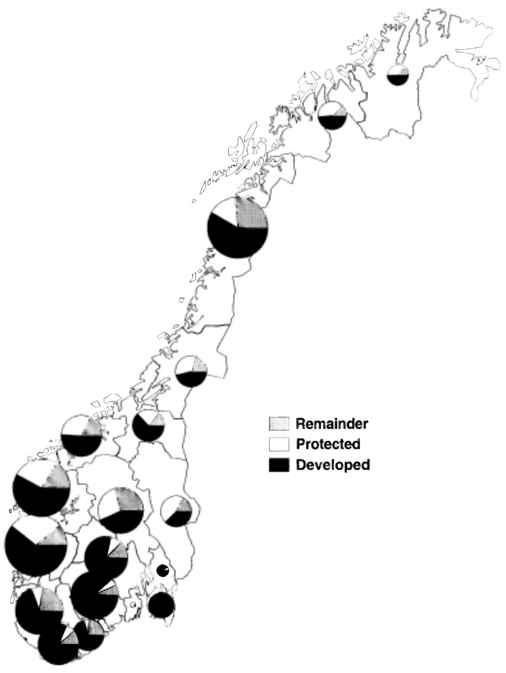
Sources: Statistics Norway and Norwegian Petroleum Directorate

Figure 1.2. **Hydropower potential as of 1 January 1997, in TWh**



Source: Norwegian Water Resources and Energy Administration

Figure 1.3. **Norway's hydropower reserves by county**



Digital map data: Norwegian Mapping Authority

Source: Norwegian Water Resources and Energy Administration

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

Energy commodity	Theoretical energy content	Fuel efficiency: Manufacturing and mining	Fuel efficiency: Transport	Fuel efficiency: Other
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 (1996)[2]	41.5 GJ/1000 Sm^3	..	..	..
Liquefied 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 and 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

As a general rule, quantities of both oil and gas used to be expressed in tonnes oil equivalents (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	0.087
1 MSm^3 o.e. oil	36.6	10.2	1	0.881
1 MSm^3 o.e. gas	41.5	11.5	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 II 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}

European country except Russia. Russia also had Europe's largest natural remaining gas reserves, followed by the Netherlands and Norway. In Western Europe, 61 per cent of the oil reserves and 29 per cent of the gas reserves are on the Norwegian continental shelf. At the end of 1996, the R/P ratio for the world's petroleum reserves was 44 years for crude oil and 61 years for natural gas.

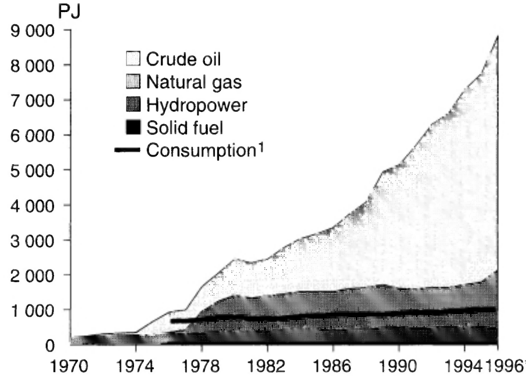
Hydropower

Hydropower resources are divided into developed reserves, reserves that have been approved for development or are being considered for licensing, protected river systems and the remainder. As of 1 January 1997, Norway's economically exploitable hydropower reserves totalled 178.3 TWh (expressed as mean annual production capability, i.e. the production capacity of the power stations in a year with normal precipitation). Of this, 112.7 TWh was already developed and 35.3 TWh permanently protected (figure 1.2). The counties Telemark, Hordaland, Sogn og Fjordane and Nordland account for 46 per cent of Norway's developed reserves, and Nordland also has 20 per cent of the country's remaining undeveloped production capacity (figure 1.3).

Coal

At the end of 1996, Norway's proven coal reserves were about 5.8 million tonnes (table A3 in Part III). At the current rate of extraction, the proven coal reserves will be exhausted in 20 years' time. In addition to the proven reserves, a further 58.1 million tonnes are defined as probable coal reserves. At the end of 1995, the world's exploitable coal reserves were 1 032 billion tonnes. At the current rate of extraction, they will last for 228 years. The largest reserves are found in the USA, the former Soviet Union and China.

Figure 1.4. **Extraction and consumption[1] of energy commodities in Norway**



[1] Including the energy sectors, excluding international maritime transport

Sources: Statistics Norway, Norwegian Petroleum Directorate, and Norwegian Water Resources and Energy Administration

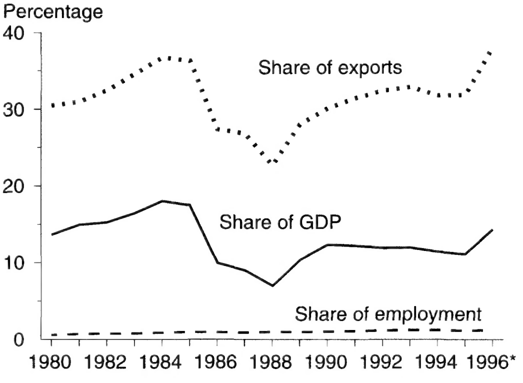
1.2 Extraction and production

Total extraction of energy commodities in Norway has risen by 11.9 per cent per year since 1976 as a result of the growth in oil and gas extraction in the North Sea (figure 1.4), while total consumption has risen by 2.3 per cent per year. If we compare total extraction with total consumption, we can see that the export potential (the part of the diagram above the consumption line) has risen dramatically since 1976. In 1996, extraction of energy commodities was 9 times consumption.

Crude oil and natural gas

In economic terms, oil and gas extraction is Norway's most important industry. In 1996, exports of crude oil and natural gas reached record levels and totalled NOK 155 billion, or 38 per cent of the country's total exports (figure 1.5). The industry accounted for 14.3 per cent of GDP, and 1.2 per cent of total labour input was directly related to oil and gas extraction.

Figure 1.5. **Oil and gas extraction: percentages of exports, GDP and employment**



Source: Statistics Norway

Table 1.3. **World production of crude oil and natural gas in 1996. Million Sm^3 o.e.**

	Oil	Gas
World	3679.0	2339.3
North America	482.3	750.4
Latin America	506.5	119.0
Western Europe	365.4	271.0
Eastern Europe and CIS	416.5	762.8
Middle East	1107.9	133.0
Africa	391.9	83.8
Asia and Australasia	408.5	219.2
OPEC	1495.6	277.6
Norway	180.0	37.4

Source: Oil & Gas Journal (1997)

According to production statistics compiled by the Norwegian Petroleum Directorate, production of crude oil and natural gas totalled 222.1 Sm3 o.e. in 1996, or 14.8 per cent more than in 1995. Natural gas production rose by 34.5 per cent, and the production of oil and NGL[1] by 11.6 and 9.5 per cent respectively.

Figures from the Norwegian Petroleum Directorate show that Norway's total production of crude oil (excluding NGL and condensate) was 175.5 Sm^3 o.e. in 1996, corresponding to an average production of 3.03 million barrels per day. Average production in 1995 was 2.71 million barrels per day. The rise in production derives mainly from fields which came on stream in 1995-1996. Production started on Troll West and Heidrun in autumn 1995, and in 1996 these fields were the fifth and sixth largest on the continental shelf in terms of production. In this period they produced 226 000 and 250 000 barrels per day, respectively. In March 1996, their plateau level was raised from 220 000 to 250 000 barrels per day. The fields Yme and Frøy also contributed substantially to the rise in production from 1995 to 1996. They came on stream in May 1996 and May 1995 respectively, and average production on both fields in 1996 was 31 000 barrels per day.

Production of natural gas rose steeply from 1995 to 1996. According to figures from the Norwegian Petroleum Directorate, gas production in 1996 was 37.4 million Sm^3 o.e. The rise from 1995 to 1996 is attributable to the fields Sleipner East, Heimdal and Troll East. Production on Sleipner East has risen by almost 50 per cent since 1995, and the field is producing more than its plateau level of 7.0 million Sm^3. Troll East was officially opened on 19 June 1996, and has been the largest producing gas field since September. Its estimated lifetime is about 50 years, and it has the capacity to produce more gas than the quantity for which sales contracts have already been signed. Production in the Frigg areas rose by 8.7 per cent from 1995 to 1996. However, production on the main field, Frigg, is expected to cease in 1997.

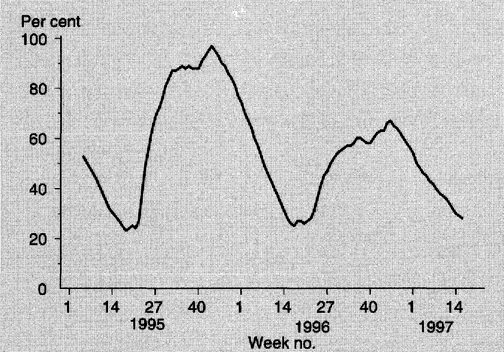
Electricity

Electricity production in Norway in 1996 totalled 104.8 TWh, which was 15 per cent

[1] Wet gas or NGL (Natural Gas Liquids) is often split into the following fractions: Etane (C2), Propane (C3), Butanes (C4) and condensates (C5+). Butane and propane are known as LPG (Liquefied Petroleum Gas).

Water levels in reservoirs

As a result of climatic conditions in Norway, electricity consumption is high in winter and inflow to the reservoirs takes place mainly in summer and autumn. The degree of filling of the reservoirs therefore varies greatly during the year. It may also vary widely from one year to another because of fluctuations in precipitation and temperatures. Variation in annual electricity production can therefore be substantial (despite the large capacity of dry-year reservoirs). However, by importing or exporting electricity it is possible to reduce the effect of natural fluctuations in Norwegian electricity production on electricity prices and consumption in the country.



Source: Statistics Norway

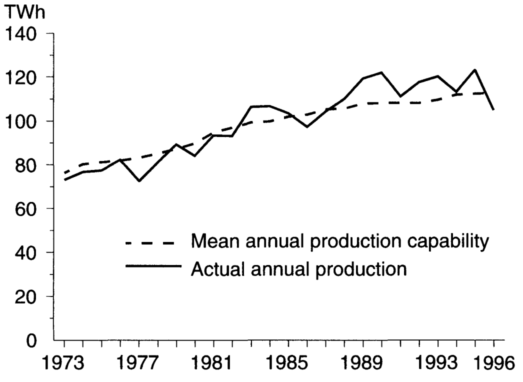
Conditions have been extreme in the last two years. In 1995, precipitation was high and there were floods in many river systems, whereas 1996 was a very dry year. There was little snow in the mountains in winter 1995-1996, and as a result inflow to the reservoirs was low, probably lower than in any year since 1931. The extreme variation in precipitation has resulted in wide variations in prices, major changes in domestic production, exports and imports, and in wider variations than normal in water levels in the reservoirs.

The figure shows the degree of filling of the reservoirs on a weekly basis since the beginning of 1995.

lower than the year before (table A7 in Part III), and the lowest level of electricity production since 1987. Production was particularly low in the latter half of the year, when it was 28 per cent below the 1995 level. This development is explained by the fact that there was unusually little snow in the mountains in 1996. Low production resulted in higher electricity prices and a substantial increase in electricity import. The total import was 13.2 TWh last year, which is the highest figure ever recorded and almost six times the 1995 level. A total of 4.2 TWh was exported in 1996, mainly at the beginning of the year when the degree of filling of the reservoirs was normal.

The rise in electricity prices last year resulted in greater interest in the construction of power plants. The number of applications for construction and operating licences submitted to the Norwegian Water Resources and Energy Administration more than doubled from the year before. Interest in small power plants with an installed capacity of less than 1 MW has been particularly strong. These are generally private power plants run by farms, industrial enterprises,

Figure 1.6. **Mean annual production capability and actual hydropower production in Norway**



Source: Norwegian Water Resources and Energy Administration

etc., and are in many cases linked to larger energy utilities.

Biofuel
Wood, wood waste and black liquor are the three most important biofuels in Norway. Production of these fuels, including production for own use, is more than 40 PJ per year. This figure is uncertain because the data are incomplete. In 1995, energy equivalent to about 4.7 PJ was generated for district heating by waste incineration, and about 90 per cent of this may be classified as bioenergy. Methane emissions from landfills totalled 322 000 tonnes (about 16 PJ) in 1995. This figure is much higher than previously calculated, mainly because better information is now available. In recent years, more and more of this gas has been used for energy purposes or flared. In 1995, 13 000 tonnes (0.7 PJ) was extracted for these purposes. Despite this, methane emissions have risen as the amount of waste deposited on landfills has grown. Methane emissions in Norway rose by 9 per cent from 1989 to 1995. Only a small proportion of the methane originates from fossil sources such as plastics and other oil-based products.

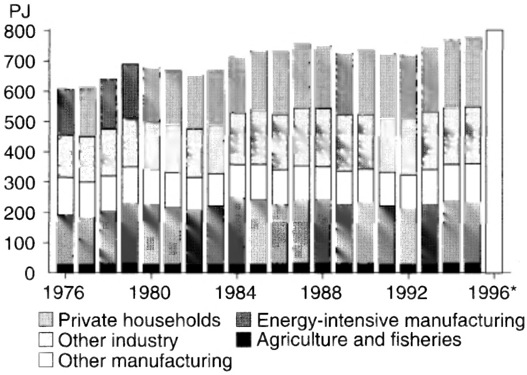
Coal
Net coal production on Svalbard in 1996 was somewhat lower than the year before, and was equivalent to about 6.5 PJ. World coal production in 1995 was more than 4.5 billion tonnes, equivalent to about 96 EJ. The largest producers were China and the USA, which accounted for 29 and 25 per cent of the total respectively. Europe excluding the former Soviet Union accounted for 19 per cent of the total, and more than half of this was produced in Germany and Poland.

1.3 Energy use

Consumption of energy commodities in Norway, excluding the energy sectors and international maritime transport, totalled 778 PJ in 1995 and 804 PJ in 1996 (preliminary figures), which gives an increase of 3.2 per cent from 1995 to 1996 (figure 1.7 and table A5 in Part III). Energy use rose by an average of 1.1 per cent per year from 1980 to 1996. In the same period, GDP rose by an average of 2.7 per cent per year.

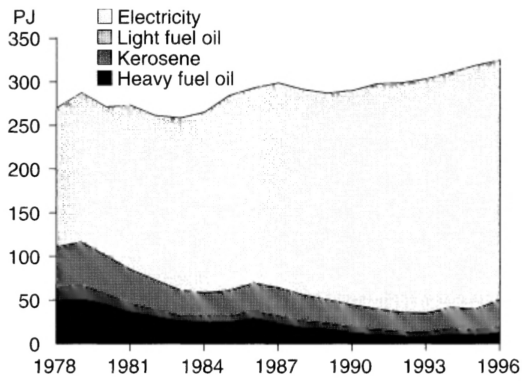
Energy use in oil and gas extraction
In 1996, net energy use in the energy sectors (sectors which produce primary and secondary energy carriers) accounted for about 19 per cent of Norway's total energy use, excluding international maritime transport. Energy use in the energy sectors has risen from 34 PJ in 1976 to 193 PJ in 1996 (preliminary figures). The use of natural gas in the extraction of crude oil and natural gas accounted for 12 PJ of this in 1976 and 146 PJ in 1996 (see table A6 in Part III). In 1996, 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

Figure 1.7. **Domestic energy use by consumer group**



Source: Statistics Norway

Figure 1.8. **Electricity consumption (excluding power-intensive manufacturing) and sales of fuel oils and kerosene as utilized energy**



Source: Statistics Norway

gas produced has been reduced in the same period.

Electricity consumption

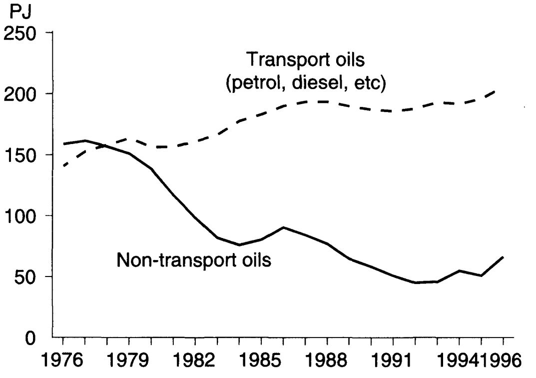
Net domestic consumption was 104.6 TWh in 1996, 1 per cent lower than the year before (see table A7 in Part III). General consumption (net domestic consumption except spot power for electric boilers and consumption by power-intensive manufacturing) in 1996 totalled 72.9 TWh (262 PJ), a rise of 1.7 per cent from the year before. However, if consumption is corrected for temperature, we find a decrease of 0.3 per cent. Until the end of July 1996, general consumption rose slightly, but from August onwards it was substantially lower than in the same period in 1995. This should be seen in relation to the rise in electricity prices. The price rise probably encouraged some energy savings through reduced use of electrical equipment, but there was also a changeover to the use of other energy carriers such as oil and coal. About three of four households can switch between two or more energy carriers. Sales statistics for petroleum products show that there was a steep rise in sales of fuel oils in the last few months of 1996.

Electricity consumption in power-intensive manufacturing was 28.4 TWh in 1996, a rise of about 1 per cent from the year before. Consumption rose most in the manufacture of aluminium and other metals, as a result of an increase in production in this sector. Consumption of spot power in electric boilers was low throughout 1996, and dropped by 45 per cent from the year before, because the high spot prices for electricity made it more economical to switch to using oil. Consumption of spot power in the pulp and paper industry dropped by about 80 per cent in 1996. At the same time, production dropped by about 7 per cent.

Oil consumption

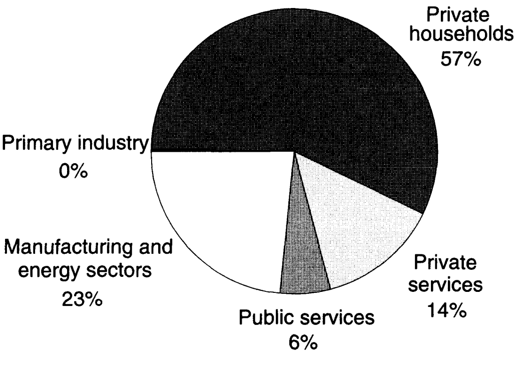
Total oil consumption, excluding international maritime transport, has dropped by about 9 per cent (preliminary figure) from 1976 to 1996, despite the fact that oil consumption for transport has risen by 46 per cent (figure 1.9). Transport now accounts for 76 per cent of total oil consumption, as compared 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 con-

Figure 1.9. **Consumption of oil products**



Sources: Statistics Norway and Norwegian Petroleum Institute

Figure 1.10. **Energy use for stationary combustion in Oslo by branch of industry, 1994**



Source: Statistics Norway

sumption of heavy fuel oil. Since 1975, the consumption of transport oils has risen by an average of 1.9 per cent per year, while passenger and goods transport (measured as passenger-km and tonne-km) have risen by 2.1 per cent and 1.0 per cent per year, respectively (see Chapter 2).

The consumption of oil for stationary purposes dropped by more than two-thirds from 1976 to 1992, but has risen again since. From 1995 to 1996, consumption rose by 27 per cent (preliminary figures). This is partly a result of greater use of oil in the boiler market, but there has also been a changeover from electricity to oil in private households and other branches of industry. The main reason for this is the rise in electricity prices (see section 1.4).

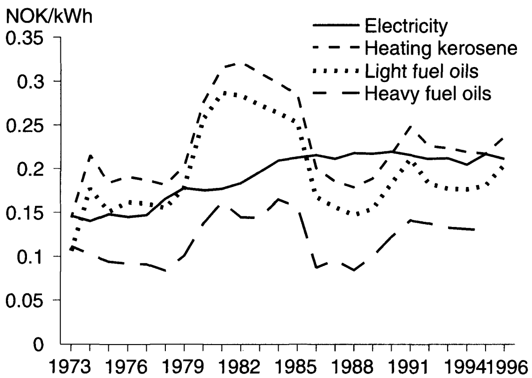
Energy use in the municipalities
Statistics Norway calculates the annual consumption of fossil fuels and biofuels for energy purposes in the municipalities. The figures are split by energy commodity and branch of industry. As an example of this, figure 1.10 and table A9 in Part III show energy use (theoretical energy content) in Oslo municipality in 1994.

World energy use
In 1994, Norway accounted for 0.28 per cent of total world energy use (table A10 in Part III), and the OECD countries for 55 per cent. Per capita energy use in Norway is higher than the average for the OECD countries, but lower than in countries such as Sweden and Finland. Energy intensity in Norway, measured as energy used per unit of GDP, is now about two-thirds of 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.

1.4 Energy prices

Since the end of May 1996 (week 22), the degree of filling of the reservoirs has been below the minimum level for the ten-year period 1982-1991. This, combined with uncertainty about future power supplies, resulted in very high spot prices in 1996 compared with the year before. The average price was NOK 0.252 per kWh, more than twice the average spot price in 1995. How-

Figure 1.11. **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

ever, if the figures are adjusted for the general rise in prices, we find that the spot price was almost as high in 1985. The spot price reached a peak in August-September 1996, when the degree of filling of the reservoirs was very low compared with the normal level for the time of year. During the autumn, many energy utilities raised their prices by up to 80 per cent because of the high spot prices and the situation in the power market. However, high precipitation in October, continued high import levels and a reduction in electricity consumption helped to reduce both spot and futures prices towards the end of the year. The price consumers pay for electricity is made up of a charge for the electricity used, a charge for use of the grid and the electricity tax, all of which are subject to VAT. The total average price for private households (based on an average annual consumption of 10 000 kWh) was NOK 0.59 per kWh on 1 January 1997, about 20 per cent higher than on 1 January 1996 (for energy prices in earlier years, see table A8 in Part III). The average electricity charge rose by almost 40 per cent. The electricity tax was raised from NOK 0.053 to NOK 0.0562 per kWh from 1 January 1997.

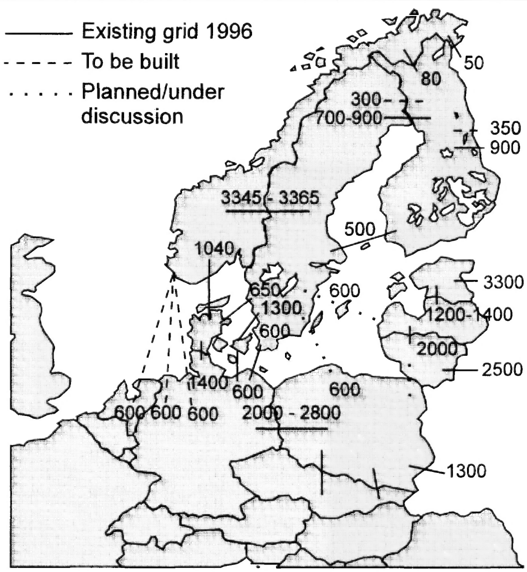
The average listed price of fuel oil in 1996 was NOK 3.4 per litre including VAT, or about NOK 0.49 per kWh. This is a rise of about 15 per cent from the year before. The listed price of heating kerosene was NOK 4 per litre, equivalent to about NOK 0.56 per kWh, which is a rise of about 10 per cent from the year before. The price rise is partly related to the rise in crude oil prices.

1.5 The power market

The volume of trade on the power exchange has grown rapidly since Swedish participants were given access on 8 January last year. Average sales per week in 1996 were 775 GWh, compared with 384 GWh the year before. At the end of 1996, the volume of trade on the power exchange was more than 1 000 GWh per week.

As a result of deregulation of the national power markets, liberalization of foreign trade, growing integration in Europe and new transmission lines between Norway and other countries, developments in the Norwegian power market are becoming more and more strongly influenced by developments in neighbouring countries. Technological progress has made it possible to construct long submarine cables. Power producers in the Nordic countries have shown great interest in the electricity markets on the continent. It has been decided to build two new cables from Norway to Germany and one to the Netherlands in the next few years. Total transmission capacity between some Northern European countries is shown in figure 1.12.

Figure 1.12. **Existing and planned transmission lines in Northern Europe, and their capacity in MW[1]**

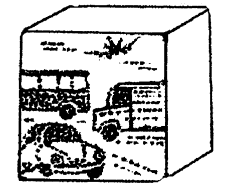


[1] National grid limitations mean that exchange capacity, for instance between Norway and Sweden, is in practice lower than installed capacity.

Source: Nutek (1995)

More information may be obtained from:
Lisbet Høgset, Bodil Merethe Larsen and Trond Sandmo

2. Transport and the environment



The volume of passenger and goods transport has risen with economic growth. During the past 50 years, passenger transport has risen eleven-fold, and in 1996 every Norwegian travelled an average distance of more than 34 km per day. Private cars account for 86 per cent of passenger transport. Road traffic is the most important cause of exposure to pollution for the Norwegian population.

Energy use and emissions to air per passenger-kilometre or tonne-kilometre vary widely from one mode of transport to another. Energy consumption and thus emissions are highest per unit of transport work for local coastal services, while railways and larger vessels are the most energy-efficient modes of transport.

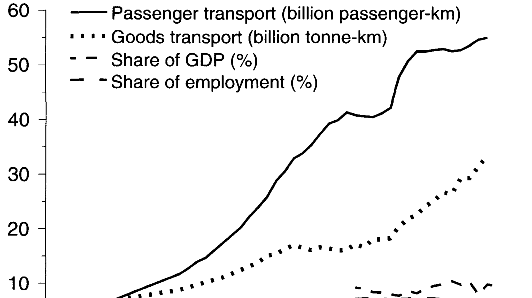
2.1 Introduction

The volume of transport work has grown steeply in recent decades. Since 1946, passenger transport has risen eleven-fold and goods transport eightfold. Since 1980, transport industries have accounted for a total of about 8-10 per cent of gross domestic product (GDP) and employment. Ocean transport accounts for the largest proportion of GDP, but much of this takes place outside Norway's borders. In 1995, current expenditure by the public administration for transport purposes was about NOK 24 billion.

2.2 Transport networks and vehicles

At the end of 1995, the total length of public roads and streets in Norway was 90 000 km, or 279 m road per km^2. These roads occupy about 0.2 per cent of the total area of the country (500 km^2), or about the same area

Figure 2.1. **Total domestic passenger and goods transport. Transport industries'[1] share of GDP and employment**



[1] Including post and telecommunications and ocean transport. Excluding transport on own account (which constitutes 80 per cent of passenger transport).

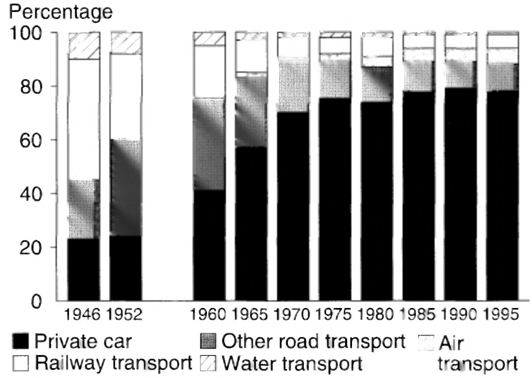
Sources: Statistics Norway and Institute of Transport Economics (1996)

Table 2.1. **Length of public roads in metres as of 1 January**

	Per motor vehicle	Per km² of Norway's total area
1945	452	136
1950	309	138
1955	170	146
1960	97	158
1965	80	203
1970	65	223
1975	58	238
1980	48	252
1985	40	265
1990	38	275
1995	36	279

Sources: Statistics Norway and Directorate of Public Roads

Figure 2.2. **Domestic passenger transport work by mode of transport**



Sources: Statistics Norway and Institute of Transport Economics (1996)

as the municipality of Oslo. The figures include the hard shoulder, but not embankments, ditches, noise zones, etc. National highways accounted for 29 per cent of the total, county roads for 30 per cent and municipal roads for 41 per cent. In addition, Norway has 45 000 km year-round forestry roads and 51 500 km winter roads and tractor roads.

The total length of public roads has risen by 1.4 per cent per year since 1945, while the number of motor vehicles has risen by 6.7 per cent per year. The length of road per vehicle has therefore dropped substantially, from 452 m public road per vehicle in 1945 to only 36 m in 1995 (table 2.1). As of 1 January 1996, car density was highest in Oslo and Akershus, where 12 m public road was available per motor vehicle, and lowest in Sogn og Fjordane, where there was 100 m per vehicle.

The total length of the railway network is slightly more than 4 000 km, and this figure has changed very little during the past 50 years. In 1945-1946, only 17 per cent of the lines were electrified, as compared with about 60 per cent today.

2.3 Passenger transport

Structure and development

In 1995, passenger transport totalled 55 billion passenger-km, as compared with about 4.5 billion passenger-km in 1946 (figure 2.1). The most important trends in passenger transport have been the steep growth in the transport by car and aircraft. In comparison, there has been relatively little change in the use of other modes of transport (figure 2.2 and table B1 in Part III). Since the early 1960s, private cars have been the dominant mode of transport, measured in passenger-km. Private cars are the dominant mode of transport for short and medium-length journeys, whereas rail and air transport are most important for longer journeys.

In 1946, private cars accounted for about 1 billion passenger-km, or about 23 per cent of total passenger transport work. This proportion continued to rise until the mid-1970s, and since then has remained between 75 and 78 per cent.

Total passenger transport, measured as passenger-km, rose by an average of 5.2 per cent per year from 1946 to 1995, while trans-

Table 2.2. **Number of passenger-km per person per day**

	Total	Private car	Other road traffic	Aircraft	Railway[1]	Shipping
1946	4.06	0.93	0.88	0.00	1.84	0.40
1952	5.42	1.32	1.92	0.01	1.76	0.42
1960	8.86	3.62	3.03	0.07	1.72	0.43
1965	12.87	7.44	3.30	0.21	1.50	0.42
1970	18.14	12.49	3.41	0.44	1.36	0.44
1975	24.18	18.02	3.45	0.70	1.56	0.45
1980	27.20	20.34	3.60	0.99	1.84	0.44
1985	31.09	24.06	3.53	1.40	1.67	0.42
1990	34.47	27.21	3.52	1.74	1.59	0.41
1995	34.23	26.38	3.58	2.22	1.67	0.38

[1] Including suburban railways and trams.
Sources: Statistics Norway and Institute of Transport Economics (1996)

port by private car rose by an average of 7.8 per cent per year.

Air transport has shown the fastest relative growth. In 1995, this mode of transport accounted for 3.6 billion passenger-km, as compared with only 0.3 billion in 1965. Despite this, air transport still only accounts for about 6 per cent of total passenger transport measured as passenger-km.

In absolute figures, the use of other modes of public transport has remained relatively stable for the past 30 years. Their share of total passenger transport has therefore dropped steeply (figure 2.2 and table B1 in Part III). During the 1990s, rail transport measured in passenger-km has risen each year.

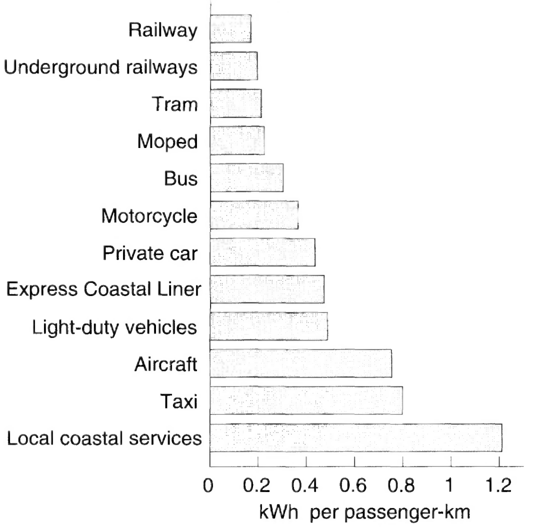
In 1995, each Norwegian travelled an average of more than 34 km per day, eight times more than in 1946 (table 2.2). However, we travelled more both by boat and by train in 1945 than in 1995.

Several factors influence the volume of transport and the distribution of transport between various modes of transport. For instance, there has been a clear relationship between the volume of transport and economic growth.

The use of private cars is strongly influenced by the location of housing and workplaces. In many cases, the existing public transport system does not meet people's daily needs. In 1990, 90 per cent of people in paid employment had the use of a car, as compared with 66 per cent of those who did not have paid employment. Changes in family structure are also important in explaining changes in car use. In 1990, 92 per cent of households consisting of more than one person and including children had the use of a car, while the corresponding figure for all households was 72 per cent. Another important factor is the growth in leisure time. A study of people's holiday activities (Vaage 1995) showed that in 1994, 60 per cent used cars as the most important mode of transport on holiday, while 25 per cent travelled by plane. Of the remaining 15 per cent, roughly equal proportions travelled by train, bus and ship/ferry.

The Institute of Transport Economics, in cooperation with the Ministry of Transport and Communications, has drawn up projections of traffic trends up to 2010 (Ministry of Transport and Communication 1996). It is calculated that the annual growth in total transport work will be substantially lower than the general growth in consumption for the whole period, irrespective of whether improvements in availability are incorporated into the projections. Improvements in availability include improvement and expansion of the road network, reduction of travel time by train and bus and an increase in the number of flights. Important factors explaining the projected reduction in traffic growth are a rise in the average age of the population, resulting in lower travel activity, and slower growth of the labour force. Growth rates are

Figure 2.3. **Energy use per passenger-km for various modes of transport, 1994**[1]



[1] 1993 figures for shipping
Source: Holtskog and Rypdal (1997)

expected to be lower for all modes of transport.

Energy use

Calculations of energy use per passenger-km for various modes of transport showed that in 1993-1994, energy use was lowest for electrified railways. Local coastal services and ferries had the poorest results, i.e. the highest energy use per passenger-km. Energy use per passenger-km for transport on own account by private car was close to the average value. Figure 2.3 shows energy use for the commonest modes of transport.

Emissions to air

The transport sector has negative impacts in the form of pollution, noise and interference with the landscape. According to the surveys of levels of living, road traffic is the main cause of exposure to pollution (Statistics Norway 1996c). However, the number of

Calculation of energy use and emissions to air from different modes of transport

Definitions

One passenger-km = one person transported one kilometre

One tonne-km = one tonne transported one kilometre

Method

Energy use by the different modes of transport is calculated "top-down" by dividing the figure for total energy use by that for total transport work. However, for road traffic, the figures used are based on calculated energy use per vehicle-km and total transport work.

The calculations are based on data for 1993 and 1994. There may be large variations both within and between the various modes of transport, for instance with respect to different regions of the country, the purpose of the transport, and the length of the average journey (compare e.g. trams and aircraft, urban buses and express coaches). Emissions and energy use therefore also depend on other factors than the properties of the mode of transport itself. This, together with the fact that it is not always possible to switch to another mode of transport, means that the figures are not always directly comparable.

The calculations for emissions and energy use take into account actual utilization of capacity.

Indirect energy use, e.g. for construction and maintenance, is not included.

Emissions from electrically-powered modes of transport (trains, trams and underground railways) are regarded as emission-free.

Table 2.3. **Emissions from various modes of passenger transport, in g per passenger-km (CO_2 in kg per passenger-km), 1994**[1]

	SO_2	NO_x	NMVOCs	CH_4	CO	CO_2	N_2O	Particu-lates[3]
Private car	0.02	0.21	1.42	0.03	11.8	0.11	0.01	0.02
Taxi	0.08	0.68	0.21	0.01	1.82	0.21	0.02	0.09
Moped	0.01	0.05	6.93	0.11	13.2	0.06	0.00	0.00
Motorcycle	0.02	0.21	3.81	0.15	21.5	0.09	0.00	0.00
Railway (diesel)	0.03	1.10	0.09	0.00	0.26	0.07	0.00	0.09
Railway (electric)	-	-	-	-	-	-	-	-
Tram and underground railway	-	-	-	-	-	-	-	-
Aircraft	0.02	0.57	0.09	0.01	0.49	0.20	0.01	0.03
Express coastal liner	0.17	2.75	0.11	0.01	0.12	0.13	0.00	0.02
Local coastal services	0.47	13.9	0.54	0.05	0.59	0.63	0.02	0.10

[1] 1993 figures for shipping

[2] Emissions of particulates include emissions from combustion only; emissions from tyre wear etc are not included.

Source: Holtskog and Rypdal (1997)

people exposed to pollution has decreased somewhat since 1983, despite the growth in traffic.

As regards emissions to air, road traffic is responsible for the largest emissions of CO and NMVOCs per passenger-km, while local coastal services and ferries are responsible for the largest emissions of NO_x, in relation to both transport work and fuel consumption. Table 2.3 shows emissions per passenger-km for the most important modes of transport in Norway. The adverse effects of emissions to air are described in Chapter 3, page 40.

If we convert emissions of greenhouse gases (CO_2, CH_4 and N_2O) to CO_2 equivalents, we find that the largest emissions are generated by local coastal services, followed by taxis and aircraft. The lowest emissions of this type are from diesel trains, buses and coaches, and mopeds (electrically-powered modes of transport are regarded as emission-free).

2.4 Goods transport

Structure and development

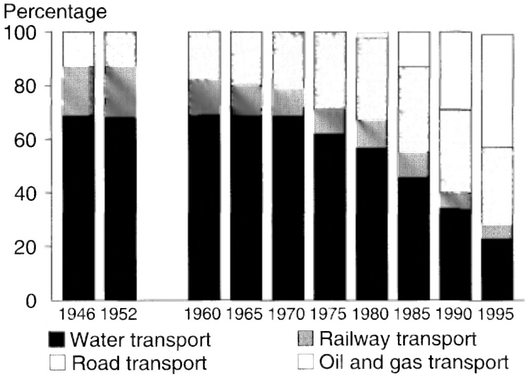
In 1995, goods transport totalled 33.5 billion tonne-km, as compared with 4.1 billion in 1946 (figure 2.1 and table B2 in Part III). The most important trend since 1965, measured in absolute figures, has been the lack of growth in railway and maritime transport and the steep growth in road transport and oil and gas transport. In 1994, the volume of road transport was larger than that of maritime transport for the first time.

Transport of oil and gas from the Norwegian continental shelf to the mainland began in about 1980, and accounted for 41 per cent of total transport work by 1995 (figure 2.4 and table B2 in Part III).

Energy use

Energy use per tonne-km is highest for goods transport by local coastal services, aircraft and light-duty vehicles. The most energy-efficient modes of goods transport in 1994 were tankers and combined carriers, dry cargo vessels, rail transport and lorries. The figures for shipping and lorries are average figures for the entire stock of these modes of transport. There is a wide range of sizes within both these categories, and in general energy use per tonne-km is inversely proportional to carrying capacity.

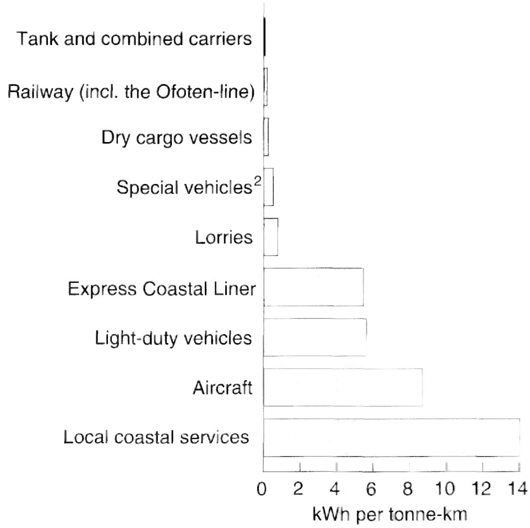
Figure 2.4. **Domestic[1] goods transport by mode of transport**



[1] Including the continental shelf

Sources: Statistics Norway and Institute of Transport Economics (1996)

Figure 2.5. **Energy use per tonne-km for various modes of goods transport, 1994[1]**



[1] 1993 figures for shipping

[2] Special vehicles include tankers, tractors for semi-trailers, lorries with concrete mixers, light-duty vehicles (carrying capacity over 1.5 tonnes), refrigerator vehicles, etc.

Source: Holtskog and Rypdal (1997)

Emissions to air

Emissions of SO_2, NO_x, CH_4 and CO_2 per tonne-km are highest from local coastal services. Light-duty vehicles are responsible for the highest emissions of NMVOCs and CO.

If we convert emissions of greenhouse gases to CO_2 equivalents, we find that the largest emissions per tonne-km are generated by local coastal services, followed by aircraft and light-duty vehicles. Lorries, diesel trains and cargo vessels generate the lowest emissions.

More information may be obtained from Per Kristian Alnes, Sigurd Holtskog and Kristin Rypdal

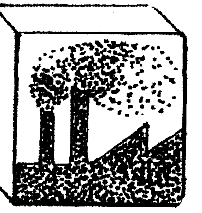
Table 2.4. **Emissions for various modes of goods transport, in g per tonne-km (CO_2 in kg per tonne-km, 1994[1]**

	SO_2	NO_x	NMVOCs	CH_4	CO	CO_2	N_2O	Particu- lates
Railway (diesel)	0.04	1.20	0.10	0.00	0.28	0.08	0.01	0.10
Plane	0.26	6.62	1.01	0.07	5.62	2.29	0.15	0.29
Light-duty vehicles	0.52	9.14	8.74	0.21	65.0	1.47	0.08	1.69
Lorries	0.09	2.43	0.31	0.00	1.15	0.20	0.03	0.19
Special vehicles	0.06	1.62	0.21	0.00	0.77	0.13	0.02	0.13
Express Coastal Liner	1.87	30.5	1.20	0.10	1.30	1.38	0.03	0.21
Local coastal services	5.44	160.0	6.30	0.52	6.86	7.27	0.19	1.16
Cargo vessels	0.11	1.05	0.03	0.00	0.03	0.05	0.00	0.01

[1] 1993 figures for shipping

Source: Holtskog and Rypdal (1997)

3. Air



Emissions of the greenhouse gas CO_2 rose by over 7 per cent from 1995 to 1996, and have risen by 15 per cent since 1989. Emissions of NO_x rose by 3 per cent from 1995 to 1996 and are now at the same level as in 1989. Emissions of non-methane volatile organic compounds (NMVOCs) rose by 35 per cent from 1989 to 1996, but did not rise from 1995 to 1996. Emissions of SO_2 were reduced by 75 per cent from 1980 to 1995, and total emissions in 1995 were 34 620 tonnes. Emissions of the environmentally hazardous substances lead (Pb) and cadmium (Cd) dropped by 97 and 43 per cent respectively in 1989-1996 and 1991-1996.

Emissions of pollutants to air may have local, regional or global effects. *Local* effects are seen in limited areas where emissions are high, e.g. towns and built-up areas, and the impact of emissions on human health is of particular importance here. 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 the next page summarizes the adverse effects of various air pollutants.

3.1 Trends in national emissions

Emissions of the greenhouse gas carbon dioxide (CO_2) are rising, and according to preliminary figures, totalled 40.7 million tonnes in 1996. This is markedly higher than in 1989 and 1990 (figure 3.1 and table C1 in Part III). Emissions were somewhat lower in the intervening years, but there was nevertheless an overall rise of 15 per cent from 1989 to 1996.

Norway's national goal has been to stabilize emissions at the 1989 level by 2000. However, this goal is no longer specified in the Government's Long-term Programme for 1998-2001 (Report No. 4 (1996-97) to the Storting), which was presented on 7 March 1997. The report describes a baseline alternative which is based on the assumption that a binding international climate agreement will be adopted with the aim of stabilizing global emissions of CO_2 at the 1990 level by 2010. Furthermore, it is assumed that from 2010 onwards, all CO_2 emissions in all countries will be subject to a tax corresponding to NOK 360 per tonne CO_2, which will be imposed in addition to existing taxes. This is about the same as Norway's current CO_2 tax on petrol. Given these assumptions, it is calculated that Norwegian CO_2 emissions will rise by 27 per cent from 1990 to 2010.

The Government considers it important for Norway to take its share of the responsibility for the problem of climate change within the framework of cost-effective international

Harmful effects of air pollutants

Component	Symbol	Effects
Ammonia	NH_3	Contributes to acidification of water and soils
Lead	Pb	Environmentally hazardous. No damage to health at concentrations currently found in air in Norway, but because lead accumulates in living organisms, formerly high emissions still constitute a health hazard
Non-methane volatile organic compounds	NMVOC	May include carcinogenic substances. Contribute to O_3 formation
Carbon dioxide	CO_2	Enhances the greenhouse effect
Carbon monoxide	CO	Increases risk of heart problems in people with cardio-vascular diseases
Nitrous oxide	N_2O	Enhances the greenhouse effect
Methane	CH_4	Enhances the greenhouse effect and contributes to O_3 formation
Nitrogen oxides	NO_x	Cause respiratory disease (particularly NO_2). Maximum concentrations recommended in Norwegian air quality guidelines (NO_2) are 75 µg per m^3 (24 hour-mean) and 50 µg per m^3 (six-monthly mean). Contribute to acidification, corrosion and O_3 formation.
Tropospheric ozone	O_3	Causes respiratory complaints and vegetation damage. Recommended threshold value set by World Health Organization (WHO) is 120 µg per m^3 (8-hour mean)
Particulate matter	$PM_{2.5}$ and PM_{10}	Increase risk of respiratory complaints, together with other components. Maximum concentrations recommended in Norwegian air quality guidelines are 70 µg per m^3 (PM_{10}) 24-hour mean and 30/40 µg per m^3 ($PM_{2.5}$/PM_{10}) six-monthly mean
Sulphur dioxide	SO_2	With other components, increases the risk of respiratory disease. Acidifies soil and water and causes corrosion. Recommended threshold values set by World Health Organization (WHO) are 125 µg per m^3 (24-hour mean) and 50 µg per m^3 (annual mean)

Sources: NILU (1996b and 1996c) and Norwegian Pollution Control Authority

agreements with flexible mechanisms for implementation. In 1997, a report on employment and the environment will be submitted to the Storting, which will also include a further evaluation of the Norwegian system of CO_2 taxes. The most important sources of CO_2 emissions in Norway are oil and gas pro-

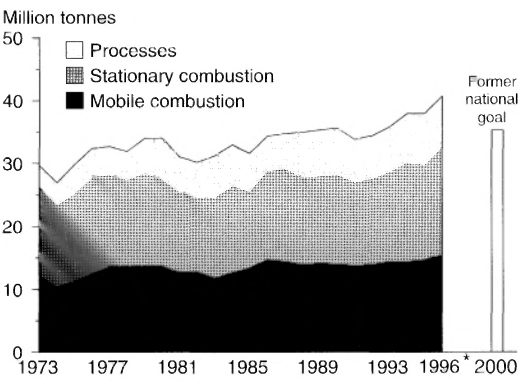
International environmental agreements

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

Protocols Norway has signed:

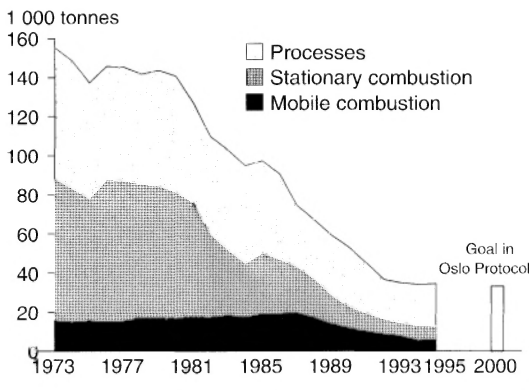
Sofia	Stabilization of NO_x emissions at the 1987 level by 1994.
Montreal	Eliminate consumption of ozone-depleting substances. In Norway, this applies only to imports, since the country does not manufacture such substances. Most substances have already been phased out, and the rest (HCFCs and methyl bromide) will be phased out in the next 15-30 years.
Geneva	30 per cent reduction of NMVOC emissions by 1994 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. This is the first protocol in which the costs of cutting emissions, calculations of dispersion and critical loads have been important in determining goals.

Figure 3.1. **Emissions of CO_2 by source**



Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 3.2. **Emissions of SO_2 by source**

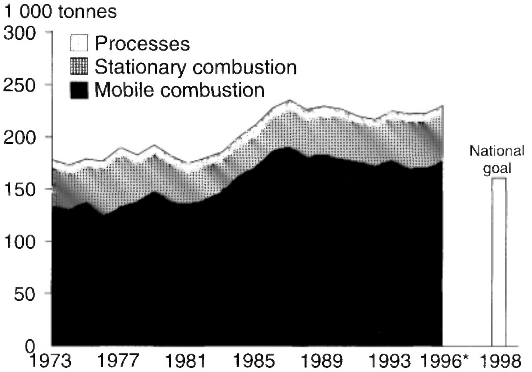


Sources: Statistics Norway and Norwegian Pollution Control Authority

duction (20 per cent) and road traffic (21 per cent).

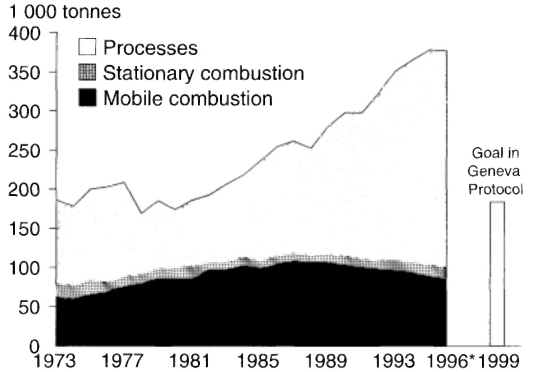
Norwegian emissions of sulphur dioxide (SO_2) were reduced by 78 per cent from 1973 to 1995 (figure 3.2), and by 75 per cent from 1980 to 1995. Both the goal set out in the Helsinki Protocol (30 per cent reduction from 1980 to 1993) and Norway's national goal (50 per cent reduction from 1980 to 1993) 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 under-

Figure 3.3. **Emissions of NO_x by source**



Sources: Statistics Norway and Norwegian Pollution Control Authority

Figure 3.4. **Emissions of NMVOCs by source**



Sources: Statistics Norway and Norwegian Pollution Control Authority

taken 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 64 per cent of Norway's SO_2 emissions in 1995 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. Norway currently uses taxes as an instrument for the reduction of SO_2 emissions. These are imposed on oil products and are as a general rule paid by the consumer.

Emissions of nitrogen oxides (NO_x) are generated mainly by shipping, road traffic and oil and gas extraction. The growth in the use of private cars resulted in a steep rise in NO_x emissions until 1987 (figure 3.3). However, from 1989 to 1996, there was no change in emissions (see table C2 in Part III). Emissions from petrol-driven cars were reduced by 33 per cent from 1989 to 1996. The main causes of the drop were lower petrol consumption by newer cars and an increase in the percentage of cars with three-way catalytic converters. The percentage rise in emissions from oil and gas extraction was about the same. 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. In 1996, emissions were barely 1 per cent higher than in 1989.

Emissions of non-methane volatile organic compounds (NMVOCs) have risen steeply since the late 1970s (figure 3.4). The most important sources in Norway are evaporation during loading of crude oil (53 per cent) and emissions from petrol engines and petrol distribution (17 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 petrol-driven cars. 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 1996 show that emissions have risen by 35 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, particularly since the amount of crude oil shipped will probably rise in the years ahead. The rising proportion of new cars with petrol engines designed to meet stricter emissions standards, together with measures to reduce evaporation of petrol, may help to reduce NMVOC emissions.

Emissions of methane (CH_4) rose by 10 per cent from 1989 to 1996, while emissions of nitrous oxide (N_2O) dropped by 7 per cent from 1989 to 1995. The most important sources of methane are biodegradation of waste (68 per cent) and domestic animals and manure (21 per cent). The dominant sources of N_2O emissions are fertilizer production, use of fertilizer and domestic animals. However, there is a large degree of uncertainty in estimates of emissions of these components.

Emissions of ammonia (NH_3) rose by 14 per cent from 1989 to 1996. Ammonia emissions

Emissions from gas-fired power plants

On 26 April 1996, the Council of State adopted the recommendation of the Ministry of Industry and Energy on gas-fired power plants in Norway. This meant that licences were granted for the construction of two such power plants, one at Kollsnes in Hordaland and one at Kårstø in Rogaland. The company Naturkraft AS, which applied for the licences, is owned by Norsk Hydro, Statkraft and Statoil. Each of the two plants will have an installed capacity of 350 MW and a production capacity of about 2.8 TWh per year. The Kårstø plant is expected to be completed in 1999 and the Kollsnes plant in 2000. The Government wishes power from Norwegian gas to be an alternative to coal, oil and nuclear power in the Nordic countries.

These power plants will increase Norway's total CO_2 emissions by about 2 million tonnes per year. However, the Government assumes that they will to some extent replace coal-fired power plants, so that in the Nordic region as a whole, there will be benefits in the form of emissions reductions. CO_2 emissions from the two new power plants will not be made subject to the CO_2 tax for the present. This is to avoid giving a competitive advantage to coal-fired power plants in Denmark, which are currently not subject to such a tax. Table below shows comparative figures from the Ministry of Industry and Energy for the efficiency of gas- and coal-fired power plants.

Efficiency[1] of gas- and coal-fired power plants and emission per TWh produced

	Gas-fired power plants	Coal-fired power plants (older)	Coal-fired power plants (modern)
Efficiency[1] (percentage)	58	38	45
CO_2 (tonnes)	360 000	815 000	690 000
NO_x (tonnes)	240	500	400
SO_2 (tonnes)	0	900	500

[1] Efficiency is a measure of the proportion of the energy supplied e.g. in the form of coal or gas actually converted to electrical energy.
Source: Ministry of Industry and Energy (1996).

are generated mainly by domestic animals and the use of fertilizer and by treatment of straw with ammonia.

Carbon monoxide (CO) emissions rose from 1973 to the mid-1980s. However, there has been a marked drop since then. From 1989 to 1996, total emissions were reduced by 17 per cent. The proportion of the total generated by dwellings rose by 10 percentage points, and the proportion from petrol engines dropped by 11 percentage points. In 1996, these two sources accounted for 21 and 60 per cent of the total, respectively. The reduction in emissions since 1989 is mainly a result of improvements in technology and lower petrol consumption.

Emissions of particulate matter from combustion were considerably reduced from 1973 to 1983. This can be explained by the drop in the use of heavy fuel oil for heating. However, from 1989 to 1996 emissions from stationary combustion rose by 26 per cent. Emissions from wood firing in private households rose by 52 per cent in this period, and accounted for 65 per cent of total emissions in 1996. Emissions of particulate matter from processes (e.g. asphalt dust from the use of studded tyres) are not included in these figures.

In 1996, leaded petrol accounted for only 0.3 per cent of petrol sales. Lead pollution in air is now well below the level believed to cause injury to human health. Emissions of lead have been reduced by more than 99 per cent from 1973 to 1996. From 1989 to 1996, total emissions were reduced by 97 per cent. About 30 per cent of lead emissions originate from leaded petrol, and almost 60 per cent can be traced back to mobile combustion sources.

Emissions of cadmium dropped by 43 per cent from 1991 to 1996. Metal manufacturing accounted for the largest proportion of emissions in 1995. The reduction in emissions in this period was also largest in this sector (22 percentage points).

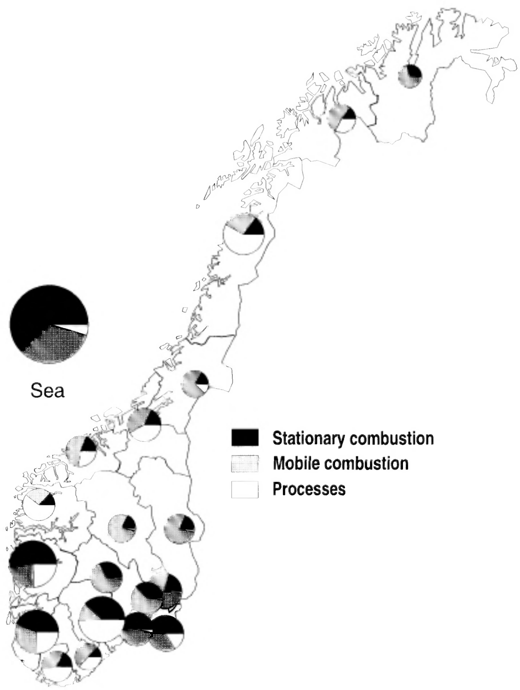
In the OECD countries, there has been a slight overall rise in CO_2 emissions during the period 1980-1992. CO_2 emissions per unit GDP (kg per USD 1 000) and per capita CO_2 emissions in Norway are lower than the average for all OECD countries (table C7 in Part III). This is mainly because hydroelectricity accounts for a large proportion of energy use in Norway. However, on a world basis, average per capita emissions are only half the Norwegian level. The conversion of energy from one form to another makes the largest overall contribution to CO_2 emissions in other countries. Per capita SO_2 emissions in Norway are lower than in most other countries, whereas per capita NO_x emissions are among the highest for OECD countries. 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.

3.2 Emissions by county

Hordaland and Telemark are the counties with the highest CO_2 emissions (figure 3.5). CO_2 emissions are also high in 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.

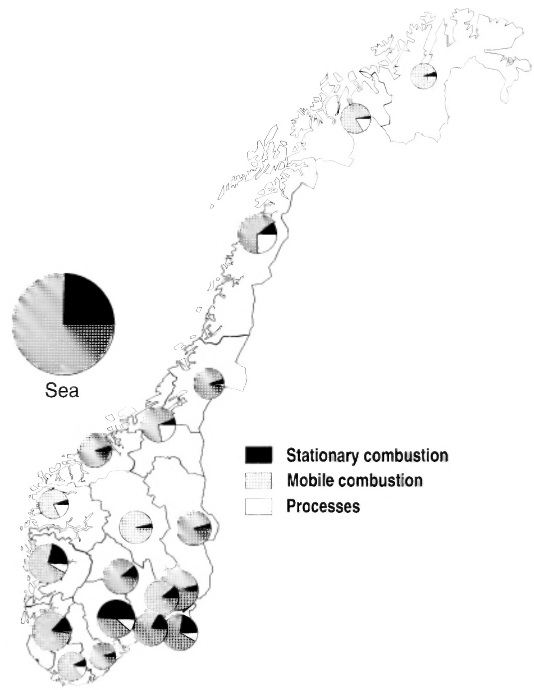
CH_4 and NH_3 emissions are highest in Rogaland, mainly because the county has large numbers of livestock and therefore large amounts of manure. On Svalbard, the coal mines are a major point source of CH_4

Figure 3.5. **CO_2 emissions in 1994 by source and county**



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

Figure 3.6. **NO_x emissions in 1994 by source and county**



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

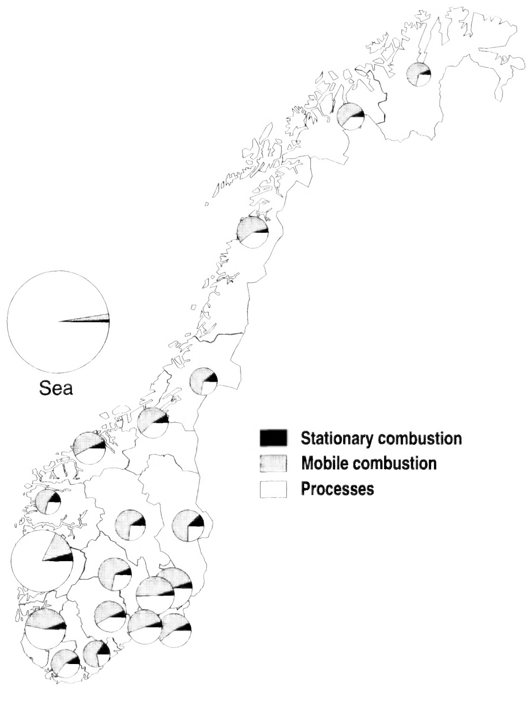
emissions. Process emissions from the manufacture of fertilizer in Telemark and Nordland account for about 40 per cent of the country's total emissions of N_2O.

Østfold, Nordland and Sør-Trøndelag account for the largest SO_2 emissions from the mainland (see table C7 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 3.6); in Akershus, where NO_x emissions are highest, 95 per cent of the total is generated by mobile sources. As a result of industrial emissions, Rogaland is also among the counties with the highest NO_x emissions.

Hordaland alone accounts for 25 per cent of total mainland emissions of NMVOCs (figure 3.7). The main sources are process emissions from loading of crude oil and oil refining.

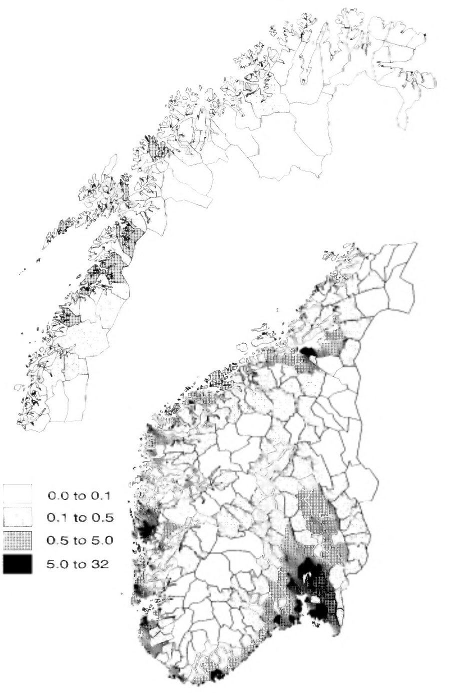
The main source of CO emissions is road traffic, and emissions are highest in Akershus. Emissions of particulate matter are highest in Hordaland, which is followed by Hedmark, Rogaland and Akershus. The main sources are wood-firing and road traffic. CO_2 emissions are high at sea, where one third of Norway's total emissions are gener-

Figure 3.7. **NMVOC emissions in 1994 by source and county**



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

Figure 3.8. **NO_x emissions by municipality in 1994. Tonnes per km^2**



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

ated (figure 3.5 and table C7 in Part III). 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.

3.3 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. 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 1995, the municipalities of Oslo, Bergen and Porsgrunn accounted for the largest NO_x emissions, and emissions exceeded 3 000 tonnes in all three towns. 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, Stavanger and Tønsberg (figure 3.8). As a general rule, emissions per km^2 are highest in munici-

Emissions to air by municipality

These figures include emissions to Norwegian territory from international maritime and air transport and foreign activities in Norway. These 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).

palities 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 Hemne; the main source of emissions in these municipalities was manufacturing industries. Per capita NO_x emissions are also high in certain municipalities with few inhabitants where there are national highways. Table C8 in Part III shows emissions to air by municipality.

The development of a new, modern system for monitoring air pollution in Norway started in autumn 1994. The measuring stations, which are in Oslo, Bergen, Trondheim, Drammen, Skien and Porsgrunn, register concentrations of nitrogen oxides (NO, NO_2 and NO_x) and particulate matter ($PM_{2.5}$ and PM_{10}). In winter 1994-1995, the six-monthly mean concentrations for these components recommended in air quality guidelines were not exceeded at any of the measuring stations.

For NO_2, the six-monthly mean value varied from 27 µg per m^3 in Porsgrunn and Trondheim to 47 µg per m^3 in Drammen. The recommended limit for the six-monthly mean for NO_2 is 50 µg per m^3. The highest hourly mean value, 203 µg per m^3, was measured in Bergen. At all stations, concentrations exceeding the recommended limit for the hourly mean of 100 µg per m^3 were measured, but the recommended limit for the 24-hour mean, 75 µg per m^3, was only exceeded in Oslo, Bergen and Drammen (NILU 1996b).

The lowest value for the six-monthly mean for particulate matter ($PM_{2.5}$) was 8 µg per m^3 and was measured in Trondheim and Bergen. The highest concentration, 15 µg per m^3, was measured in Porsgrunn, but this was nevertheless well within the national recommended limit, which is 30 µg per m^3 (NILU 1996b).

For particulate matter (PM_{10}), the six-monthly mean values varied between 14 µg per m^3 in Bergen and 28 µg per m^3 in Porsgrunn, but the concentrations were below the recommended limit of 40 µg per m^3 in all the towns. The highest 24-hour mean value, 141 µg per m^3, was measured in Trondheim. The recommended limit for the 24-hour mean is 70 µg per m^3, and this was exceeded at all measuring stations except for the station in Porsgrunn and one of the stations in Bergen (NILU 1996d).

The surveys of levels of living show that people are more exposed to pollution now than previously. If we compare the years 1980 and 1995, we find that the proportion of the population who consider themselves to be exposed to pollution from road traffic, industry, etc has risen by 4 per cent for the country as a whole. The largest rises in these figures are for Trøndelag and North Norway, where they are 10 and 7 per cent respectively. The lowest rise was in Eastern Norway (Statistics Norway 1982 and 1996d).

3.4 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 high in the United Kingdom, Eastern Europe and the former East Germany. A large proportion of European SO_2 emissions is generated by point sources, especially coal- and oil-fired power stations.

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. Freshwater 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 1995, sulphur deposition over Norway totalled 100 000 tonnes (see table C12 in Part III). This is eight times as much sulphur as Norway's total emissions. About 3 400 tonnes of the total originates from Norwegian emissions, and 5 500 tonnes from sea water and other natural sources. Other large sources in 1995 were the United Kingdom (about 16 500 tonnes), Germany (9 400 tonnes) and Eastern Europe, Russia and the Baltic states (17 200 tonnes). Of Norway's own sulphur emissions in 1995, a large proportion was deposited over the North Sea and North Atlantic, and some in Sweden and over Norwegian territory. From 1985 to 1995, sulphur deposition over Norway was reduced by about 40 per cent as a result of reductions in emissions in Europe (Barrett and Berge 1996).

Total deposition of oxidized and reduced nitrogen in 1995 was 118 000 tonnes (see tables C10 and C11 in Part III). Of this, 22 per cent originated from Norwegian emissions, and emissions from the United Kingdom and Germany together accounted for a further 24 per cent. 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. Tropospheric ozone 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. In 1995, pollution episodes totalling 15 days were registered[1], and the highest hourly mean

[1] Number of days when one measuring station records a maximum hourly mean concentration of 200 µg pr. m3 or several measuring stations record an hourly mean concentration of more than 120 µg pr. m3

value in the same year was 160 µg per m^3 (SFT 1996a).

3.5 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 during the spring months. 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.

The amount of UV radiation reaching the earth depends not only on the ozone layer, but also on cloud cover, reflection from the ground and how high the sun is in the sky. Thick cloud cover can reduce UV radiation by 90 per cent, whereas snow-covered ground can increase it by 40 per cent (as a result of reflection). UV radiation increases with the elevation of the sun above the horizon: thus, the level of radiation at Ny-Ålesund on Svalbard is lower than in Oslo under the same weather conditions.

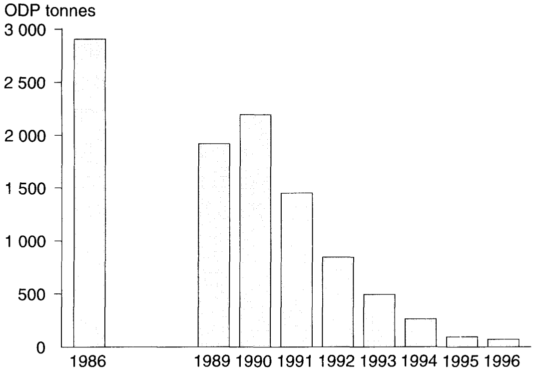
Satellite measurements of ozone above Oslo show that the total amount of ozone has been reduced by 0.4 per cent per year from 1979 to 1995 (NILU 1996a). The change is largest in spring, when the average annual reduction has been 0.7 per cent. All the measuring stations registered a drop in ozone concentrations compared with mean values for earlier years. The thickness of the ozone layer is measured daily in Oslo, Tromsø and Ny-Ålesund (Svalbard) by the Norwegian Institute for Air Research and the Universities of Oslo and Tromsø.

The consumption of ozone-depleting substances in Norway has dropped since the mid-1980s (figure 3.9). 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 deplete the ozone layer. For an overview of this and more details about the ozone layer and substances that deplete the ozone layer, see SSB/SFT/DN (1994) and Ministry of the Environment (1996).

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

Figure 3.9. **Imports of ozone-depleting substances to Norway**



Source: Norwegian Pollution Control Authority

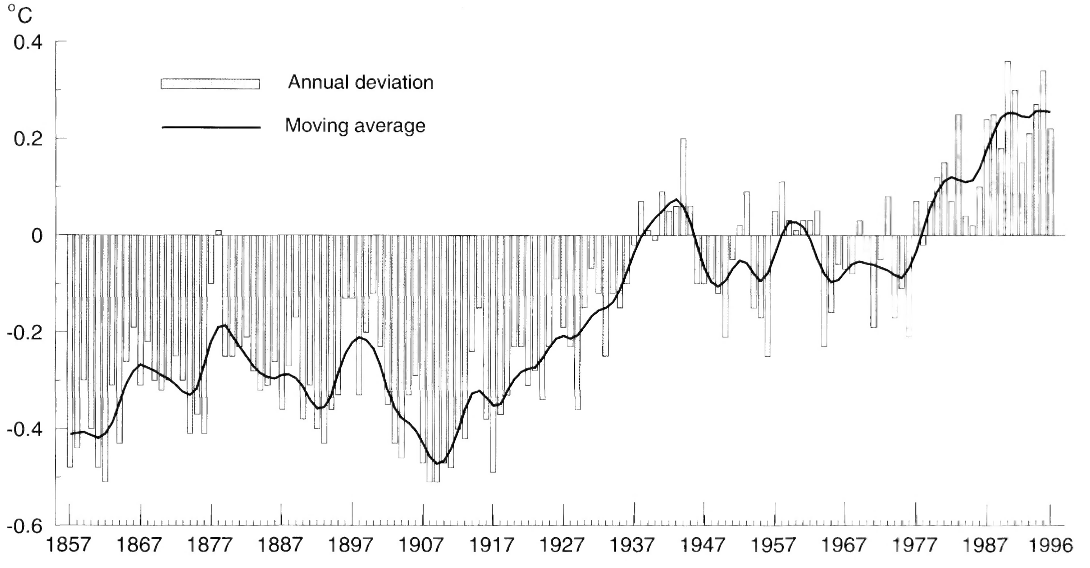
global mean temperature would be about -18 °C, not 15 °C as it is now. The heat balance of the atmosphere depends on its chemical composition. Anthropogenic emissions of the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorine-containing gases, as well as emissions of particulate matter (PM_{10}) from combustion, can alter the composition of the atmosphere more rapidly than natural processes. This in turn may accelerate changes in the global climate system. It is difficult to quantify what proportion of fluctuations in climate is a result of human activity, but data from the last hundred years suggest that the variations are too large to be due to natural fluctuations alone.

During the 1980s, the CO_2 concentration of the atmosphere rose by an average of 0.4 per cent per year, which is equivalent to about half the total anthropogenic emissions of CO_2. 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. From 1750 to 1994, the concentrations of the three most important greenhouse gases, CO_2, CH_4 and N_2O, rose by 30, 145 and 15 per cent respectively (IPCC 1996).

Some carbon accumulates in natural and anthropogenic sinks. Green plants assimilate carbon during photosynthesis, but this is released through combustion and decay. Carbon can also accumulate in soils and in sediments in lakes and the sea. In 1992, the estimated net sink was 15 million tonnes CO_2 per year, and 80 per cent of this was accounted for by the net increment in the standing volume of forests (Ministry of the Environment 1994). For more details, see Chapter 7. Anthropogenic sinks are discussed in Chapter 7.4 in Part II.

The global mean surface temperature has risen by between 0.3 and 0.6 °C during the past 100 years (figure 3.10). 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 0.34 °C higher than the average for 1961-1990 and 0.63 °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 1.0 - 3.5 °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 rise in sea level of 15-95 cm. This could have serious consequences for world agricultural production and for low-lying agricultural areas.

Figure 3.10. **Changes in global mean temperature compared with the normal value for 1961-1990**

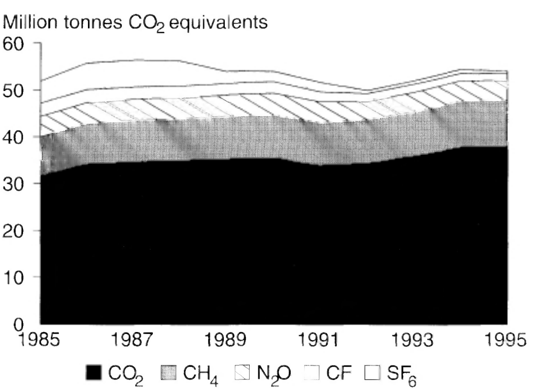


Sources: University of East Anglia and Norwegian Meteorological Institute

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 1995, emissions of greenhouse gases in Norway totalled 54.1 million tonnes CO_2 equivalents (see figure 3.11 and tables C1 and C3 in part III).

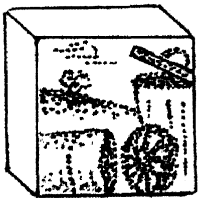
More information may be obtained from:
Ketil Flugsrud, Sigurd Holtskog and Kristin Rypdal

Figure 3.11. **Emissions of greenhouse gases in Norway**



Sources: Statistics Norway, Norwegian Pollution Control Authority and IPCC (1966)

4. Waste



Every Norwegian generated an average of 289 kg household waste in 1995. This is the highest figure ever recorded. About 18 per cent of all household waste was recycled. Even though this is the highest proportion to date, the amount of waste disposed of on landfills also rose.

In 1995, 645 000 tonnes hazardous waste was generated in Norway. Of this, 16 per cent was collected by the system for hazardous waste management, 37 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 3 per cent was disposed of illegally.

The number of waste treatment and disposal plants has been almost halved from 395 in 1978-79 to 208 in 1995. There is also a strong tendency for a small number of the remaining plants to treat a growing proportion of the waste generated.

The cost of municipal waste management averaged NOK 452 for each Norwegian in 1995. Collection, transport and treatment of the waste accounted for three-quarters of the costs.

4.1 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, 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 and to monitor the effects of any waste management measures introduced. They can also help to reveal environmental problems associated with waste. However, the statistics available are not complete in all respects, and need to be expanded in various ways in the future.

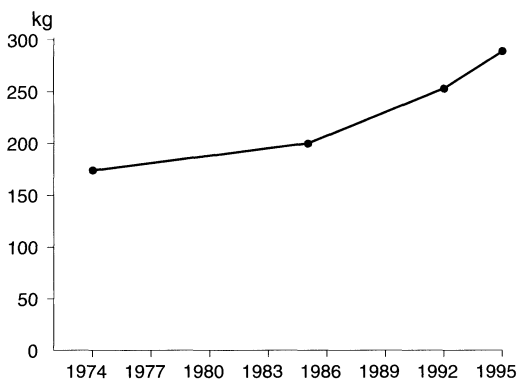
4.2 Waste generation

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

Household waste

The amount of household waste generated has increased ever since the first surveys were made in the early 1970s. In 1974, each person generated an average of 174 kg household waste. In 1995, this had risen to 289 kg (figure 4.1, Ligård 1982, Statistics Norway 1989 and 1996g). Between 1974 and 1985, the per capita quantity of waste generated rose by 2.4 kg per year. Between 1985 and 1992, the rise was 7.6 kg per year, and between 1992 and 1995 the average per capita annual increase has been 12 kg. There is some variation in the methods used to obtain these figures, but there is little doubt that the quantities of waste generated have been rising steadily faster.

Figure 4.1. **Per capita generation of household waste**



Source: Statistics Norway

Differences in per capita waste generation have been analysed both in Norway and in other countries. There is strong evidence of a positive relationship between general welfare trends in a country, expressed as gross domestic product, and per capita waste generation: per capita waste generation is also higher in urban municipalities than in rural municipalities (Halmø 1984 and Ligård 1982).

The composition of household waste has been investigated in some studies, but the results available are uncertain and should be treated as estimates. Paper and cardboard accounts for about 40 per cent of the total, wet organic matter for about 25 per cent, glass for 5 per cent, plastic for 8 per cent and other fractions for about 22 per cent (Estensen 1995, SFT 1995).

Waste from manufacturing industries and the public sector

Calculations based on sample surveys show that in 1993, manufacturing industries generated 3.0 million tonnes production and consumer waste and in addition, 320 000 tonnes of hazardous waste. The pulp and paper industry, printing and publishing generated 35 per cent of this 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 (Statistics Norway 1994a and 1995).

In 1995, Statistics Norway carried out a survey of waste from a sample of institutions and services in the public sector (Statistics Norway 1996h, 1996i).

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 special waste (including 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.

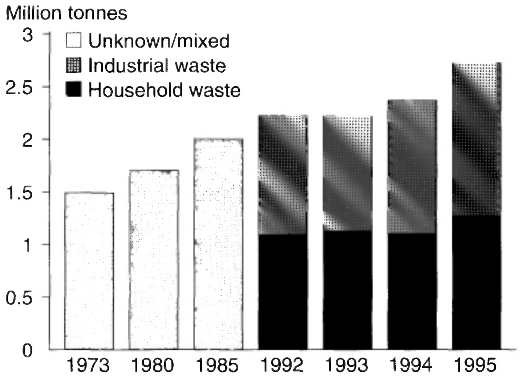
Household waste
Waste from normal activities in private households.

Industrial waste
Waste from all 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.

Hazardous waste
The high concentrations of toxic substances in hazardous waste represent a serious threat to the environment, even though the quantities of waste involved are relatively small. Calculations show that 645 000 tonnes of hazardous waste was generated in Norway in 1995 (Norsas 1996).

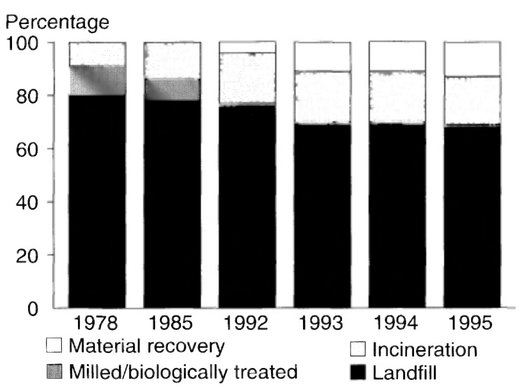
Corrosive substances are the largest category of hazardous waste, and make up 36 per cent of the total. The next largest categories are environmentally hazardous metals (29 per cent) and waste oil (11 per cent).

Figure 4.2. **Quantities of municipal waste by origin**



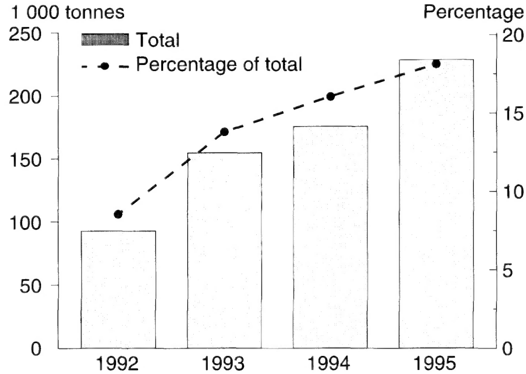
Source: Statistics Norway

Figure 4.3. **Municipal waste according to method of treatment**



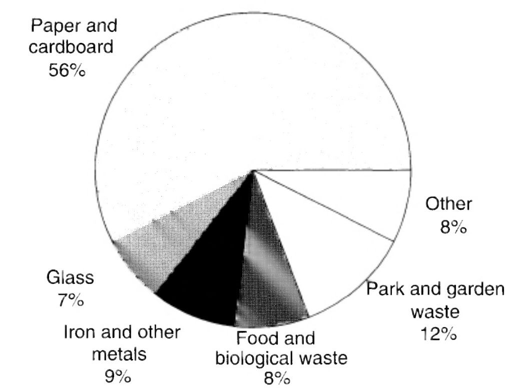
Source: Statistics Norway

Figure 4.4. **Household waste delivered for material recovery**



Source: Statistics Norway

Figure 4.5. **Household waste delivered for material recovery, by material, 1995**



Source: Statistics Norway

4.3 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.

Municipal waste management

Statistics Norway recorded statistics on municipal waste management for selected years in the 1980s and has done so annually since 1992. The surveys 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 recent years, reports have been obtained from all municipalities and waste treatment and disposal plants in 1992 and 1995, and from a sample of municipalities in 1993 and 1994.

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 played a central role in establishing waste statistics in their current form.

Municipal waste management
In the 1970s and 1980s, Statistics Norway twice prepared annual statistics on waste and its management through the municipal waste collection system. Since 1992, this has been done annually. In 1992 and 1995, these statistics 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.

Special surveys of industrial waste and waste from the public sector
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. This will be repeated in 1997 for manufacturing industries. The 1997 survey will give greater weight to packaging waste.

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 packaging waste. 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.

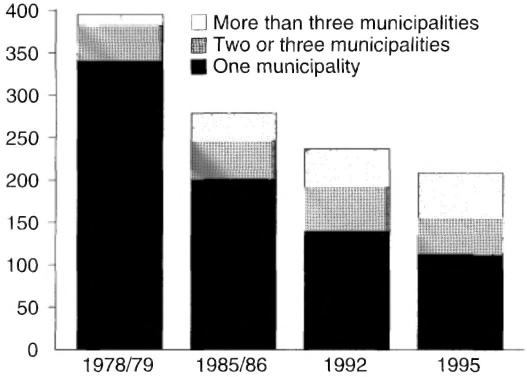
Hazardous waste
Norsas A/S (the Norwegian Resource Centre for Waste Management and Recycling) publishes annual statistics of the amounts of hazardous waste delivered.

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. There are also plans to use the register to collect data on waste quantities and management.

In 1995, municipal waste collection systems dealt with 2.7 million tonnes waste (figure 4.2). This is an increase of about 0.5 million tonnes since 1992.

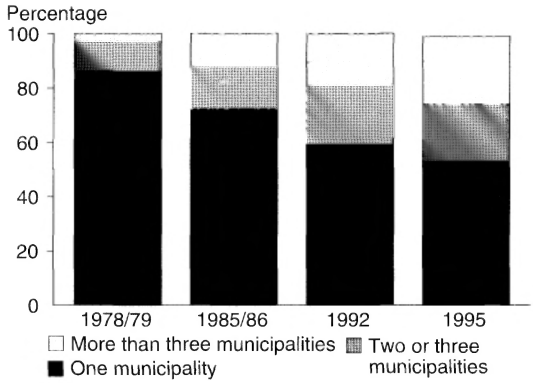
Most municipal waste is still disposed of in landfills, even though the proportion delivered for material recovery is rising (figure 4.3). In 1995, 68 per cent of municipal waste was dumped in landfills, 18 per cent was incinerated, 13 per cent recycled and 1 per cent was treated biologically. The residues from incineration are counted twice in these figures, since they are landfilled after incineration. Ash and slag from waste incineration plants totalled about 97 000 tonnes in 1995, or about 5 per cent of all waste landfilled.

Figure 4.6. **Numbers of waste treatment and disposal plants according to number of municipalities they serve**



Source: Statistics Norway

Figure 4.7. **Percentages of waste treatment and disposal plants serving different numbers of municipalities**



Source: Statistics Norway

Figures for recent years show a relatively steep increase in the amount of waste recycled. In 1995, 373 000 tonnes waste was delivered for material recovery from municipal collection schemes. This corresponds to an annual increase of 34 per cent since 1992. Waste delivered by private households explains most of the increase. The proportion of household waste recovered has risen from 9 per cent in 1992 to 18 per cent in 1995 (figure 4.4). The proportion of industrial waste that is recycled has risen from 8 per cent to 10 per cent during the same period (municipal waste collection schemes only).

Of the household waste delivered for material recovery, 53 per cent was collected where it was generated (sorting and collection at source), 29 per cent was delivered to special containers, and 18 per cent was sorted at waste treatment and disposal plants or at recycling centres.

Paper and cardboard accounted for 56 per cent of the household waste delivered for material recovery. The quantity delivered has more than doubled since 1992, and was 131 000 tonnes in 1995 (figure 4.5). Other important fractions are waste from parks and gardens (12 per cent), iron and other metals (9 per cent) and glass (7 per cent). The amount of glass recovered rose by 36 per cent from 1992 to 1995, and was 16 000 tonnes in 1995. The amount of plastic delivered for material recovery is still insignificant. In 1995, the 1 054 tonnes of plastic waste recovered made up 0.5 per cent of all household waste recovered. For most materials, we do not know the quantities of waste generated, and therefore have no reliable figures for the proportion recycled.

A proportion of the industrial waste is also processed through municipal waste collection schemes. In 1995, this totalled 1.46 million tonnes, a rise of 0.33 million tonnes since 1992.

Waste treatment and disposal plants

The number of waste treatment and disposal plants dropped from almost 400 at the end of the 1970s to 208 in 1995. There is also a strong tendency to retain a few large remaining plants that take waste from a number of municipalities (figure 4.6 and 4.7, Statistics Norway 1996h). Landfills for bulky waste

Norwegian waste accounts

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.

The objective of the waste accounts is to specify the following for all waste:

1) Origin (which branch of industry/sector discards the waste?)
2) Material
3) Product type
4) Management (how is the waste treated/disposed of after it is discarded?)

The project will be based on the use of data from existing statistics. This means, for instance, that waste quantities will be estimated using data on manufacturing and foreign trade.

So far, work on the following waste fractions has started: paper and cardboard, glass, wood, and wet organic material. The first results will be published in the second half of 1997.

and plants that received less than 50 tonnes of waste are not included. In 1995, one-quarter of the waste treatment and disposal plants took waste from more than three municipalities, and these accounted for three-quarters of the total quantity of waste.

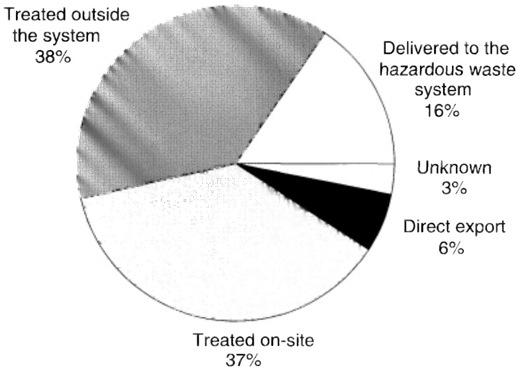
Leachate from landfills
Polluted leachate is an environmental problem associated with many landfills. In 1995, only 20 per cent of all landfills had systems for the treatment of leachate, and the proportion has remained almost unchanged since 1992. Most landfills without such facilities release leachate to fjords or the coast (36 per cent), rivers and streams (26 per cent) or soil (25 per cent). The remaining discharges (14 per cent) are to other types of recipients.

Emissions of methane from landfills
Emissions of the greenhouse gas methane as a result of decay constitute another environmental problem associated with landfills. These emissions are calculated to total 322 000 tonnes in 1995, or 6.8 million tonnes CO_2 equivalents. This corresponds to about 12 per cent of total Norwegian emissions of greenhouse gases (see Chapter 3).

This problem can be dealt with by extracting the gas and burning it, thus generating the less harmful greenhouse gas carbon dioxide. In addition, it is possible to make use of the combustion energy. In 1995, there were gas recovery facilities at 15 landfills. These accounted for 26 per cent of all waste deposited in landfills, and 5 per cent of the methane generated was burnt. Of this, fifteen per cent was used as an energy source, and the rest was flared (Statistics Norway 1996f).

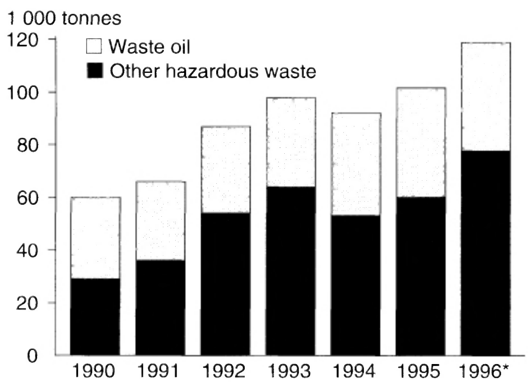
Waste from manufacturing industries and the public sector
In 1993, 26 per cent of all production and consumer waste from manufacturing industries was delivered for material recovery, 29 per cent was incinerated and 28 per cent was sent to municipal or private landfills. The remaining 17 per cent was either biologically treated, used for landscaping or treated in other ways.

Figure 4.8. **Calculated amounts of hazardous waste by method of treatment. 1995**



Source: Norsas

Figure 4.9. **Quantities of hazardous waste delivered**



Source: Norsas

The main method of disposal for waste from the public sector was landfilling. More than half the total 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 used for landscaping (Statistics Norway 1994a, 1995, 1996c, 1996i). The figures apply to a sample of public institutions and services.

Table 4.1. **Exports and imports of hazardous waste 1989-1995. Tonnes**

	Exports	Imports
1989	16576	
1990	21766	
1991	14643	2419
1992	14533	6262
1993	18208	15222
1994	32811	4358
1995	37257	8958

Source: Norsas

Hazardous waste
Calculations by Norsas, the Norwegian Resource Centre for Waste Management and Recycling, show that of the hazardous waste generated (645 000 tonnes in 1995) large amounts 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 (figure 4.8, tables D8 - D9 in Part III, Norsas 1996a).

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 1996 it had risen to almost 120 000 tonnes (figure 4.9, Norsas 1997).

Exports and imports of waste
Most of the waste generated in Norway is treated within the country's borders, but there are substantial exports of waste for recycling, including large amounts of waste paper of de-inking quality. This includes newspapers and other printed matter. In 1996, more than 182 000 tonnes of waste paper was exported (PIL 1997). 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. Substantial amounts of waste paper, mainly packaging waste, are also imported. In 1996, 47 000 tonnes of waste paper was imported, which is about the same as in previous years.

With permission from Norwegian Pollution Control Authority, consignments of hazardous waste have regularly been exported from Norway. Norsas compares information on this with data registered in the hazardous waste management system (Norsas 1996b, table 4.1). 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.

4.4 Recycling and return schemes

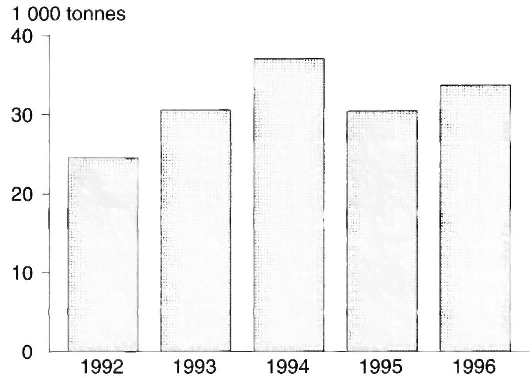
There are a number of schemes for collection and recycling of various types of waste, but because it is difficult to draw a hard-and-fast line between waste and returned raw materials, it is also difficult to draw up reliable statistics for the quantities involved. Many schemes have been established because it is more economical to recycle waste or subject it to special treatment than to deal with it in the normal refuse collection system. In other cases, however, the authorities have found it necessary to promote recycling by order, by means of taxes or through agreements with industry. Some of the most important return and recycling schemes are presented below.

Glass

The amount of glass recovered has increased in recent years, but there have been fluctuations, for instance because breweries and producers of mineral water and soft drinks have switched to plastic packaging for many of their products. In 1996, 33 658 tonnes of glass was collected, mainly in the form of packaging (figure 4.10, Norsk Glassgjenvinning 1997).

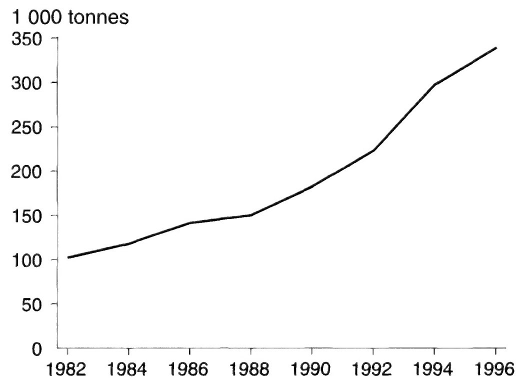
The deposit and return scheme for beer, mineral water, wine and spirits bottles is the most important re-use scheme already established in Norway. Between 95 and 100 per cent of all beer and mineral water bottles are returned, and 72 per cent of wine and spirits bottles (Statistics Norway 1996c).

Figure 4.10 **Amounts of glass collected for material recovery**



Source: Norwegian Glass Recycling A/S

Figure 4.11. **Amounts of paper and cardboard collected for material recovery**



Source: Federation of Norwegian Process and Manufacturing Industries

Paper
Regular statistics are compiled for paper and cardboard, and show a substantial increase in the amounts collected during the past ten years. In 1996, almost 340 000 tonnes waste paper was collected (figure 4.11, PIL 1997). This includes both printed matter and paper and cardboard packaging.

A collection scheme for drinking cartons have been established, and is available to about 85 per cent of the population. The company *Norsk Returkartong* is responsible for administration of the scheme, which is based on an agreement between the manufacturers of drinking cartons and the authorities. The scheme applies both to drinking cartons which are subject to a tax and to those (for dairy products) which are not. By the end of 1996, about one-third of all drinking cartons were being returned after use. The agreement is based on collection of a considerably higher proportion of the packaging, and *Norsk Returkartong* is taking steps to ensure that more cartons are returned.

Similar agreements have been made for other types of paper and cardboard packaging. The proportion of board used for transport packaging recovered has now reached 64 per cent. This corresponds to about 110 000 tonnes corrugated and other board.

Plastics
It is estimated that about 140 000 tonnes plastic waste per year is generated in Norway. Of this, more than 100 000 tonnes consists of packaging or plastic foil. About 5 500 tonnes plastic was returned for material recovery in 1996. Most of this was plastic foil from agriculture, trade and industry. An agreement between the authorities and the packaging industry is intended to ensure that the proportion recycled rises in the next few years. The proportion of plastic waste incinerated for energy recovery is also to be increased. The company *Plastretur AS* will be responsible for implementing the agreement (Plastretur 1997).

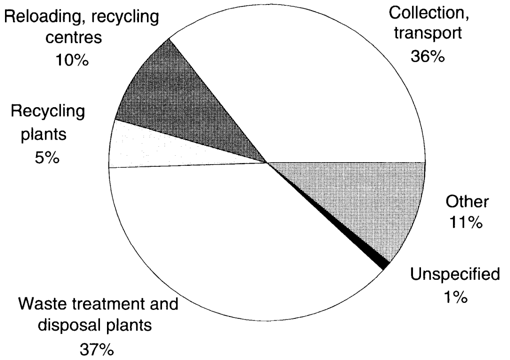
Car tyres
Since 1 January 1995, sales of tyres for passenger cars and lorries have been subject to a fee intended to cover the costs of a collection and recycling scheme. From 1997 onwards, tyres for industrial vehicles and tractors will also be included in the scheme. In 1996, most of the tyres (2.0 million) were incinerated in cement kilns. Some tyres were re-used after retreading. A substantial number (estimated at 700 000) were collected with scrapped cars and were therefore not utilized. From 1997, arrangements have been made to remove tyres when cars are scrapped (Norsk Dekkretur 1997).

Iron and other metals
About 350 000 tonnes of scrap iron per year has been collected in Norway during the past few years (Stålverkenes skrapjernkontor 1997). A substantial proportion of this consists of scrapped cars. Because the amount payable to a person who delivered a scrapped car to a breaker's yard was raised in 1996, the number of cars delivered rose to about 220 000 from 60 000 in 1995.

As for other types of packaging, an agreement has been drawn up to encourage recycling of metal packaging. The scheme is currently being established, and is to be funded by fees which the manufacturers have added to the prices of their products.

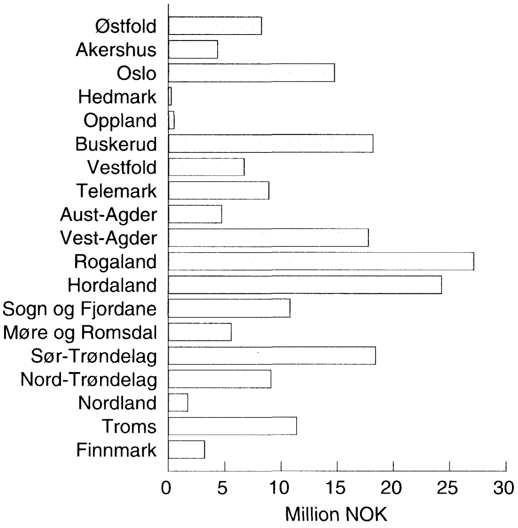
Hazardous waste
Waste which comes within the scope of the hazardous waste regulations must be delivered to approved reception or treatment centres. Norsas is responsible for establishing and administering the system for hazardous waste management. Treatment of hazardous

Figure 4.12. **Municipal investments in the waste management sector by type, 1995**



Source: Statistics Norway

Figure 4.13. **Investments by the counties in the waste management sector, 1995**



Source: Statistics Norway

waste includes material recovery, energy recovery and final disposal. Special collection schemes have been established for certain categories of waste.

The scheme for the delivery and recycling of lead accumulators is funded by a tax of NOK 25 on each battery sold. This is sufficient to make the scheme self-financing. The scheme is organized by the company A/S *Batteriretur*, which is owned by Norwegian importers and manufacturers of lead accumulators, and is the result of an agreement between the Ministry of the Environment and the manufacturers and importers. Nearly all lead accumulators are now collected after use. The lead is extracted from the accumulators and exported for material recovery, and the other waste fractions are also treated appropriately (Norsk Batteriretur 1997)

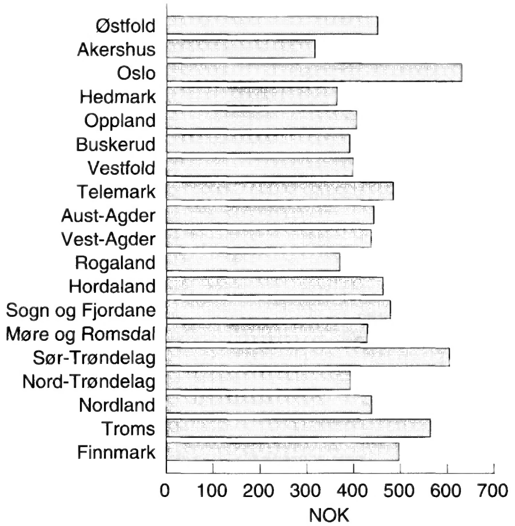
Waste oil poses a serious pollution risk. The authorities now impose a tax on sales of lubricating oils, and this is used to finance recovery schemes. Waste oil is now used for heating purposes only. Previously, there was some re-use of lubricating oils. In 1995, 42 000 tonnes of waste oil was collected. This is 49 per cent of the sales volume of lubricating oils subject to the tax. However, it should be noted that a certain proportion of the sales volume is non-recoverable (Norsas 1996b).

4.5 Investments in municipal waste management

In 1995, the municipalities invested NOK 196 million in municipal waste management. Investments in waste treatment and disposal plants accounted for 37 per cent of this, and collection and transport for 36 per cent. 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 only a little more than 5 per cent of the total. However, a number of recycling plants are owned by inter-municipal or private companies. Only direct investments by the municipalities are included for such companies.

Investments in this sector varied substantially from one county to another in 1995. In-

Figure 4.14. **Per capita municipal waste management costs. Weighted averages, 1995**



Source: Statistics Norway

Table 4.2. **Municipal costs, income and net fees in the waste management sector, 1995. Million NOK**

Operating costs	1 800
+ Capital costs	173
+ To investment fund	70
+ Miscellaneous	1
– Operating income	72
– Income from sale of capital	2
= Net costs	1 970

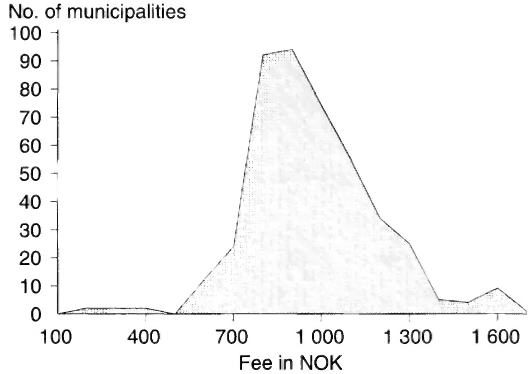
Source: Statistics Norway

vestments were highest in Rogaland and Hordaland and lowest in Hedmark and Oppland.

4.6 Costs associated with municipal waste management

In 1995, the costs incurred by the municipalities in connection with waste management totalled NOK 1 974 million. This is equivalent to NOK 452 per person. The average cost per tonne of waste in 1994 was NOK 725. Operating costs accounted for most of the total, or about NOK 1 800 million. Comparison with the sample surveyed

Figure 4.15. **Number of municipalities and size of waste management fee per subscriber, 1995**



Source: Statistics Norway

in 1994 shows that total costs rose by 8 per cent in the ten largest municipalities from 1994 to 1995.

Costs varied widely from one county to another in 1995. The costs were highest in Oslo and lowest in Finnmark.

Per capita costs were highest in Oslo at NOK 630 and lowest in Akershus at NOK 316 (figure 4.14).

4.7 Fees for municipal waste collection systems

The central authorities encourage the municipalities to grade their waste collection fees in order to promote waste reduction and recycling, and 40 per cent of the municipalities now do so. The average annual fee per subscriber was NOK 924 in 1995. Although there was wide variation from one municipality to another (from NOK 110 to NOK 1 672), the average fee in 85 per cent of the municipalities was between NOK 700 and NOK 1 200 (figure 4.15). The county average varied from NOK 791 in Vest-Agder to NOK 1 168 in Sogn og Fjordane.

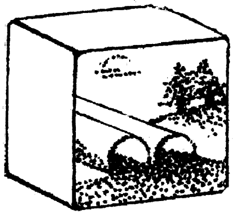
In 1995, the municipalities collected a total of NOK 1 878 million in fees from subscribers. This corresponds to an overall income-to-cost ratio[1] of 95 per cent, and the ratio was between 90 and 110 per cent in 70 per cent of the municipalities. To implement the recommendations of Report No. 44 (1991-92) to the Storting, amendments to the provisions of the Pollution Control Act concerning waste have been adopted. From the budget year 1995 onwards, the municipalities are required to cover all the costs of waste management through the fees they charge. This is in accordance with the "polluter pays principle". The ultimate objective is to reduce the amounts of waste generated. However, it should be noted that the regulations do not currently take into account external costs, such as pollution caused by emissions generated by waste management.

By the end of 1995, some form of sorting and collection at source had been introduced in 234 of the country's 435 municipalities. These schemes were available to more than one million households, or half the population. The average refuse collection fee in a municipality where waste is sorted and collected at source was NOK 931, while the corresponding figure for municipalities without such a system was NOK 905. The size of the fee also depends on other variable costs.

More information may be obtained from Anders Falnes, Ole Osvald Moss and Olav Skogesal

[1] The income-to-cost ratio is the ratio between income from fees and annual costs.

5. Waste water treatment



In all, 2 020 operative municipal waste water treatment plants were registered in Norway in 1995. Their total waste water treatment capacity was 5.2 million population units (p.u.). Operating and capital costs were calculated at NOK 3.2 billion in 1995, which is equivalent to NOK 2 228 per subscriber, or an average per capita cost of NOK 740. Sewage fees covered 92 per cent of this. Since 1975, gross investments of NOK 27 billion have been made in the municipal waste water treatment sector. In 1995, investments totalled NOK 1.3 billion, and 78 per cent of this was used for laying new sewers and renovation of the existing sewer systems. Waste water treatment plants removed 69 per cent of the phosphorus entering the plants. For the North Sea counties alone, this figure was 89 per cent.

5.1. Introduction

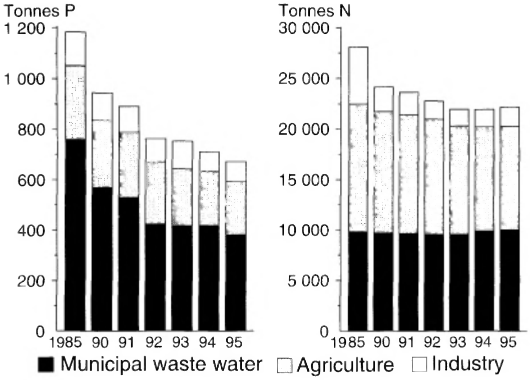
Statistics Norway and the Norwegian Pollution Control Authority together organize the annual registration of data from the waste water treatment sector in all municipalities in Norway. The county departments of environmental affairs are responsible for data collection. In 1994, the computerized data collection system SSB-AVLØP 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 1995, total Norwegian anthropogenic inputs of nutrients to the Norwegian coast from agriculture, industry and municipal waste water were calculated to be of the order of 2 500 tonnes of phosphorus and 46 000 tonnes of nitrogen. The coastal waters in the North Sea area (see box page 69) received 26 per cent and 48 per cent respectively of the total inputs of phosphorus and nitrogen (NIVA 1996). Per capita inputs of phosphorus and nitrogen are thus 0.3 kg and 9.4 kg respectively for the North Sea counties and 1.0 kg and 12.3 kg respectively for the rest of the country.

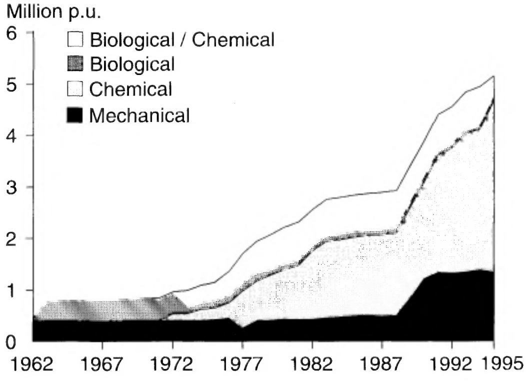
According to the North Sea Declarations, Norway undertook to reduce inputs of phosphorus and nitrogen to the North Sea by about 50 per cent in the period 1985 - 1995. However, calculations have shown that total inputs of phosphorus and nitrogen were in fact reduced by 43 per cent and 21 per cent respectively during this period (figure 5.1).

Figure 5.1. **Norwegian anthropogenic inputs of phosphorus and nitrogen to the North Sea**[1]



[1]Calculated inputs to the coastal zone outside the North Sea area, particularly from agriculture, are uncertain
Source: Norwegian Institute for Water Research

Figure 5.2. **Hydraulic capacity by treatment method**

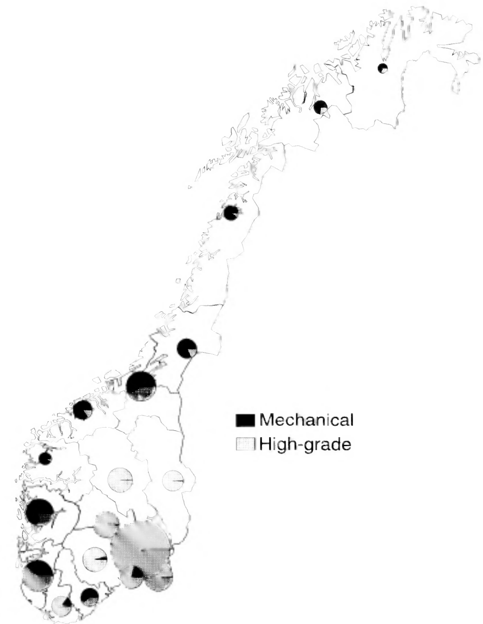


Source: Statistics Norway

5.2 Waste water treatment plants

Most waste water treatment plants in Norway have been built within the last 20 years (figure 5.2). The earliest plants provided mechanical and/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. Figure 5.2 shows a sharp increase in mechanical treatment capacity from 1988 to

Figure 5.3. **Hydraulic capacity at primary and high-grade treatment plants. By county, 1995**



Digital map data: Norwegian Mapping Authority
Source: Statistics Norway

1990. The main reason for this is the inclusion of strainers and sludge separators in this category. The change in the relative proportions of chemical and biological/chemical treatment from 1994 to 1995 was caused by temporary alterations at a large plant in Eastern Norway.

In Norway, the most important measure used to prevent excessive algal growth in fjords and river systems is the reduction of phosphorus inputs, 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 1996b).

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 annual interest charge of 7.25 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.

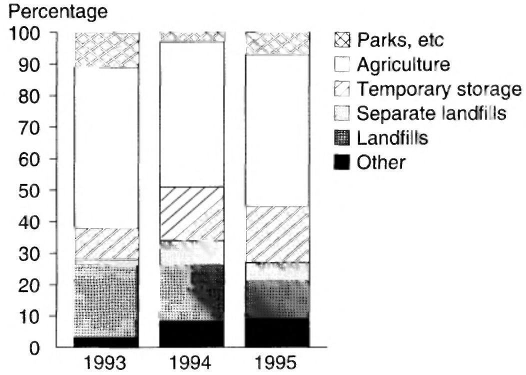
In 1995, 2 020 municipal waste water treatment plants with a treatment capacity of at least 50 p.u. were registered in Norway. In the same year, the total treatment capacity of all types of municipal waste water treatment plants was 5.2 million p.u. The eighteen largest plants each had a treatment capacity of 50 000 p.u. or more, and they treated almost half 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 5.3), whereas along the coast from Hordaland county and northwards, most waste water is only mechanically treated.

5.3 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. In 1995, the total amount of sludge produced, expressed as dry weight, was calculated to be 92 900 tonnes. Of this, 55 per cent was used in integrated plant nutrient management (figure 5.4).

The composition of the sewage sludge produced, including its content of heavy metals, varies substantially from one plant to another depending on the type of treatment used and the amount and type of waste water (table 5.1).

Figure 5.4. **Disposal of sewage sludge**



Source: Statistics Norway

Table 5.1. **Heavy metals in sewage sludge in 1995. mg per kg dry weight**

Heavy metal	No. of plants	Mean value	Min. value	Max. value	Standard deviation
Cadmium	186	1.1	0.1	21.5	1.6
Lead	198	23.5	2.3	180.0	19.2
Mercury	189	1.4	0.2	15.3	1.3
Nickel	183	12.8	2.0	169.8	14.4
Zinc	183	373.1	1.6	1991.3	229.8
Chromium	183	25.5	0.9	659.0	47.7
Copper	183	299.9	17.5	1697.0	272.8

Source: Statistics Norway

5.4 Sewer systems

The total length of sewer systems in 1995 was calculated to be 33 000 km, which corresponds to 7.6 m per inhabitant. By way of comparison, the total length of sewer systems in 1984 was calculated to be 27 400 km, which corresponds to 6.5 m per inhabitant (Brunvoll 1987).

In 1995, the total length of new sewers laid was 833 km, which is about the same as the year before. Combined sewer systems accounted for 16 per cent of this, waste water sewers for 55 per cent, and storm water sewers for 29 per cent.

The data available on types of sewer systems, length, age and materials is incomplete in both this year's and earlier reports. It is therefore difficult to say anything definite about the current situation and trends.

5.5 Waste water treatment in scattered settlements

Whereas the county governors are responsible for discharges from municipal waste water treatment plants, 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.

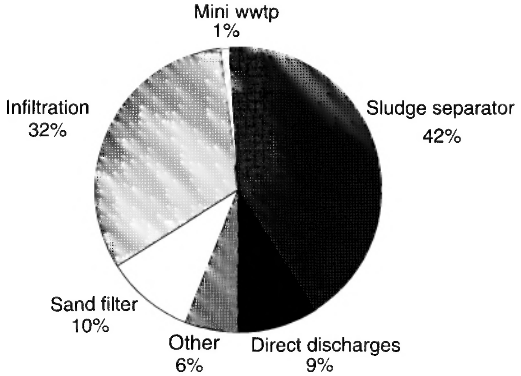
About 20 per cent of the population is connected to separate waste water treatment plants in scattered settlements. For 1995, total discharges from these were calculated to be 364 tonnes of phosphorus. The average treatment efficiency was about 30 per cent, which means that about 160 tonnes of phosphorus was retained by the treatment plants. Sludge separators and infiltration are the commonest treatment methods for waste water from scattered settlements (figure 5.5.)

5.6 Removal of phosphorus in waste water treatment plants

About 80 per cent of the population of Norway lives in areas served by municipal waste water treatment plants or in other areas where there are municipal sewer systems for waste water. Total discharges of phosphorus from municipal waste water treatment plants in 1995 were calculated to be 601 tonnes (figure 5.6), and the average treatment efficiency of these plants was 69 per cent.

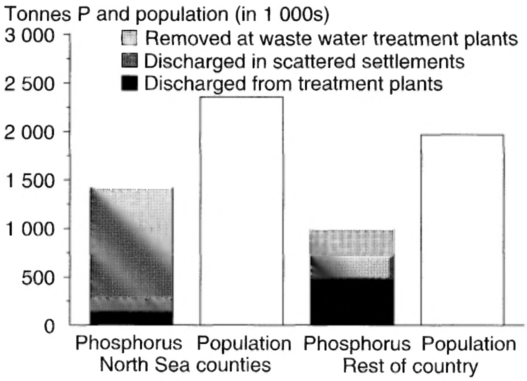
Calculations show that in 1995, the average treatment efficiency for phosphorus in municipal waste water treatment plants in the North Sea counties was 89 per cent. Treatment efficiency is relatively high in the North Sea counties because most of the treatment plants provide a chemical or biological treatment phase. In all, the North Sea counties, which account for 55 per cent of Norway's population, discharged 128 tonnes of phosphorus, or about 21 per cent of the country's total discharges from municipal waste water treatment plants.

Figure 5.5. **Treatment methods for waste water from scattered settlements in 1995**



Source: Statistics Norway

Figure 5.6. **Phosphorus removal and discharge at municipal treatment plants and in scattered settlements in 1995**[1]



[1] Losses of phosphorus from sewer systems and discharges from scattered settlements not connected to sewer systems are not included

Source: Statistics Norway

The counties along the coast from Rogaland and northwards have a larger proportion of treatment plants which use relatively simple means of purifying water, such as screens, strainers and sand traps, and these retain phosphorus less efficiently.

5.7 Annual costs in 1995

In 1995, the total costs of municipal waste water treatment were about NOK 3.2 billion. Operating costs, management and maintenance accounted for NOK 1.7 billion of the total, and capital costs for NOK 1.5 billion. Total costs increased by 2.5 per cent from 1994.

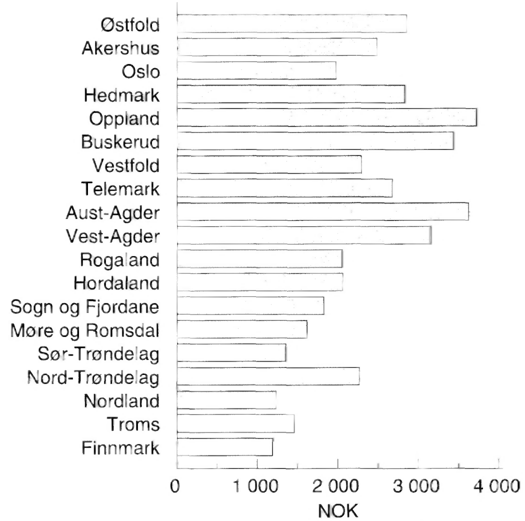
The average annual cost per subscriber for the whole country was NOK 2 228. The costs per subscriber were higher in municipalities in the North Sea counties than in other parts of the country. The weighted mean for the North Sea counties was NOK 2 638, compared with NOK 1 706 for the rest of the country. The high level of costs in the North Sea counties is a result of the high treatment standards these counties are required to achieve.

5.8 Investments

The purpose of building and operating waste water treatment facilities is to ensure that the transport and treatment of polluted waste water do not result in injury to health, adversely affect human welfare or reduce the capacity of the natural environment for production and self-renewal, cf the Pollution Control Act of 13 March 1981.

In 1995, gross investments in municipal waste water treatment totalled about NOK 1.4 billion, the same as the year before. During the 1990s, investments in municipal waste water treatment have been much higher than in the 1980s and almost as high as in the 1970s, calculated as fixed NOK. The relatively high level of investments in the 1990s may be related to the implementation of the North Sea Declarations. The municipalities expect investments in this sector to remain high during the next few years. According to the municipalities' own estimates, total investments in the waste water treatment sector will probably be about NOK 5.2 billion for the period 1996-1998. The municipalities' initial estimates for investments in

Figure 5.7. **Annual costs of municipal waste water treatment per subscriber. Weighted averages by county in 1995**



Source: Statistics Norway

1994 and 1995 were NOK 1.7 and NOK 1.6 billion, respectively.

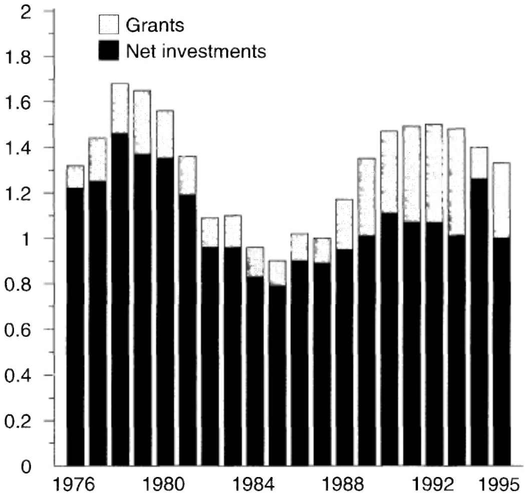
Figure 5.8 includes grants from the Ministry of the Environment to the municipalities. The amounts allocated in the form of such grants have varied, but have been higher throughout the 1990s than previously, with the exception of 1994.

The amounts invested in 1995 varied substantially from one county to another. Total investments in a county depend on various factors, including the number of subscribers and its geographical position. In 1995, investments were highest in Hordaland and lowest in Finnmark (figure 5.9).

Investments per subscriber were highest (NOK 2 113) in Aust-Agder, and lowest (NOK 450) in Oslo (figure 5.10).

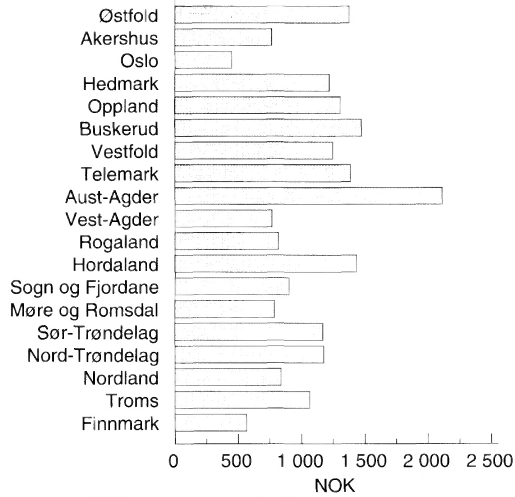
In 1995, 78 per cent of the amount invested was used for laying sewers and renovation of

Figure 5.8. **Investments in municipal waste water treatment in fixed 1993-NOK. Whole country**



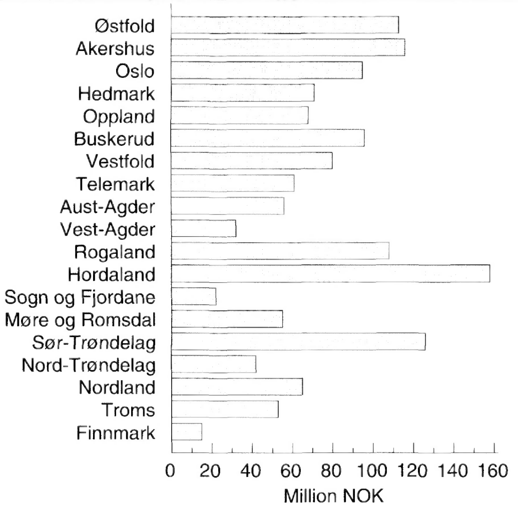
Source: Statistics Norway

Figure 5.10. **Gross investments per subscriber in the municipal waste water treatment sector in 1995, by county**



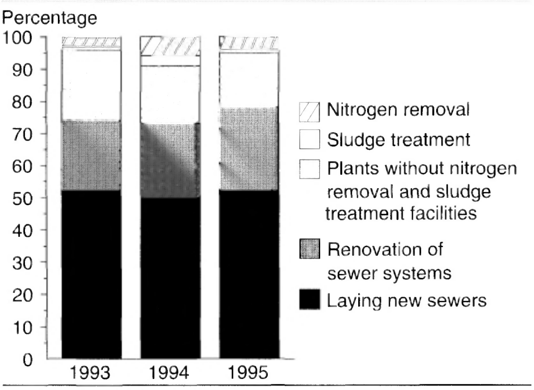
Source: Statistics Norway

Figure 5.9. **Gross investments in the municipal waste water treatment sector in 1995, by county**



Source: Statistics Norway

Figure 5.11. **Gross investments in the municipal waste water treatment sector by type, for the whole country**



Source: Statistics Norway

sewer systems (figure 5.11). This is 5 percentage points higher than the year before. The proportion of investments in plants without nitrogen treatment facilities was about the same in 1995 as the year before. Investments in sludge treatment plants accounted for only 1 per cent of the total figure, and investments in nitrogen removal facilities dropped from 6 to 4 per cent of the total.

5.9 Fees

The municipalities are authorized to levy connection fees and annual fees to cover the capital and operating costs of waste water treatment. In 1995, the municipalities collected a total of NOK 2.96 billion in waste water treatment fees, of which annual fees accounted for NOK 2.72 billion and connection fees for about NOK 242 million.

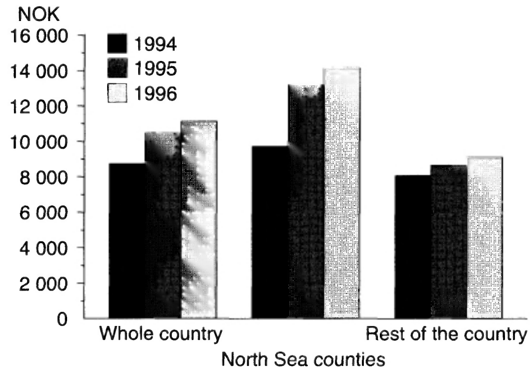
Income in the form of fees for the whole country covered 92 per cent of the total costs in 1995, which is an increase of four percentage points from the year before. The average income-to-cost ratio for municipalities in the North Sea counties was about 91 per cent, and the average for the rest of the country was about 94 per cent. However, there were wide variations from one municipality to another. Twenty-eight per cent of all municipalities had an income-to-cost ratio of less than 50 per cent, and 23 per cent had an income-to-cost ratio exceeding 100 per cent.

The connection and annual fees charged vary widely from one municipality to another. The amounts are fixed on the basis of costs in each municipality.

On average, the connection fees were higher in the North Sea counties than in the rest of the country (figure 5.12). There has also been a general increase in the connection fees payable in 1996 compared with both 1994 and 1995.

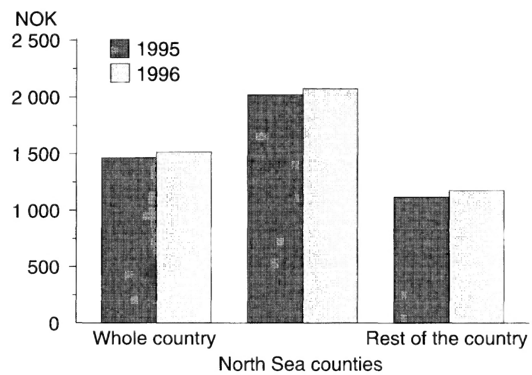
The municipalities fix annual fees on the basis of either the area of the subscriber's dwelling or measured water consumption. Using the first method of calculation, the annual fee averaged NOK 1 517 in 1996 (figure 5.13). This is 4 per cent higher than the corresponding figure for 1995. On average, the fee was higher in the North Sea counties than in the rest of the country (NOK 2 072 as compared with NOK 1 176). These figures are 3 and 5 per cent higher, respectively, than the year before.

Figure 5.12. **Connection fees for municipal waste water treatment. Weighted averages**



Source: Statistics Norway

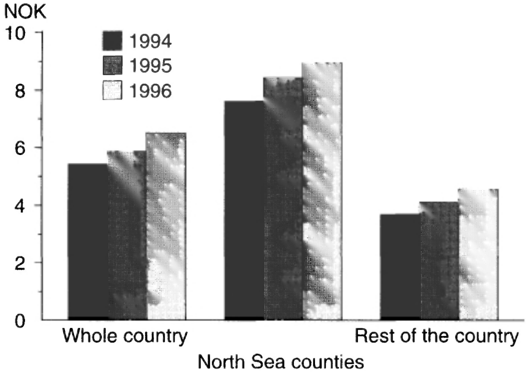
Figure 5.13. **Annual fee for municipal waste water treatment, based on the area of an average dwelling (140 m²). Weighted averages**



Source: Statistics Norway

For the whole country, the average fee per m^3 water was NOK 6.50 in 1996 (figure 5.14). The corresponding figures for the municipalities in the North Sea counties and for the rest of the country were NOK 8.96 and NOK 4.56 respectively. These figures are higher than in both 1994 and 1995.

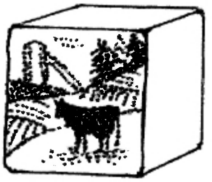
Figure 5.14. **Annual fee for municipal waste water treatment, based on water consumption in m3. Weighted averages**



Source: Statistics Norway

Further information may be obtained from
Kjetil Mork, Per Schøning or Marianne Vik Dysterud

6. Agriculture



In 1995, the agricultural sector accounted for 1.3 per cent of Norway's GDP and 3.7 per cent of total employment. These figures have dropped by almost half since 1980. However, the total agricultural area in use has increased, and in 1995 was 10.0 million decares[1].

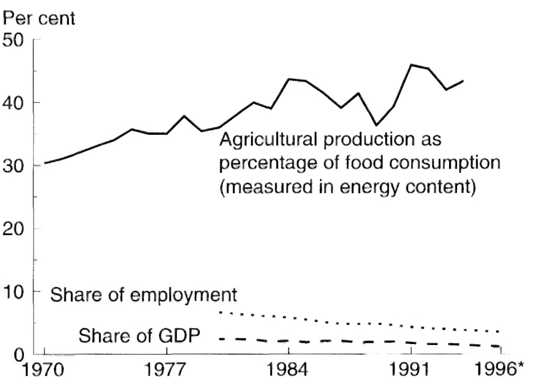
The environmentally beneficial trends of the early 1990s, such as reduction of tillage in autumn and reduction of the use of phosphorus fertilizer and pesticides, have slowed or even been reversed in more recent years.

The environmental benefits of reduced tillage in autumn (less erosion and runoff) entail an environmental cost in the form of greater use of pesticides. During the past four years, an average of 15 per cent of the area ploughed in autumn has been sprayed, compared with 39 per cent of the area that was not tilled.

6.1 The economic importance of agriculture

From 1980 to 1995, the agricultural sector's share of total employment (measured as full-time equivalent persons) sank from 6.6 to 3.7 per cent (figure 6.1). In absolute figures, the drop was from 111 000 to 66 000 full-time equivalent persons. The share of gross domestic product (GDP) derived from agriculture dropped from 2.4 per cent to 1.3 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 43 per cent in the period 1970 to 1994 (Statens ernæringsråd 1996).

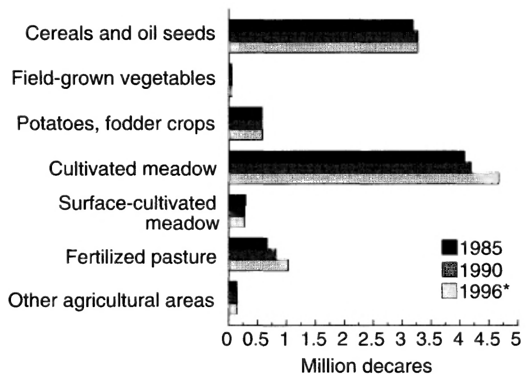
Figure 6.1. **Some indicators of the economic importance of the agricultural sector**



Sources: Statistics Norway and National Nutrition Council

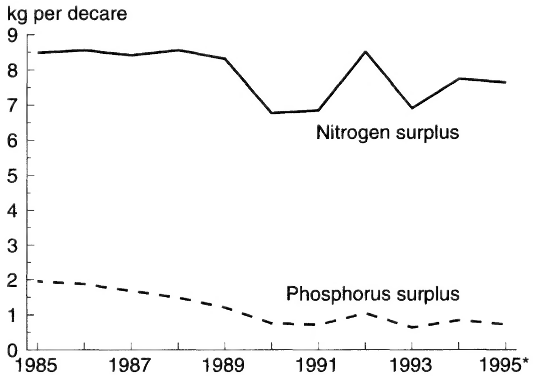
[1] 1 decare = 0.1 hectare.

Figure 6.2. **Use of agricultural areas**



Source: Statistics Norway and Norwegian National Grain Administration

Figure 6.3. **Surplus of nutrients (nitrogen and phosphorus) on agricultural areas**



Sources: Statistics Norway and Norwegian National Grain Administration

6.2 Land use

From 1985 to 1996, the agricultural area in use increased by 12 per cent, and was 10.0 million decares in 1996 (table F1 in Part III). Cereal and oil-seed acreage made up 32.6 per cent of this, and cultivated meadow 46.6 per cent. The acreage of cultivated meadow has risen by more than 14 per cent since 1985, whereas the area of surface-cultivated meadow has dropped (figure 6.2). The area of fertilized pasture has risen by 56 per cent. There are only small changes in the areas for other types of crops. (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.)

6.3 Environmental impacts

Nutrient balance

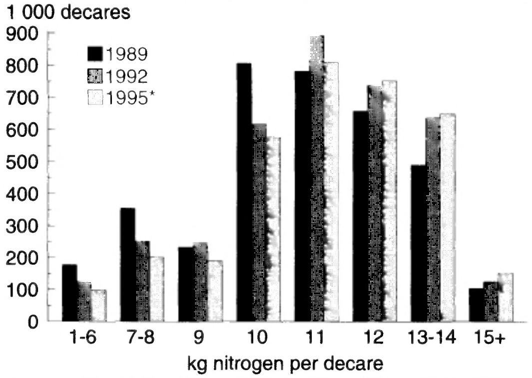
There are two main sources of nutrient discharges from the agricultural sector; point discharges (seepage from manure storage facilities and silos) and diffuse discharges (runoff). Calculations show that runoff accounts for 90 per cent of the total, and point discharges for 10 per cent (JORDFORSK 1989). 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 6.3 shows changes in the nitrogen and phosphorus balance from 1985 to 1994. The balance has been corrected for nitrogen losses in the form of NH_3 emissions from commercial fertilizer and animal manure.

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

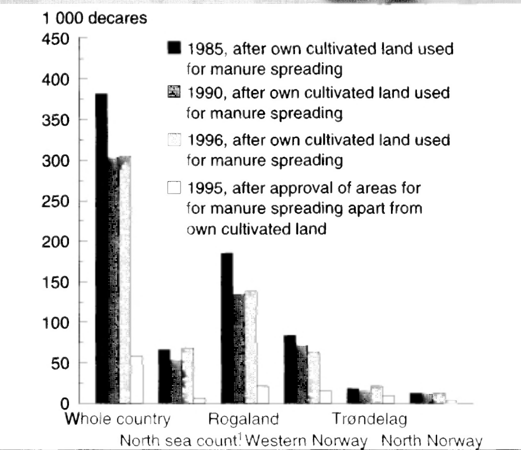
Using this method of calculation, we find that in 1985, the surplus per decare of agricultural land was 8.5 kg nitrogen and 2.0 kg phosphorus. By 1994, these figures had dropped to 7.6 kg nitrogen and 0.7 kg phosphorus. The relative reduction was much

Figure 6.4. **Area of cereals and oil seeds in relation to fertilizer application (kg nitrogen per decare in commercial fertilizer)**



Source: Statistics Norway

Figure 6.5. **Shortfall in areas for manure spreading**



[1]Counties to which the North Sea Declarations apply, see page 69

Sources: Statistics Norway and Norwegian National Grain Administration

greater for phosphorus than for nitrogen, mainly because farmers now apply much less phosphorus in the form of commercial fertilizer. The uneven results from year to year are explained by fluctuations in yields caused by variable weather conditions. Some of the data on which figure 6.3 is based are given in table F3 in Part III.

Commercial fertilizer

For the country as a whole, sales of phosphorus in commercial fertilizer have dropped by 44 per cent from 1984-1985 to 1995-1996, whereas sales of nitrogen in commercial fertilizer have changed relatively little. Given that the area of agricultural land has increased slightly 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 is either intensively or very lightly fertilized (more than 25 kg or less than 4 kg nitrogen per decare) has decreased. The cereal acreage that is intensively fertilized has risen in recent years (figure 6.4).

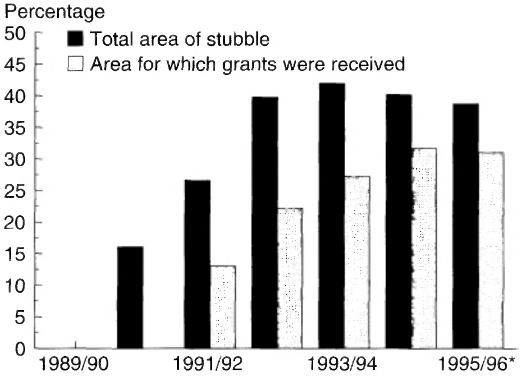
Animal manure

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 87 per cent in 1995.

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. 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.

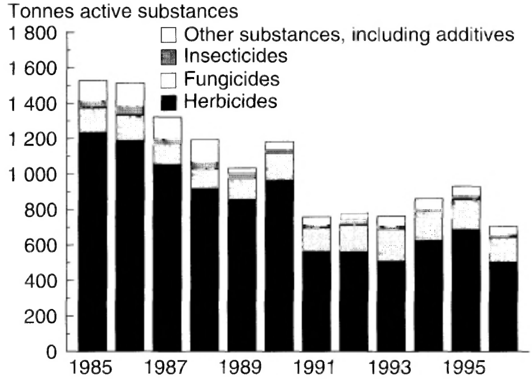
If only farmers' own cultivated land is considered, the calculated shortfall of areas suitable for manure spreading in 1996 was 304 000 decares, as compared with 380 000 decares in 1985. From 1994, the shortfall of areas for manure spreading on farms with more than 20 animal manure units has been

Figure 6.6. **Proportion of cereal acreage under stubble in autumn**



Sources: Statistics Norway and Ministry of Agriculture

Figure 6.7. **Sales of pesticides expressed as tonnes active substances**



Source: Norwegian Agricultural Inspection Service

taxed, and we now have an overview of the area still required after the approval of other areas for manure spreading. In 1995, it was estimated that the shortfall was 57 000 decares (figure 6.5), 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.

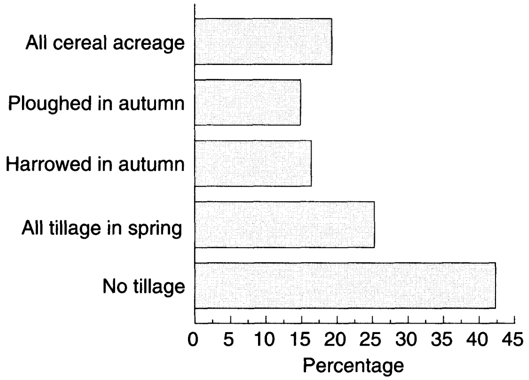
To reduce soil losses, the authorities provide grants for areas that are vulnerable to erosion on condition that the farmers leave them under stubble during the winter, i.e. do not till such areas in autumn. The proportion of such areas which were overwintered under stubble rose from 16 per cent in 1990-91 to 42 per cent in 1992-93. Since then, the area under stubble has decreased somewhat (figure 6.6). The proportion of the area under stubble for which support is granted, on the other hand, has risen steadily throughout the period, and was 80 per cent in 1995-96 (figure 6.6). A growing proportion of the grants is being provided for areas that are particularly vulnerable to erosion.

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 1991, but has not been reduced since then (figure 6.7). 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 different pesticides vary widely, as do their selectivity and toxicity. Nevertheless, changes in the total consumption of pesticides do give some indication of whether their

Figure 6.8. **Proportion of cereal acreage sprayed against perennial weeds according to soil management regime. Average for the period 1992-93 to 1995-96**



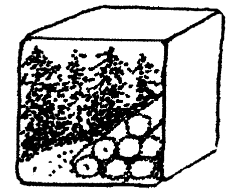
Source: Statistics Norway

environmental impact is increasing or decreasing.

During the past four 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, 39 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 6.8). This means that the environmental cost of reducing erosion by limiting tillage is greater use of pesticides.

Further information may be obtained from Henning Høie and Dagfinn Sve

7. Forest

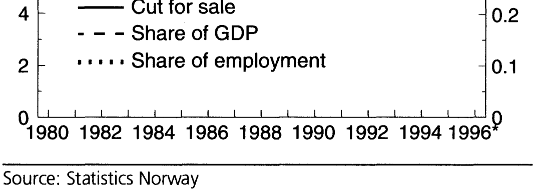


In 1996, forestry accounted for 0.3 per cent of Norway's gross domestic product (GDP) and total employment. In 1995, the total volume of the roundwood cut for sale and industrial production was 9.3 million m^3. The volume of the growing stock has risen from 310 million m^3 in 1925 to 630 million m^3 in 1994-95. The annual increase in the growing stock results in an uptake of CO_2 from the atmosphere corresponding to one-third of Norway's anthropogenic CO_2 emissions. 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 tendency to deteriorate slightly, and this is continuing.

7.1 The economic importance of forestry

According to the national accounts, forestry's share of total employment has dropped by half from 1980 to 1996. In 1996, labour input in forestry was 5 400 full-time equivalent persons. Forestry's share of Norway's GDP has dropped by 36 per cent, and in 1996 forestry accounted for 0.33 per cent of GDP. In 1995, the total volume of the roundwood cut for sale and industrial production was 9.3 million m^3. This is 10 per cent more than the year before, which brought the roundwood cut back to the same level as in 1992 and 1993 (figure 7.1). At the same time, the gross value of the roundwood cut rose by 38 per cent from NOK 2.5 billion in 1994 to NOK 3.5 billion in 1995 (current NOK).

Figure 7.1. **Forestry: share of employment and GDP. Roundwood cut**

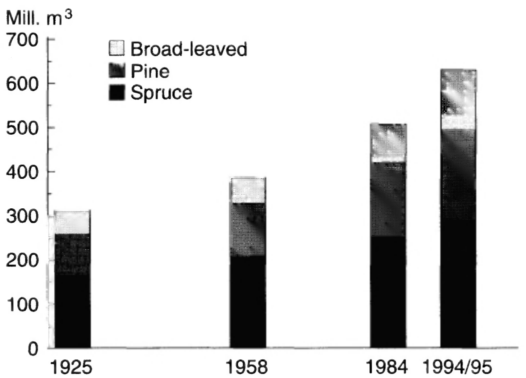


Source: Statistics Norway

7.2 Forest resources

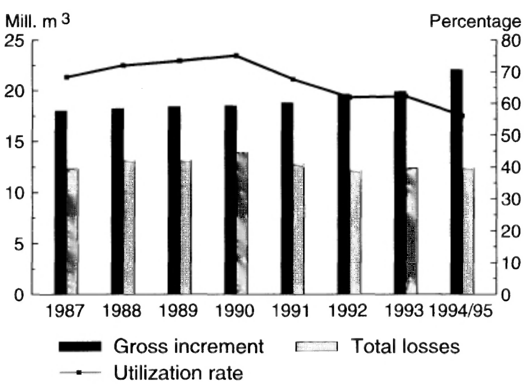
The total area of productive forest in Norway is about 72 000 km^2, divided among 125 000 forest properties. Individuals own 79 per cent of the productive area of forest, and more than half the forest properties are run in combination with agricultural operations. For several hundred years, Norwegian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

Figure 7.2. **Volume of the growing stock without bark**



Sources: Statistics Norway and National Forest Inventory

Figure 7.3. **Gross increment, total losses and utilization rate of the growing stock**



Source: Statistics Norway

Growing stock

Forest inventories and calculations of volume show that the volume of the growing stock below the coniferous forest line nearly doubled from 1925 to 1994-95 (figure 7.2). 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. These figures are regularly updated on the basis of inventories carried out by the Norwegian Institute for Land Inventory (NIJOS). The most recent data from such inventories show that the total volume of the growing stock, without bark, below the coniferous forest line was 630 million m^3. This is an average figure for the years 1994 and 1995 (NIJOS 1997). This total consisted of 46 per cent spruce, 33 per cent pine and 22 per cent broad-leaved trees. In 1994-95, the *net* increment (annual increment minus roundwood cut and calculated natural losses) in the growing stock was 9.8 million m^3, or 1.6 per cent of the total volume (figure 7.3 and tables G1 and G2 in Part III). The net increment was highest for broad-leaved trees and pine.

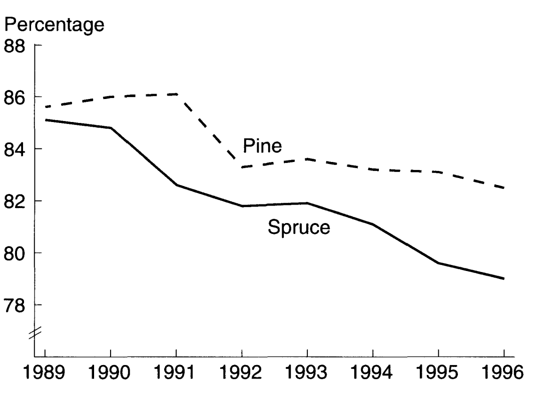
The annual utilization rate for forest resources can be calculated as the total annual losses in the volume of the growing stock as a percentage of the gross increment in volume. The utilization rate decreased from 1990 to 1994-95, when it was 56 per cent.

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

7.3 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 1997) show the current state of health of forests, measured as mean crown density and crown colour for the country as a whole (tables G3 and G4 in part III). The mean crown density for spruce dropped from 85 per cent to 79 per cent in the period 1989 to 1996 (figure 7.4). 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. Crown density for both these tree species is lowest in the Trøndelag counties, and the drop in crown density from 1989-1996 was also largest in this region. In 1996, every fourth spruce tree in southern and central Norway showed discoloration of the needles, which is twice as many as in 1991. The proportion of spruce trees aged over 60 years showing discoloration of the needles was 38 per cent.

Figure 7.4. **Mean crown density of spruce and pine**



Source: Norwegian Institute for Land Inventory (1997)

Birch has been included in the monitoring programme since 1992, and preliminary records of birch trees in coniferous forest were made from 1990 onwards. After a steep decrease in 1992-1995, an increase in crown density was recorded in the next two years, so that mean crown density in 1996 was only one percentage point lower than in 1992, just under 73 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 1995, 30 countries took part in the programme, and a total of 117 035 trees were sampled (Bundesministerium für Ernährung, Landwirtschaft und Forsten 1996).

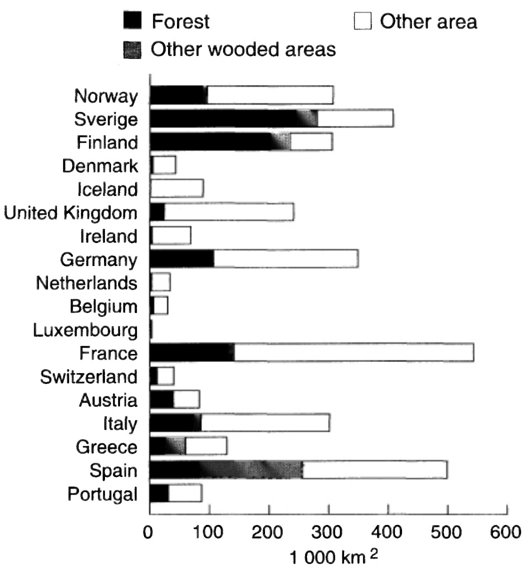
Earlier experience has shown that defoliation of up to 20-25 per cent does not necessarily indicate declining health, but can be regarded as normal adaptations to variations in climate and nutrient supply. However, the results from 1995 show that 25 per cent of all the trees surveyed showed clear signs of damage, with more than 25 per cent defoliation. The most sensitive species are beech, cork oak and several species of fir (Bundesministerium für Ernährung, Landwirtschaft und Forsten 1996)

The results for individual countries show that there are large regional variations in the health of European forests. The extent of the damage is greatest in eastern parts of Central Europe, but significant damage is also found in both Northern and Southern Europe. Particularly widespread damage has been reported in Poland, where 53 per cent of the trees investigated showed clear signs of damage in 1995. In Denmark, 37 per cent of the trees observed were reported to show clear signs of damage in the same year. In Austria, the proportion of trees showing clear signs of damage fell from 11 per cent in 1989 to 7 per cent in 1995. In France, the proportion of trees showing signs of damage has remained low for a number of years, but rose from 7 per cent to 13 per cent from 1994 to 1995.

7.4 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 7.5). 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 7.5. **Area of forest and other wooded areas in European countries**

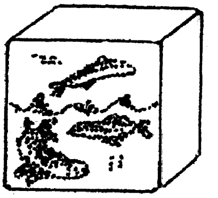


Source: UN-ECE/FAO (1995)

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

8. Fishing, sealing and whaling

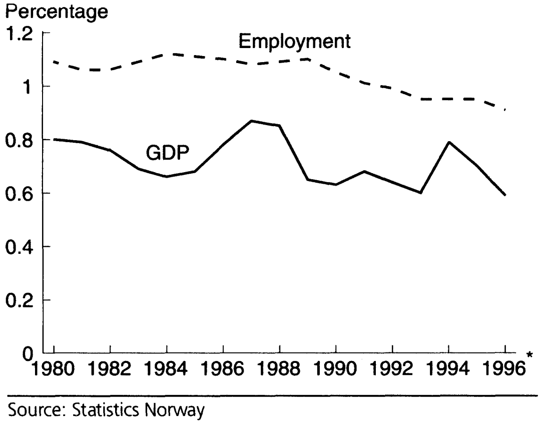


The stock of Norwegian spring-spawning herring is growing strongly. After severe depletion in the 1970s, the spawning stock rose to 5.4 million tonnes in 1996. The total catch in Norwegian fisheries in 1996 was 2.8 million tonnes, with a first-hand value of NOK 8.6 billion. In 1996, the slaughtered quantity of farmed salmon was about 290 000 tonnes, 30 000 tonnes more than in 1995. The export value of fish in 1996 was NOK 22.5 billion, and farmed fish accounted for NOK 7 billion of this.

8.1 Principal economic figures for the fisheries

According to the national accounts, the share of Norway's gross domestic product (GDP) derived from fishing, sealing and whaling decreased from 0.8 per cent in 1980 to 0.6 per cent in 1996. In the same period, the share of total employment decreased from 1.1 per cent to 0.9 per cent (figure 8.1). At the end of 1995, 23 653 fishermen were registered in Norway, and fishing was the main occupation of 17 160 of these.

Figure 8.1. **Fishing, sealing, whaling and fish farming. Proportion of GDP and employment**



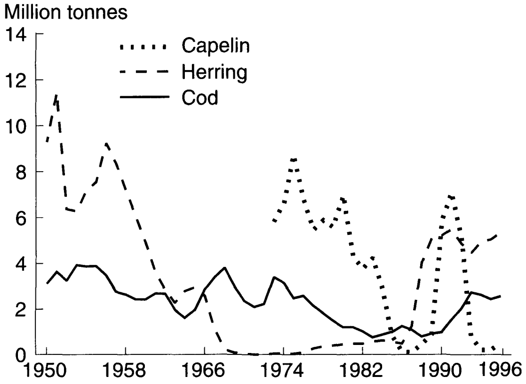
Source: Statistics Norway

8.2 Trends in stocks

Barents Sea and Norwegian Sea

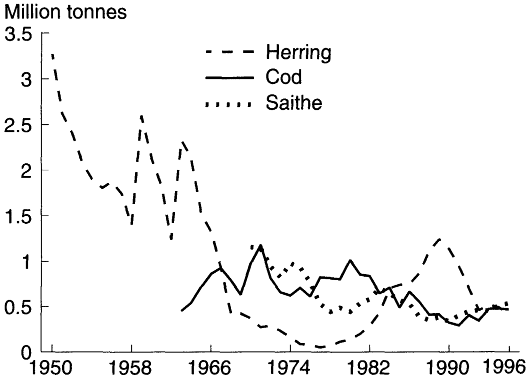
Norwegian spring-spawning herring, capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Since the end of the 1960s, all three of these stocks have at some time reached a historical low (figure 8.2). The herring stock was severely depleted by overfishing at 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 H1 in Part III). The capelin stock in the Barents Sea recovered rapidly after its collapse, but dropped sharply again in 1993. The latest development is a result of a significant increase

Figure 8.2. **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 8.3. **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

in the natural mortality of both larvae and older capelin. This is explained by predation; cod and marine mammals in particular feed on adult capelin, and juvenile herring feed on capelin larvae. The capelin stock will remain very low for the next two to three years (Havforskningsinstituttet 1996a).

North Sea

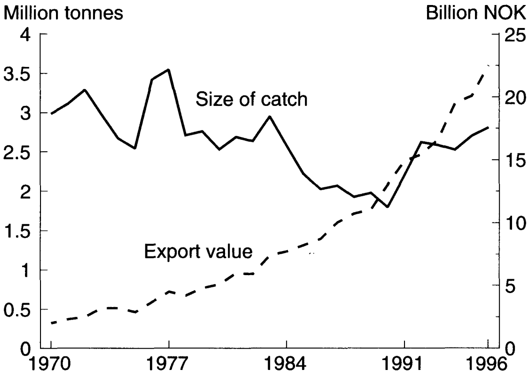
The stock of North Sea herring rose steadily from 1980 onwards, but the spawning stock has dropped considerably during the 1990s (figure 8.3 and table H1 in Part III). One reason for this is that recruitment to the stock has been poorer than in the mid-1980s. The fishing pressure has also been too high. Stocks of demersal fish in the North Sea are currently at a historical low, so that the natural mortality 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 1996a). The spawning stocks of both North Sea mackerel and the mackerel stock which spawns south-west of Ireland (there is a certain amount of exchange between these stocks, and both are caught on Norwegian fishing grounds) are currently very low. The Western mackerel stock is the larger, and has a spawning stock of about 2 million tonnes, while that of the North Sea mackerel is just under 100 000 tonnes.

8.3 Fisheries and fish farming

Fisheries

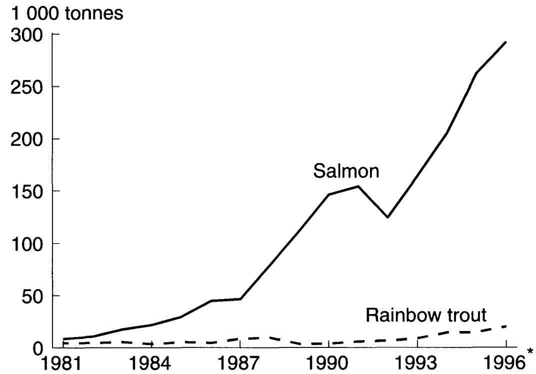
The total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) in 1996 was 2.8 million tonnes (figure 8.4 and table H2 in Part III), and the first-hand value was NOK 8.6 billion. The total catch was about 100 000 tonnes higher than in 1995, and its value rose by almost NOK 400 million. The catch of herring rose in 1996, and its value increased by nearly NOK 0.5 billion from 1995 to NOK 1.45 billion. The catch of mackerel dropped substantially (by 65 000 tonnes), but as a result of high prices, the value of the catch rose by about

Figure 8.4. **Catches and export value**



Sources: Statistics Norway and Directorate of Fisheries

Figure 8.5. **Fish farming. Slaughtered quantities of salmon and rainbow trout**



Sources: Statistics Norway, Directorate of Fisheries and Kontali AS

NOK 350 million to NOK 1.05 billion. The catch of cod was slightly lower than in 1995, and its value dropped by about NOK 300 million to NOK 2.52 billion.

Production of farmed fish

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 262 000 tonnes in 1995 to 292 000 tonnes in 1996 (figure 8.5). More than 80 per cent of the farmed salmon is exported. In 1995, Norway accounted for 53 per cent of total world production of farmed Atlantic salmon (Havforskningsinstituttet 1996b). The production of rainbow trout has also risen and was about 20 000 tonnes in 1996. Production in the Norwegian fish farming industry is now higher than total meat production in Norwegian agriculture, which was about 240 000 tonnes in 1995.

The health of farmed salmon

The most important diseases affecting salmon farming are:

- Furunculosis, caused by the bacterium *Aeromonas salmonicida* (diagnosed at seven fish farms in 1995);
- Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum* (diagnosed at six fish farms in 1995);
- Vibriosis and cold-water vibriosis, caused by the bacteria *Vibrio anguillarum* and *Vibrio salmonicida* (diagnosed at 22 and seven fish farms respectively in 1995);
- Infectious salmon anaemia (ISA), a virus disease (diagnosed at two fish farms in 1995);
- infectious pancreatic necrosis (IPN), a virus disease (diagnosed at 215 fish farms in 1995).

The health of farmed fish has 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 was highest in 1987, when it reached 49 tonnes (table H3 in Part III). This corresponded to 58 per cent of total consumption of antibiotics in Norway (for fish, livestock and in human medicine), and to 0.9 g per kg fish produced. In 1994, consumption had been reduced to 1.4 tonnes, corresponding to 3.6 per cent of total consumption and 0.007 g per kg fish produced (Havforskningsinstituttet 1995). In 1996, consumption of antibiotics was 1.04 tonnes. Consumption for livestock and in human medicine has not changed markedly during this period. Sound routines for the use of antibiotics are important if we are to avoid their transfer to other organisms and the development of resistant forms of bacteria.

8.4 Exports

Preliminary figures show that in 1996, exports of fish and fish products rose to about 1.8 million tonnes, with a value of NOK 22.5 billion (figure 8.4 and tables H4 and H5 in Part III). The value of exports to EU countries was NOK 13.9 billion, or 62 per cent of the total.

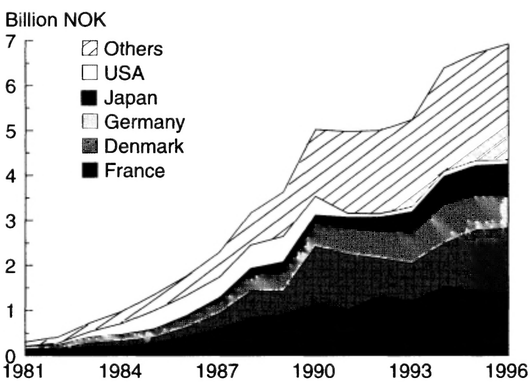
Exports of fresh and frozen farmed salmon totalled 214 000 tonnes, with a value of NOK 5.7 billion. In addition, smoked salmon and salmon fillets to a value of more than NOK 1.2 billion were exported, so that salmon exports in 1996 had a total value of NOK 6.9 billion (figure 8.6 and table H6 in Part III). This is equivalent to 31 per cent of the total value of 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 14.6 per cent of exports of traditional goods from Norway in 1996 (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.

8.5 Sealing and whaling

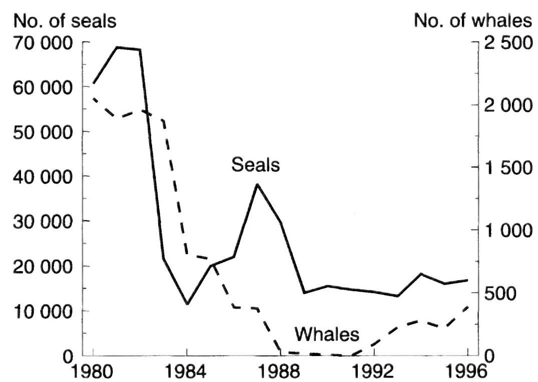
Since 1983, Norwegian sealing has taken place in the West Ice (off Jan Mayen) and in the East Ice (the White Sea). Catches have been small, varying between 10 000 and 40 000 animals per season (figure 8.7). In 1996, the total catch was 16 737 animals

Figure 8.6. **Exports of farmed salmon to the main purchasing countries**



Source: Statistics Norway, Foreign Trade Statistics

Figure 8.7. **Norwegian catches of seals and small whales[1], 1980-1995**



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

(15 926 harp seals and 811 hooded seals). The catch of harp seals included 8 559 weaned pups.

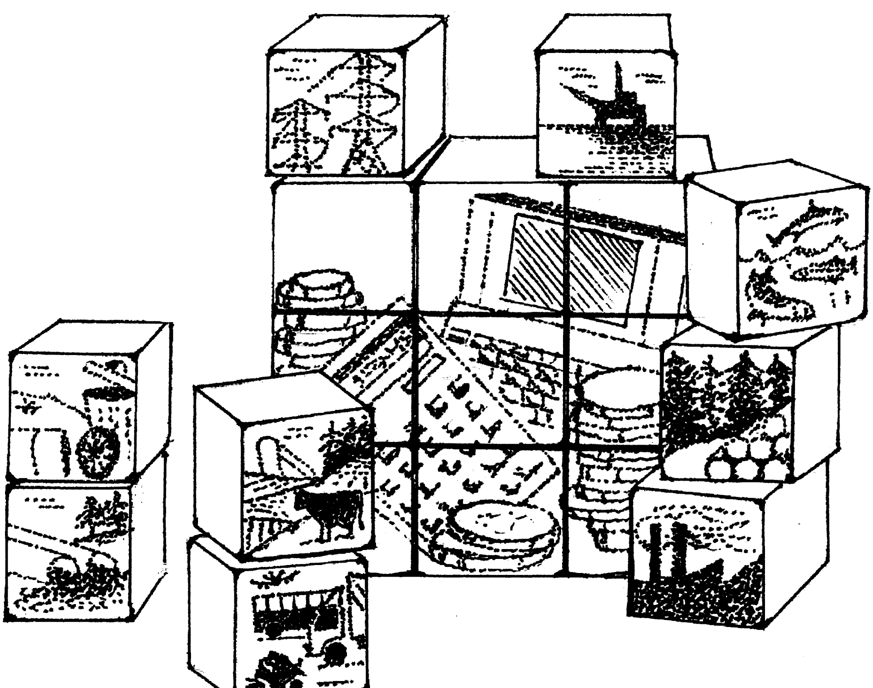
Until the early 1980s, the annual value of the seal catch was between NOK 10 and 40 million. In 1996, the value was almost NOK 2 million.

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 1996, 388 minke whales of a total quota of 425 animals were caught. After the most recent sighting survey carried out by the Institute of Marine Research in 1995, the Northeast Atlantic minke whale stock (which includes animals on the whaling grounds in the North Sea, along the Norwegian coast, in the Barents Sea and off Svalbard) was calculated to be 112 000 animals (95 per cent confidence interval 91 500 - 137 000). If the Jan Mayen area is included, the figure calculated for the stock is 118 000 animals.

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 1996, the value of the catch was between NOK 15 and 16 million. The export of whale products is still prohibited.

Further information may be obtained from
Frode Brunvoll

Part II. Economic research on resources and the environment



1. Introduction

Norway has an abundance of important *natural resources*, such as hydropower, oil, gas, forests and fish. High international demand for these resources entails that we are in a more favourable position than most other countries. But this also means that Norway bears a considerable responsibility for managing its natural resources in an optimal manner. The exploitation of our natural resources and the revenues we derive from their sale influence the welfare of future generations. If petroleum resources are extracted swiftly, future generations will not benefit from them unless part of the revenues are saved in the form of investment. The responsibility is amplified by the close link between resource management and important *environmental problems*. The use of natural resources often has negative side-effects such as the pollution of air, soil and water. Examples of this are emissions to air through the combustion of oil, coal and gas, which may not only have harmful local effects on human health, buildings and crops, but also harmful global effects as a result of higher quantities of greenhouse gases in the atmosphere.

In this section of the report, Statistics Norway presents research projects on environmental and resource problems carried out in 1996. As in earlier years, these cover a broad range of national and international issues.

During the past year considerable attention has been focused on the *electricity market*, primarily as a result of the water shortage in the southern part of Norway due to little precipitation in the winter of 1995/1996. A limited inflow of water to the reservoirs has contributed to higher electricity prices, and considerable imports of electricity from Sweden and Denmark were necessary to satisfy demand. Another important event was that the electricity markets in the Scandinavian countries were linked through a joint market from 1 January 1996. This may have a considerable influence on changes in the use of energy in the Nordic countries in the years ahead. A higher taxation of fossil fuels and phase-out of Swedish nuclear reactors will, for example, result in noticeable changes in electricity generation and trade in electricity. In the longer term we will probably see a further link-up between the Scandinavian electricity market and markets on the continent. The link-up of hydropower systems and thermal power systems may result in a more efficient use of resources. A third event was the presentation of a proposal by the Government in the spring of 1996 to revise the tax system for the electricity sector. According to our calculations, the proposal would result in a redistribution of tax revenues from municipalities with substantial tax revenues from power stations to municipalities that have lower revenues of this type.

Considerable changes may occur in the European *gas market* in the period ahead if the EU adopts a new gas directive, which provides for a greater liberalization for the transport of gas. This will have an influence on such exporters as Norway, Russia and Algeria. Our analyses of the gas market indicate that, unlike earlier years, strategic investments, i.e. investments to keep competitors out of the market, are not very probable in the years ahead. In recent years Norway has become one of the world's largest oil exporters, and the taxation of *oil products* in consumer countries will have a substantial impact on our future oil revenues. An international taxation of fossil fuels as a result of a climate agreement may reduce the oil revenues of producer countries. Calculations derived from our models show, however, that OPEC's behaviour influences the distribution of the tax burden between consumers and producers. A dissolution of the OPEC cartel might reduce oil prices dramatically. It is therefore interesting to study the reasons why OPEC might choose this solution. According to our calculations, exploration activity and higher reserves in non-OPEC countries may have a considerable impact on the economic gains OPEC can achieve through cooperation.

Valuation analyses are often used in order to evaluate the *harmful effects of pollution* on the environment and health. These studies attempt to quantify the values individuals place on the environment. Such analyses are associated with considerable uncertainty. Statistics Norway has carried out studies to calculate the harmful effects of atmospheric emissions of particulates and polluting gases. In a study of the health effects of air pollution in Oslo, it is estimated that just below 100 people die prematurely each year as a result of local emissions of particulates. The health of a large number of people is also impaired as a result of chronic pulmonary diseases. This entails substantial costs for society, for example through sickness absence, disability pensions and hospital admissions. A detailed study of sickness absence in a large Oslo enterprise demonstrates a close correlation between sickness absence and particulate concentration. Air pollution also has a negative effect on agricultural areas. Ozone in the lower atmosphere can result in reduced harvests of wheat, potatoes and cultivated meadows. Crop losses in 1992 are estimated at about 2 per cent of the agricultural sector's total value of production, and total social costs are estimated to be up to twice the level of the direct costs of crop losses.

The "Green Tax Commission" presented its report in 1996. A *green tax reform* entails a reduction in taxes on factors one wishes to stimulate, such as employment, and higher taxes on factors one wishes to limit, such as polluting emissions. Our analyses show that this type of reform can yield welfare gains even when the effects on the environment are not taken into account. Moreover, a sharp rise in the CO_2 tax combined with reductions in the payroll or investment tax will generate substantial environmental and traffic gains. Taxes on waste were also evaluated in connection with a green tax reform. Steadily rising quantities of waste result in a need for new deposit sites, involving the risk of run-offs from landfills and contributing to an increased waste of scarce resources, such as metals. A tax on packaging can encourage a reduced use of raw materials and thus reduced production of packaging and waste in the production process. However, it is important to view waste problems in a wider context since the environmental gains linked to reduced waste quantities are small compared with the environmental gains linked to reductions in polluting emissions, packaging raw materials and other types of material inputs. One alternative to taxing packaging is a general tax on the use of materials. An increase in such a tax combined with a reduced payroll tax, in such a way that central government tax revenues remain unchanged, might improve the environment through a reduction in waste generation and lower environmental stress in general. Economic activity, however, may be reduced, partly because some will prefer more leisure time.

One of the most serious environmental threats facing the world is the potential for *climate change* as a result of man-made atmospheric emissions of greenhouse gases (CO_2, methane, CFCs, etc.) International negotiations are under way to bring about reductions in emissions of greenhouse gases. For Norway, this will involve costs in the form of a lower gross domestic product if other taxes are not reduced at the same time. These costs will be of about the same magnitude as in other OECD countries, excluding the US, but the taxes necessary to stabilize CO_2 emissions are higher in Norway since we do not have the same possibilities for switching to less polluting energy sources. Catastrophes in the long term as a result of climate change cannot be ruled out. One example might be changes in the Gulf Stream which would have considerable consequences for Europe. The possibility of catastrophes is an important argument for reducing emissions of greenhouse gases. How much depends, in part, on how much importance current decision-makers attach to the welfare of future generations.

The last chapter deals with various studies of other environmental problems. Soil degradation has been singled out as an important reason for poor productivity trends in tropical agriculture, and the reasons for this degradation have been studied. A methodological analysis looks at how the demand for sustainable development can be viewed in relation to an equitable distribution between generations. Other studies examine the costs of waste treatment, emissions of cadmium and phthalates in Norway, the storage of CO_2 in man-made reservoirs, and an improvement in land use statistics for built-up areas in Norway.

MSG-model

A number of the research projects carried out in 1996 are based on the use of MSG, which is a multi-sectoral equilibrium model for the Norwegian economy. Various versions of this model have been used by the Ministry of Finance since the end of the 1960s for analyses of long-term developments in the Norwegian economy. Until recently, Statistics Norway made use of two main versions of the Model: MSG-5 and MSG-EE (Multi Sectoral Growth-Energy and Environment). The latter version is particularly suitable for analyzing issues relating to natural resources and the environment. In particular, transport is specified in several sectors. These two versions of the model have now been combined into the model MSG-6.

Growth in total production is determined in the model by assumptions concerning technological change, the required rate of return on real capital, the total number of man-hours worked and the supply of raw materials and natural resources. Equilibrium between demand and supply is assumed in all markets, and consumer and producers use the existing resources. This means that the entire supply labour is employed and the model is therefore not suitable for analyzing short-term adjustment problems or changes in unemployment.

In addition to the key assumptions on growth, the model user must make estimates of changes in production and income in the petroleum sector, government purchases of goods and services, developments in the international economy, prices on the world market, required changes in the current external account and the financial balances of households and general government, and rules relating to taxes, excise duties and subsidies.

Based on these assumptions, the model calculates changes in total output and the distribution of production, employment and capital stock by industry, private consumption, prices of goods produced in Norway and changes in wages.

The model also provides a relatively detailed description of the production and consumption of energy in Norway. In the model, electricity can be produced either as hydropower or at thermal power stations based on the use of natural gas. The transmission and distribution of electricity is also modelled. Transport in included as a separate factor input in the production modelling. Transport services, which are split up into road, sea, air and railway transport in addition to postal and telecommunication services, can either be produced in the sector which uses the service (own transport) or be purchased from commercial transport companies (commercial transport). A supplementary model has also been constructed to calculate emissions of various pollutants from the use of fossil fuels and various industrial processes. The model can therefore be used to evaluate relationships between developments in the economy, the use of energy and some environmental aspects.

MSG is based on figures and definitions from the national accounts, which makes it easy to compare the results with historical trends. The detailed sectoral classification provides a basis for studying the structure of industries and adjustments in a growth process.

2. Analyses of the electricity market

2.1 Analyses of the deregulated Nordic electricity market

The aim of this project was to expand an existing Nordic electricity market model to include the interdependence of the electricity market and the rest of the economy. The electricity markets in Norway and Sweden were linked in a joint market as of 1 January 1996. It is important to analyze the implications of this linkage since agents in Finland and Denmark can also trade in this market. A model was therefore constructed which makes this possible. The calculations resulting from the model indicate that a higher carbon tax and an earlier phase-out of Swedish nuclear power result in significant changes in electricity production and trading patterns, but that their effect on gross domestic product (GDP) and total consumption is modest.

The model, NORMEN, was constructed with a joint deregulated Nordic energy market as a framework and links the energy market, the general economy and the environment (i.e. the level of CO_2 emissions) in Denmark, Finland, Norway and Sweden. This simplified general equilibrium model is innovative compared with other models because it features a very detailed electricity block combined with trade in electricity between countries. The activity level is determined through the interaction between the energy market and the rest of the economy. Because there are wide variations in production methods among countries, and therefore in the cost structure and electricity prices, the Nordic area as a whole can achieve considerable gains from trade in electricity.

Unlike models which focus solely on the electricity market, and where electricity prices do not influence general economic activity (see, for example, Bye et al. 1995), in NORMEN all domestic prices are determined simultaneously. This is important because electricity prices differ widely among countries as well as for various end-uses. Using a model like NORMEN allows us to capture the indirect effects on the rest of the economy resulting from electricity price changes. Such price changes might result, for example, from the introduction of less expensive generation methods, an increase in carbon taxation, or a change in trading conditions for electricity.

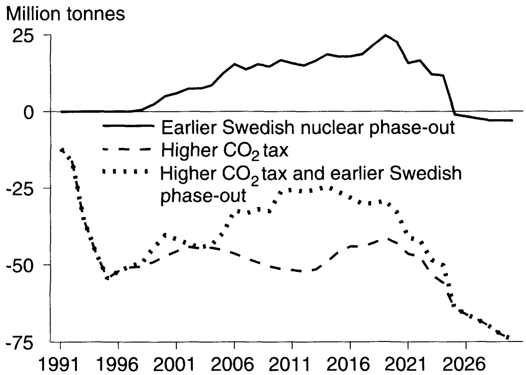
In addition to model building, one goal of the project was to collect sufficient data for model-based calculations. A database for the four Nordic countries was developed in cooperation with a number of Nordic research and statistical institutes. The base year of the model is 1991.

Two possible scenarios in the Nordic electricity market are analyzed: An increase in CO_2 taxes and an earlier-than-planned phase-out of Swedish nuclear reactors (after 25 years' use instead of 40). A scenario in which both are implemented at the same time is also examined. The calculations from the model show the effects on electricity demand and prices, CO_2 emissions[1] and on general economic indicators such as GDP and consumption. The results are compared with a reference scenario with unchanged (i.e. base-year) CO_2 taxes and the shutting down of Swedish nuclear reactors after 40 years' use[2]. Compared with an earlier partial Nordic energy market model (Bye et al. 1995), electricity consumption in NORMEN is more sensitive to electricity price changes because the model takes into account substitution possibilities between energy and other production factors and the effects of price changes on the general economy.

By introducing a common Nordic CO_2 tax of NOK 350 per tonne CO_2,[3] total Nordic CO_2 emissions (excluding CO_2 emissions from transport) fall by about 40 per cent compared with the reference scenario, see figure 2.1.1. Most of this reduction occurs in the power generation sector (coal, oil and gas-fired power stations). The results indicate that a 50 per cent rise in electricity prices, which is the long term result of higher CO_2 taxes, only reduces Nordic GDP by around 1 per cent (figure 2.1.2). This is because the cost of electricity for most production sectors is only a small fraction of total factor costs. Even for the most electricity-intensive sectors in NORMEN, the electricity cost share is not greater than 10 per cent. The sectors which are hardest high by the carbon tax increase are the metals and pulp and paper sectors in Finland, Norway and Sweden, where production declines by between 4 and 7 per cent by 2030, compared with the reference scenario.

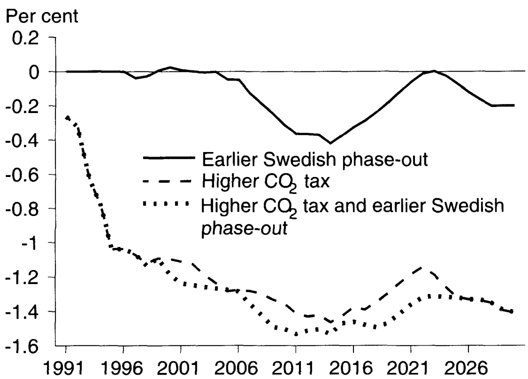
The result of a Swedish referendum held at the beginning of the 1980s was that all Swedish nuclear reactors were to be phased out (given that a set of economic conditions were satisfied) after 25 years' use, i.e. 15 years earlier than previously recommended. The calculations based on this early phase-out show modest changes in electricity prices both in the scenario with and without higher carbon taxes. This is because even in 2010-

Figure 2.1.1. **Nordic CO_2 emissions. Deviation from reference scenario**



Source: Aune et al. (1996)

Figure 2.1.2. **Nordic GDP. Deviation from reference scenario**



Source: Aune et al. (1996)

[1] Emissions from the transport sector are not included in these calculations.
[2] The reference scenario refers to developments over time in the variables explained by the model when the assumptions are the same as they were in the base year 1991.
[3] Other taxes are not reduced, i.e. this is not a revenueneutral tax change. In the base year, CO_2 taxes varied from 0 to NOK 300 per tonne CO_2 in the various countries (1991 prices).

2020 in the reference scenario, it is the backstop technology,[4] coal-fired electricity, which determines the price of electricity. Important economic variables such as GDP and consumption therefore remain almost unchanged when Swedish nuclear reactors are phased out after 25 years instead of 40 (figure 2.1.2). In the scenario with an early phase-out (and unchanged CO_2 taxes), the Norwegian pulp and paper sector is the most adversely affected, with production declining between 0.4 and 1 per cent by 2030, compared with the reference scenario.

Even though the effects on important economic variables for the general economy are minimal, NORMEN shows substantial changes in production patterns for electricity (i.e. the technology used) in each Nordic country. For example, the higher CO_2 tax results in a 16 per cent (77 TWh) decline in Nordic electricity generation by 2030 compared with the reference scenario. Sweden and Finland switch from coal-fired generation (condense) to biofueled power generation, whereas Denmark primarily increases its use of gas power. In Norway, hydropower generation increases by 6 per cent (8 TWh) compared with the reference scenario in 2030, while gas power becomes unprofitable under the higher CO_2 tax. With an early phase-out of Swedish nuclear power, the effects on electricity generation are more modest. Total Nordic electricity production falls by 1 per cent (5 TWh) in 2030 compared with the reference scenario. Sweden and Denmark start to use condense (coal-based) technology approximately ten years earlier than in the reference scenario. These countries use a little more gas power (1 TWh in Sweden and 6 TWh in Denmark) in 2030, while Norway reduces its consumption of gas power by 29 per cent (8 TWh) compared with the reference scenario. The long-term results when both higher CO_2 taxes and an early phase-out of Swedish nuclear reactors are implemented are very similar to the results in the scenario involving only higher carbon taxes because all Swedish nuclear reactors will have been phased out before 2030 in any case.

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

Financed by: Nordic Council of Ministers

Documentation:
Aune, F.R., T. Bye, T.A. Johnsen and A. Katz (1996): NORMEN: A General Equilibrium Model of the Nordic Countries Featuring a Detailed Electricity Block, Documents 96/19, Statistics Norway.

2.2 The Nordic electricity market to the year 2020

New electricity transmission cables to Europe will increase the trade in electricity between Norway and other countries. Norwegian electricity will be exported in periods of high demand and high prices in Europe. Electricity will be imported when consumption and prices abroad are low. Given the European electricity prices that have been assumed in this study, the price of electricity in Norway will be about 22/24 øre/kWh in the period to the year 2020, i.e. approximately the same as the level in 1996. Lower transmission tariffs, however, will result in falling prices for consumers.

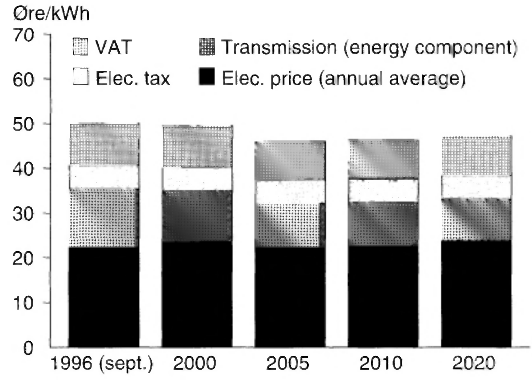
Statnett SF (the Norwegian Power Grid Company) has commissioned Statistics Norway to draw up projections for the Norwegian electricity market to the year 2020. The work is based on models developed by Statistics

[4] Backstop technology refers here to a known technology which can result in the production of unlimited quantities of electricity at a given unit cost.

Norway. The assumptions concerning general economic developments are based on estimates from the Green Tax Commission (Ministry of Finance 1996). Electricity prices in Europe are estimated on the basis of the costs linked to new power generation projects and fuel costs for gas and coal-fired power stations. It is assumed that four new transmission cables to the European continent will be built within the projection period, of which three have already been granted a licence. It is assumed that power-intensive industries, which today have long-term electricity contracts at low prices, will gradually be confronted with more market-determined prices. This will result in a reduction of 15-20 per cent in the sector's electricity consumption. It is also assumed that the two planned gas-fired power stations at Kårstø and Kollsnes will be built in Norway. In addition, some new hydropower projects will become profitable, entailing that hydropower production increases by about 10 per cent from 1996 to the year 2020.

Production in conventional thermal power stations is difficult to adjust in step with current consumption. Fluctuations in demand entail that power stations must be started and stopped based on the load situation. Due to the considerable costs associated with starting and stopping thermal power stations, it may be profitable for foreign electricity producers to export in periods of low domestic demand instead of halting production at power stations during these periods. In the Norwegian hydropower-based system, however, there are considerable possibilities for adjusting production, and the cost differentials between production in peak/off-peak periods are small. Norway can therefore import electricity at low prices during off-peak periods and then export at higher prices in peak periods. Additional cables to other countries provide opportunities to increase electricity exports during the day and

Figure 2.2.1. **Estimated average electricity prices through the year for Norwegian households, excluding the fixed component for transmission. Constant 1996-prices**



Source: Hansen et al. (1996)

import electricity at night and during the weekend. As a result, the price of electricity in Norway will be higher during the day in winter than at other times of the day and year.

The price for the consumer is composed of the electricity price (producer price), transmission costs and taxes. The costs of transmission are in turn split up into a consumption-dependent component and a fixed component. The fixed component is the price for being linked up to the electricity grid, and must be paid irrespective of whether electricity is used or not. Figure 2.2.1 shows estimated movements through the year in average electricity prices for Norwegian households. The calculations refer to a normal year in terms of precipitation.

Water reservoirs were at low levels in 1996, resulting in a spot price of a little more than 30 øre/kWh in the second half of the year. As a result of high spot prices, the price of electricity (producer price) for households rose from an average 18.5 øre/kWh in 1995 to

22.4 øre/kWh in September 1996. The calculations show that the price of electricity will remain stable at around 22-24 øre/kWh in the period to 2020. Increased efficiency in grid companies, however, will result in lower costs for the transmission of electricity. It is also assumed that transmission tariffs are shifted from the consumption-dependent component to the fixed component. This will make it more expensive to link up to the grid whereas current electricity consumption will be cheaper. The price of electricity for households, excluding the fixed component, therefore falls in the period to the year 2005 and then remains stable.

It is assumed that the integration of electricity markets in Europe will continue. The calculations are also based on the assumption that the Norwegian electricity market develops in such a way that most electricity consumers are gradually confronted with prices that can vary through the day and night, week and year. Consumers will thus have an opportunity to shift consumption to periods with low prices. Similarly, power producers may achieve gains by producing at times when prices are highest.

Project personnel: Mona Irene Hansen, Tor Arnt Johnsen and Jan Øyvind Oftedal

Financed by: Statnett SF (Norwegian Power Grid Company)

Documentation:

Hansen, M.I., T. A. Johnsen and J. Ø. Oftedal (1996): *Det norske kraftmarkedet til år 2020. Nasjonale og regionale framskrivninger* (The Norwegian electricity market to the year 2020. National and regional projections. In Norwegian), Reports 96/16, Statistics Norway.

2.3 Electricity taxation. An analysis of various tax schemes for power stations

In the spring of 1996 the Government tabled a proposal to change the tax system for the electricity sector in Norway. Applying a model, which comprises 80 per cent of Norwegian electricity production, we analyze the distributional effects among municipalities and between municipalities and the state as a result of this change. We show that municipal tax revenues are relatively robust both in relation to various future price estimates for electricity and in relation to various estimates for the fixed and variable costs at power stations. Central government revenues from the taxation of power stations are more sensitive to various estimates of these factors than municipal revenues. The new tax regime generally implies higher revenues for electricity-producing municipalities. However, the 10 per cent of electricity-producing municipalities that have the highest revenues from electricity taxation will be in a less favourable position, even though these municipalities will still have considerable revenues from the taxation of power stations.

The Ministry of Finance's Proposition no. 23 (1995-96) on "Taxation of electricity enterprises" resulted in extensive discussions of the consequences for individual municipalities as a result of a changeover to a new tax system. Our paper discusses how various assumptions concerning future electricity prices and various assumptions concerning the basis for calculating estimates of production costs in power stations will influence total municipal taxes. Estimates are also presented for the distributional consequences which will result from the various alternative tax schemes. The proposed tax system is relatively complicated and calculations of municipal distributional effects by looking at an individual municipality in isolation are not possible. One of the reasons is the very complex ownership structure across municipalities in the electricity sector. A model constructed with the aim of capturing the complexity in the proposed tax system is used in this analysis in order to take this interrelationship into account. The construction of the model - KRAFTSKATT, see Fjærli (1997) - which comprises 80 per cent of Norway's electricity production, was commissioned by the Ministry of Industry and Energy and the Ministry of Finance.

The desire for a coherent and effective overall tax system was the starting point for revising the previous system for the taxation of power stations. The current (before 1996) electricity taxation system discriminates, among other things, between privately and publicly owned power stations. A free electricity market will entail that virtually all electricity will be approximately equally priced in the long run. Power stations that are cheapest will then achieve a higher return than the most expensive power stations. The extra return which arises in such stations and which exceeds the normal return of an alternative investment is called resource rent. This rent was not taxed in the earlier electricity taxation system, whereas the plans call for such taxation in the new system.

The tax proposal calls for the taxation of ordinary income (accounting profit), hydropower income (appraised gross income) as well as resource rent and property tax. When calculating taxes, it is important to take account of a very strong link between the various types of taxes in the proposed tax scheme. A decline, for example, in the tax on resource rent may result in an increase in property taxes in that the first is deductible from the basis of calculation for the latter. An increase in the resource rent tax rate will thus not result in an equivalent tax increase in relation to power companies since the property tax will automatically decline. With higher prices, resource rent and the tax on this rent will increase, whereas the property tax will fall. Municipalities, which receive the property tax and parts of the resource rent tax, are therefore also partly protected against the uncertainty inherent in future electricity prices, whereas central government tax revenues (no property tax) from power stations are more exposed to such changes. The risk of a fall in prices or, in the event, the advantage of a rise in prices is thus almost in its entirety transferred from municipalities to the central government as a result of the coordinating rules for various types of taxes. Central government tax revenues can therefore vary substantially with electricity prices. Similarly, central government tax revenues are sensitive to various cost estimates.

The calculations show that the tax proposal in isolation results in a slight decline in future municipal tax revenues from the 1992 level, but a noticeable increase in total municipal tax revenues compared with the estimate for taxes in 1994. The proposed scheme results in a redistribution of taxes between municipalities. Based on the proposal, tax revenues are more evenly distributed than tax revenues based on the current rules. For those municipalities where total property taxes and licensed-based electricity revenues are between 25 and 50 per cent of the national average for ordinary taxes per inhabitant, the tax proposal results on average in higher revenues per inhabitant compared with 1992. The 10 per cent of electricity-producing municipalities which have the highest tax revenues from power stations record a deterioration in revenues while the remaining municipalities benefit from the change. The calculations also show that the new electricity tax system will not result in substantial problems for the most expensive power stations.

Revenues from the taxation of power stations account for a fairly high share of total municipal tax receipts in some electricity-producing municipalities. In the project documentation we look a little more closely at the distributional effects in these municipalities, and find that even though these municipalities lose out to some extent, revenues from the taxation of power stations will remain very high.

The Standing Committee on Finance in the Storting (Norwegian parliament) debated the Government's proposal for a new tax system for power stations in the spring of 1996, and proposed some changes in the Government's scheme, see Report O. no. 62, Act no. 41 of 28 June 1996. The most important changes related to splitting up the resource rent tax into an economic rent tax and a resource tax, a few minor changes in some tax rates and in the distribution of taxes between the central government and municipalities. The changes which were proposed and adopted in the Storting do not significantly alter the main conclusions concerning the sensitivity of tax revenues with regard to price and cost estimates and the possible distributional effects of a new tax scheme as described above.

Project personnel: Torstein Bye, Erik Fjærli and Bård Lian

Financed by: Ministry of Finance, Ministry of Industry and Energy and Statistics Norway

Documentation:

Bye, T. and E. Fjærli (1996): Kraftbeskatning. En analyse av ulike skatteopplegg i forhold til kraftverk (An analysis of various tax schemes for power stations. In Norwegian), *Økonomiske analyser* 1996, 4, Statistics Norway.

3. Analyses of the oil and gas markets

3.1 Developments in the European gas market

In 1995, Norway exported about 30 billion standard cubic metres (bcm) of gas to Europe. 40.2 per cent of this gas was exported to Germany, while the second largest export market for Norwegian gas was France with a share of 25.7 per cent. In 2005, Norwegian gas producers have undertaken commitments to supply a little more than 60 bcm, and if ongoing negotiations with Italy and the Czech Republic result in contracts, total Norwegian exports may reach 80 bcm/ year. Developments in the European gas market are consequently of considerable importance to the Norwegian economy. This project looks at how investment behaviour and production of the three major gas producers Norway, Algeria and Russian are influenced by various assumptions concerning the market situation in the European gas market. The results indicate that Russia's investment behaviour is influenced the most by changes in the market situation.

A gas market model for Europe has been developed in a joint project between Statistics Norway and the Center for Operation Research and Econometrics (CORE), Université Catholique de Louvain in Belgium. Somewhat simplified it can be said that CORE has modelled the demand side (TEG model), while Statistics Norway's dynamic oligopoly model DYNOPOLY contributes the supply side in the model. In DYNOPOLY, the focus is on a few large producers with market power and the model shows how the supply of gas changes over time. By using the DYNOPOLY/TEG model developments in the European gas market are analyzed under three different assumptions concerning the market situation in the short term.

Norway, Algeria and Russia are the dominating suppliers of gas to Western Europe. The DYNOPOLY model focuses in particular on competition between these three 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. In DYNOPOLY, production in the Netherlands and the UK is assumed to be determined exogenously. This simplification can be justified on the grounds that production capacity in these countries has basically been developed and production will decline later in the next century due to limited reserves.

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. When capacity has first been expanded, it is maintained though the model's horizon to 2075. Each of the three countries chooses its optimal investment profile which entails that they attempt to maximize profits. The model takes account of strategic behaviour among the three producer countries, in that a produce is aware that his investments influence the profitability of the other gas suppliers' investment projects. Strategic investments can be motivated by the desire to prevent other producers from implementing their investments. The model is divided into five-year periods, and in each period the production capacity is determined by the initial capacity and investments carried out in earlier periods.

Within each five-year period, when production capacity is given, the demand model TEG calculates the profit for each of the three producers. TEG takes account of the regional aspect of the European gas market. Among other things, TEG models the network of gas pipelines and transport routes for LNG (Liquefied Natural Gas) in Europe. The use of TEG makes it possible to analyze the effects of various market situations in the short term.

This study looks at the following three scenarios. First, we study a situation with perfect competition in which the three producers have no influence on the price in the short term when production capacity is given. Moreover, we look at the effect of the introduction of restrictions by consumer countries, based on supply security, such that no single producer exceeds a given threshold level in the supply of each consumer. Finally, we look at the case with imperfect competition. Producers now take into account that their production has an influence on prices, also within each five-year period, while they look upon production from other producers as given.

The model-based calculations show that it is the timing for the implementation of the Russian investment projects which is most influenced by changes in the market situation. The Russian projects are postponed the longest as a result of supply security restrictions, and it is also Russia which benefits most from the situation with imperfect competition. Russia is assumed to be able to export 75 bcm/year to Western Europe beginning in 2000. By implementing three major investment projects, this capacity can be expanded by 40, 25 and 25 bcm/year, respectively. Under perfect competition, however, Russia will not carry out the third investment project and does not implement its first two investment projects until after Algeria and Norway have implemented all their projects.

According to the calculations, Algeria will implement its investment projects by 2015 irrespective of the market situation. The starting point is assumed to be an export capacity of 56 bcm/year. After having carried out two investment projects which will boost capacity by 10 and 6 bcm/year, Algeria will then have a capacity of 72 bcm/year from 2015.

Norway is assumed to have a capacity of 60 bcm/year from 2000. Production can later be increased to a total of 80 bcm/year by implementing two investment projects, each of which will boost capacity by 10 bcm/year. Both of the Norwegian investment projects will be implemented by 2020 in the scenario with perfect competition, but will be postponed to 2030 and 2050, respectively, under imperfect competition.

Producers find it optimal to have considerable excess capacity particularly in the situation with imperfect competition. Even if Russia implements its three large investment projects in 2000, the total production of gas is modest. The reason is that the suppliers hold back considerable quantities of gas to achieve a higher gas price in the market. Compared with the perfect competition situation, there is a drastic reduction in gas consumption in Western Europe in this case.

In the model-based calculations we find only one investment that is strategically motivated. This relates to the third Russian project which is implemented in 2000 in the situation with imperfect competition. One interpretation of the lack of strategic investments in the European gas market 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.

Project personnel: Elin Berg, Kjell Arne Brekke, Emmanuel Canon and Yves Smeers

Financed by: EU's research programme Joule II

Documentation:
Statistics Norway and Center for Operation Research and Econometrics, Université Catholique de Louvain (1996): Modelling strategic investments in the European Gas Market, Final report to the contract JOU2-CT92-0260.

3.2 Effects of higher CO_2 taxes on the oil market

An international agreement on global CO_2 taxes will have consequences for oil producers and oil consumers. In the longer term, higher CO_2 taxes will result in lower oil prices for producers, higher oil prices for consumers and a reduction in the total demand for oil. How the burden of higher CO_2 taxes will be distributed between producers and consumers will vary depending on assumptions concerning OPEC's behaviour. If OPEC prefers higher production and thus lower oil prices, this will result in a smaller increase in consumer prices than in the opposite case.

The greenhouse effect is recognized today as one of the most important international environmental problems. This may result in an international agreement to introduce global CO_2 taxes. A CO_2 tax will usually result in both a lower producer price (crude oil price) and higher product prices for consumers (price of end-products). If the supply of oil varies little with price changes, the effect on the producer price will be greatest, while the price for consumers will only be negligibly higher. The tax will in such an event have little influence on the volume sold and thus little impact on emissions of CO_2.

In most long-term models for the oil market OPEC is assumed to have economically rational behaviour in that it attempts to maximize the value of its oil revenues or wealth. In such models it can be taken into account that in the longer run oil is a non-renewable resource. Other models focus on the short and medium term where it is assumed that OPEC has problems in making optimal economic decisions, in addition to the fact that the political situation may have an influence. Due to considerable uncertainty, OPEC is assumed to make relatively extensive use of rules of thumb and trial and error when decisions are to be made. An example of each of these model types is used in the analysis below. In both models one can regard OPEC as a cartel with more or less coinciding interests.

The starting point for the analysis is the introduction of a global CO_2 tax of USD 10 per barrel. The effects on prices and demand in the year 2010 are analyzed by using two different models (PETRO and WOM)[1]. In both models producers are divided into OPEC and other producers (called the fringe). The fringe consists of many small producers which individually look upon the oil price as given. It is primarily the supply side in the two models that is different. In the PETRO

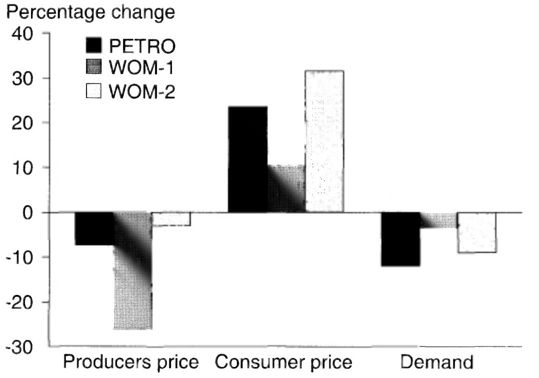
[1] PETRO is an intertemporal optimization model that is dynamic (Berg et al. 1996). WOM is a behavioural simulation model that is recursive (Bøeng 1996, Lorentsen and Roland 1986).

model, the supply over time is a result of attempts by both OPEC producers and the fringe to maximize the value of their petroleum wealth, something which depends on how income today is valued against income at a later date. OPEC is modelled as a cartel with market power, and price movements are the result of the cartel maximizing its petroleum wealth. In the WOM model, OPEC does not behave as a coherent cartel. In this case OPEC's aim is to maintain generally constant capacity utilization. The oil price is determined year after year by changes in capacity utilization. When production approaches the capacity limit, OPEC decides to let oil prices rise in the short term. Demand for oil from OPEC thus declines and capacity utilization is reduced. Through changes in production capacity OPEC can influence the price of oil in the slightly longer run. For a given level of demand, higher capacity will result in a reduction in oil prices. Two different scenarios have been studied. In WOM-1, OPEC increases its capacity by a constant rate from 1997 to 2010. In WOM-2, OPEC maintains constant production capacity.

Figure 3.2.1 shows that in the PETRO model the CO_2 tax results in a slight reduction in the producer price in the year 2010, whereas it is primarily consumers that are affected by higher prices for end-products. The tax leads to a relatively sharp reduction in demand. Due to its market power, OPEC will reduce its supply of oil considerably in order to reduce downward pressures on crude oil prices as a result of the CO_2 tax. In this period OPEC's petroleum revenues are thus reduced substantially. The fringe benefits from the fact that OPEC keeps the producer price at a high level. It is optimal for OPEC to postpone some production (and revenues) until later periods.

OPEC is assumed to increase its production capacity by a constant rate in WOM-1 even

Figure 3.2.1. **Effects of a global CO_2 tax of USD 10 p/b on oil prices and demand based on different model-based calculations. Percentage change in the period 1995-2010**



Source: Grepperud and Bøeng (1996)

after the introduction of a CO_2 tax. The tax results in a greater burden for producers in that the crude oil price falls sharply, while the consumer price only increases moderately. The relatively modest rise in the consumer price results in only a slight decline in the demand for oil in the period to the year 2010.

Compared with the previous case, given capacity in WOM-2 entails that the crude oil price is pushed up in a situation without a CO_2 tax. This is because the growth in the demand for oil which takes place as a result of global economic growth will now bring OPEC's production steadily closer to its capacity limit. With the introduction of a CO_2 tax, capacity is still held constant, and OPEC exercises a type of market power which only results in a minimal reduction in the price of crude oil. Like the results from the PETRO model, it is now consumers which must bear the greatest burden of the higher tax in the form of higher oil prices. Demand is thus reduced considerably. In PETRO and WOM-2, OPEC prefers reduced demand to a reduction in oil prices.

In the PETRO model, it is assumed that OPEC countries have coinciding interests. When a CO_2 tax is introduced, they are in this case willing to accept a sharp reduction in oil production to prevent a considerable fall in oil prices. Some countries in OPEC require revenues quickly and thus give priority to higher production now instead of higher production at a later time. To the extent these countries influence decisions in OPEC, a small reduction in supply can be expected entailing that revenues in the period can be maintained at an acceptable level. The introduction of a tax will thus result in a relatively greater decline in crude oil prices and a smaller rise in oil prices for consumers than shown by the results.

In the PETRO model, OPEC chooses changes in production capacity, and thus production, which result in the highest petroleum revenues in the long term. In WOM-1 and WOM-2, OPEC must weigh reduced demand on the one hand and lower crude oil prices on the other. Some OPEC countries probably have a less flexible economy and thus greater problems in expanding capacity than others. If many OPEC countries are in this situation, the introduction of CO_2 taxes may result in a relatively sharp increase in the consumer price and a smaller reduction in the crude oil price as shown in the results in WOM-2.

If a global CO_2 tax is introduced, OPEC's reaction is of key importance for changes in consumer and producer prices. The analysis above, however, shows that the magnitude of the changes is not very robust to the choice of model and model assumptions.

Project personnel: Sverre Grepperud, Ann Christin Bøeng and Lars Lindholt

Financed by: Statistics Norway

Documentation:

Grepperud, S. and A.C. Bøeng (1996): Konsekvensene av økte oljeavgifter for råoljepris og etterspørsel etter olje. Analyser i PETRO og WOM (Consequences of higher oil taxes for crude oil prices and the demand for oil. Analyses in PETRO and WOM. In Norwegian), Notater 96/12, Statistics Norway.

3.3 Gains from cartelization in the oil market

Since 1973 OPEC's market power has been an important determinant in the oil market. By imposing production limitations on member countries, the cartel has to some extent succeeded in maintaining high oil prices. For member countries, this has been an advantage, but the gains have been even greater for non-OPEC oil producers. This project looks more closely at OPEC's gains from cartelization in the oil market and how the behaviour of non-OPEC producers and various moves by consumer countries influence these gains. The results indicate that changes in exploration activity and reserves in non-OPEC countries have the greatest effect on cartelization gains. If non-OPEC reserves are sufficiently large, the gains from cartelization vanish and it will be profitable for OPEC to dissolve its cartel.

In 1995 Statistics Norway carried out a study which looked at the effect of an introduction of international CO_2 taxes on petroleum wealth (Berg et al. 1996). The results of this analysis indicated that a dissolution of OPEC is a greater threat to Norway's petroleum wealth than the introduction of international CO_2 taxes. This is the background for a further examination of factors which may entail that OPEC is dissolved or ceases to function as a cartel. In particular, the project tries to determine whether there are measures which result in an elimination of OPEC's gains from cartelization so that it is profitable for OPEC to be dissolved. With regard to changes in the behaviour of non-OPEC oil producers (the fringe), we look at the effects if fringe producers move ahead production and the effect of higher expenditure on research and development which results in greater technological advances for fringe producers. We also examine the effect of considerably larger reserves for non-OPEC producers as a result of intensified exploration activity. Steps taken by consumer countries include energy conservation and lower growth in the demand for energy, as well as the introduction of international CO_2 taxes.

A model for the international markets for the fossil fuels oil, gas and coal is used in the analysis. When producers determine production in each period, they take into account that higher production today reduces the availability of the resource in the future. The model thus focuses on the optimal depletion rate for the resources over time.

In the model, the unit cost of production increases as the resource is depleted. It is also taken into account that considerable advances are made in extraction technology with the unit cost of production being reduced over time by a constant annual rate. On the demand side, it is assumed that there are some possibilities for switching from one type of fuel to another. Changes in one market thus also have effects in the other markets. Moreover, it is assumed that there is an alternative carbon-free energy source of which there is a copious supply, and which can serve as a perfect substitute for all fossil fuels (backstop technology). This alternative is initially assumed to be considerably more expensive than fossil fuels, but due to technological progress the backstop price falls over time and entails that the extraction of fossil fuels becomes unprofitable in the long run.

Producers are divided into two groups in the oil market: OPEC and a fringe of all producers outside OPEC. The fringe consists of many small oil producers which individually look upon the oil price as given. OPEC, on the other hand, has market power in the sense that the organization can influence the price by changing the level of production. The model is constructed in such a way that both OPEC and the fringe determine their production profile given the production of the other producer group.

We have also modelled the oil market as a hypothetical competitive market in which OPEC, like the fringe, considers the oil price path as given when it determines its optimal production profile over time. OPEC's gains from cartelization thus emerge by comparing the value of OPEC's total oil wealth in the two market situations.

In addition to the oil market, the model operates with three separate gas markets: OECD-Europe (including imports from Russia and Algeria), rest-OECD and non-OECD, and a global coal market. Perfect competition has been assumed in these markets for the sake of simplicity.

The calculations derived from the model show that when OPEC operates as a cartel, an oil price of USD 21 p/b in 2000, rising to USD 39 in 2040, is estimated in the reference scenario. Initially, OPEC accounts for about a third of total oil production. In the period 2030-2050, however, OPEC gradually takes over the entire oil market when the fringe's reserves are depleted. In the competitive model, producers in OPEC look upon the price as given and increase production considerably at the start. In the reference scenario under perfect competition, production from OPEC countries increases almost fourfold in the first period, which results in a reduction in the oil price from USD 21 to

USD 11 p/b in 2000. The fringe producers are then squeezed out of the market in the first period because their production costs are higher than the oil price. A dissolution of OPEC thus has serious consequences for non-OPEC producers. According to our calculations, OPEC itself achieves cartelization gains of 17.5 per cent since OPEC's oil wealth increases from USD 3 431 billion in the competitive model to USD 4 030 billion in the cartel model.

The results indicate that increased exploration activity leading to larger reserves in non-OPEC countries than the level incorporated in the reference scenario has the greatest influence on OPEC's relative gains from cartelization. If non-OPEC oil reserves increase by a little less than 70 per cent, OPEC's relative cartelization gains are reduced to 1.2 per cent. When non-OPEC reserves increase to approximately twice the current level, OPEC's gains from cartelization will be negative.

If production in non-OPEC countries is moved ahead as a result of a more short-term policy among the fringe, this reduces OPEC's oil wealth both in the competitive model and when OPEC operates as a cartel. The relative gains from cartelization are therefore roughly constant.

Substantial advances have been made in oil extraction technology in non-OPEC countries in recent years. If we model more rapid technological progress outside OPEC, this results in higher production for the fringe at any given price, and we reach the same conclusion as when production is moved ahead in non-OPEC countries. In both cases OPEC's oil wealth is reduced, both in the cartel model and in the competitive model. The relative gains from operating as a cartel are therefore influenced very little.

Steps taken in consumer countries also prove to be of little significance for any disintegration of OPEC. Energy conservation in the OECD area has little impact, both on OPEC's total oil wealth and on the relative gains from cartelization. The introduction of an international CO_2 tax reduces OPEC's oil wealth, but the effect on the relative gains from cartelization is not clear-cut, see also section 3.2.

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

Financed by: Statistics Norway

Documentation:

Berg, E., S. Kverndokk and K.E. Rosendahl (1996): Gains from Cartelization in the Oil Market, Discussion Papers 181, Statistics Norway.

4. Analyses concerning environmental and health valuations

4.1 The political man and environmental valuation

In many contexts it may be useful to determine how individuals value the environment, by for example asking what they are willing to pay for maintaining environmental standards. If it is unclear which role the respondents in a valuation study have assumed, it is difficult to interpret the answers given. This may be one possible explanation for a number of phenomena which often arise in such studies, and which may be difficult to explain using ordinary consumer theory alone.

In the past decade a large number of studies have been carried out measuring people's willingness to pay for environmental goods using contingent valuation, see for example Navrud (1992). The environmental good could, for example, be clean air or pristine wilderness. In these studies a sample of the population is asked how much they are willing to pay for a specific environmental good. Even though the method has been developed with considerable emphasis placed on obtaining honest and consistent answers, these studies often show some results that may appear unreasonable based on ordinary consumer theory. For example, it is common that a fraction of the sample indicates a willingness to pay which constitutes a very large share of their disposable income, even though the good in question is of seemingly little personal relevance. Moreover, the values reported are often very sensitive to the number of questions asked in the same survey, the sequence of these questions and the hypothetical method of payment (for example, higher taxes or a charitable donation). Finally, very large discrepancies are often observed between the amount people say they are willing to pay for a specific good (willingness to pay) and the amount they demand to forego the same good (compensation demanded). In this project, a formal model is presented which can provide one possible explanation for such phenomena.

In the theory of consumer behaviour, it is normally assumed that consumers attempt to maximize their well-being or utility. In welfare economics, however, it is often assumed in addition that a central planner exists whose aim is to achieve maximum benefits for society, expressed with the help of a social welfare function. This social welfare function can be used to judge the social desirability of a certain change in the social state.

What happens if all individuals occasionally assume the role of the planner, and look upon an issue from a political/ethical point of view instead of their own personal interests? In this case all individuals have two preference orderings over social states: one for personal preferences and one for social motives. These two rankings may conflict with each other, implying that the person's choices in two different situations may appear inconsistent because the person assumes two different roles.

In most economic analyses it seems reasonable to assume that the description of the consumer as a utility maximizer is satisfactory. When valuing environmental goods, however, it is not obvious that this is the case. Most of us have been taught to some extent to put our own interests aside in relation to nature. For example, there are strong norms implying that one should not throw away trash in unspoiled nature even if one has no intention of ever returning to the site. Thus, it seems plausible that a question concerning one's willingness to pay for an environmental good is easily interpreted as a political or moral issue, and that the respondents therefore reply from a social point of view and not on the basis of their own personal interests.

If a respondent answers from a social point of view, the willingness to pay will heavily depend on assumptions about others' payments. If a person believes that nobody else will pay, the willingness to pay may be very high. This may be an explanation for the extremely high amounts reported by some people in willingness to pay studies. If, on the other hand, the respondent believes he or she is supposed to report an amount everyone should pay, the amount may either be higher or lower than it would have been if the respondent had replied on the basis of personal interests. It is therefore not possible to separate answers that are socially motivated by simply looking for extreme amounts. Moreover, it can be demonstrated that the other phenomena mentioned above, for example that the willingness to pay is sensitive to the sequence of questions, can be explained on the basis of this model.

Ethically or politically motivated answers do not measure individual well-being. Hence, they are also unsuitable for use in cost-benefit analyses, which may otherwise yield quite unintended results. One of the main problems is that it is difficult to know the motives of the individual respondent. If the motives have been different for various persons, the summation of individual willingness to pay will be like adding apples and oranges. In order to interpret reported willingness to pay, it is therefore necessary to know the motives behind the answers given.

Project personnel: Karine Nyborg

Financed by: The Research Council of Norway under the Economics and ecology programme

Documentation: Nyborg, K. (1996): The Political Man and Contingent Valuation: Motives Do Count, Discussion Papers 180, Statistics Norway.

4.2 Damage to health resulting from air pollution in Oslo

Estimates of annual damage to health resulting from air pollution in Oslo, and the associated social costs, are presented in this project. The calculations indicate that about 90 persons die prematurely each year in Oslo as a result of air pollution. All in all, these health effects entail social costs in the order of NOK 1.7 billion, of which 90 per cent of the costs is ascribable to a subjective valuation of a reduced quality of life.

The air in Oslo and other Norwegian towns contains polluting gases and particulates. The relationship between air pollution and the magnitude of effects on health have in recent years been studied through extensive international research for other towns and countries. This research indicates that especially suspended particulates are important in this connection. In this project, these research results are used to calculate the annual damage to health as a result of air pollution if these results are also relevant for Oslo. Emphasis has been placed on the most serious health effects and effects that influence economic activity. Even though there is considerable uncertainty associated with such calculations, they may provide an indication of the magnitude of health effects in Oslo. Moreover, attempts have been made to quantify the social costs through the impact on economic activity and a deterioration in the state of health of the population.

Knowledge of pollution levels in Oslo is required in order to estimate the magnitude of health effects. The Norwegian Institute for Air Research (NILU) has calculated the concentration of particulates (PM_{10}) in ambient air in various parts of Oslo (Walker 1997). Based on these calculations, the NILU estimated average concentrations through the year for the city as a whole. They also found how much of the concentration was due to vehicle traffic, space heating and emissions outside Oslo. In 1992 the mean annual concentration of PM_{10} in Oslo was 23.2 $\mu g/m^3$,[1] of which 14.5 $\mu g/m^3$ was due to local contributions in Oslo. Of the local contribution, heating emissions accounted for 40 per cent while the remainder stemmed from vehicle traffic. Based on the NILU's report, a little more than half of road traffic's contribution is assumed to stem from exhaust emissions, while the remainder came from asphalt dust as a result of the use of studded tyres.

Based on the above assumptions, the results indicate that about 90 people die prematurely each year as a result of local particulate pollution in Oslo. Recent European studies indicate, however, that this figure may be overestimated. The persons affected are primarily the elderly and the chronically ill, and it is uncertain whether life expectancy is substantially reduced as a result of pollution. Other research results in recent years nevertheless indicate that particulate concentration over a longer period can cause a certain reduction in the population's life expectancy.

With regard to an increased incidence of illness, the calculations indicate that each year about 400 new persons are diagnosed as suffering from chronic pulmonary disease resulting from particulate pollution in Oslo. This means that more people become disability pensioners in subsequent years. Along with increased sickness absence and reduced labour productivity, this results in an annual disappearance of about 400 person-years from the labour market in Oslo. The results also indicate that particulate emissions, including asphalt dust, cause about 5,000 hospital bed-days per year.

The social costs associated with the health effects are partly pure economic costs and partly costs related to a reduced quality of life. The pure economic costs refer primarily to the direct value of lost person-years and public hospital expenditure, and the indirect effects on the economy due to a scarcer supply of labour. The indirect effects are analyzed with the help of the macroeconomic model MSG-EE. Pure economic costs amount to a total of NOK 160 million each year, of which lost person-years account for nearly 80 per cent.

The value of a reduction in the quality of life (beyond the economic effects) is difficult to determine. A common method is to make use of studies which show how much people are willing to pay to avoid a higher risk of

[1] $1\ \mu g = 1 \cdot 10^{-6} g$

mortality or increased incidence of chronic disease. There are, however, a number of problems associated with using the results of such studies. The estimates should thus be considered illustrative. The costs of quality-of-life reductions are then estimated at between NOK 1.5 and 1.6 billion per year, of which the valuation of the loss as a result of increased mortality accounts for 60 per cent.

All in all, this means that the annual social costs associated with local particulate pollution in Oslo are estimated at about NOK 1.7 billion, of which as much as 90 per cent stems from a valuation of a reduction in the quality of life. 60 per cent of the costs, i.e. about NOK 1 billion, is due to vehicle traffic. This is distributed relatively evenly between exhaust emissions and the use of studded tyres because the contributions to particulate concentration are about the same. Based on these results, the average social cost of burning one litre of diesel in Oslo is between NOK 3 and 7, while the average cost of burning one litre of petrol is between 10 and 50 øre. The sizeable difference is related to the fact that diesel engines emit on average considerably more particulates than petrol engines. The average social cost of using studded tyres is about 30 øre per kilometre. The social cost resulting from the use of heating oil comes to about 40 øre per litre. The social cost of wood heating is probably considerable compared with the price of wood, but here the statistical material is particularly uncertain.

There are a number of uncertainties linked to the calculations 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 (see, however, section 5.2). 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 relevant for Norway is that the World Health Organization no longer recommends threshold levels for particulates because higher mortality has been observed for very low concentrations.

Project personnel: Knut Einar Rosendahl

Financed by: Ministry of the Environment

Documentation:

Rosendahl, Knut Einar (1996): *Helseeffekter av luftforurensning og virkninger på økonomisk aktivitet* (Health Effects of Air Pollution and Impacts on Economic Activity), Reports 96/8, Statistics Norway.

Rosendahl, Knut Einar (1996): Helseeffekter av partikkelforurensning i Oslo (Health effects of particulate pollution in Oslo. In Norwegian), *Økonomiske analyser* 1996, 5, Statistics Norway.

4.3 Air pollution and sick-leaves - is there a connection?

Relatively clear-cut relationships between air pollution and adverse health effects have been demonstrated in several studies. Studies of the effects of air pollution on sick leaves, however, have been limited. The purpose of this project is to study the relationship between sick leaves and ambient air pollution by using daily absence data from a large Oslo enterprise along with air pollution data and meteorological data for a five-year period. Particulate matter is found to influence sickness absence, while the effects of SO_2 *and* NO_2 *are more uncertain.*

One important effect of air pollution is adverse health effects linked to respiratory diseases and increased mortality. The relationships are documented in a number of international studies and for different air pollution components and diagnoses (see Clench-Aas and Krzyzanowski (1996) for a survey).

Adverse health effects result in a welfare loss for those affected in addition to the direct economic costs for society. The direct costs consist of treatment costs and efficiency losses in the economy as a result of an increase in sick leaves and a reduction in the labour force. Moreover, productivity losses may come in addition because many people are on the job even though they are afflicted.

Statistics Norway has carried out studies in order to calculate the health effects and direct health costs of air pollution in Norway, see section 4.2. In order to make economic calculations of this type, it is important to document how sick leaves, and thus productivity in enterprises, depend on the degree of air pollution. Few international studies focus on the effects of air pollution on the productive segment of the population. If only the elderly and disabled segment of the population are affected by air pollution, the productivity effect will be negligible. An American study by Ostro and Rothschild (1989) indicates, however, that the working population is also affected. They show that the concentration of fine particulates ($PM_{2,5}$, particulates with a diameter of less than 2.5 μm[1]) has a clear effect on the number of limited activity days among workers between the age of 18 and 65 due to acute respiratory afflictions. Limited activity days are defined as days where a person changes normal activities but is not necessarily absent or bedridden due to illness.

Air pollution is one of many circumstances that can influence sick leaves. Other factors may be the working environment and individual aspects such as age, sex, income and illnesses due to factors other than air pollution. Erratic factors presumably also play a role. By studying a relatively homogeneous group over a period combined with various measures of air pollution and temperature, we want to see whether the effects of air pollution have an impact on sick leaves.

The study made use of daily data on sick leaves, including short-term absences based on self-certified sick leave, from a large commercial enterprise in the centre of Oslo from the period 1 January 1991 to 1 February 1996. Daily measurements of air pollution were made by the Norwegian Institute for Air Research (NILU) and the Department of environmental health and food control in the city of Oslo during the winter months, i.e. from 1 October to 1 April. NO_2, SO_2 and black smoke were measured throughout the period, whereas regular measurements of particulate matter (PM_{10}, particulate matter with a diameter of less than 10 μm) did not begin until the 1994/1995 season. Black smoke and PM_{10} to some extent reflect the same air pollution problem (suspended particulates). Soot is measured as the degree of blackening of a filter through which the air is drawn, while PM_{10} indicates the number of particulates per cubic metre. Several components that are included in PM_{10}, for example dust from the use of studded tyres, do not, due to the colour, have the same effect in the measurement of soot as in the measurement of particulates. PM_{10} is used in the years this is possible while black smoke, which is a more uncertain indicator of particulate concentration, is used in the other periods. Table 4.3.1 provides a summary of the data used.

We have estimated the effect on sick leaves of the average concentration of PM_{10}, black smoke, SO_2 and NO_2 the last seven days with one day lag. In addition, we have looked at the effect of temperature. The results of the calculations show that an increase in the average weekly concentration of PM_{10} covaries with an increase in sick leaves. Neither SO_2, NO_2 nor soot show any effect on sick leaves, while it was found that a low temperature has a negative effect. The

[1] 2.5 μm = 2.5 mikrometres = $2.5 * 10^{-6}$ m.

Table 4.3.1. **Seasonal average for sick leaves per day in per cent, air pollution in μg per m³ measured at St. Olavs plass/Nordahl Bruns gate and morning temperature at Blindern in °C**

Season[1]	Sick leaves[2]	PM_{10}	Black smoke	SO_2	NO_2	Temperature
	Per cent	μg/m³				7 am °C
91	4.16	..	35.60	17.49	49.90	-2.91
91/92	4.22	..	28.33	12.13	39.57	0.78
92/93	3.79	..	25.93	13.20	40.86	-0.65
93/94	4.42	..	22.80	11.48	42.60	-2.85
94/95	4.06	24.36	23.19	6.57	40.86	-0.29
95/96	3.48	25.65	30.00	6.37	39.87	-1.81
1.1.91-1.2.96	4.04	24.91	26.72	10.79	41.65	-1.09

[1] Period 1 October to 1 April, excluding 1991: 1 January to 1 April 95/96: 1 October to 1 February.

[2] Sick leaves at a large commercial enterprise in the centre of Oslo, number of employees: 1500. Working days between Christmas and New Year's day and during Easter week are not included.

Sources: Statistics Norway, Department of environmental health and food control in the city of Oslo, NILU and the Norwegian Meteorological Institute

latter means that sick leaves increase the lower the temperature for a given level of the other variables. The results are in accordance with international studies of relationships between air pollution and health, where the clearest results have been found for PM_{10}, while the effects of SO_2 and NO_2 are more uncertain. The reason that black smoke does not show a correlation with sick leaves may be that black smoke only comprises part of the total quantity of particulates.

Project personnel: Anett C. Hansen and Harald K. Selte

Financed by: Ministry of the Environment

Documentation:

Hansen, A.C. and H.K. Selte (1997): Air pollution and sick-leaves - is there a connection?, to be published in the series Discussion Papers, Statistics Norway.

4.4 Crop damage caused by tropospheric ozone

Excess concentrations of tropospheric ozone reduce yields of wheat, potatoes and cultivated meadow, resulting in economic losses to society. Depending on the goals defined by the authorities for the agricultural sector, we find that the value of the reduction in yields will lie between NOK 206 and 555 million (1995 NOK). The overall social costs are also strongly dependent on the agricultural policy we assume that the authorities will pursue.

In cooperation with the Norwegian Pollution Control Authority, the Norwegian Institute for Air Research and Statistics Norway have tried to assess the physical and economic effects of crop damage caused by tropospheric ozone. Excess ozone concentrations have adverse effects on human health, damage building materials and reduce crop yields. The costs of corrosion and injury to health attributable to ozone have previously been calculated by Glomsrød et al (1996) and Rosendahl (1996).

The unit AOT40 is used in measurements of tropospheric ozone concentrations to indicate the accumulated amount of ozone above 40 ppb (parts per billion). The Norwegian Institute for Air Research has used measurements of tropospheric ozone concentrations to calculate the exposure of crops to ozone. These results together with data on the crops involved have been used to calculate the areas of agricultural land where critical loads for ozone exposure have been exceeded. The calculated relationship between ozone exposure and reduction of crop yields has also been used to estimate the losses in yields in Norway in 1992 for wheat, potatoes and meadow. The estimated figures are shown in table 4.4.1.

The Norwegian authorities wish to sustain agricultural production in Norway. The agri-

Table 4.4.1. **Agricultural areas where critical loads for ozone were exceeded in Norway, and the calculated loss of yields. 1992**[1,2]

Crop type	Area in use 1994 (km²)	Area where critical loads were exceeded (km²)	Expected yield 1994 (tonnes)	Reduction in yield (tonnes)
Wheat	676	600	274 000	31 000
Potatoes	166	100	426 000	32 000
Meadow, total	5 705	3 300	3 371 000	332 000

[1] The ozone figures are for 1992, whereas the figures for agricultural area and yields are from 1994.
[2] Ozone exposure in 1992 is considered to be relatively high compared with typical levels for Norway.
Source: Hansen et al (1997)

Table 4.4.2. **Costs of reduction in yield caused by tropospheric ozone. Million 1995 NOK**

	Fixed input of resources	Fixed production level
Direct costs	206	555
Total social costs	382	1 236

Source: Hansen et al (1997)

cultural sector is therefore regulated and largely sheltered from imports. This makes calculations of the social costs of reductions in crop yields more complicated than they would be if competition in the sector was free. We have therefore considered two alternative sets of assumptions concerning official goals for the agricultural sector. In the first scenario, we assume that the objective is to maintain a certain level and composition of resources (labour, capital, etc) used in the agricultural sector. The allocation of resources to this sector is therefore independent of crop damage, and in order to compensate for production losses caused by excess ozone levels, imports of agricultural products must increase. We call this the *fixed input of resources* scenario. In the second alternative, we assume that the authorities wish to maintain a certain level of agricultural production. This scenario is called *fixed production level*. In order to maintain production if yields are reduced by ozone damage, inputs of resources must be increased, and the composition of the input factors may also be altered. It is assumed that the total volume of resources used in production in Norway is constant, and resources must therefore be transferred from other parts of the economy to the agricultural sector. The reallocation of resources in the economy will reduce production in other sectors.

The value of the loss in yield (called the direct costs) depends on which policy is followed. In the *fixed input of resources* scenario, the value of the reduction in yield is calculated mainly on the basis of world market prices, and is found to be NOK 206 million. In the *fixed production level* scenario, the value is based on domestic prices. The cost of the reduction in yields is then found to be NOK 555 million, which is the cost of replacing the loss in yield by domestic production. See table 4.4.2.

To analyse the macro-economic effects of reduced yields, we used the general equilibrium model MSG-EE (for further discussion, see page 98). The reduction in yields is modelled in such a way that productivity in agriculture decreases, i.e. the ratio between the quantity of agricultural products produced and the input of resources decreases. Calculations show that the macro-effects depend on which policy we assume the authorities will pursue.

The social costs are measured as changes in gross domestic product (GDP), but since this figure is calculated on the basis of domestic prices, it has to be corrected for the *fixed input* scenario. Since the input of resources remains unchanged here, the social costs are calculated by adding together the value of the loss of yield (NOK 206 million) and the change in GDP outside the agricultural sector (calculated at NOK 176 million), i.e. a total of NOK 382 million. This method of calculation can be justified here, since the reduction in yields is compensated for by an increase in imports. Thus, no resources are withdrawn from other sectors, and the secondary effects in the agricultural sector are negligible. In the *fixed production level* scenario, domestic prices are used, and the social costs of the loss in yield are calculated to be NOK 1 236 million.

The actual policy followed contains elements of both alternatives. The true cost of the loss in yield therefore probably lies somewhere between the estimates given for the two alternatives.

It is important to be aware of sources of uncertainty in the calculations. These are related both to calculations of the physical damage caused by ozone and to the economic calculations. Nevertheless, the results give some indication of the physical and economic consequences of tropospheric ozone in years when ozone concentrations are high, such as 1992.

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Financed by: Norwegian Pollution Control Authority and Statistics Norway

Documentation:

Hansen, A.C., L.M. Mortensen, H. Høie, K.E. Rosendahl and K. Tørseth (1997): *Avlingstap som følge av bakkenær ozon. Vurderinger for perioden 1989-1993* (Reductions in yields caused by tropospheric ozone. Evaluation for the period 1989-1993), Report 97:02, Oslo: Norwegian Pollution Control Authority.

5. Analyses based on the Green Tax Commission

In recent years a "green" tax reform has been the subject of increased attention. Among other things, the report of the Green Tax Commission (Ministry of Finance 1996) was presented in the summer of 1996. The point of departure for this discussion has been a desire to reduce the pollution of the environment combined with a desire to stimulate higher employment and a higher level of economic welfare. A shift in taxation from labour to polluting emissions may conceivably satisfy both these requirements, often referred to as a double dividend.

5.1 Two analyses of a "green" tax reform

A key proposal that was discussed by the Green Tax Commission was an increase in the CO_2 tax from the current level combined with a reduction in the payroll tax so that government revenues remain unchanged.

In the first study presented in this section, the economic consequences of this tax reform are analyzed by using a macroeconomic model in which the supply and demand for labour is determined on the basis of prices and costs in the economy. The study concludes that economic welfare increases as a result of the tax reform and CO_2 emissions are reduced substantially. This means that the tax change produces a double dividend. The second study presented makes use of a macroeconomic model in which the level of employment is given, i.e. that gains in the labour market are disregarded. The study instead looks more closely at the environmental gains that can be expected from a tax reform as outlined above. Emphasis is placed on concretizing the environmental effects which arise, and particularly focuses on feedback effects on the economy.

Analysis 1: "Green" tax reform and a double dividend: An intertemporal general equilibrium analysis

This study analyzes welfare effects of a "green" tax reform, with the exception of the effects via an improved environmental quality. By using an intertemporal general equilibrium model for Norway, an analysis is made of the effects of increasing the CO_2 tax to NOK 700 per tonne CO_2 and using the higher tax revenues to reduce the payroll tax. The welfare effect of this tax reform is positive because the tax reform exploits existing tax wedges[1] between consumption and saving, and between paid work and leisure. An analysis is also made of whether

[1] The taxation of labour through the payroll tax and the tax labour income entails that the value of one hour of work, which is measured by wages before tax, is considerably higher than the value of one hour of leisure for the worker, which is measured by wages after tax. The social marginal value of labour is therefore substantially higher than the private marginal value of leisure. This deviation is called a tax wedge.

the welfare effect is influenced by the formation of expectations by economic agents.

Higher environmental taxes combined with a reduction in other distortionary taxes can result in both less pollution and higher economic welfare. This analysis looks in particular at the possibilities for achieving this *double dividend*[2] by increasing the carbon tax. A higher carbon tax and lower payroll tax will affect prices and costs in the economy, and thus have consequences for investments in financial and real capital. In order to shed light on the effects of this type of tax reform, intertemporal general equilibrium analysis is used, which illustrates some of the effects on capital accumulation and thus the long-term possibilities for economic growth. Earlier Norwegian analyses of green tax reforms, see for example Håkonsen and Mathiesen (1995) and Brendemoen and Vennemo (1994), have been limited to studying the effects of tax reforms when the stock of real capital and financial wealth is not changed. Intertemporal general equilibrium analyses of green tax reforms for the US economy, such as Jorgenson and Wilcoxen (1993) and Goulder (1995), indicate a welfare loss from such taxation. This may partly be explained by the lower level of labour income taxation in the US, entailing that the potential for a welfare gain from a lower tax on labour is smaller.

The intertemporal general equilibrium model MSG-6 (see section 6.1), which is used in this analysis, contains a number of production sectors and consumer goods. The description of production and demand for energy commodities is also relatively detailed, which makes the model well suited for analyzing the effects of environmental and energy policies on the Norwegian economy. The model describes Norway as a small, open economy in which domestic producers and consumers are assumed to be price takers in the world market. The interest rate is also exogenously given from international financial markets, implying that net saving in financial capital may not necessarily be correlated with net investment in real capital. It is assumed, however, that Norwegian producers exercise some market power in the domestic market, see Holmøy (1996). The assumption that domestic producers are price takers in the world market implies that it is not possible to achieve terms of trade gains as a result of changes in export prices and volumes through domestic tax increases. The assumption that producers have some market power in the home market implies that the sectors competing in the international market will not be exposed to full specialization, even in the long run.

The effects of the tax reform are measured as deviations from a reference path. The reference path is simulated by keeping all tax rates and other policy variables constant at their benchmark (1992) values. World market prices and other exogenous variables are also held constant along the path. Under the tax reform, the CO_2 tax is increased to NOK 700 per tonne CO_2 for all kinds of fossil fuels, and no producers or consumers are exempted from this tax. The tax revenue is rebated through a reduction in the payroll tax so that government revenues and expenditure are unchanged from the reference path in each period. The tax reform is introduced in the year 2000, but it is announced in the first year of simulation. Because producers and consumers in this intertemporal general equilibrium analysis are assumed to have perfect foresight with regard to future prices, they will start adjusting to the new tax from the first simulation period. Total welfare, measured by discounted utility,

[2] Goulder (1994) and Christiansen (1996) provide an overview of the literature on the double dividend issue.

increases by 0.12 per cent, while CO_2 emissions are reduced by 13.5 per cent in the long run (the year 2050). Gross domestic product is approximately unchanged. The tax reform thus supports the *double dividend* hypothesis. In an intertemporal general equilibrium model welfare gains are achieved through reallocations between sectors, goods and factor inputs in a single year, and between saving and consumption over time. Reallocations originate from existing tax wedges and imperfections which result in an inefficient use of resources. In the long run both the stock of real capital and employment increase, partly as a result of lower prices and labour costs, while net foreign debt is reduced. There are particularly two tax wedges which give rise to the positive welfare effect: The social marginal value of labour is considerably larger than the private marginal value of leisure as a result of relatively high taxes on labour. A lower payroll tax results in higher employment which has a positive welfare effect. In addition, the reduction in net foreign debt has a positive welfare effect since the social marginal costs of debt are higher than the private marginal costs due to the taxation of financial income.

The analysis also sheds light on to what extent the assumption that agents have perfect foresight influences the welfare effect of the tax reform. In an optimally adapted economy without existing tax wedges or other imperfections, expectation errors will result in a welfare loss. However, in an initially distorted economy with tax wedges, as in Norway, the welfare effect of expectation errors is negligible.

Project personnel: Brita Bye

Financed by: The Research Council of Norway through the project SAMMEN

Documentation:
Bye, B. (1996) Environmental tax reform and producer foresight: An intertemporal computable general equilibrium analysis, Discussion Papers 185, Statistics Norway.

Analysis 2: Environmental gains from a "green" tax reform

This project analyzes the effects of a "green" tax reform, with an emphasis on measurable gains from an improvement in environmental quality and reduced traffic. The analysis is carried out with the help of a model which integrates the economy and the environment. A sharp increase in the CO_2 tax accompanied by reductions in the payroll or investment tax results in considerable environmental and traffic gains. Since the economy is also influenced to a large extent, and many environmental gains are not included in the analysis, it is difficult to reach a definite conclusion concerning the extent to which this tax reform is desirable or not.

In the discussion surrounding green taxes, a higher CO_2 tax has been one of the most prominent proposals, often in combination with a lower payroll tax. A higher CO_2 tax will make the use of fossil fuels more expensive, which may result in a reduced use of this type of energy. The effect of this will be lower air pollution and a reduction in the harmful effects of road traffic. This study focuses on the environmental and traffic gains which may be expected if the current CO_2 tax is increased considerably and the payroll tax is reduced in such a way that government revenues remain unchanged. The study also looks at what happens if the investment tax is reduced instead of the payroll tax.

The macroeconomic model MSG-EE (see Alfsen, Bye and Holmøy (1996)) is used for this analysis. The model contains a calculation of emissions to air for a number of polluting components. In this study, MSG-EE has been expanded so that it describes various environmental and health effects of air pollution, and also how these effects feed through to the resource base of the economy (see Glomsrød et al. (1996) and Rosendahl (1996). The model thus takes into account the interaction between economic activity and the environment. It also describes a similar interaction between economic activity and traffic accidents based on Glomsrød et al. (1997). Furthermore, some environmental and traffic effects are dealt with in separate calculations. In order to analyze the environmental and traffic gains from a "green" tax reform, the MSG-EE model without feedback effects was also used as a basis for comparison.

Employment is assumed to be independent of other factors in the economy. The model can thus not be used to study to what extent a "green" tax reform stimulates employment, and therefore focuses primarily on important environmental gains from this tax change. This refers to positive effects on health, materials and crop yields. The calculations concretize some important environmental gains that can be expected from a "green" tax reform, but largely underestimate the total environmental gains since many of these are not covered by the analysis.

In the model, the CO_2 tax is increased by 12 per cent a year compared with the current level in the period 1995-2020. If the payroll tax is reduced in such a way that government revenues remain unchanged, the level of GDP is reduced by 1.7 per cent in 2020, i.e. about NOK 20 billion (1994 prices), when account is not taken of environmental feedback effects. The reduction in GDP is due to more expensive energy, which results, among other things, in lower investment, at the same time that the reduced payroll tax does not stimulate employment in the model. The latter factor provides grounds for believing that the GDP loss is overestimated, see analysis 1 above, based on the model MSG-6. If, instead, the investment tax is reduced correspondingly, the level of GDP *increases*. This is because investment rises, entailing that the level of capital grows faster. It is uncertain how robust this conclusion is.

In both tax alternatives (lower payroll tax and lower investment tax) emissions of polluting gases and particulates are reduced. The tax changes result in reduced corrosion of materials on buildings as a result of lower SO_2 emissions, fewer damages to health as a result of lower emissions of particulates and NO_x, and a slight reduction in the damage to crops due to lower NO_x emissions. Moreover, there will be fewer traffic accidents inasmuch as the volume of traffic is reduced. The magnitude of these environmental and traffic gains emerge in the expanded MSG-EE model. The gains are greatest in the case with a reduced payroll tax because economic activity is lower in this scenario. In this scenario, the value of environmental and traffic gains that are documented is estimated at about NOK 3 billion. Half of this, i.e. NOK 1.5 billion, can be considered GDP gains, entailing that the GDP loss is less than estimated above. The remaining gains are ascribable to a valuation of reduced health problems. About three fourths of the total gains of NOK 3 billion stem from fewer traffic accidents.

When evaluating the results, however, it must be taken into account that many environmental gains are not included in the calculations. This applies, for example, to the value of reduced CO_2 emissions and the value of a reduction in acid rain. Nor are additional traffic gains, such as reduced noise and queuing costs, included in the results. Moreover, there is uncertainty linked to the gains that are included, partly because the value of improved health and higher environmental standards is not an objective magnitude. Estimates of such gains can therefore differ.

Project personnel: Solveig Glomsrød, Anett Christin Hansen and Knut Einar Rosendahl

Financed by: Ministry of the Environment

Documentation:
Glomsrød, S., A.C. Hansen and K.E. Rosendahl (1996): *Integrering av miljøkostnader i makroøkonomiske modeller* (Integration of environmental costs in macroeconomic models. In Norwegian), Reports 96/23, Statistics Norway.

5.2 Two analyses of waste taxes

Waste problems are steadily increasing as a result of a high level of consumption and problems in finding satisfactory waste treatment methods (the subject of waste is dealt with extensively in chapter 4, part I). The aim of introducing waste taxes is to correct for externalities and to reflect waste treatment costs.

The first analysis studies how taxes on plastic and paper raw materials influence waste quantities. Other environmental effects and consequences for key economic variables as a result of this tax are also studied. Environmental gains linked to a reduction in waste quantities are small compared with other environmental gains, which among other things include reduced emissions to air. The tax results in increased costs which vary from one sector to another.

The second analysis studies the effect of a tax on all material inputs as an example of a situation where the use of all materials results in waste problems. The revenues from this tax are used to reduce the payroll tax. Due to the tax, the quality of the environment is improved and people spend more leisure time. Both tax reforms result in a decline in production and material consumption.

The analyses are carried out by using two different models. Both analyses follow up the Green Tax Commission (Ministry of Finance 1996) which points to the need for further studies of the use of taxes on material inputs.

Analysis 1: Taxes on packaging raw materials
In recent years a number of measures have been implemented for sorting and recycling packaging waste, but few measures have been *directly* focused on waste generated in the production of various goods. In the analysis, a tax on packaging raw materials is studied. The tax results in higher prices for the finished packaging products, which also reduces the demand for and production of packaging products. Moreover, this tax will provide an incentive for a greater use of returnable goods and recycling, which is one of the Government's main goals in the area of waste policy (Ministry of the Environment 1995).

The tax is imposed on plastic and paper raw materials and thus affects not only packaging products, but also other products based on the same raw materials. The harmful environmental effects of final treatment are usually independent of the type of product. By taxing all plastic and paper raw materials, we thus achieve a more effective taxation than by only taxing those raw materials which are used directly to produce packaging products. The optimal policy would be to tax the damage where the damage arises, but such measures are often costly or not possible to implement. By, for example, taxing CO_2 emissions from fossil fuels, it has been found appropriate to tax the factor inputs instead of the actual CO_2 emissions. The same applies to CO_2 emissions linked to plastic products. If the harmful environmental effects of the use of raw materials are independent of what the raw material is used for, there are good theoretical and practical reasons for using raw material taxes.

A tax of 15 per cent is levied on all plastic and paper raw materials, which is far below the estimates for environmental and treatment costs linked to the use of packaging raw materials. The revenues are used to reduce the payroll tax. The analysis is carried out with the help of the general equilibrium model MSG, where the baseline scenario is obtained from the last Long-Term Programme (Ministry of Finance 1993).

The results show that in 2030 the tax will reduce the use of packaging raw materials and projected packaging waste quantities by 11 per cent. The gain from the estimated environmental effects, that are linked to reduced quantities of packaging waste and polluting emissions, range between NOK 0.3 to 4.0 billion. Of this, the gain linked to reduced waste quantities accounts for 10-35 per cent, depending on the valuation study applied. Due to the lack of data, only the gains linked to a reduction in packaging have been estimated. However, it is argued that the gains from a reduction in the use of the same raw materials for other products and other material inputs are greater than the gains that can be estimated based on available data.

The cost in the form of a lower net domestic product in 2030 is about NOK 3 billion, a reduction of 0.3 per cent. Private consumption is reduced by NOK 0.6 billion, equivalent to 0.1 per cent. Since the tax has a different effect on various sectors depending on the use of packaging raw materials, some sectors will experience a relatively large cost increase. The greatest increase in costs is recorded by the sector producing paper and paper products since these raw materials constitute a substantial share of material inputs. Sectors which use little or none of the taxed raw materials record little or no cost increase.

The analysis indicates that environmental gains linked to a reduction in waste quantities are small compared with the environmental gains linked to a general reduction in the use of materials. This reminds us how important it is to study waste policy instruments in a macroeconomic framework, as the waste problems are intertwined with other environmental problems and market failures. Waste problems cannot be solved within a limited waste policy framework, but must rather be dealt with as part of the general environmental policy.

Analysis 2: Taxes on the use of materials in a model with environmental feedbacks

The environmental effects of the use of materials in production and consumption are manifold and the costs are difficult to estimate. Considerable costs and practical problems are associated with the direct taxation of emissions. This provides an incentive for studies of instruments that are simpler to use for a wide range of environmental problems. The taxation of the use of materials in production may be a suitable policy for reducing both the use of natural resources and emissions linked to this use. It may also contribute to a better utilization of raw materials in the production process and the use of higher quality raw materials which last longer.

This study analyzes the effects of taxing the use of materials by imposing an extra tax of 1 per cent on all material inputs. This corresponds to government tax revenues of NOK 6 billion in 1996, which are used to reduce the payroll tax. The analysis is based on the dynamic equilibrium model DREAM, see Vennemo (1996). The model contains some

Table 5.2.1. **Percentage changes resulting from a tax of 1 per cent on materials in 2030 compared with a situation without the tax**

Generated waste in manufacturing	-4.4
Environmental damage	-1.5
Leisure	5.8
Material consumption	-0.6
GDP	-1.2
Material inputs	-2.3

Source: Statistics Norway

relationships between economic activity and the environment and thus permits analyses of various environmental effects in addition to the traditional economic effects. Am important part of the interaction between the economy and the environment is atmospheric emissions, which influence the quality of the environment. This in turn influences production through, first, a poorer state of health and thus lower labour productivity, and second, increased capital consumption.

The tax change entails that the environmental costs for the use of materials are to a greater extent reflected in the costs of materials, which reduce the use of material inputs, see table 5.2.1. Even though the payroll tax is reduced, the reform results in a net increase in costs for enterprises. As a result, production is reduced and thereby also the demand for labour. This, along with given product prices on the world market, pushes down labour costs, which entails that people prefer to work less and spend more leisure time.

An important effect of the tax change is a reduction in environmental problems, both due to reduced waste generation and the use of materials. Polluting emissions are reduced due to lower economic activity, and the state of health and the environment are improved. The tax change, however, does not provide a double dividend in the form of both an improved environment and higher production and employment.

Project personnel: Annegrete Bruvoll and Karin Ibenholt

Financed by: The Research Council of Norway, MILFOR and the Ministry of the Environment

Documentation:

Bruvoll, A. and K. Ibenholt (1997): Green Throughput Taxation, Possibility of a Welfare Improving Tax System? To be published in the series Documents, Statistics Norway.

Bruvoll, A. (1997): Taxes on waste. A study of taxes on packaging raw materials, to be published in *Economic Survey,* Statistics Norway.

6. Other climate-related analyses

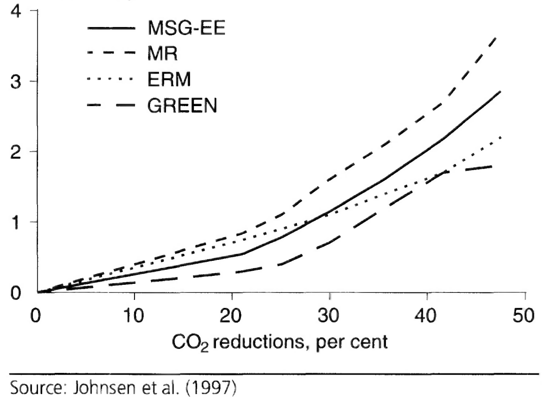
6.1 Costs of limiting CO_2 emissions - a general equilibrium model approach

Given the role of environmental issues in the policy debate, and perhaps particularly issues relating to the greenhouse effect, it is natural that the development of integrated economy-energy-environment models has been given high priority in the literature. Both nationally and internationally, a number of analyses have been carried out of the costs of measures to reduce greenhouse gases. We report some results of such analyses in this section. All the analyses show the same main features, but some important differences are nevertheless revealed.

Costs of reduced CO_2 emissions in Norway and the rest of the world

In connection with the problem of the greenhouse effect, the question arises, also in Norway, as to what it costs to reduce domestic CO_2 emissions. This will depend on a number of factors, such as to what extent the reduction occurs in Norway alone or as part of an international effort to combat man-made climate change. Moreover, the reaction of oil and gas markets to measures focused on CO_2 emissions will also have an influence as will the competitive advantage Norway's hydropower-based manufacturing sector can achieve in a situation with such climate measures. All in all, this makes it difficult to comment precisely on the domestic costs of climate measures. Some general estimate of GDP losses worldwide, however, can be made based on various studies. The OECD, for example, has applied various models to calculate global GDP losses linked to reduced CO_2 emissions (Hoeller et al. 1990 and 1991). We compare these general results with corresponding estimates results for Norway based on a national general equilibrium model. The results for Norway, however, are based on an assumption of unilateral measures, thereby disregarding possible reactions in international oil and gas markets. Due to this assumption, we probably underestimate the costs for Norway. Figure 6.1.1 shows the interrelated reduction in GDP and CO_2 emissions in the year 2020 relative to the baseline scenario for four different models.

Figure 6.1.1. **Percentage reduction in GDP and CO_2 emissions relative to baseline scenarios for the world (MR, ERM and GREEN models) and for Norway (MSG-EE) in the year 2020**



Source: Johnsen et al. (1997)

The models represented in the figure, besides MSG-EE, are:

- MR: Manne-Richels Global 2100 Model (Manne 1992) which is a forward looking intertemporal model with international trade in carbon rights
- ERM: Edmonds-Reilly Model (Barns et al., 1992) which is a partial equilibrium model with a detailed dynamic energy submodel, and
- GREEN (Oliveira Martins et al., 1992) which is a recursive dynamic general equilibrium model with full trade links plus trade in carbon rights

Apparently, see figure 6.1.1, the results for Norway in terms of magnitude are more or less in line with the international results calculated by the three other models. However, the results vary by about 50 per cent, partly reflecting differences in substitution possibilities between various energy goods and between energy and other material inputs in production. In all cases the effects on GDP are rather small. The estimated Norwegian GDP loss connected to a 50 per cent reduction in emissions relative to a reference scenario is between the lowest and highest OECD estimate for the world as a whole, i.e. between 2 and 4 per cent.

Tax rates and GDP losses when stabilizing CO_2 emissions

The OECD project also calculated GDP losses for some large regions. The region most suitable for comparison with Norway seems to be the "OECD excluding the US". Emissions in the baseline scenarios vary slightly in the various models. The annual baseline growth of emissions in the OECD area outside the US varies from 0.94 (ERM) to 1.35 (MR) per cent. In the baseline scenario of the MSG-EE simulation the average annual growth of emissions is slightly lower, i.e. 0.9 per cent.

Table 6.1.1. **Stabilization of CO_2 emissions at 1990 levels in 2020 for the OECD excluding the US and for Norway (MSG-EE). Required taxes and corresponding GDP losses relative to the baseline scenario**

Model	CO_2-tax (USD/tonne CO_2)	GDP-losses (Per cent)
ERM	31	0.7
GREEN	16	0.3
MR	33	0.7
MSG-EE	52	0.5

Source: Johnsen et al. (1997)

Table 6.1.1 shows the CO_2 tax rates that are required to stabilize CO_2 emissions in 2020 at 1990 levels for the OECD excluding the US and for Norway, and the corresponding GDP losses in the various model simulations. The tax needed to stabilize OECD emissions ranges from USD 16/tonne CO_2 (GREEN) to USD 33/tonne CO_2 (MR). The corresponding losses in GDP vary from 0.3 (GREEN) to 0.7 (ERM and MR) per cent.

The 0.5 per cent GDP loss connected with a stabilization of CO_2 emissions in Norway is in line with the results for the rest of the OECD area. On the other hand, the tax required to stabilize emissions in Norway (USD 52/tonne CO_2) is significantly higher than the tax required in other OECD countries. This reflects the limited substitution possibilities and low cost shares for carbon fuel in Norway compared with other countries. The fact that Norway has a very low consumption of the energy commodity producing the most CO_2, notably coal, has a very significant effect, see table 6.1.2. In other countries substantial emission reductions can be obtained by substituting coal with oil or gas.

It would perhaps have been reasonable to expect that the higher tax required would also lead to a higher GDP loss in Norway than in

Table 6.1.2. **Energy requirements per GDP for oil, coal and gas in OECD-Europe and Norway in 1988. Mtoe/USD billions**

	Oil	Coal	Gas
OECD-Europe	0.152	0.066	0.053
Norway	0.124	0.015	0.026

Source: Alfsen et al. (1997)

the other OECD countries. This is not the case because the fossil fuel-output ratio is relatively low in Norway. The additional cost of a high CO_2 tax is therefore not so great. The cost, however, is unevenly distributed, with very high costs for power-intensive industries. Short-term adjustment costs may also be higher in Norway than in other industrialized countries due to a higher tax rate.

Project personnel: Tor Arnt Johnsen, Bodil M. Larsen and Hans Terje Mysen

Financed by: Ministry of the Environment, the Research Council of Norway and Statistics Norway

Documentation:
Johnsen, T.A., B.M. Larsen and H.T. Mysen (1997): Economic impacts of a CO_2 tax, chapter 5 in: Alfsen, K.H., T. Bye and E. Holmøy (eds.) (1997): *MSG-EE: An applied general equilibrium model for energy and environmental analyses*, Social and Economic Studies 96, Statistics Norway.

6.2 Optimal climate policy under the possibility of global catastrophes

This project studies how an optimal global climate policy should be formulated as a result of both continuous climate-feedback damage caused by the greenhouse effect as well as the possibility of a catastrophic outcome. The results show that emissions of greenhouse gases should be reduced rather dramatically when account is only taken of continuous climate-feedback damage. Further reductions in emissions are necessary when the possibility of a catastrophic outcome is also taken into account. The analysis also shows that the importance attached to the welfare of future generations is very decisive in determining the extent to which global emissions should be reduced.

Human activity contributes to an increase in the concentration of greenhouse gases in the atmosphere. The most important greenhouse gas is carbon dioxide (CO_2), but methane, CFCs, nitrous oxide and ozone also contribute to increasing the greenhouse effect. Emissions of these gases come in addition to the atmosphere's natural stock of greenhouse gases. The global mean temperature may thus rise over time. Possible negative effects of global warming include a rise in sea levels, desertification, a reduced supply of water and health problems. This means that emissions of greenhouse gases today represent future costs in the form of land area lost, reduced food production and higher health expenditure.

Emissions of greenhouse gases can also have other dramatic consequences. Rising temperature levels can contribute to instability in vulnerable ecological systems. The concentration of greenhouse gases in the atmosphere is now increasing more rapidly than ever before, and we thus know very little about what the effects of this will be. We also lack knowledge concerning the catastrophes which might occur and what they may entail.

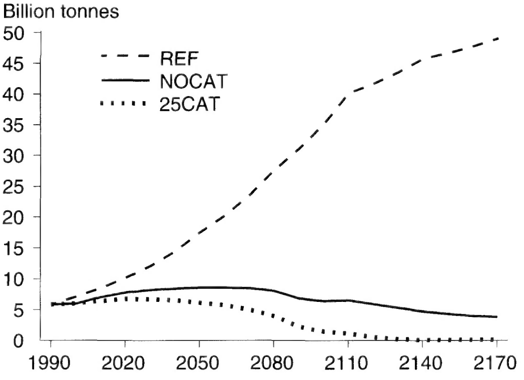
Since we cannot disregard the possibility of a global environmental catastrophe, this study attempts to derive the principles which should be adhered to when responding to this possibility. In order to answer this question, a numerical model has been constructed. A key assumption in the model is that reduced emissions today will result in lower growth in the global economy than would otherwise have been the case. At the same time, lower emissions will result in future gains through a smaller increase in the average temperature. In the long run this contributes to reducing the negative climate-feedback effects on welfare. The model is an extended version of Kverndokk (1994). The world is divided into 7 regions, and the time horizon is from 1990 to 2170. The model-based calculations determine how emissions of greenhouse gases must be distributed over time and across regions in order to maximize global welfare.

The model consists of relatively complex relationships between emissions of greenhouse gases, the concentration of greenhouse gases in the atmosphere and changes in the temperature level. It is assumed that we can only influence emissions of CO_2, while emissions of all other greenhouse gases are given. The possibility of a catastrophic outcome is also incorporated in the model with the likelihood of a catastrophe rising with the level of the global mean temperature. Various calculations have been made based on different assumptions concerning costs arising from a catastrophe.

The starting point is a reference scenario (REF) which is a result of projections of CO_2 emissions and growth in global production over time, based on estimates from the OECD's GREEN model (Burniaux et al. 1992). A reduction in emissions relative to the level shown in the reference scenario will curb the rate of growth in production. This type of cost is assumed to be reduced over time since the prices of alternative energy sources are assumed to decline.

In the scenario NOCAT, account is only taken of continuous climate-feedback damage,

Figure 6.2.1. **Annual global carbon emissions under different assumptions concerning the harmful effects of emissions**



Source: Gjerde et al (1997)

thereby ignoring the possibility that a catastrophe can occur. The possibility of a catastrophic outcome is included in other scenarios. The likelihood of a catastrophe and its consequences are based on estimates from an interview survey of climate experts presented in Nordhaus (1994). The probability that a catastrophe occurs before the year 2090 is estimated at 12 per cent given the rise in temperature resulting from our reference scenario (3 °C higher than the current level). In the scenario 25CAT, Nordhaus' (1994) definition of a major catastrophe has been used by assuming that this outcome results in an immediate GDP reduction of 25 per cent compared with a situation in which a catastrophe does not occur.

In the reference scenario, annual emissions increase relatively dramatically in the period from 2000 to 2100, while the growth slows slightly after the year 2100 (see figure 6.2.1). Annual emissions in the year 2090 come to 32 billion tonnes of CO_2 with a global mean temperature that is 3 °C higher than the current level. When only continuous climate-feedback damage is taken into account and less emphasis is placed on the welfare of future generations (time preference rate of 3 per cent), annual emissions will be relatively stable over time and vary between 5 and 8 billion tonnes within the model's horizon (NOCAT). In this scenario, the model-based analysis thus suggests rather dramatic reductions compared with the reference scenario. If we, in addition, take account of catastrophic outcomes, annual emissions of CO_2 will be reduced gradually to 2 billion tons in the year 2090 (25CAT). The global mean temperature will be 1.5 °C lower in the year 2090 and 3 °C lower in the year 2150 in 25CAT compared with the reference scenario. The relative reductions in CO_2 emissions in the 7 regions vary. The greatest relative reductions occur in industrialized countries, while the consequences for emissions are smaller in relative terms for the former Soviet Union and developing countries. Annual emissions of CO_2 are reduced sharply when it is assumed that greater importance is attached to future generations than assumed thus far (time preference rate is changed from 3 to 1 per cent).

The analysis shows that when we only take continuous climate-feedback damage into account (NOCAT), annual emissions of CO_2 are reduced quite dramatically compared with emissions in the reference scenario. When the possibility of a catastrophic outcome is included in the analysis, this has additional consequences for emissions, and the higher the costs associated with a catastrophe the more the emissions must be reduced. These reductions are also considerable in relative terms. Moreover, the results show that the reduction in emissions largely depends on the emphasis placed on the welfare of future generations in relation to the present generation.

Project personnel: Jon Gjerde, Sverre Grepperud and Snorre Kverndokk

Financed by: The Research Council of Norway

Documentation:
Gjerde, J., S. Grepperud and S. Kverndokk (1997): Optimal Climate Policy under the Possibility of Catastrophes, to be published in the series Discussion Papers, Statistics Norway.

7. Other environmental issues

7.1 Soil management in developing countries

Soil degradation is an important factor behind the lack of productivity growth in tropical agriculture. This project identifies reasons for the degradation of cultivated land and analyzes how attitudes towards risk can influence farmers' incentives for soil conservation.

This project begins by examining the empirical literature in order to identify how the use of inputs and choice of cultivation techniques influence processes which reduce the quality of the soil over time (erosion, salinization, acidification and leaching). Based on the survey of the literature in this field, a model is presented in which inputs are classified in three different categories, according to their effect on the future fertility of soil. The three types are:

- Productive soil degrading investments (irrigation and letting the land lie fallow).
- Productive soil improving investments (chemical fertilizer and pesticides).
- Soil conservation measures (terraces and ditches).

In many developing countries, agricultural prices are often lower than world market prices for the same products. This is usually due to price regulations and production quotas as well as tax policies. One subject to which considerable attention has been devoted in the literature is how macroeconomic reforms which increase output prices will influence farmers' soil management incentives. A review of this type of analysis shows that, in spite of different approaches, the conclusions are relatively robust: Higher crop prices contribute to increasing the use of all types of inputs. As a result, it is not possible to arrive at clear-cut effects on soil management. The use of both *soil degrading practices* and *soil conservation measures* will be increased.

Based on the study of the literature in this field, a theoretical model is proposed which includes all three types of inputs. This model is used to analyze how farmers' attitudes towards risk can influence soil management over time. Output price uncertainty is analyzed first, and the analysis shows that risk-averse farmers attempt to reduce the use of all three types of inputs. The study also looks at the effects of output uncertainty, and in this case the conclusions concerning the use of inputs are less clear-cut and depend on assumptions concerning how the use of each factor of production influences risk. A reasonable assumption appears to be that higher soil quality reduces output uncertainty over time. Under this assumption, farmers tend to use less soil degradation inputs and more soil conservation measures given that their behaviour is governed by the need to reduce risk (variation in production).

The analysis shows that the use of minimum price schemes (reduced price uncertainty) cannot be expected to influence soil management in any specific direction. On the other hand, it appears that an expansion of insurance markets in agriculture (reduced output uncertainty) might increase soil degradation over time.

Project personnel: Sverre Grepperud

Financed by: Statistics Norway

Documentation:
Grepperud, S. (1996): Soil Depletion Choices under Price and Production Uncertainty, Discussion Papers 186, Statistics Norway.

Grepperud, S. (1997): The Impact of Policy on Farm Conservation Incentives in Developing Countries: What can be learned from Theory? To be published in the *Quarterly Journal of International Agriculture*, 1997.

7.2 Can the demand for sustainability be justified?

Considerable attention has been focused on the question of intergenerational justice in the discussion of the limits for economic growth. The purpose of the analysis described here has been to look at sustainability in the light of earlier discussions of a just distribution. In this discussion sustainability, as it is usually defined in economic literature, comes into conflict with central axioms of the welfarist tradition. The principles it conflicts with are so fundamental that the conclusion is that sustainability must either be redefined or cannot be an absolute moral requirement but only apply under specific assumptions, for example when it is easy to reallocate resources to future generations.

In economic literature the most common definition of sustainable development, also referred to as weak sustainability, is that the welfare of future generations shall be no worse than that of the present generation, see for example Solow (1993). The alternative definition, strong sustainability, entails that the environment and natural resources remain intact. The definition of weak sustainability permits us to extract natural resources today if we compensate future generations by investing in other forms of wealth.

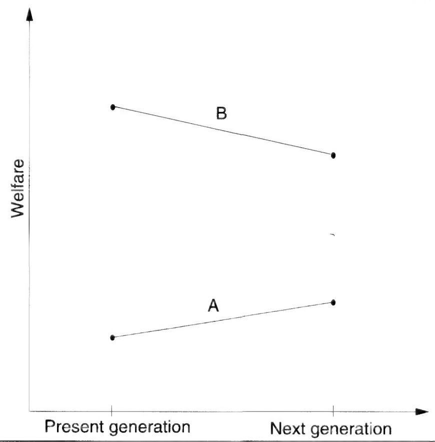
The definition of weak sustainability presupposes that we can compare the welfare of different generations. That we can speak of the welfare of an entire generation is far from obvious. Even the welfare of an individual has proved difficult to define, and the problem of finding methods for comparing the welfare of two individuals has proved to be virtually insurmountable, see Elster and Romer (1992). The problem becomes even more difficult when we are to compare the welfare of two generations.

A survey of the discussion concerning intergenerational choices is found in, inter alia, Dasgupta and Heal (1979). One of the key principles in this discussion has been the Pareto principle, which entails that a policy change which leaves at least one generation better off while leaving none worse off represents an improvement. If we push weak sustainability to its extreme consequence, it will be inconsistent with the Pareto principle.

Figure 7.2.1 illustrates how sustainability can conflict with the Pareto principle. The problem has been simplified by only considering two generations. Path A is now sustainable, while B is not. If we find an unsustainable path unacceptable, we must exclude B. However, saying that A is acceptable, while B is not, conflicts with the Pareto principle since both generations are better off in path B.

In its extreme consequence, sustainability is also incompatible with many of the other principles discussed in the literature, but it is particularly the violation of the Pareto

Figure 7.2.1. **Weak sustainability conflicts with the Pareto principle**



Source: Statistics Norway

principle that is worrying. There are several possible conclusions to be drawn from this recognition. It can be maintained that sustainability is poorly grounded, in any case the definition of weak sustainability. Alternatively, it may be maintained that weak sustainability is based on a perception that it is inexpensive to reallocate resources from the present generation to future generations.

Let us first look at some alternatives to weak sustainability. Because it is not obvious that it is meaningful to talk about the welfare of a generation, many will be of the view that an analysis based on the notion of the welfare of generations is not the right approach for justifying the commitment to sustainability. In such an event the definition of sustainability cannot be that future generations shall have a welfare no lower than ours. Those who reject this welfare-based moral philosophy will often perceive rights and duties as fundamental concepts. For example, Page (1983) argues that the management of natural resources by the present generation can be likened to a person who has lent his house to a friend. It is then taken as a matter of course that he leaves the house in the same condition as he found it. His possible perception that he himself has greater benefit (welfare) from eating the food in the freezer than his friend, however, does not give him the *right* to do so. He argues that, similarly, we should leave nature in the same good condition that we found it. This is called strong sustainability. The problem with this approach is how to justify the rights and duties one has and how to determine what it means that future generations are to take over the environment and natural resources in just as good condition as when we inherited them. If we interpret this to mean that we shall leave future generations with exactly the same amount of all resources that we ourselves inherited, we cannot, for example, extract any oil. Since the same applies to the next generation, no one will benefit from the natural resources.

The choice between paths A and B in the figure is not typical for the type of conflict of interest when we want to use the concept of sustainability. Instead of resorting to alternative foundational principles of moral philosophy, we can use as a starting point the considerations that must typically be weighed in questions concerning intergenerational choices. Asheim (1993) has pointed to a possible justification for weak sustainability which is based on the common assumption that the economy is productive, i.e. that investments made today will provide a return in the future. If the present generation saves one billion kroner in current consumption and places this in sound investments, a future generation may be able to increase its consumption by more than one billion kroner. The transfer does not cost anything, since those receiving the transfer will receive more than what we forego. The opposite is not the case in a productive economy. We cannot increase our consumption by one billion kroner today without forcing one or more future generations to forego more than one billion kroner. We thus receive less than what they forego, and it thus costs something to transfer resources from future generations to us. A transfer from our generation thus involves no costs, and if the future generation is worse off than we are, i.e. that the path is unsustainable, the transfer will on top of this equalize the distribution of income between generations. Such a transfer is often considered desirable. In other words, if a future generation is worse off than we are, then it is both possible and desirable to reallocate resources from the rich to the poor generation. Consequently, it is always possible to improve the development if it is not sustainable, and it is therefore sensible to demand that development shall be sustainable.

Project personnel: Kjell Arne Brekke and Richard B. Howarth

Financed by: The Research Council of Norway, Methodology programme

Documentation:
Brekke, K.A. and R. B. Howarth (1996): Is welfarism compatible with sustainability? in the *Nordic Journal of Political Economy*, 23, 69-74.

7.3 Estimated costs of waste treatment

Waste treatment involves costs and results in considerable environmental problems. The Government's stated objective in waste policy is to reduce the quantities which arise, and then to treat waste in a more environmentally satisfactory manner. In practice, the latter has proved to be the most relevant. In this study we have calculated the social costs of combustion and disposal of municipal waste and evaluated the social costs of recycling. In this connection waste quantities for the various forms of treatment have been projected to the year 2010 under two different policy scenarios which promote recycling.

Projections of waste treatment in 2010
In 1992 (the base year for our economic model), 2.2 million tonnes of waste were treated at municipal waste treatment plants, and it is estimated that the quantity will increase to 3.2 million tonnes in 2010. In the first scenario, it is assumed that agreements are entered into between producing firms and the state concerning the recycling of packaging materials. The share of materials that is recycled then increases from 8 per cent in 1992 to 18 per cent in 2010, and the share for waste disposal sites declines from 73 to 64 per cent. An absolute decline in quantities of waste at disposal sites will not be seen until wet organic material is also sorted for composting at separate facilities. The share at disposal sites then falls to only 38 per cent.

Costs of combustion and waste disposal
The largest cost of *waste combustion* is probably the environmental effects of emissions to air, and is estimated in this study at NOK 730 million for 1992. In the literature, however, the estimates for the marginal damage of various gases vary considerably, and the estimate for emission costs can therefore range from NOK 180 million (lowest marginal costs) to NOK 1.4 billion (highest estimate). Private costs of combustion plants are estimated at NOK 700 per tonne, and thus amount to altogether NOK 277 million.

Emissions to air are also an important cost component for the *disposal* of waste at landfills, where methane accounts for as much as 94 per cent of the total costs estimated at NOK 3.1 billion in 1992. There is, however, considerable uncertainty concerning the marginal damage of this greenhouse gas. If the lowest estimates for marginal damage are used, total social costs will amount to only NOK 121 million, while the highest estimates show total costs of NOK 4.7 billion. Land use costs only account for 5 per cent of our estimate of total waste disposal costs when we use the price of housing sites (NOK 220 000 per quarter acre) as an alternative value. if forest value (NOK 600 per quarter acre) is used instead, land use costs are only NOK 0.5 million. Seepage also represents a problem at landfills, and the cost is estimated at NOK 6 million a year, although this problem disappears with the establishment of new secured landfill sites. It has not been possible to find estimates of private costs for the operation of waste disposal sites.

Recycling
Waste which is treated at municipal waste treatment plants, however, only accounts for a small share of total waste quantities in Norway. Industrial waste, recycling, etc. come in addition, and the total quantities of this waste are estimated at 12 million tonnes annually. It has been found that only 12 per cent of the materials is recycled, and that 6 per cent is used for energy. When large fractions such as stone, gravel, concrete and slam (accounting for 68 per cent of the total) are excluded, the recycling share rises to 29 and 20 per cent, respectively.

It has been difficult to estimate the social costs associated with the recycling of materials and energy, and it has therefore not been possible to calculate the costs of all components in the processes (for example, collection, treatment, emissions, etc.) for all waste fractions. It is particularly difficult to obtain information on the private costs associated with recycling, and it is also difficult to estimate the environmental costs/gains of recycling. The recycling of materials probably entails more transport and thereby higher air pollution. Emissions arise in the processing of waste for new products, and these products are probably of a poorer quality than products made from virgin raw materials.

Project personnel: Annegrete Bruvoll and Henrik Wiig

Financed by: The Research Council of Norway

Documentation:
Bruvoll, A. and H. Wiig (1996): Konsekvenser av ulike håndteringsmåter for avfall (Consequences of various waste disposal methods. In Norwegian), Notater 96/31, Statistics Norway.

7.4 Storage of carbon in products of wood

Forests are very important for carbon uptake and storage in Norway. The increase in growing stock results in an annual uptake of CO_2 corresponding to about one-third of Norwegian anthropogenic emissions. However, no figures have been available for the quantity of CO_2 stored in products of wood (paper, building materials, furniture, textiles, etc). The purpose of this study was to calculate the size of this reservoir and changes in the reservoir from 1960 to the present. The carbon reservoir in products of wood (for example houses and paper) has increased in Norway since 1960, but the amounts involved are small compared with emissions and natural uptake by forests.

The annual roundwood cut in Norway is either exported or used within the country. In the domestic market, timber is used to manufacture various products. The average lifetime of some of these, such as paper, is short, whereas that of others (e.g. building materials) is much longer. All such commodities form a reservoir of carbon which is converted to CO_2 when they are burnt, discarded or decay. To calculate the size of the reservoir, we considered the supply of wood and wooden products (the amount of timber

Table 7.4.1. **Anthropogenic carbon reservoir. Million tonnes carbon**

	1960	1970	1980	1988	1990	1991	1992	1993
Total	3.6	5.1	7.1	9.2	9.6	9.7	9.9	10.0
Wood products	3.4	4.6	6.1	7.8	8.1	8.2	8.2	8.3
Buildings	3.1	4.2	5.6	7.1	7.4	7.4	7.5	7.6
Furniture	0.4	0.4	0.6	0.7	0.7	0.7	0.7	0.7
Paper	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4
Textiles[1]	-	0.1	0.3	0.4	0.4	0.4	0.5	0.5
Waste[1]	-	0.2	0.4	0.6	0.7	0.8	0.8	0.8

[1] Reservoir calculated for textiles and waste includes accumulation from 1960 onwards only.
Source: Flugsrud et al (1997)

Table 7.4.2. **Changes in the carbon reservoir. Net annual accumulation, 1000 tonnes carbon**

	1960	1970	1980	1988	1990	1991	1992	1993
Total	158	157	196	254	226	122	146	131
Wood products	121	121	151	203	160	64	94	74
Buildings	112	112	139	189	145	58	85	65
Furniture	9	9	11	14	15	6	9	9
Paper	7	7	5	11	4	-8	-10	9
Textiles[1]	14	13	18	13	15	16	13	14
Wastel[1]	16	16	22	28	47	50	49	34

[1] Reservoir calculated for textiles and waste includes accumulation from 1960 onwards only.
Source: Flugsrud et al (1997)

harvested and imports and exports of all wooden products), the manufacture of wooden products and losses (waste and emissions) for the years 1960, 1970, 1980 and 1988-1993. The calculations are based on the available statistics and expert assessment. In general, the statistics for carbon inputs are better than those for outputs.

The carbon reservoir

Carbon stored in buildings and landfills makes up the largest proportion of the anthropogenic carbon reservoir in Norway (table 7.4.1). The total reservoir is about 10 million tonnes carbon, which is about the same as annual anthropogenic emissions in Norway. However, this is relatively little compared with the carbon reservoir in forests, where tree trunks alone account for more than 130 million tonnes carbon.

It has been calculated that about 4.5 million tonnes carbon originating from trees accumulated in buildings between 1960 and 1993. This means that the reservoir has increased by 0.1 million tonnes carbon per year (table 7.4.2), which corresponds to 0.5 million tonnes CO_2 per year, or about 1.5 per cent of Norway's annual anthropogenic emissions of CO_2. Since 1988, the annual rate of accumulation in wood products has dropped as a result of a lower level of construction activity. In all, 7.6 million tonnes carbon originating from trees is stored in buildings in Norway (1993).

Table 7.4.3. **Balance of biotic carbon in Norway. Million tonnes carbon**

	1960	1970	1980	1988	1990	1991	1992	1993
Inflow[1]	2.7	2.8	2.5	3.0	2.8	2.4	2.4	2.4
Production (roundwood cut)[2]	2.7	2.5	2.7	3.1	3.2	2.9	2.8	2.8
Net import	-0.1	0.3	-0.3	-0.1	-0.5	-0.5	-0.4	-0.4
Outflow	1.1	0.9	1.2	1.7	1.7	1.5	1.5	1.6
Net accumulation in products and waste	0.2	0.2	0.2	0.3	0.2	0.1	0.1	0.1
Emissions	1.0	0.8	1.0	1.4	1.4	1.4	1.3	1.5
Net inflow	1.5	1.9	1.2	1.3	1.1	0.9	0.9	0.8

[1] Norwegian production of wool, leather, etc is negligible in this connection and is therefore omitted.
[2] The data are for timber volume without bark. This results in underestimation of wood supplied to industry by 5-10 per cent.
Source: Flugsrud et al (1997)

Paper consumption has increased since 1960, but the statistics suggest that consumption has been stable in recent years. It is difficult to calculate the amount of carbon that has accumulated as a result of the rise in paper consumption, but our estimate is 6 000 tonnes per year, based on assumptions relating to the lifetime of different types of paper. The reservoir of carbon in paper is about 0.4 million tonnes.

Wood products finally become waste, which is deposited on landfills, incinerated or recycled, resulting in emissions of methane and CO_2. Landfills form a temporary, but large and rapidly increasing reservoir of carbon. Since 1960, 0.8 million tonnes carbon has accumulated in landfills, and this corresponds to 25 000 tonnes per year.

The figures calculated for the carbon reservoir and changes in it are very uncertain. Better statistics for waste generation, the composition of waste, waste management and the types of materials used in buildings will reduce the level of uncertainty.

CO_2 emissions

CO_2 emissions from the combustion of biofuels and the decay of wood are not generally included in calculations of Norwegian emissions. However, such emissions are of interest in setting up a carbon balance (table 7.4.3). Burning of fuel wood, wood waste and black liquor make the most important contributions to these emissions, but emissions from landfills and waste incineration are also important. The latter sources are underestimated, since not all waste is registered. CO_2 emissions of this type have risen by about 40 per cent from 1960 till the present. In 1993, "biological" emissions of CO_2 totalled 5.4 million tonnes, compared with 35.7 million tonnes (non-biological) anthropogenic emissions and 12 million tonnes fixed by forests as a result of the increase in standing volume in the same year.

Import and export of carbon

The figures discussed so far are for the carbon reservoir and emissions in Norway. Exports of Norwegian wood products result in carbon storage and emissions in other countries. Norway is a net exporter of carbon originating from trees, and such exports total about 0.1- 0.5 million tonnes carbon per year. Most of the carbon exported is in the form of pulp, paper, paperboard and paper products, which on average have a relatively short lifetime. Norwegian imports consist mainly of wood used by the pulping industry, which is also used to manufacture goods with a short lifetime. The quantity of wood imported varies from year to year, from a few per cent to 25 per cent of total primary wood available, depending on prices in the Norwegian market.

Carbon balance for wood products
The overall carbon balance shows that the known outflow of carbon in the form of accumulation and emissions is much lower than the inflow (table 7.4.3). This indicates that both emissions and accumulation in products and waste have been underestimated. The unaccounted difference dropped from 60 per cent in 1960-70 to 30 per cent in 1993. Accumulation in and emissions from all types of waste are likely sources of error. For example, discharges of black liquor into water were high at the beginning of the period.

Project personnel: Ketil Flugsrud, Sonia F.T. Gjesdal, Tone C. Mykkelbost and Kristin Rypdal

Financed by: Norwegian Pollution Control Authority and Ministry of Agriculture

Documentation:
Flugsrud, K., S.F.T. Gjesdal, T.C. Mykkelbost and K. Rypdal (1997): *A balance of use of wood products in Norway*, Report 96:04, Oslo: Norwegian Pollution Control Authority.

7.5 Material flow analysis for two environmentally hazardous substances in Norway

Norway is endeavouring to reduce consumption and emissions of environmentally hazardous substances. Cadmium and di(2-ethylhexyl) phthalate (DEHP) are considered to be toxic and may be hazardous to animals and humans. Both substances are found in a wide range of products, and people are exposed to them through various areas of use. We have investigated the possibility of using existing registers and statistics to carry out material flow analyses for these two substances.

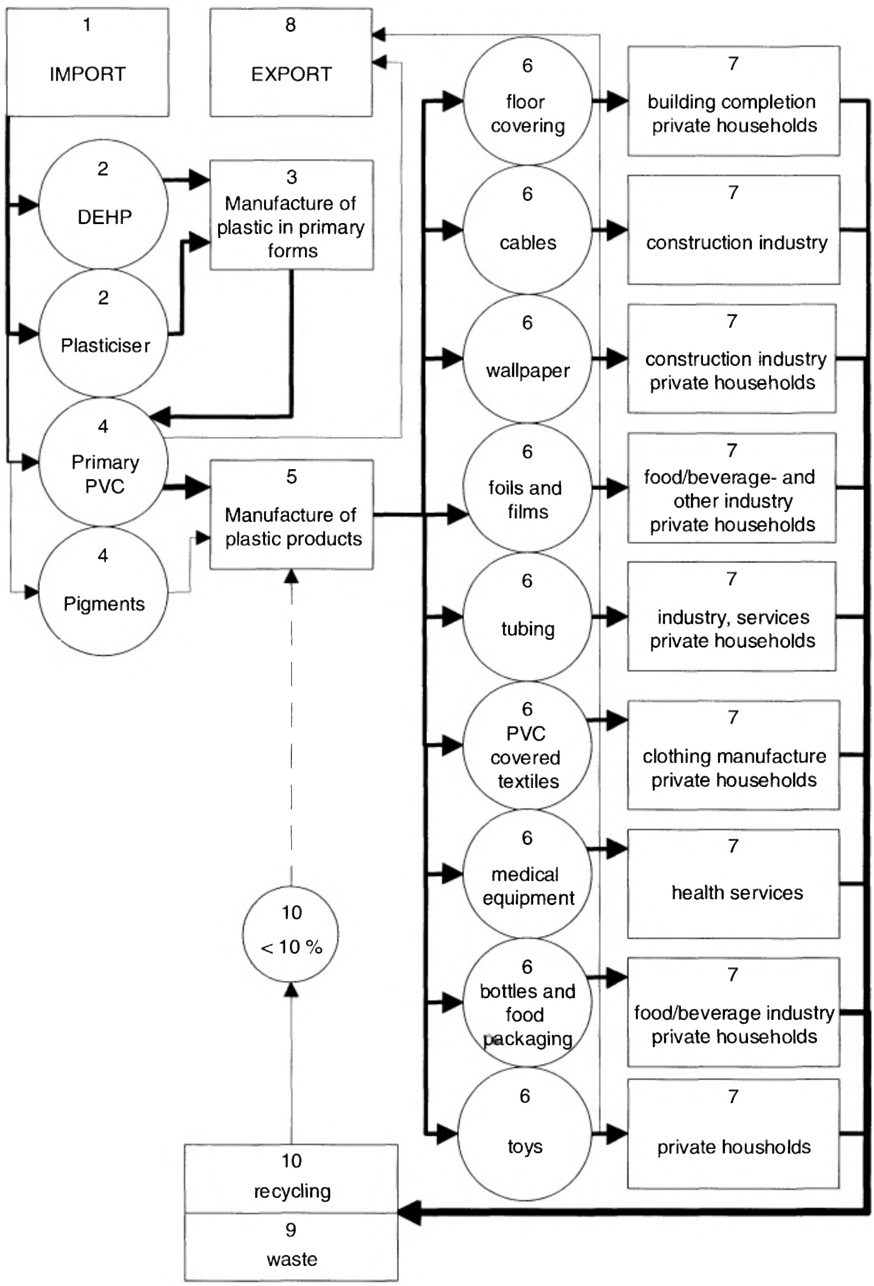
Choice of substances
For this methodological study, we chose one heavy metal, cadmium, and one organic compound, di(2-ethylhexyl) phthalate (DEHP). These were chosen because they are widely used and have different patterns of consumption and different dispersion patterns. Cadmium is considered to be very toxic and accumulates in internal organs, where it can cause serious injury to the lungs and kidneys. The most important routes of exposure to cadmium are through tobacco smoke and various foodstuffs, although the quantities of cadmium in these commodities are small compared with total cadmium consumption. DEHP is the most widely-used plasticizer, and is currently under risk assessment in the EU system for existing chemicals.

Methods
The material flow analyses are based on commodity balances calculated from external trade and industrial statistics. The relevant products were selected from the commodity list for external trade, and include both relatively pure chemicals and products containing only a fraction of the substance in question. Some commodities are used in the manufacture of other products which are also included in the balance, so the feedstock for such production must be subtracted to avoid counting the same quantities twice. Consumption of the substance is calculated separately for each type of commodity, using the following equation:

Consumption = (Import - Export + Production - Feedstock) content of the hazardous substance*

Consumption for each type of commodity is then added up to give consumption for

Figure 7.5.1. **Flow diagram for DEHP in the plastics industry and plastic production**



Source: Mykkelbost and Rypdal (1997)

groups of products and total national consumption, which can be split between various branches of industry. In addition to data from the foreign trade and industrial statistics, data from the Product Register were used to determine the chemical composition of various product groups. However, this register does not include finished commodities such as plastic products, and the composition of such products must therefore be determined from earlier material flow analyses (cf for example Huse 1995) and information from the manufacturers.

Consumption of DEHP

Polyvinyl chloride (PVC) is a hard, brittle material, but if a plasticizer is added, it becomes more flexible and its temperature stability improves. Phthalates are the most important group of plasticizers, and DEHP is the most widely used of these. Figure 7.5.1 shows a flow diagram for DEHP in the plastics industry, from import to finished plastic articles. DEHP is used in products such as jointless floor coverings, wallpaper, cables, rainwear, toys, packaging and medical equipment such as bags and tubing used for blood transfusion and intravenous drips. DEHP is not used as a plasticizer in food packaging of Norwegian manufacture. The concentration of plasticizer in soft PVC is generally 10-40 per cent by weight. DEHP is not manufactured in Norway, and all pure DEHP used as feedstock in production must therefore be imported from abroad. Phthalates are imported from Belgium, the UK, Germany, the Netherlands and Sweden. DEHP belongs to the group of chemicals known as dioctyl orthophthalates, and is the isomer imported in the largest quantities. From 1988 to 1994, annual imports of dioctyl orthophthalates totalled 2 500 - 3 500 tonnes. During this period, there has been a small drop in the quantity imported, followed by a rise during the past two years. In addition to pure phthalates, a substantial amount of DEHP is imported under the designation compound plasticizers for rubber and plastics. Net imports of plasticizers for plastics, which consist mainly of DEHP, have dropped from 1 702 tonnes in 1988 to 950 tonnes in 1993. The largest quantities of pure DEHP and plasticizers are imported by wholesalers who in turn sell them to the most important consumers, manufacturers of plastics.

Table 7.5.1. **DEHP consumption in 1988 and 1993, tonnes. Preliminary results**

	1988*	1993*
Total	2331	2808
Paints	137	109
Printing ink	139	67
Plastic commodities	2032	2554
Other commodities	24	78

Source: Mykkelbost and Rypdal (1997)

Table 7.5.1 shows the consumption of DEHP in 1988 and 1993. Most DEHP is used in soft PVC products. This analysis only includes products classified as plastic products. Many other products such as clothing, footwear, furniture, electric machinery, vehicles and sports articles may also contain some PVC, but these are not currently included in the analysis because of the difficulty of estimating the content of plastic and DEHP. A large proportion of PVC can be recycled. A total of 142 000 tonnes plastic waste is generated annually, and about 9 000 tonnes of this is recycled. Half of this currently originates from the plastics industry.

Phthalates are also used in paints, varnishes and printing ink, but in much lower concentrations than in plastic products. The model calculated DEHP consumption in such products to be 276 tonnes in 1988 and 176 tonnes in 1993. The DEHP content of fungicides and bactericides was difficult to deter-

Table 7.5.2. **Cadmium consumption in 1988 and 1993, in kg. Preliminary results**

	1988*	1993*
Total	176214	245293
Fossil fuels	700	700
Fertilizer and lime	165	165
Tobacco	3	3
Foodstuffs	not calculated	not calculated
Plastic commodities	400	400
Batteries	6400	15000
Pigments	546	25
Cadmium commodities	168000	239000

Source: Mykkelbost and Rypdal (1997)

mine, since very few relevant products were registered in the Product Register. However, similar studies in other countries have shown that the total consumption of DEHP in such products is very low.

A preliminary division of DEHP consumption by branches of industry and consumers shows that private households account for 10 per cent of final consumption.

Consumption of cadmium

No material balance has as yet been drawn up for cadmium. This is because cadmium is found in many more products and thus has many more applications than DEHP, and because it was far more difficult to survey the cadmium content of products. For example, little information was available from the Product Register. However, there was adequate information for certain applications and products containing cadmium.

Food and tobacco are important sources of cadmium, since they result in direct uptake in the body. The quantity of cadmium originating from tobacco is calculated annually in Statistics Norway's national emissions model. The cadmium concentration in tobacco is about 0.5 g/tonne, and tobacco consumption was 6 500 tonnes in 1988 and 5 700 tonnes in 1993. This gives a cadmium consumption of 3.3 and 2.9 kg, respectively. Even though these quantities are insignificant in comparison with total consumption, this is an important source since it results in direct exposure of the lungs. The cadmium content of foodstuffs has two main sources, the most important of which is phosphate fertilizer and lime used in agricultural production. Cadmium is found as a contaminant in the raw materials used in the manufacture of these products. Cadmium is also deposited with other pollutants formed by the combustion of oil and coal products. Emissions of cadmium from this source are calculated annually in the national emissions model. The cadmium content of the 9 - 10 million tonnes of fossil fuels consumed in Norway each year is 700 kg. It is important to be aware of this in order to avoid counting the same quantities twice when calculating cadmium consumption in food. A survey of the cadmium content of various foodstuffs is a major task, which has not yet been attempted. Cadmium exposure via drinking water is relatively low in Norway.

Cadmium is no longer used as a stabilizer in plastics of Norwegian manufacture, but may be found in imported plastic products. The most important products in this context are hard plastics with a long lifetime which are exposed to light and weather, for example window profiles and other plastic building materials. The cadmium content of such products has not yet been surveyed, but a preliminary estimate suggests that consumption is 400 kg per year in plastic products. Batteries containing cadmium are defined as a separate category in the foreign trade statistics. Given a cadmium content of 5 per cent (preliminary estimate), cadmium consumption in batteries was 6.4 tonnes in 1988 and 15 tonnes in 1993. The consumption of cadmium sulphide (CdS) as a pigment has dropped rapidly as a result of concern about the use of heavy metals. In 1988, cadmium consumption in this pigment was 547 kg, compared with only 25 kg in 1993. The total cadmium content of other pigments containing cadmium is not yet known.

The most difficult part of the material flow analysis was to find the cadmium content of alloys, anti-corrosion paints and electrodes (sacrificial anodes). There are many possibly relevant products, and it is difficult to estimate their cadmium content. Products of these types are not included in the Product Register. The consumption of products defined as containing cadmium in the commodity list for external trade was 168 tonnes in 1988 and 239 tonnes in 1993. These products thus dominate the preliminary cadmium balance, according to which total cadmium consumption was 176 tonnes in 1988 and 245 tonnes in 1993.

Project personnel: Tone C. Mykkelbost and Kristin Rypdal

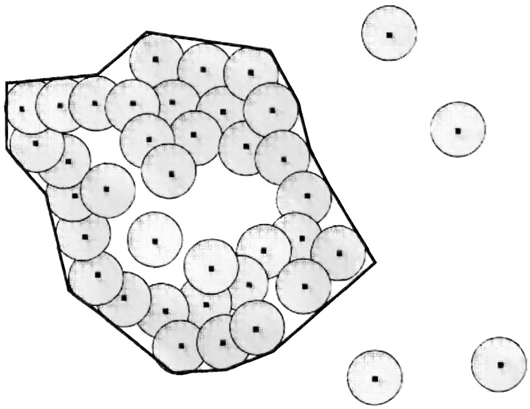
Financed by: Eurostat

Documentation:
Mykkelbost, T.C. and K. Rypdal (1997): Material flow analysis of Cadmium and di-2-etylhexylphthalate (DEHP) in Norway, Documents 97/1, Statistics Norway.

7.6 Land use in urban settlements

The boundaries of urban settlements and land use within them are important in environmental studies. Using existing records of buildings and population, a method for automatic delimitation of urban settlements has been developed. This makes it possible to produce updated statistics on the size of urban settlements and land use within them, and the areas delimited generally agree well with the official

Figure 7.6.1. **Delimitation of an urban settlement using a buffer zone around each building**



Source: Statistics Norway

boundaries used by Statistics Norway. The area available per inhabitant averaged 625 m^2 for all the settlements in the survey. In the urban settlements investigated, the built-up area varied between 6 and 8 per cent of the total.

Background
Statistics Norway has carried out a methodological study for the purpose of drawing up national statistics for land use in towns and urban settlements. Such statistics will provide information on how national goals and guidelines are being followed up in local planning and development. The project used a GIS (Geographical Information System) software tool for analyses of data from the GAB register, which is the official Norwegian register for property, addresses and buildings (Statens kartverk 1991), and the National Population Register.

Urban settlements constitute functional regions which are important analytical units for environmental, economic and demographic studies. They are of key importance because the majority of the population lives

[1] GIS = geografisk informasjonssystem

Figure 7.6.2. **Delimitation of Svelvik urban settlement by the buffer method compared with Statistics Norway's official boundary. 1996**

Source: Statistics Norway

in such areas (74 per cent on 1 January 1995), and the high level of economic activity and large volume of traffic result in environmental problems and pressures as regards land use. There is often a shortage of space, and the physical design of urban settlements has a great impact on living conditions for their inhabitants. Data on land use in urban settlements is important in various types of analyses, for instance of population or building density, travel distances, the accessibility of services and exposure to road-traffic noise and pollution.

Urban settlements are geographical areas without static boundaries, and their outer limits vary with time depending on building activity and population trends. It has proved difficult to produce maps of the extent of urban settlements at regular intervals, but the method developed here will make this easier. Figures were also calculated for important indicators such as area of urban settlement per inhabitant, plot utilization, built-up area and area used for transport purposes.

Delimitation of urban settlements
An urban settlement is defined as having at least 200 residents in an area where the distance between buildings does not exceed 50 metres. Single buildings or clusters of buildings which naturally belong to the settlement (satellites of the core) may be included even if they are more than 50 m from the nearest building. Large areas without buildings, such as industrial areas, car parks or sports facilities connected with the urban settlement may also be included (Statistics Norway 1986). All buildings in the GAB register are defined by their coordinates.
A buffer zone (radius 50 m) is placed round each building, and the urban settlement consists of the area of contiguous buffer zones. Figure 7.6.1. illustrates the delimitation of an urban settlement using the buffer method.

Population data from the National Population Register are linked to each building using the addresses registered for the building and the inhabitants. If there are 200 or more residents in the buildings in the area delimited, it is defined as an urban settlement. The method can also be used to delimit the area of urban settlements at earlier dates, and thus to draw up time series showing the development of urban settlements. Land use can also be recorded for different industry groups. This makes it possible to link the data with macro-economic models which use the same division by industry groups, and projections for land use in urban settlements can be drawn up.

Area of urban settlements
All urban settlements within the municipalities of Hurum, Sandefjord and Svelvik (nine in total) were delimited by means of the buffer method. Figure 7.6.2 shows the delimitation of the urban settlement of Svelvik, which agrees well with the official boundaries used by Statistics Norway. The figure also shows areas of more than 50 decares without buildings within the urban settlement.

For some urban settlements, there are large discrepancies between the official boundaries and the boundaries given by the buffer method, whereas in other cases there is better agreement. For most settlements, the buffer method tends to delimit a smaller area than that within Statistics Norway's official boundaries. This is because the buffer method does not detect large areas without buildings on the edges of the settlement, such as industrial areas, car parks, etc. Furthermore, no satellites are included in urban settlements defined by the buffer method. For some settlements, the opposite is true, and the area found by the buffer method is larger than Statistics Norway's official definition. The most important reason for this is that the buffer method includes continuous areas of holiday housing lying no more than 50 m from the core settlement, whereas these are generally excluded from the officially defined urban settlement.

Official delimitations of urban settlements are based partly on local assessment. The buffer method, on the other hand, generates urban settlement boundaries on the basis of uniform, verifiable criteria, and helps to produce a more uniform delimitation of urban settlements and more comparable data. The buffer method can be used as a common methodological basis, but because the definition of an urban settlement allows for some degree of individual judgement and the data available vary in quality, other methods will still have to be taken into consideration, based on for example local knowledge of the area, up-to-date economic map sheets, or aerial or satellite photographs.

To obtain good results using the buffer method, the quality of the data used must be as high as possible. For many municipalities, the quality of the data from the GAB register is not satisfactory. Particularly in the case of buildings erected before 1983, the information in the register is incomplete, and the statistics cannot be as complete as for later years. Thus, 1983 can be used as the base year for land use statistics based on data from the register, and we must use other sources for earlier years, for example the earlier land use accounts (Engebretsen 1989).

Table 7.6.1 shows the results of calculations of the area of urban settlements in 1996 using the buffer method.

Table 7.6.1. Area per inhabitant and land use (percentages of total area) in selected urban settlements in 1996

	Area per inhabitant (decares)	Built-up area	Transport area	Large areas without buildings	Plot utilization
Hurum municipality, all settlements	914	6	17	..	..
Sandefjord town	570	8	16	..	..
Svelvik municipality, all settlements	645	8	21	8	21[1)]

[1]Svelvik urban settlement only
Source: Statistics Norway

The area of urban settlement per inhabitant gives information on land use and population density. The area per inhabitant varied from 415 m^2 to 3 369 m^2, and the average for all the settlements in the study was 625 m^2. This agrees well with earlier calculations by Statistics Norway (Statistics Norway 1986) and the Norwegian Institute for Urban and Regional Research (Larsen and Saglie 1995).

The built-up area is another indicator of the density of the entire urban settlement. The built-up area is defined as the total base area of all buildings in the settlement. Car parks, roads, parks, other green spaces and sports facilities are not included in this definition, even though they are clearly "developed" areas. For an area to be defined as built up, some kind of physical structure must stand on it; it is not sufficient that the area is asphalted, for example. Table 7.6.1 shows the percentages of various urban settlements that are defined as built up. These vary from 6 per cent (settlements in Hurum municipality) to 8 per cent (Sandefjord town) of the total area.

The area used for transport purposes is measured using the indicator area of all motor roads. Areas used for car parks and garages belonging to private housing are not included. Footpaths, cycle paths, railways and port facilities are also excluded, but these will be relatively simple to include as the method is further developed. The area used for transport purposes varies from 16 per cent (Sandefjord town) to 21 per cent (urban settlements in Svelvik municipality) of the total.

Plot utilization is defined as the net floor area of buildings as a percentage of the total area of the plot. This is an overall measure of density for the built-up part of the settlement. So far, this indicator has only been calculated for the urban settlement of Svelvik, where it is 21 per cent.

Further work

To test the quality of the method, it is to be tried in other urban settlements. It will also be developed further so that satellites, roads, railways, industrial areas, parks, etc can be included in delimiting settlements. A national system for producing regularly updated land use statistics for urban settlements is also to be developed. Statistics on land use in urban settlements will also be available for use by individual municipalities and counties.

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Documentation:

Rogstad, L. (1996): "Arealstatistikk for byer og tettsteder. Utvikling av metode basert på bruk av geografiske informasjonssystemer (GIS) og registerdata" (Land use statistics for towns and urban settlements. Development of a method based on geographical information systems (GIS) and administrative records. In Norwegian.), in M.V. Dysterud, L. Rogstad and P. Schøning (red.): Bærekraftig arealpolitikk og behovet for arealstatistikk (Sustainable land use policies and the need for land use statistics) (report from a seminar), Notater 96/42, Statistics Norway.

Part III. Appendix of tables

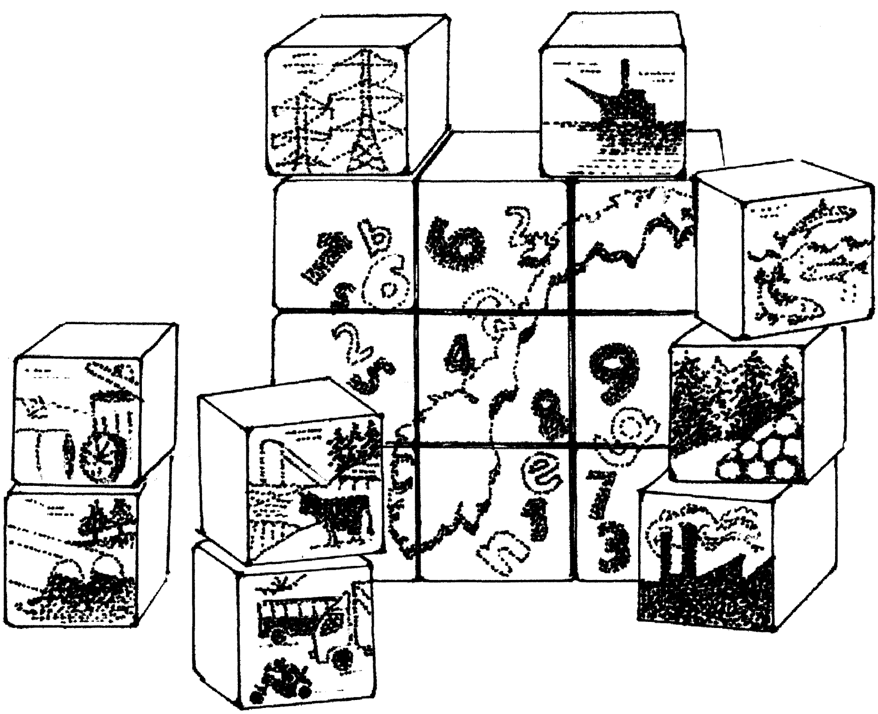

Table A1. Reserve accounts for crude oil. Fields already developed or where development has been approved. Million Sm^3 o.e.

	1989	1990	1991	1992	1993	1994	1995	1996
Reserves as of 1.1	1213	1189	1340	1354	1496	1473	1477	1654
New fields	-	126	114	117	5	34	131	315
Re-evaluation	66	123	12	152	110	124	212	10
Extraction	-89	-98	-112	-127	-139	-154	-166	-185
Reserves as of 31.12	1189	1340	1354	1496	1473	1477	1654	1795
R/P-ratio	13	14	12	12	11	10	10	10

Sources: Norwegian Petroleum Directorate and Statistics Norway

Table A2. Reserve accounts for natural gas. Fields already developed or where development has been approved. Million Sm^3 o.e.

	1989	1990	1991	1992	1993	1994	1995	1996
Reserves as of 1.1	1267	1261	1230	1274	1381	1356	1346	1352
New fields	-	17	54	138	1	2	32	195
Re-evaluation	25	-20	17	-2	2	18	5	-27
Extraction	-31	-28	-28	-29	-28	-30	-31	-41
Reserves as of 31.12	1261	1230	1274	1381	1356	1346	1352	1479
R/P-ratio	41	45	46	48	49	45	43	36

Sources: Norwegian Petroleum Directorate and Statistics Norway

Table A3. Reserve accounts for coal. Million tonnes

	1989	1990	1991	1992	1993	1994	1995	1996
Reserves as of 1.1	13.6	13.3	13.0	4.5	4.1	4.0	6.1	6.1
Re-evaluation	0.1	-	-8.2	-	0.2	2.4	0.3	-
Extraction	-0.3	-0.3	-0.3	-0.4	-0.3	-0.3	-0.3	0.3
Reserves as of 31.12	13.3	13.0	4.5	4.1	4.0	6.1	6.1	5.8
R/P-ratio	33	43	15	11	15	20	20	20

Source: Store Norske Spitsbergen Kulkompani

Table A4. Extraction, conversion and use[1] of energy commodities. 1995*. 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 1976-1995	Average annual change, per cent 1994-1995
Extraction of energy commodities	8	-	5729	1303	239[3]	441	-	7720		
Energy use in extraction sectors	-	-	-	-140[4]	-13	-12	-	-164		
Imports and Norwegian purchases abroad	55	0	60	-	262	8	-	386		
Exports and foreign purchases in Norway	-10	0	-5240	-1154	-550	-31	-	-6984		
Stocks (+decrease,–increase)	-1	.	-10	.	-7	.	.	-3		
Primary supplies	53	0	540	9	-55	407	-	954		
Oil refineries	6	-	-551	-	514	-2	-	-33		
Other energy sectors or supplies	-1	42	-	-	14	1	6	62		
Registered losses, statistical errors	0	-	11	-8	-48	-32	-2	-79		
Registered use outside energy sectors	58	42	-	1	425	375	4	905	0.5	0.7
Domestic use	58	42	-	1	298	375	4	778	1.3	1.1
Agriculture and fisheries	0	-	-	-	26	6	0	32	0.3	0.9
Energy-intensive manufacturing	44	-	-	1	53	104	1	202	1.2	-1.3
Other manufacturing and mining	13	16	-	-	32	63	0	126	0.1	2.9
Other industry	-	-	-	-	115	73	2	189	1.6	0.8
Private households	0	26	-	-	72	130	1	229	2.1	2.6
International maritime transport	-	-	-	-	127	-	-	126	-2.8	-1.7

[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. PJ. Percentage change

Energy commodity	1976	1980	1985	1990	1991	1992	1993	1994	1995	1996*	Average annual change, per cent 1976-1995	1995-1996
Total	607	679	737	736	725	721	747	769	778	804	1.3	3.2
Electricity	241	269	329	349	356	358	363	367	375	373	2.3	-0.5
Firm power	232	265	312	324	330	330	335	347	353	361	2.2	2.2
Spot power	9	4	17	24	27	28	28	19	22	12	4.7	-44.5
Oil, total	300	294	263	245	236	233	239	247	247	272	-1.0	10.1
Oil other than for transport	159	138	80	58	51	45	46	55	51	66	-5.8	27.3
Petrol	9	3	0	0	0	0	0	0	0	0	.	-
Kerosene	17	16	9	7	7	7	7	7	7	8	-4.6	17.1
Middle distillates	66	63	43	36	31	28	28	31	30	41	-4.1	35.0
Heavy fuel oil	66	56	28	15	13	10	11	17	14	18	-8.0	15.6
Oil for transport	141	156	183	187	186	188	193	192	196	206	1.8	5.6
Petrol, aviation fuel, jet fuel	74	81	92	100	97	96	97	97	95	98	1.4	4.5
Middle distillates	64	70	83	84	87	90	96	94	100	108	2.4	6.8
Heavy fuel oil	3	5	7	4	2	1	1	0	1	1	8.8	-16.7
Gas[1]	1	41	52	52	47	47	54	54	52	53	20.6	1.5
District heating	-	-	2	3	4	4	4	4	4	4	.	-
Solid fuel	65	74	91	88	81	80	88	98	100	102	2.3	1.1
Coal, coke	47	48	57	50	45	45	48	54	58	58	1.1	-0.9
Wood, wood waste, black liquor, waste	18	26	34	38	36	34	39	44	42	44	4.6	3.9

[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. PJ

	1976	1980	1983	1985	1987	1989	1990	1991	1992	1993	1994	1995*	1996*
Total	34	65	66	75	82	96	122	154	164	172	188	188	193
Of this:													
Electricity	4	6	6	8	7	7	7	8	8	8	11	13	8
Natural gas	12	30	43	45	55	68	79	113	118	125	137	140	146

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

Table A7. Electricity balance[1]. TWh. Percentage change

	1975	1980	1985	1990	1994	1995*	1996*	Average annual change, per cent 1975-1985	1985-1996
Production	77.5	84.1	103.3	121.8	113.2	123.2	104.8	2.9	0.1
+ Imports	0.1	2.0	4.1	0.3	4.8	2.3	13.2	47.6	11.3
– Exports	5.7	2.5	4.6	16.2	5.0	9.0	4.2	-2.1	-0.8
= Gross domestic consumption	71.9	83.6	102.7	105.9	113.1	116.6	113.7	3.6	0.9
– Consumption in pumped storage power plants	0.1	0.5	0.8	0.3	1.5	1.7	0.4	20.8	-5.7
– Consumption in power plants, losses and statistical differences	7.1	8.0	10.0	7.9	8.7	9.1	8.7	3.6	-1.3
= Net domestic consumption	64.7	75.1	91.9	97.7	102.9	105.7	104.6	3.6	1.2
– Spot power	3.2	1.2	4.8	6.7	5.4	5.9	3.3	4.0	-3.4
= Net firm power consumption	61.4	73.9	87.1	91.0	97.6	99.8	101.4	3.6	1.4
– Energy-intensive manufacturing	26.2	27.9	30.0	29.6	28.2	28.1	28.4	1.4	-0.5
= General consumption	35.2	46.0	57.1	61.5	69.4	71.7	72.9	4.9	2.3
General consumption, corrected for temperature	36.3	45.1	54.6	65.4	69.8	72.2	71.9	4.2	2.5

[1] Statistics Norway's electricity statistics have been used up to and including 1994. For 1995 and 1996, figures from the Norwegian Water Resources and Energy Administration have been used, but the import and export figures are adjusted 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

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996*
Heating products[3]:											
Price in øre[4]/kWh											
Electricity	35.6	37.9	41.7	43.5	45.7	46.5	46.6	47.8	46.8	50.8	49.3
Heating kerosene	24.8	25.0	25.7	28.3	33.9	40.1	37.4	37.8	37.6	38.2	42.1
Fuel oil no. 1/light fuel oils[5]	19.4	19.6	19.7	21.6	26.6	31.9	28.3	28.0	28.2	29.6	34.0
Fuel oil no. 2	18.1	18.3	18.8	20.7	25.7	30.8	27.2	26.9	27.1	..[4]	..
Heavy fuel oil	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/litre											
Petrol, leaded, high octane	476.0	510.0	536.0	578.5	642.8	741.0	795.0	836.2	851.0	893.0	.
Petrol, unleaded 98 octane	.	.	.	.	622.1	705.0	747.0	787.1	791.0	838.0	880.0
Petrol, unleaded 95 octane	457.0	489.0	503.0	540.5	594.4	677.0	717.0	757.4	761.0	807.0	849.0
Auto diesel	207.6	210.0	214.0	233.0	285.9	341.0	326.0	402.5	649.0	701.0	757.0

[1] Including all taxes. [2] Households and agriculture. For 1986-1992, firm power only. For 1993-1996, both firm power and spot power. [3] To find the price of utilized energy, we use the following figures for efficiency: electricity 1.0, kerosene and heavy fuel oil 0.75, and light fuel oils 0.70. [4] 100 øre = 1 NOK. [5] Fuel oil 1 and fuel oil 2 are so similar that they have been combined in the category light fuel oils after 1994.
Sources: Statistics Norway, Norwegian Water Resources and Energy Administration, Norwegian Petroleum Institute

Table A9. Consumption of energy commodities for combustion. Oslo, 1994. MWh theoretical energy content

	Fossil energy	Bioenergy
Total	3 798 769	330 284
Stationary combustion	1 309 097	330 284
Manufacturing and energy sectors	241 931	854
Public services	112 746	-
Private services	459 851	37
Primary industries	7 385	-
Private households	477 834	245 242
Waste and landfill gas	9 350	84 152
Mobile combustion	2 489 672	-
Road traffic	2 337 127	-
- Private households	813 413	-
- Public transport	174 863	-
- Other transport	1 348 851	-
Motorized equipment and tractors	124 955	-
- Private households	27 952	-
- Other sectors	97 002	-
Railways	9 682	-
Shipping, in port	17 909	-
Ships in international trade, in port[1]	717 029	-

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

Table A10. Total primary energy supply. World total and selected countries. Million toe

	1971 Mtoe	1980 Mtoe	1990 Mtoe	1991 Mtoe	1992 Mtoe	1993 Mtoe	1994 Mtoe	Per unit GDP (1994) (toe/1000 USD)	Per capita (1994) (toe per capita)
World total	4997.7	6579.4	7908.3	7958.0	8003.7	8081.4	8118.7	..	..
OECD	3188.5	3808.2	4204.8	4264.9	4311.4	4381.7	4457.4	0.25	4.58
Norway	13.9	18.9	21.5	22.1	22.5	23.5	23.1	0.17	5.32
Denmark	19.2	19.5	18.3	20.2	19.4	19.8	20.7	0.15	3.98
Finland	18.4	25.0	28.6	29.1	27.4	28.7	30.5	0.25	6.00
Sweden	36.5	41.0	47.8	49.3	47.0	47.1	50.3	0.23	5.72
France	154.7	190.7	221.2	232.5	236.4	241.0	234.2	0.19	4.04
United Kingdom	211.1	201.2	212.1	217.7	217.9	219.2	220.3	0.22	3.77
Germany	308.0	359.2	355.1	347.3	340.7	337.7	336.5	0.19	4.13
Turkey	13.7	31.3	53.2	54.2	55.5	58.9	57.6	0.35	0.95
Canada	142.8	193.2	210.2	209.7	214.0	220.7	229.7	0.38	7.85
USA	1581.4	1801.0	1913.6	1926.6	1956.4	2006.3	2038.0	0.34	7.81
Japan	269.9	347.1	432.6	442.9	453.1	459.6	481.9	0.16	3.86
Ethiopia	0.6	0.6	1.1	1.1	1.1	1.1	1.2	0.13	0.02
Guatemala	0.8	1.4	1.4	1.5	1.6	1.8	2.2	0.24	0.21
India	63.0	93.9	184.0	193.4	205.0	211.9	226.6	0.66	0.25
Bangladesh	1.3	2.8	6.4	6.0	6.4	7.1	7.6	0.29	0.06

Sources: OECD/IEA (1996a and b)

Table B1. Domestic passenger transport. Million passenger-km

	Total	Total road transport	Car	Bus	Taxi, hired car	MC, moped	Air trans-port	Rail trans-port	Water trans-port
1946	4591	2051	1053	687	218	93	3	2081	456
1952	6524	3893	1584	1847	291	171	9	2115	507
1960	11646	8739	4758	2776	376	829	93	2254	560
1961	12721	9846	5676	2929	386	855	103	2199	573
1962	13893	10998	6675	3093	396	834	144	2186	565
1963	14642	11824	7724	2866	403	831	185	2093	540
1964	16017	13207	8875	3108	402	822	232	2035	543
1965	17384	14512	10053	3263	398	798	280	2020	572
1966	18836	15893	11304	3426	395	768	295	2071	577
1967	20185	17088	12495	3452	399	742	423	2088	586
1968	22244	19140	14414	3600	407	719	484	2029	591
1969	23939	20833	16001	3707	423	702	558	1932	616
1970	25824	22631	17781	3726	429	695	632	1930	631
1971	28734	25344	20452	3770	441	681	758	1970	662
1972	30514	26946	21969	3867	447	663	858	2021	689
1973	32826	29218	24207	3907	463	641	916	1991	701
1974	33792	29980	24842	4058	452	628	915	2221	676
1975	35305	31353	26311	3963	475	604	1021	2271	660
1976	37310	33135	28200	3916	481	538	1139	2338	698
1977	39172	34824	29760	3987	538	539	1286	2377	685
1978	39837	35326	30287	3930	562	547	1395	2449	667
1979	41229	36458	31169	4124	613	552	1482	2636	653
1980	40705	35819	30436	4257	625	501	1475	2751	660
1981	40518	35582	30146	4297	621	518	1535	2767	634
1982	40443	35641	30504	3952	635	550	1626	2575	601
1983	41100	36160	31112	3811	665	572	1797	2530	613
1984	42137	37066	32050	3712	712	592	1929	2525	617
1985	47657	42300	36884	3948	838	630	2147	2567	643
1986	50534	45013	39488	3878	949	698	2301	2582	638
1987	52404	46704	41243	3743	1002	716	2505	2563	632
1988	52381	46734	41230	3901	912	691	2548	2463	636
1989	52707	47136	41684	3956	792	704	2469	2459	643
1990	52844	47113	41717	3890	801	705	2665	2430	636
1991	52446	46606	41210	3935	760	701	2699	2487	654
1992	52634	46561	41130	3945	782	704	2946	2511	616
1993	53503	47094	41644	3927	815	708	3204	2588	617
1994	54538	47804	42211	3956	928	709	3397	2703	634
1995	54978	48116	42365	3956	1071	724	3567	2681	614

Sources: Statistics Norway and Institute of Transport Economics (1996)

Table B2. Domestic goods transport. Million tonne-km

	Total[1]	Water transport	Rail transport	Road transport	Air transport	Timber floating	Oil and gas transport from the continental shelf
1946	4091	2679	687	481	0	244	-
1952	6662	4202	1186	807	0	467	-
1960	8741	5854	1056	1493	1	337	-
1965	11107	7550	1160	2183	2	212	-
1970	14984	10253	1448	3194	5	84	-
1975	16014	9836	1508	4569	9	92	-
1980	16761	9794	1657	5252	14	44	348
1985	17610	9300	1771	6485	19	35	2718
1990	18960	9078	1632	8231	19	-	7603
1992	18995	8883	1746	8348	18	-	10226
1993	18943	8735	1774	8413	21	-	10350
1994	18638	8142	1599	8877	20	-	12662
1995	19644	8142	1647	9834	21	-	13843

[1] Not including oil and gas transport from the continental shelf.
Sources: Statistics Norway and Institute of Transport Economics (1996)

Table C1. Emissions of greenhouse gases to air. Tonnes unless otherwise specified

	CO_2	CH_4	N_2O	HFC 125	HFK 134	HFC 143	HFC 152	CF	SF_6	CO_2-equivalents
	Mtonnes	ktonnes	ktonnes							Mtonnes
GWP	1	21	310	2800	1300	3800	140	6500	23900	
1973	30	216 [1]	12 [1]	..	..	..	..	..	..	..
1974	27	..	..	..	..	..	..	..	..	..
1975	30	..	..	..	..	..	..	..	..	..
1976	32	..	..	..	..	..	..	..	..	..
1977	33	..	..	..	..	..	..	..	..	..
1978	32	..	..	..	..	..	..	..	..	..
1979	34	..	..	..	..	..	..	..	..	..
1980	34	364	14	..	..	..	..	..	..	..
1981	31	..	..	..	..	..	..	..	..	..
1982	30	..	..	..	..	..	..	..	..	..
1983	31	..	..	..	..	..	..	..	..	..
1984	33	..	..	..	..	..	..	..	..	..
1985	32	402	14	0	0	0	0	428	199	52
1986	34	409	15	0	0	0	0	418	240	56
1987	35	416	15	0	0	0	0	405	240	56
1988	35	416	15	0	0	0	0	388	223	56
1989	35	429	15	0	0	0	3	376	107	54
1990	36	432	15	0	0	0	3	385	92	54
1991	34	432	15	0	1	0	3	327	86	52
1992	34	438	13	0	2	0	3	253	29	50
1993	36	448	14	0	31	0	1	266	30	52
1994	38	467	14	11	40	4	1	241	35	55
1995*	38	469	14	31	47	25	5	217	24	54
1996*	41	471	..	..	..	..	..	..	..	..

[1] 1970 figure

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table C2. Emissions to air, 1 000 tonnes unless otherwise specified

	SO_2	NO_x	NH_3	Acid equi-valents[1]	NMVOCs	CO	Particu-lates[2]	Heavy metals	
								Pb	Cd
								Tonnes	kg
1973	155	178	..	..	186	731	28	882	..
1974	149	173	..	..	178	685	26	826	..
1975	137	179	..	..	199	747	25	919	..
1976	146	177	..	..	202	795	25	756	..
1977	145	190	..	..	208	846	27	758	..
1978	142	182	..	..	169	872	25	781	..
1979	143	192	..	..	185	908	27	825	..
1980	140	182	..	..	174	906	24	774	..
1981	127	175	..	..	185	893	21	572	..
1982	110	180	..	..	192	914	19	647	..
1983	103	185	..	..	205	918	19	555	..
1984	95	200	..	..	217	947	20	398	..
1985	97	212	..	..	235	983	21	413	1143
1986	91	228	..	..	254	1028	22	349	..
1987	74	235	..	..	261	1035	22	300	..
1988	67	227	21	8.3	252	1019	20	301	..
1989	59	230	23	8.2	280	975	21	278	1212
1990	53	227	23	7.9	298	961	22	230	1193
1991	45	220	24	7.6	298	901	20	184	1168
1992	37	216	25	7.3	323	870	20	150	1064
1993	35	225	25	7.4	351	853	23	107	1110
1994	34	222	25	7.4	365	864	25	22	625
1995*	35	222	25	7.4	378	829	25	15	641
1996*	..	230	26	..	377	813	28	8	665

[1] Total acidifying effect of SO_2, NO_x og NH_3
[2] Emissions not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table C3. Emissions of greenhouse gases to air by sector, 1994. Tonnes unless otherwise specified

	Greenhouse gases										CO_2-equivalents
	CO_2	CH_4	N_2O	HFC 125[3]	HFC 134[3]	HFC 143[3]	HFC 152	CF_4	C_2F_6	SF_6	
	Mtonnes	ktonnes	ktonnes								Mtonnes
Total	37.8	466.7	14.3	10.62	39.74	4.00	1.10	230.5	10.5	35.3	54.5
Energy sectors	11.4	32.8	0.2	-	-	-	-	-	-	2.4	12.3
Extraction of oil and gas[1]	9.1	27.2	0.1	-	-	-	-	-	-	-	9.7
Extraction of coal	0.0	5.4	0.0	-	-	-	-	-	-	-	0.1
Oil refining	2.0	0.2	0.1	-	-	-	-	-	-	-	2.1
Electricity supplies[2]	0.3	0.1	0.0	-	-	-	-	-	-	2.4	0.3
Manufacturing and mining	11.0	101.6	6.2	0.11	0.40	0.04	0.01	230.5	10.5	33.0	17.4
Oil drilling	0.3	0.2	0.0	-	-	-	-	-	-	-	0.3
Manufacture of pulp and paper	0.6	50.2	0.4	-	-	-	-	-	-	-	1.8
Manufacture of chemical raw materials	2.5	1.0	5.5	-	-	-	-	-	-	-	4.2
Manufacture of minerals	1.9	0.0	0.1	-	-	-	-	-	-	-	1.9
Manufacture of iron, steel and ferro-alloys	2.5	0.0	0.0	-	-	-	-	-	-	-	2.5
Manufacture of other metals	1.9	0.0	0.0	-	-	-	-	230.5	10.5	32.8	4.3
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	50.1	0.1	0.11	0.40	0.04	0.01	-	-	-	1.3
Manufacture of consumer goods	0.7	0.0	0.1	-	-	-	-	-	-	-	0.7
Other	15.4	332.3	7.8	10.51	39.34	3.96	1.09	-	-	-	24.8
Construction	0.6	0.0	0.1	-	-	-	-	-	-	-	0.6
Agriculture and forestry	0.8	97.5	6.4	-	-	-	-	-	-	-	4.8
Fishing, whaling and sealing	1.3	0.1	0.0	-	-	-	-	-	-	-	1.3
Land transport, domestic	2.4	0.1	0.3	-	-	-	-	-	-	-	2.5
Sea transport, domestic	1.2	0.1	0.0	-	-	-	-	-	-	-	1.2
Air transport, domestic	1.1	0.0	0.1	-	-	-	-	-	-	-	1.2
Other private services	2.0	0.3	0.2	10.51	39.34	3.96	1.09	-	-	-	2.1
Public sector, municipal[4]	0.2	218.6	0.1	-	-	-	-	-	-	-	4.8
Public sector, state	0.6	0.0	0.0	-	-	-	-	-	-	-	0.6
Private households	5.3	15.5	0.6	-	-	-	-	-	-	-	5.8

[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] Includes water supplies.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table C4. Emissions to air by sector, 1994. 1 000 tonnes unless otherwise specified

	SO_2	NO_x	NH_3	Acid equi-valents	NMVOCs	CO	Particu-lates[1]	Heavy metals	
								Pb	Cd
								Tonnes	kg
Total	34.3	222.0	24.8	7.4	364.8	864.5	25.2	21.7	625.1
Energy sectors	3.2	44.0	0.0	1.1	204.7	8.1	0.6	1.4	22.1
Extraction of oil and gas[2]	0.5	39.7	-	0.9	185.6	6.3	0.2	0.0	1.1
Extraction of coal	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Oil refining	1.8	2.8	0.0	0.1	18.6	0.0	0.1	0.0	0.0
Electricity supplies[3]	0.9	1.4	0.0	0.1	0.5	1.6	0.2	1.3	20.9
Manufacturing and mining	25.0	28.4	0.3	1.4	23.9	59.1	1.9	2.3	427.8
Oil drilling	0.1	4.4	-	0.1	0.4	0.3	0.0	0.0	0.4
Manufacture of pulp and paper	2.5	2.0	0.0	0.1	0.3	2.1	0.6	0.2	20.9
Manufacture of chemical raw materials	8.5	4.9	0.3	0.4	2.8	39.5	0.1	0.1	3.3
Manufacture of minerals	2.3	7.0	0.0	0.2	1.4	0.7	0.3	1.3	62.3
Manufacture of iron, steel and ferro-alloys	7.6	4.9	0.0	0.3	1.4	0.1	0.0	0.1	12.1
Manufacture of other metals	2.5	1.4	0.0	0.1	0.1	9.2	0.1	0.5	302.9
Manufacture of metal goods, boats, ships and platforms	0.2	1.0	0.0	0.0	3.3	1.2	0.1	0.0	1.1
Manufacture of wood, plastic, rubber, and chemical goods, printing	0.2	0.7	0.0	0.0	12.6	4.2	0.6	0.0	22.5
Manufacture of consumer goods	1.0	2.2	0.0	0.1	1.5	1.9	0.2	0.1	2.2
Other	6.1	149.6	24.5	4.9	136.2	797.3	22.7	18.1	175.3
Construction	0.2	5.9	0.0	0.1	13.8	7.3	0.6	0.2	1.1
Agriculture and forestry	0.3	7.4	23.9	1.6	4.4	8.9	1.0	0.1	1.6
Fishing, whaling and sealing	0.7	29.2	0.0	0.7	0.8	6.5	0.2	0.1	2.9
Land transport, domestic	1.0	24.5	0.0	0.6	5.2	20.9	2.5	0.3	5.1
Sea transport, domestic	1.0	24.1	-	0.6	1.6	1.1	0.2	0.1	2.9
Air transport, domestic	0.1	3.3	-	0.1	1.7	2.8	0.1	1.7	-
Other private services	0.7	13.6	0.1	0.3	21.3	104.7	0.5	2.9	2.2
Public sector, municipal[4]	0.1	0.4	0.0	0.0	1.3	0.5	0.0	0.0	0.6
Public sector, state	0.1	3.6	0.0	0.1	1.5	1.9	0.1	0.0	0.5
Private households	1.9	37.7	0.5	0.9	84.8	642.8	17.5	12.7	158.5

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

Table C5. 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	NMVOCs	CO	Par-ticu-lates[2]	Pb	Cd
	Million tonnes									Tonnes	kg
Total	37.8	466.7	14.3	34.3	222.0	24.8	364.8	864.5	25.2	21.7	625.1
Stationary combustion	15.9	17.6	1.6	7.7	44.0	-	14.3	172.5	18.3	1.9	292.0
Oil extraction	7.5	2.6	0.1	0.2	27.5	-	1.2	5.6	0.1	0.0	-
--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	0.1	0.0	-
--Flaring	1.0	0.3	0.0	-	6.3	-	0.4	0.5	-	-	-
Gas terminal and oil refineries	2.6	0.4	0.1	0.1	3.4	-	0.9	0.5	0.1	0.0	0.0
Other industry	3.6	0.4	0.8	5.4	9.4	-	0.7	6.2	1.6	0.5	119.7
Dwelling, offices, etc	2.0	14.1	0.5	1.6	2.7	-	11.1	159.9	16.5	0.1	160.8
Waste incineration	0.1	0.1	0.0	0.4	0.9	-	0.3	0.3	0.0	1.3	11.4
Process emissions	7.7	446.9	11.7	21.4	8.6	24.1	258.2	48.4	..	1.7	316.2
Oil and gas sector	0.7	24.4	-	1.7	-	-	201.9	-	..	-	..
--Venting, leaks, etc	0.0	8.8	-	-	-	-	3.6	-	..	-	..
--Oil loading	0.6	15.0	-	-	-	-	179.2	-	..	-	..
--Gas terminal and oil refineries	0.1	0.6	-	1.7	-	-	19.1	-	..	-	..
Petrol distribution	0.0	-	-	-	-	-	6.5	-	..	-	..
Manufacture of pulp and paper	-	-	-	1.1	-	-	-	-	..	-	..
Manufacture of chemicals	1.0	1.0	5.4	5.3	1.5	0.3	0.7	39.4	..	-	0.3
Manufacture of cement and other minerals	0.9	-	-	0.8	-	-	-	-	..	1.1	..
Manufacture of metals	4.7	-	-	12.4	7.1	-	1.6	9.0	..	0.6	315.8
--Ferro-alloys	2.4	-	-	10.0	6.3	-	1.4	-	..	-	5.0
--Aluminium	1.5	-	-	1.6	0.6	-	-	-	..	0.4	102.0
--Other metals	0.8	-	-	0.8	0.2	-	0.3	9.0	..	0.2	208.9
Agriculture	0.2	97.4	6.4	-	-	23.8	-	-	..	-	..
Landfills	0.0	318.5	-	-	-	-	-	-	..	-	..
Solvents	0.1	-	-	-	-	-	46.6	-	..	-	..
Other process emissions	0.0	5.6	0.0	0.2	-	-	0.9	-	..	-	..
Mobile combustion	14.3	2.2	0.9	5.1	169.5	0.7	92.3	643.6	6.9	18.1	17.0
Motor vehicles	8.1	1.6	0.7	2.3	74.3	0.6	71.1	572.0	4.1	15.5	
-Petrol engines	5.0	1.5	0.3	1.0	43.8	0.6	66.7	555.6	0.6	15.4	..
--Light vehicles	5.0	1.5	0.3	1.0	43.3	0.6	66.1	548.8	0.6	15.3	..
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.7	0.0	0.1	..
-Diesel engines	3.1	0.1	0.4	1.4	30.5	0.0	4.5	16.4	3.5	0.1	6.9
--Light vehicles	0.8	0.0	0.0	0.4	3.0	0.0	0.9	3.4	1.3	0.0	1.8
--Heavy vehicles	2.3	0.0	0.3	1.0	27.5	0.0	3.5	13.0	2.2	0.1	5.0
Motorcycles, mopeds, snow scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.2	14.0	0.0	0.2	..
Motorized equipment	0.8	0.1	0.0	0.3	12.1	0.0	3.9	25.8	1.5	0.2	1.7
Railways	0.1	0.0	0.0	0.0	1.6	-	0.1	0.4	0.1	0.0	0.2
Air traffic	1.5	0.0	0.1	0.2	4.3	-	0.7	3.6	0.2	1.7	..
Shipping	3.7	0.4	0.1	2.2	77.1	-	11.3	27.9	1.0	0.5	8.2
--Coastal traffic, small boats,etc	2.2	0.2	0.1	1.5	43.9	-	10.3	21.5	0.8	0.5	4.9
--Fishing vessels	1.3	0.1	0.0	0.7	29.1	-	0.7	6.2	0.2	0.1	2.9
--Mobile oil rigs, etc	0.2	0.0	0.0	0.1	4.1	-	0.3	0.2	0.0	0.0	0.4

[1] Does not include international maritime and air transport.
[2] Emissions not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table C6. 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	NMVOCs	CO	Particulates[2]	Pb	Cd
	Million tonnes									Tonnes	kg
Total	37.9	469.0	14.2	34.6	222.4	25.4	377.6	829.0	24.9	14.8	641.3
Stationary combustion	15.2	17.6	1.5	7.0	43.4	-	14.1	172.2	18.0	1.8	307.1
Oil extraction	7.6	2.6	0.1	0.2	28.2	-	1.1	5.7	0.1	0.0	-
--Natural gas	6.2	2.4	0.1	-	16.6	-	0.6	4.5	-	-	-
--Diesel combustion	0.4	0.1	0.0	0.2	6.4	-	0.4	0.5	0.1	0.0	-
--Flaring	1.1	0.3	0.0	-	6.4	-	0.4	0.5	-	-	-
Gas terminal and oil refineries	2.3	0.4	0.1	0.1	2.8	-	0.8	0.5	0.1	0.0	0.0
Other industry	3.3	0.3	0.8	5.0	8.8	-	0.7	6.3	1.5	0.4	119.7
Dwellings, offices, etc	1.9	14.1	0.5	1.5	2.6	-	11.1	159.5	16.2	0.1	160.3
Waste incineration	0.1	0.1	0.0	0.2	0.9	-	0.3	0.2	0.0	1.3	27.1
Process emissions	8.1	449.6	11.7	22.2	8.4	24.6	275.1	49.7	..	1.2	316.2
Oil and gas sector	0.7	24.8	-	1.8	0.0	-	220.8	-	..	-	-
--Venting, leaks, etc	0.0	8.8	-	-	-	-	3.6	-	..	-	-
--Oil loading	0.6	15.1	-	-	-	-	196.7	-	..	-	-
--Gas terminal and oil refineries	0.1	0.9	-	1.8	0.0	-	20.6	-	..	-	-
Petrol distribution	0.0	-	-	-	-	-	6.4	-	..	-	-
Manufacture of pulp and paper	-	-	-	0.7	-	-	-	-	..	-	-
Manufacture of chemicals	1.3	1.0	5.3	5.9	1.3	0.3	0.7	39.7	..	-	0.3
Manufacture of cement and other minerals	0.8	-	-	0.9	-	-	-	-	..	0.6	-
Manufacture of metals	4.8	-	-	12.7	7.1	-	1.8	10.0	..	0.6	315.9
--Ferro-alloys	2.6	-	-	10.3	6.3	-	1.5	-	..	-	5.0
--Aluminium	1.5	-	-	1.5	0.6	-	-	-	..	0.4	102.0
--Other metals	0.8	-	-	0.8	0.2	-	0.3	10.0	..	0.2	208.9
Agriculture	0.2	96.4	6.4	-	-	24.2	-	-	..	-	-
Landfills	0.0	322.0	-	-	-	-	-	-	..	-	-
Solvents	0.1	-	-	-	-	-	44.7	-	..	-	-
Other process emissions	0.0	5.4	0.0	0.1	-	-	0.8	-	..	-	-
Mobile combustion	14.6	2.1	1.0	5.5	170.6	0.8	88.4	607.1	6.9	11.7	18.0
Motor vehicles	8.4	1.5	0.8	2.5	73.4	0.8	67.3	534.8	4.1	9.5	-
-Petrol engines	5.0	1.4	0.4	1.0	41.0	0.8	62.7	518.2	0.6	9.4	-
--Light vehicles	4.9	1.4	0.4	0.9	40.4	0.8	62.0	510.5	0.6	9.3	-
--Heavy vehicles	0.0	0.0	0.0	0.0	0.6	0.0	0.7	7.7	0.0	0.1	-
-Diesel engines	3.4	0.1	0.4	1.5	32.4	0.0	4.6	16.6	3.5	0.1	7.5
--Light vehicles	0.9	0.0	0.0	0.4	3.2	0.0	0.9	3.5	1.3	0.0	1.9
--Heavy vehicles	2.5	0.1	0.4	1.1	29.2	0.0	3.7	13.0	2.2	0.1	5.6
Motorcycles, mopeds, snow scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.2	14.5	0.0	0.1	-
Motorized equipment	0.8	0.1	0.0	0.3	12.3	0.0	3.9	25.9	1.5	0.1	1.7
Railways	0.1	0.0	0.0	0.0	1.5	-	0.1	0.4	0.1	0.0	0.2
Air traffic	1.4	0.0	0.1	0.2	4.2	-	0.6	3.5	0.2	1.5	-
Shipping	3.8	0.4	0.1	2.4	79.1	-	11.2	28.0	1.0	0.4	8.5
--Coastal traffic, small boats,etc	2.3	0.2	0.1	1.6	45.4	-	10.1	21.5	0.8	0.3	5.1
--Fishing vessels	1.3	0.1	0.0	0.7	29.5	-	0.7	6.3	0.2	0.1	3.0
--Mobile oil rigs, etc	0.2	0.0	0.0	0.1	4.2	-	0.3	0.2	0.0	0.0	0.4

[1] Does not include international maritime and air transport.
[2] Emissions not calculated for processes.
Sources: Statistics Norway and Norwegian Pollution Control Authority

Table C7. Emissions to air[1] by county, 1994. 1 000 tonnes unless otherwise specified

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Par-ticu-lates[2]	Pb	Cd
	Million tonnes									Tonnes	kg
Total	37.6	466.7	14.2	42.9	236.0	24.8	365.4	863.8	25.2	20.7	629.7
Of this, international maritime and air transport	1.5	0.1	0.0	9.0	25.0	-	1.0	1.8	0.3	0.2	5.3
Østfold	1.5	25.2	0.6	5.0	7.2	1.8	10.1	45.8	1.5	2.4	20.3
Akershus	1.5	35.5	0.5	0.7	10.8	1.6	16.4	89.8	1.9	2.1	18.0
Oslo	1.1	1.9	0.1	0.6	7.2	0.1	14.1	56.6	1.0	2.0	9.7
Hedmark	0.8	35.5	0.6	0.4	6.6	2.1	8.3	52.2	2.1	1.0	23.1
Oppland	0.7	30.9	0.7	0.3	5.7	1.9	7.2	43.5	1.5	1.0	15.1
Buskerud	1.0	31.6	0.5	1.0	7.0	0.9	9.1	51.7	1.4	1.2	18.6
Vestfold	1.2	20.5	0.3	1.3	6.3	1.0	10.3	40.2	1.0	1.0	16.0
Telemark	3.1	17.0	3.6	1.2	9.1	0.8	7.5	42.7	1.1	0.8	46.4
Aust-Agder	0.5	12.2	0.1	2.9	2.6	0.3	4.4	59.8	1.2	0.5	11.3
Vest-Agder	0.9	15.4	0.2	2.0	3.8	0.5	5.7	27.7	1.0	0.6	17.9
Rogaland	2.7	45.9	1.1	1.7	9.9	2.8	17.1	62.4	1.6	1.5	50.8
Hordaland	3.2	40.7	0.6	2.6	10.4	1.2	51.1	69.0	2.7	1.4	226.0
Sogn og Fjordane	1.1	14.4	0.4	1.5	4.1	1.0	3.7	22.2	1.0	0.4	19.2
Møre og Romsdal	1.0	20.6	0.6	0.8	6.0	1.3	8.5	38.7	1.2	1.1	48.5
Sør-Trøndelag	1.2	19.6	0.6	3.8	6.6	1.5	7.3	43.5	1.2	1.0	11.3
Nord-Trøndelag	0.6	24.7	0.6	0.7	4.2	1.7	5.0	29.6	1.2	0.6	9.5
Nordland	2.2	24.9	2.5	4.3	9.4	1.3	7.9	35.3	0.9	1.1	36.9
Troms	0.7	10.5	0.2	1.1	4.1	0.9	4.9	24.7	0.7	0.6	7.5
Finnmark	0.3	7.9	0.2	0.5	2.3	2.1	3.0	14.1	0.5	0.3	3.6
Svalbard	0.1	5.4	0.0	0.5	0.3	0.0	0.1	0.5	0.1	0.0	8.6
Continental shelf	12.0	26.6	0.2	10.2	112.2	0.0	163.7	13.8	0.9	0.4	11.6

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

Table C8. Emissions to air by municipality, 1994. Tonnes, CO_2 in 1 000 tonnes

	CO_2	SO_2	NO_x	NMVOCs
	1 000 tonnes			
Total	39247	43225	247032	365842
Of this, international maritime and air transport	1462	8972	25033	1014
Østfold	1526	5030	7203	10133
Halden	164	542	634	808
Moss	166	427	775	876
Sarpsborg	578	2828	2046	1854
Fredrikstad	313	1126	1450	3247
Hvaler	13	4	98	377
Aremark	6	2	53	55
Marker	16	5	135	169
Rømskog	2	1	14	17
Trøgstad	17	6	135	172
Spydeberg	17	9	141	178
Askim	37	10	201	363
Eidsberg	40	14	321	501
Skiptvet	8	3	68	85
Rakkestad	29	11	221	268
Råde	36	11	307	368
Rygge	50	20	329	487
Våler	15	5	119	147
Hobøl	18	6	156	160
Akershus	1529	710	10824	16376
Vestby	49	16	420	652
Ski	62	21	463	810
Ås	62	20	526	620
Frogn	35	12	260	594
Nesodden	29	11	202	734
Oppegård	42	15	305	552
Bærum	368	102	2299	3143
Asker	142	48	1041	1754
Aurskog-Høland	41	15	332	471
Sørum	49	16	403	508
Fet	27	9	197	534
Rælingen	47	102	301	236
Enebakk	17	6	132	195
Lørenskog	52	19	358	690
Skedsmo	154	162	961	1452
Nittedal	56	23	357	514
Gjerdrum	10	3	75	96
Ullensaker	125	43	893	1073
Nes	51	18	399	550

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Eidsvoll	80	38	667	82
Nannestad	20	8	156	211
Hurdal	9	3	77	159
Oslo	1102	556	7200	14073
Hedmark	815	406	6647	8283
Kongsvinger	62	31	513	626
Hamar	75	34	478	745
Ringsaker	132	60	958	1410
Løten	28	12	235	286
Stange	90	34	747	828
Nord-Odal	15	6	128	193
Sør-Odal	42	16	320	472
Eidskog	28	22	271	330
Grue	25	10	218	266
Åsnes	34	13	290	361
Våler	20	8	157	198
Elverum	65	26	532	712
Trysil	33	26	300	423
Åmot	31	54	215	220
Stor-Elvdal	34	13	340	279
Rendalen	17	6	165	154
Engerdal	9	7	89	116
Tolga	9	4	84	86
Tynset	31	12	286	270
Alvdal	18	7	167	141
Folldal	8	3	70	79
Os	9	3	84	88
Oppland	711	301	5743	7212
Lillehammer	70	32	504	799
Gjøvik	103	48	724	1057
Dovre	24	8	217	194
Lesja	18	6	172	138
Skjåk	13	5	117	120
Lom	11	4	101	129
Vågå	18	6	157	169
Nord-Fron	27	10	218	232
Sel	34	12	262	327
Sør-Fron	15	5	132	155
Ringebu	26	9	225	228
Øyer	30	10	256	287
Gausdal	20	7	163	200
Østre Toten	45	22	336	462
Vestre Toten	41	15	299	385

Table C8 (cont.). Emissions to air by municipality. 1994. Tonnes. CO_2 in 1 000 tonnes

	CO_2	SO_2	NO_x	NMVOC
	1000 tonnes			
Jevnaker	16	6	120	196
Lunner	28	29	278	349
Gran	43	15	350	440
Søndre Land	23	9	179	234
Nordre Land	23	9	195	258
Sør-Aurdal	16	6	145	147
Etnedal	8	3	71	87
Nord-Aurdal	31	11	260	325
Vestre Slidre	9	4	75	76
Øystre Slidre	13	5	111	132
Vang	8	3	76	84
Buskerud	988	997	7020	9139
Drammen	154	63	954	1591
Kongsberg	74	46	490	767
Ringerike	118	66	940	1184
Hole	29	9	240	278
Flå	13	4	121	125
Nes	16	6	140	158
Gol	21	8	184	200
Hemsedal	11	4	95	91
Ål	22	25	170	194
Hol	25	9	216	236
Sigdal	15	6	127	163
Krødsherad	19	6	162	199
Modum	47	58	298	379
Øvre Eiker	89	125	566	569
Nedre Eiker	46	20	293	787
Lier	124	100	816	1059
Røyken	32	12	233	371
Hurum	97	420	643	391
Flesberg	13	4	118	148
Rollag	8	3	71	79
Nore og Uvdal	16	5	141	171
Vestfold	1157	1330	6301	10324
Borre	57	21	425	640
Holmestrand	84	14	313	368
Tønsberg	446	749	1698	3480
Sandefjord	128	71	818	1200
Larvik	166	202	1216	1636
Svelvik	39	5	107	161
Sande	72	215	487	499
Hof	13	4	96	141
Våle	30	9	253	294
Ramnes	10	3	85	114

	CO_2	SO_2	NO_x	NMVOC
	1000 tonnes			
Andebu	13	4	98	132
Stokke	37	12	295	365
Nøtterøy	37	13	229	860
Tjøme	12	4	79	311
Lardal	12	4	102	123
Telemark	3149	1171	9084	7506
Porsgrunn	2096	798	5124	1304
Skien	156	188	799	1263
Notodden	40	14	308	471
Siljan	6	2	46	70
Bamble	640	20	1120	1804
Kragerø	44	58	286	757
Drangedal	12	5	109	142
Nome	25	39	167	226
Bø	13	5	99	134
Sauherad	15	5	129	164
Tinn	18	7	154	240
Hjartdal	8	3	74	89
Seljord	14	6	126	154
Kviteseid	13	5	117	142
Nissedal	7	2	63	73
Fyresdal	5	2	45	85
Tokke	13	4	115	142
Vinje	23	8	205	245
Aust-Agder	521	2854	2587	4398
Risør	23	9	177	390
Grimstad	51	21	390	716
Arendal	217	1647	725	1331
Gjerstad	12	5	100	129
Vegårshei	6	3	51	75
Tvedestrand	24	9	195	348
Froland	15	6	134	171
Lillesand	107	1124	285	463
Birkenes	23	6	140	202
Åmli	9	9	98	138
Iveland	3	1	24	31
Evje og Hornnes	12	7	97	141
Bygland	8	3	70	92
Valle	7	3	62	107
Bykle	5	2	38	65
Vest-Agder	945	1985	3825	5674
Kristiansand	322	1339	1680	2309

Table C8 (cont.). Emissions to air by municipality, 1994. Tonnes, CO_2 in 1 000 tonnes

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Mandal	29	13	223	451
Farsund	206	349	338	383
Flekkefjord	27	11	204	361
Vennesla	83	218	324	352
Songdalen	15	6	115	169
Søgne	21	8	164	305
Marnardal	6	3	60	75
Åseral	4	1	34	33
Audnedal	5	2	43	61
Lindesnes	21	8	141	390
Lyngdal	23	14	171	299
Hægebostad	5	2	41	59
Kvinesdal	169	9	206	326
Sirdal	9	3	78	101
Rogaland	2728	1657	9899	17143
Eigersund	101	198	552	478
Sandnes	139	55	1081	1701
Stavanger	244	244	2037	3164
Haugesund	61	23	430	875
Sokndal	26	55	117	135
Lund	15	5	139	163
Bjerkreim	17	5	137	255
Hå	52	15	361	489
Klepp	54	22	348	476
Time	34	12	254	380
Gjesdal	25	10	213	293
Sola	344	345	993	4061
Randaberg	14	5	109	203
Forsand	8	4	93	64
Strand	26	11	192	259
Hjelmeland	16	6	165	137
Suldal	16	7	162	185
Sauda	341	14	68	296
Finnøy	16	7	116	126
Rennesøy	17	7	157	143
Kvitsøy	1	1	13	27
Bokn	8	3	84	86
Tysvær	659	13	878	1824
Karmøy	472	586	1000	1057
Utsira	1	0	6	22
Vindafjord	24	8	195	244
Hordaland	3250	2583	10448	51091
Bergen	479	236	3242	6473
Etne	17	7	145	188
Ølen	11	4	88	135
Sveio	15	6	140	191
Bømlo	18	9	157	388
Stord	29	16	253	489
Fitjar	10	5	93	144
Tysnes	8	4	75	136
Kvinnherad	195	281	373	474
Jondal	3	1	28	54
Odda	369	124	433	276
Ullensvang	15	6	151	165
Eidfjord	8	3	85	79
Ulvik	5	2	49	48
Granvin	7	3	78	63
Voss	43	17	339	554
Kvam	210	798	779	401
Fusa	10	5	95	141
Samnanger	9	3	81	111
Os	27	12	231	353
Austevoll	9	5	97	151
Sund	9	4	70	121
Fjell	31	13	245	475
Askøy	56	129	292	431
Vaksdal	18	7	144	188
Modalen	1	1	14	17
Osterøy	15	7	127	176
Meland	8	4	61	127
Øygarden	67	3	60	19816
Radøy	9	4	71	113
Lindås	1523	855	2185	18388
Austrheim	6	3	60	84
Fedje	1	1	12	27
Masfjorden	9	4	93	114
Sogn og Fjordane	1068	1455	4126	3689
Flora	35	34	324	319
Gulen	13	6	132	97
Solund	3	2	42	40
Hyllestad	5	2	48	66
Høyanger	116	167	185	173
Vik	9	4	89	95
Balestrand	11	5	102	80
Leikanger	8	4	85	84
Sogndal	20	9	158	219
Aurland	10	4	93	88
Lærdal	12	5	117	102
Årdal	393	305	319	125
Luster	13	6	113	165

Table C8 (cont.). Emissions to air by municipality, 1994. Tonnes, CO_2 in 1 000 tonnes

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Askvoll	8	4	87	109
Fjaler	7	3	72	86
Gaular	12	5	111	126
Jølster	12	5	107	120
Førde	29	12	204	309
Naustdal	8	3	70	89
Bremanger	217	666	683	250
Vågsøy	57	173	344	165
Selje	7	3	71	112
Eid	18	8	162	178
Hornindal	3	1	32	42
Gloppen	19	8	161	178
Stryn	26	10	215	271
Møre og Romsdal	978	758	5984	8540
Molde	53	21	424	638
Kristiansund	31	12	212	847
Ålesund	118	74	831	1479
Vanylven	17	31	125	137
Sande	8	4	86	112
Herøy	44	116	235	225
Ulstein	12	5	103	195
Hareid	11	4	100	159
Volda	18	8	172	199
Ørsta	29	14	275	335
Ørskog	9	3	82	94
Norddal	9	4	95	74
Stranda	15	6	133	173
Stordal	4	1	28	67
Sykkylven	16	7	141	227
Skodje	20	7	145	169
Sula	19	15	166	184
Giske	14	4	99	143
Haram	22	9	200	275
Vestnes	23	9	196	245
Rauma	34	13	319	326
Nesset	12	4	109	155
Midsund	6	2	59	65
Sandøy	3	2	30	44
Aukra	7	3	71	84
Fræna	27	10	213	292
Eide	11	4	98	114
Averøy	14	6	126	147
Frei	8	3	69	103
Gjemnes	12	4	108	163
Tingvoll	12	5	114	133
Sunndal	291	327	336	284

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Surnadal	19	7	167	247
Rindal	7	3	60	78
Aure	8	3	85	97
Halsa	6	3	67	68
Tustna	4	2	40	46
Smøla	7	3	64	117
Sør-Trøndelag	1179	3822	6559	7285
Trondheim	352	896	1833	3017
Hemne	223	930	731	237
Snillfjord	8	3	79	77
Hitra	12	5	114	132
Frøya	12	5	103	135
Ørland	18	6	111	122
Agdenes	7	3	66	62
Rissa	24	9	225	242
Bjugn	20	28	152	157
Åfjord	11	4	102	117
Roan	3	1	32	38
Osen	3	1	34	38
Oppdal	29	10	272	278
Rennebu	20	7	193	176
Meldal	12	4	100	127
Orkdal	247	1843	810	456
Røros	19	7	145	194
Holtålen	9	3	81	90
Midtre Gauldal	28	10	269	289
Melhus	47	17	430	471
Skaun	19	8	169	203
Klæbu	6	3	53	78
Malvik	35	12	324	376
Selbu	12	4	99	132
Tydal	3	1	30	42
Nord-Trøndelag	557	677	4209	4957
Steinkjer	73	36	613	740
Namsos	30	17	204	346
Meråker	56	394	193	126
Stjørdal	100	71	618	743
Frosta	7	3	53	75
Leksvik	9	4	85	126
Levanger	65	31	564	628
Verdal	50	19	371	607
Mosvik	3	1	24	35
Verran	10	5	75	92

Table C8 (cont.). Emissions to air by municipality, 1994. Tonnes, CO_2 in 1 000 tonnes

	CO_2	SO_2	NO_x	NMVOCs		CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes					1000 tonnes			
Namdalseid	9	3	82	96	Tjeldsund	7	3	60	71
Inderøy	32	49	254	203	Evenes	18	4	108	91
Snåsa	15	6	152	119	Ballangen	14	8	117	122
Lierne	6	3	63	73	Røst	2	1	16	23
Røyrvik	3	1	20	25	Værøy	2	1	16	19
Namsskogan	12	4	129	86	Flakstad	4	1	35	66
Grong	19	7	189	162	Vestvågøy	28	10	215	279
Høylandet	8	3	70	84	Vågan	25	10	195	238
Overhalla	13	5	111	136	Hadsel	23	9	199	198
Fosnes	3	1	34	34	Bø	9	3	77	86
Flatanger	4	2	33	52	Øksnes	12	5	85	104
Vikna	9	4	81	121	Sortland	29	14	223	304
Nærøy	18	7	162	206	Andøy	25	7	168	205
Leka	2	1	26	44	Moskenes	3	1	26	24
Nordland	2220	4316	9372	7884	**Troms**	669	1066	4143	4918
Bodø	101	43	634	1044	Harstad	51	26	372	610
Narvik	47	25	365	464	Tromsø	130	86	908	1402
Bindal	7	3	72	72	Kvæfjord	12	6	103	110
Sømna	7	3	64	60	Skånland	13	6	108	120
Brønnøy	20	9	149	243	Bjarkøy	2	1	26	15
Vega	4	2	34	67	Ibestad	6	3	50	97
Vevelstad	3	2	40	19	Gratangen	7	3	62	59
Herøy	5	2	36	73	Lavangen	5	2	41	44
Alstahaug	20	8	153	201	Bardu	21	9	149	211
Leirfjord	8	3	72	77	Salangen	7	4	56	76
Vefsn	332	314	488	413	Målselv	44	16	277	380
Grane	18	6	184	121	Sørreisa	13	6	81	131
Hattfjelldal	7	5	68	94	Dyrøy	4	2	37	43
Dønna	5	2	42	55	Tranøy	6	3	54	61
Nesna	6	3	63	79	Torsken	3	1	20	43
Hemnes	17	7	161	169	Berg	6	3	44	34
Rana	553	1808	1389	1085	Lenvik	242	842	936	463
Lurøy	5	3	54	66	Balsfjord	31	13	257	296
Træna	1	0	10	18	Karlsøy	8	4	70	84
Rødøy	5	2	53	62	Lyngen	10	5	76	89
Meløy	21	16	602	165	Storfjord	11	5	92	114
Gildeskål	10	4	92	99	Kåfjord	10	5	87	107
Beiarn	3	1	32	35	Skjervøy	6	4	48	65
Saltdal	23	9	232	194	Nordreisa	18	8	138	191
Fauske	31	11	269	321	Kvænangen	6	3	51	73
Skjerstad	4	2	43	45					
Sørfold	330	1772	1224	331	**Finnmark**	331	544	2327	2970
Steigen	10	4	79	105					
Hamarøy	14	5	128	123	Vardø	7	7	54	57
Tysfjord	394	161	909	73	Vadsø	20	14	173	206
Lødingen	10	4	93	83	Hammerfest	22	29	134	197

Table C8 (cont.). Emissions to air by municipality, 1994. Tonnes, CO_2 in 1 000 tonnes

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Guovdageaidnu - Kautokeino	14	6	128	180
Alta	68	31	528	780
Loppa	3	2	33	54
Hasvik	3	2	23	40
Kvalsund	10	4	89	92
Måsøy	4	2	32	62
Nordkapp	12	8	108	92
Porsanger	27	10	180	239
Karasjohka - Karasjok	12	6	108	132
Lebesby	5	2	44	59
Gamvik	4	2	32	46
Berlevåg	4	2	30	40
Deatnu - Tana	17	8	143	180
Unjarga - Nesseby	8	3	70	78
Båtsfjord	8	9	72	54
Sør-Varanger	82	398	348	382
Other regions	13822	11006	123530	164249
Spitsbergen	104	466	265	137
Bjørnøya	0	0	0	0
Hopen	0	-	-	4
Jan Mayen	0	0	1	15
Continental shelf south of 62°N	10164	7730	75289	158749
Continental shelf noth of 62°N	1878	2490	36928	4914
Air space above 1000 m	1348	154	3679	274
Fishing in distant waters	329	166	7368	156

Sources: Statistics Norway and Norwegian Pollution Control Authority

Table C9. International emissions of CO_2 from energy use[1]. Million tonnes CO_2. Emissions per unit GDP and per capita

	1970	1980	1985	1990	1992	Per unit GDP (kg/1000 USD)[2] 1992	Per capita (tonnes per capita) 1992
Whole world	14640	18347	19185	21109	21141	..	3.9
OECD	8848	10145	9788	10434	10510	662	11.0
Norway	28	31	30	32	31	419	7.2
Denmark	64	63	63	53	57	629	11.0
Finland	41	59	52	53	51	680	10.1
Sweden	98	73	62	53	51	356	5.9
France	443	487	388	379	374	356	6.5
Italiy	307	377	363	412	416	424	7.3
Netherlands	161	159	149	160	166	662	10.9
Portugal	16	26	27	42	47	453	4.8
United Kingdom	662	594	568	584	570	634	9.8
Switzerland	39	42	42	44	45	305	6.5
Germany	1018	1085	1034	983	911	656	11.3
Canada	342	435	405	432	439	835	15.4
USA	4267	4770	4621	4895	4948	845	19.4
Japan	781	920	913	1068	1101	464	8.9

[1] The figures for Norway according to these data from the OECD differ somewhat from more recent Norwegian calculations of emissions.
[2] GDP 1992 expressed in 1991 prices.
Source: OECD (1995)

Table C10. Deposition of reduced nitrogen in Norway. 1 000 tonnes as N

	1980	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995*	Percentage change 1980-1995
Emissions from												
Norway	16.7	16.8	16.8	16.9	17.3	16.9	17.5	18.5	16.3	16.6	18.8	13
Sweden	1.5	1.4	1.6	1.5	1.0	1.1	1.1	1.0	1.3	1.4	1.3	-13
Finland	0.3	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	-33
Denmark	3.0	2.8	3.3	3.5	2.8	3.5	2.6	2.7	2.2	3.2	2.9	-3
Netherlands	1.7	2.2	1.2	2.3	1.7	2.4	2.0	1.5	1.0	1.3	1.0	-41
United Kingdom	3.4	3.1	2.6	3.3	4.5	4.4	3.4	3.3	2.1	2.4	2.7	-21
Germany	4.8	5.1	3.7	6.2	4.9	4.8	4.0	3.7	2.8	5.0	3.7	-23
France	1.0	1.9	0.8	1.6	1.7	2.3	1.2	1.2	1.0	1.2	1.7	70
Belgium	0.4	0.5	0.2	0.6	0.5	0.7	0.4	0.4	0.3	0.3	0.3	-25
CIS	0.9	2.4	2.1	2.2	0.9	1.3	1.6	0.7	2.3	1.8	1.7	89
Poland	2.1	2.0	1.7	2.8	1.7	1.5	2.5	1.0	1.2	1.9	1.6	-24
Czechia, Slovakia	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.5	0.4	0
Other countries	1.3	2.0	1.7	1.1	1.8	1.9	1.3	1.5	1.0	1.3	1.5	15
Unspecified	11.5	11.5	10.4	10.3	14.1	14.7	11.7	12.4	8.9	9.3	12.2	6
TOTAL	48.9	52.5	46.9	52.9	53.5	56.0	49.9	48.5	41.0	46.4	50.0	2

Source: Barrett and Berge (1996)

Table C11. Deposition of oxidized nitrogen in Norway. 1 000 tonnes as N

	1980	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995*	Percentage change 1980-1995
Emissions from												
Norway	5.3	6.5	7.8	7.4	6.9	6.4	7.2	7.1	7.1	6.7	7.6	43
Sweden	4.3	4.9	5.8	5.0	3.3	3.7	3.6	3.4	4.6	4.2	3.7	-14
Finland	1.0	1.4	1.4	1.0	0.9	1.1	0.9	0.8	1.2	1.0	0.9	-10
Denmark	2.8	2.3	3.6	3.2	2.7	2.8	3.1	2.7	2.3	3.0	2.8	0
Netherlands	3.1	2.5	2.4	4.4	3.2	4.3	3.5	3.2	2.2	2.3	2.1	-32
United Kingdom	15.3	13.2	13.6	17.9	23.1	23.3	18.6	18.3	10.8	12.0	12.9	-16
Germany	11.9	10.7	10.0	15.5	12.2	11.2	11.2	9.5	8.2	10.6	8.7	-27
France	2.7	2.1	1.9	3.0	3.4	4.5	2.1	2.4	1.6	1.8	3.0	11
Belgium	1.6	1.1	0.8	1.7	1.6	1.8	1.4	1.3	0.9	1.0	1.0	-38
CIS	1.5	2.5	2.3	2.4	1.1	1.8	1.7	1.0	2.4	1.8	1.4	-7
Poland	2.9	2.7	2.9	3.7	2.0	2.0	3.2	1.7	2.1	2.5	2.4	-17
Czechia, Slovakia	1.8	1.4	1.4	1.7	1.3	1.4	1.9	1.5	1.2	1.0	0.9	-50
Ocean	2.4	2.3	2.2	2.7	2.7	3.1	2.3	2.5	1.9	2.2	2.3	-4
Other countries	1.4	1.6	1.9	1.3	2.3	2.8	1.7	1.8	1.0	1.6	2.3	64
Unspecified	14.9	15.6	14.6	14.0	17.7	18.9	15.4	15.1	12.6	13.4	15.7	5
TOTAL	72.7	70.8	72.6	84.9	84.4	89.1	77.8	72.3	60.1	65.1	67.7	-7

Source: Barrett and Berge (1996)

Table C12. Deposition of oxidized sulphur in Norway. 1 000 tonnes as S

	1980	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995*	Percentage change 1980-1995
Emissions from												
Norway	13.2	9.1	7.2	6.6	5.8	5.2	4.5	3.7	3.1	3.0	3.4	-74
Sweden	8.3	5.2	5.1	4.2	2.2	2.0	1.7	1.4	1.9	1.7	1.5	-82
Finland	2.5	2.3	1.9	1.2	0.8	1.1	0.7	0.5	0.6	0.5	0.5	-80
Denmark	5.9	3.3	3.9	3.6	2.6	2.6	3.1	2.3	1.8	2.4	2.1	-64
Netherlands	2.4	1.3	0.9	1.7	1.0	1.4	1.0	0.8	0.5	0.6	0.5	-79
United Kingdom	33.4	23.7	22.4	28.3	35.6	36.4	25.5	24.0	14.5	13.8	16.5	-51
Germany	27.0	25.2	21.9	28.7	19.6	16.9	15.9	9.6	9.6	14.8	9.4	-65
France	5.4	2.4	1.6	2.4	2.7	3.4	1.9	1.9	1.3	1.7	2.3	-57
Belgium	3.1	1.7	0.9	1.9	1.5	1.6	1.2	1.1	0.8	0.9	0.9	-71
CIS	16.5	20.7	18.9	14.6	10.4	11.0	11.5	7.7	9.1	7.0	7.9	-52
Poland	8.4	7.9	8.2	11.2	6.7	5.5	7.4	4.1	5.5	6.7	6.2	-26
Czechia, Slovakia	5.6	4.5	4.8	5.5	3.3	4.2	4.3	3.3	2.9	4.0	3.1	-45
Ocean	2.6	2.6	2.4	2.9	2.8	3.1	2.4	2.6	2.0	2.5	2.5	-4
Natural emissions[1]	3.2	3.2	2.8	2.8	3.8	3.7	3.1	3.2	2.2	2.5	3.1	-3
Other countries	4.4	4.0	4.1	2.1	3.9	4.0	2.4	2.9	2.2	2.4	3.1	-30
Unspecified	35.8	36.0	32.8	33.3	41.9	43.1	36.2	37.8	29.2	29.9	36.3	1
TOTAL	177.6	153.1	139.8	151.0	144.6	145.2	122.8	106.9	87.2	94.4	99.3	-44

[1] Emissions from natural sources in oceans.
Source: Barrett and Berge (1996)

Table D1. Municipal waste by county, 1992 and 1995. Tonnes

	Total			Household waste			Industrial waste		
	1992	1995	Change (%)	1992	1995	Change (%)	1992	1995	Change (%)
Whole country	2222781	2722158	22	1088379	1261982	16	1134403	1460176	29
Østfold	142671	157118	10	72232	70679	-2	70439	86439	23
Akershus	174886	204447	17	101733	129772	28	73154	74675	2
Oslo	293509	429862	46	110844	130778	18	182665	299084	64
Hedmark	80911	103173	28	48371	57873	20	32541	45300	39
Oppland	97428	100988	4	48944	48625	-1	48485	52363	8
Buskerud	118670	141094	19	55767	67566	21	62904	73529	17
Vestfold	114408	137844	20	54684	64363	18	59724	73481	23
Telemark	76230	96584	27	43464	51839	19	32766	44745	37
Aust-Agder	45549	55437	22	23306	33022	42	22243	22415	1
Vest-Agder	94290	99390	5	40779	45289	11	53512	54101	1
Rogaland	194859	221107	13	93000	111259	20	101859	109849	8
Hordaland	237517	334160	41	108732	130432	20	128786	203729	58
Sogn og Fjordane	54956	54769	0	25379	30766	21	29577	24003	-19
Møre og Romsdal	107437	123830	15	58824	64513	10	48613	59317	22
Sør-Trøndelag	122684	150728	23	59798	71654	20	62886	79074	26
Nord-Trøndelag	47400	61465	30	25948	32386	25	21452	29080	36
Nordland	114234	127886	12	61400	61695	0	52835	66191	25
Troms	70090	83281	19	37960	37866	0	32131	45416	41
Finnmark	35052	38994	11	17218	21605	25	17835	17389	-3

Source: Statistics Norway

Table D2. Municipal waste recycled, by county, 1992 and 1995. Tonnes

	Total			Household waste			Industrial waste		
	1992	1995	Change (%)	1992	1995	Change (%)	1992	1995	Change (%)
Whole country	185542	372512	101	92864	228698	146	92678	143814	55
Østfold	8302	31988	285	6061	14206	134	2241	17782	693
Akershus	17100	36070	111	15102	33282	120	1998	2788	40
Oslo	17726	52223	195	12207	26278	115	5519	25945	370
Hedmark	4753	15701	230	1974	9611	387	2779	6091	119
Oppland	9118	22206	144	4136	14511	251	4982	7695	54
Buskerud	11233	15724	40	7446	13480	81	3787	2244	-41
Vestfold	25129	29771	18	12495	15317	23	12634	14454	14
Telemark	4170	16207	289	3595	10759	199	575	5448	847
Aust-Agder	5174	6462	25	3753	4832	29	1421	1629	15
Vest-Agder	17821	18258	2	4500	12156	170	13321	6102	-54
Rogaland	12375	26190	112	9344	19187	105	3031	7004	131
Hordaland	25719	41423	61	3998	19093	378	21721	22330	3
Sogn og Fjordane	1603	4255	165	890	3277	268	713,5	978	37
Møre og Romsdal	13530	14876	10	3120	10542	238	10410	4335	-58
Sør-Trøndelag	3265	12158	272	1960	8933	356	1305,5	3224	147
Nord-Trøndelag	5868	10333	76	1585	5728	262	4283	4605	8
Nordland	1199	7928	561	614	3567	481	585	4361	645
Troms	1439	9390	553	67	3459	5102	1372	5930	332
Finnmark	18	1348	7389	18	478	2556	0	870	-

Source: Statistics Norway

Table D3. Households which sort waste at source and compost waste, 1995

		Sorting at source		Composting own waste	
	Total	Number	Percentage	Number	Percentage
Whole country	1776615	1033514	58.2	20777	1.2
Østfold	98712	66045	66.9	829	0.8
Akershus	159764	127321	79.7	453	0.3
Oslo	244000	210000	86.1	0	0.0
Hedmark	70930	22223	31.3	82	0.1
Oppland	77219	54945	71.2	1135	1.5
Buskerud	94479	70328	74.4	335	0.4
Vestfold	85492	72200	84.5	85	0.1
Telemark	70538	42643	60.5	267	0.4
Aust-Agder	39117	31311	80.0	426	1.1
Vest-Agder	57938	35274	60.9	2296	4.0
Rogaland	135636	87633	64.6	1055	0.8
Hordaland	174166	57741	33.2	6532	3.8
Sogn og Fjordane	40175	20375	50.7	1953	4.9
Møre og Romsdal	86665	69082	79.7	2529	2.9
Sør-Trøndelag	108419	15071	13.9	940	0.9
Nord-Trøndelag	49898	21360	42.8	603	1.2
Nordland	96272	8877	9.2	767	0.8
Troms	58362	1709	29.3	420	0.7
Finnmark	28833	3993	13.8	70	0.2

Source: Statistics Norway

Table D4. Municipal waste delivered for material recovery, by material. 1992 and 1995. Tonnes

Material	1992 Total	1992 Household waste	1992 Industrial waste	1995 Total	1995 Household waste	1995 Industrial waste
Total	185 542	92 864	92 678	372 513	228 699	143 814
Paper and cardboard, total	90 703	60 860	29 843	169 608	131 356	38 252
Paper	75 340	58 902	16 439	71 717	61 801	9 916
Cardboard	15 363	1 959	13 404	24 720	5 548	19 172
Drinking cartons	..	..	..	816	816	0
Paper and cardboard, mixed	..	..	..	72 355	63 191	9 164
Glass	14 613	11 682	2 931	17 968	16 035	1 933
Plastic	1 055	154	901	1 786	969	817
Iron and other metals	36 711	7 143	29 568	47 292	19 470	27 822
Food and biol. waste, total	9 280	1 170	8 110	34 399	18 120	16 728
Food, slaughterhouse waste and fish waste to animal feed	..	..	..	17 014	3 353	13 661
Food and biol. waste to central composting facilities	..	..	..	17 834	14 767	3 067
Wood waste (incl. park and garden waste)	5 374	603	4 771	77 970	36 377	41 573
Textiles	1 214	1 206	8	4 101	3 996	105
Other	26 592	10 045	16 547	18 934	2 374	16 560

Source: Statistics Norway

Table D5. Household waste delivered for material recovery, by sorting method and material. 1995. Percentages

Material	Total	Sorting at source: Sorting and collection source	Sorting at source: Sorting on delivery	Sorting at waste treatment and disposal plants/ recycling centres
Total	100	53	29	18
Paper and cardboard, total	100	77	21	2
Paper	100	68	30	1
Cardboard	100	50	31	19
Drinking cartons	100	43	56	1
Paper and cardboard, mixed	100	89	10	1
Glass	100	4	94	2
Plastic	100	14	35	51
Iron and other metals (not scrapped cars)	100	9	32	58
Food and biol. waste, total	100	86	2	12
Food, slaughterhouse waste and fish waste to animal feed	100	98	1	1
Food and biol. waste to central composting facilities	100	83	2	15
Wood waste	100	0	25	75
Park and garden waste	100	1	43	55
Textiles	100	8	82	10
Other	100	2	20	78

Source: Statistics Norway

Table D6. Number of waste treatment and disposal plants and quantity of waste, according to number of municipalities served[1]

	Number of plants	Number of plants serving		
		One municipality	Two or three municipalities	More than three municipalities
Number of plants				
1978/79	395	340	42	13
1985/86	279	200	46	33
1992	237	139	53	45
1995	208	111	44	53
Percentage of total waste	Percentage			
1978/79	100	39	42	19
1985/86	100	31	31	38
1992	100	16	27	57
1995	100	15	10	75
Quantity of waste per plant	1000 tonnes			
1978/79	3.8	1.6	14.6	21.8
1985/86	6.8	2.9	12.8	22
1992	9.1	2.6	11.2	27.6
1995	12.1	3.4	6	35.5

[1] Landfills for bulky waste and plants receiving less than 50 tonnes not included.
Source: Statistics Norway

Table D7. Number of waste treatment and disposal plants where leachate was treated or gas extracted, 1995

	Total[1]	Landfills			Incineration plants
		Total	Gas extraction	Leachate treatment	
Whole country	285	274	15	55	16
Østfold	7	7	1	6	1
Akershus	8	8	1	6	
Oslo	3	1	1	1	2
Hedmark	15	15	0	1	
Oppland	14	13	1	3	1
Buskerud	19	18	1	1	1
Vestfold	5	5	1	3	
Telemark	14	14	0	7	1
Aust-Agder	8	8	0	4	
Vest-Agder	13	13	1	4	
Rogaland	15	15	2	3	
Hordaland	14	14	1	3	
Sogn og Fjordane	17	16	0	0	1
Møre og Romsdal	23	22	1	4	1
Sør-Trøndelag	20	18	2	4	1
Nord-Trøndelag	13	13	1	2	
Nordland	39	36	0	2	
Troms	18	18	1	1	1
Finnmark	20	20	0	0	6

[1] Certain plants include both landfill and incineration facilities.
Source: Statistics Norway

Table D8. Hazardous waste delivered to the system for hazardous waste management, by category. Tonnes

	Category of hazardous waste	1990	1991	1992	1993	1994	1995*	1996*
	Total	59643	65629	87542	98369	92211	101756	118740
1	Waste oil	31203	29921	32896	34261	39115	41637	41162
2	Other oil-contaminated waste	17512	8259	9625	10967	12808	16676	16235
3	Stable oil emulsions	4003	2095	1747	2051	2813	2002	2480
4	Waste solvents	1530	2379	2485	3022	4884	4319	3989
5	Paints, glue, varnish and printing ink	2047	2308	2849	2820	2782	3580	4060
6	Distillation residues	141	259	287	389	668	207	69
7	Tars	1	31	0	17	220	253	673
8	Waste containing mercury (Hg) or cadmium (Cd)	881	1099	950	1244	1371	346	93
9	High-priority metals or metal compounds that constitute a health or environmental hazard	-	-	-	-	19	1883	3262
10	Waste containing cyanide	6	19	8	33	22	13	14
11	Pesticides	16	16	12	45	52	72	87
12	Isocyanates and other very reactive substances	8	4	14	22	37	55	63
13	Corrosive substances and products	1439	1343	1264	2473	1896	2554	4084
14	Waste brought ashore from oil-drilling/production	-	16590	33592	36673	19867	21296	35244
15	Other very toxic or environmentally hazardous substances	808	948	1240	2739	1978	2865	2464
21	Waste containing PCBs	16	16	13	27	911	123	287
22	Photographic chemicals	8	312	527	1554	2682	3838	4417
23	Halons	-	-	-	-	-	3	2
24	CFCs	-	-	-	-	-	0	46
99	Other unspecified waste	24	30	33	32	86	34	7

Source: Norsas (1997)

Table D9. Hazardous waste delivered to the system for hazardous waste management, by county. kg

	1991	1992	1993	1994	1995*	1996*
Total	49 091 000	53 890 000	61 709 000	72 090 000	101 765 694	118 739 724
Østfold	1 990 000	2 226 000	3 100 000	5 993 000	5 998 360	6 133 431
Akershus	3 361 000	4 080 000	4 623 000	4 957 000	4 845 341	4 810 078
Oslo	3 261 000	2 987 000	3 744 000	5 597 000	5 532 415	6 937 750
Hedmark	1 010 000	1 155 000	1 230 000	1 534 000	1 401 330	2 101 362
Oppland	1 478 000	1 149 000	1 740 000	2 145 000	2 220 549	2 673 113
Buskerud	2 906 000	2 534 000	2 787 000	3 581 000	3889 656	3 680 672
Vestfold	2 318 000	3 238 000	3 754 000	4 419 000	4 889 571	4 820 046
Telemark	2 563 000	2 393 000	2 200 000	2 191 000	3 427 653	3 743 418
Aust-Agder	647 000	700 000	655 000	859 000	959 7610	1 001 472
Vest-Agder	2 019 000	1 799 000	2 689 000	2 544 000	1 958 851	2 445 080
Rogaland	5 816 000	8 290 000	9 060 000	10 258 000	14 094 727	17 201 010
Hordaland	10 518 000	10 251 000	10 681 000	12 693 000	26 570 541	27 823 852
Sogn og Fjordane	1 383 000	1 822 000	2 901 000	1 989 000	11 638 616	13 086 368
Møre og Romsdal	2 785 000	3 430 000	4 131 000	4 206 000	4 534 425	11 628 175
Sør-Trøndelag	1 761 000	2 125 000	1 985 000	2 248 000	2 616 123	2 737 748
Nord-Trøndelag	976 000	1 015 000	1 157 000	1 443 000	1 370 171	1 332 706
Nordland	2 395 000	2 539 000	2 994 000	3 133 000	3 36 5548	3 362 084
Troms	1 086 000	1 398 000	1 560 000	1 517 000	1 756 028	2 250 411
Finnmark	789 000	718 000	674 000	747 000	656 2956	873 616
Svalbard and Jan Mayen	29 000	41 000	42 000	37 000	39 733	48 201

Source: Norsas (1997)

Table E1. Municipal waste water treatment. Hydraulic capacity (p.u.) and number of plants by size categories and treatment methods. 1995

Treatment method	Total	Size by hydraulic capacity (p.u.) 50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total p.u.	5219617	26068	198449	355795	810330	1274780	2554195
Mechanical	1318464	11867	113168	149204	317530	452000	274695
Chemical	3326177	1148	7125	60044	316160	737200	2204500
Biological	69535	995	14285	32255	6500	15500	-
Chemical/biological	410546	1641	33485	106280	139140	55000	75000
Unconventional	67599	10001	29308	4790	23500	-	-
Other/unknown	27296	416	1078	3222	7500	15080	-
Number of plants, total	2020	392	948	389	204	69	18
Mechanical	1001	182	544	163	84	25	3
Chemical	234	16	31	61	74	38	14
Biological	121	15	66	36	3	1	-
Chemical/biological	315	26	129	119	36	4	1
Unconventional	332	147	173	7	5	-	-
Other/unknown	17	6	5	3	2	1	-

Source: Statistics Norway

Table E2. Municipal waste water treatment plants. Hydraulic capacity (p.u.) by treatment method. County. 1995. p.u.

County	Total	Treatment method: Mechanical	Chemical	Biological	Chemical/ biological	Unconventional	Other/ unknown
Whole country	5219617	1318464	3326177	69535	410546	67599	27296
Counties 10-10	3415690	181488	2831708	37630	320881	43214	769
Counties 11-20	1803927	1136976	494469	31905	89665	24385	26527
01 Østfold	346175	2250	323400	530	19995	-	-
02 Akershus	1104650	-	1091960	250	12005	60	375
03 Oslo	351105	-	350000	75	80	950	-
04 Hedmark	204875	-	81170	2555	109640	11510	-
05 Oppland	284640	1345	160264	450	102611	19576	394
06 Buskerud	296371	1913	250244	2210	33680	8324	-
07 Vestfold	236046	50430	171030	-	14380	206	-
08 Telemark	256780	11000	218100	14150	12930	600	-
09 Aust-Agder	143088	86070	32450	15850	7800	918	-
10 Vest-Agder	191960	28480	153090	1560	7760	1070	-
11 Rogaland	414579	161234	250460	1450	1250	185	-
12 Hordaland	330395	234571	66950	2715	24330	1829	-
14 Sogn og Fjordane	75456	65740	129	4450	1350	3717	70
15 Møre og Romsdal	163647	134032	20000	800	2840	975	5000
16 Sør-Trøndelag	388441	223116	138335	4325	19555	3040	70
17 Nord-Trøndelag	172155	138700	9920	10180	10355	3000	-
18 Nordland	119709	87714	2050	7075	850	633	21387
19 Troms	94730	61960	4550	785	17685	9750	-
20 Finnmark	44815	29909	2075	125	11450	1256	-

Source: Statistics Norway

Table E3. Municipal waste water treatment. Number of people[1] connected to separate waste water treatment plants, by type of treatment. County. 1995

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	828300	70825	344992	4393	5950	268254	87018	35042	11826
Fylke 01-10	394811	14673	124580	3226	4139	177991	30826	30294	9082
Fylke 11-20	433489	56152	220412	1167	1811	90263	56192	4748	2744
01 Østfold	34191	1346	21619	255	731	1076	2368	6575	221
02 Akershus	52492	4329	23991	2166	1175	11684	6081	1222	1844
03 Oslo	1518	-	150	-	120	30	1218	-	-
04 Hedmark	70146	706	11199	-	432	45535	4600	7457	217
05 Oppland	72838	451	6122	-	59	57472	916	7453	365
06 Buskerud	45576	1043	11759	87	615	25008	2375	2014	2675
07 Vestfold	41147	4990	27100	336	402	2556	2537	1031	2195
08 Telemark	30879	327	10277	74	122	12356	6511	671	541
09 Aust-Agder	23550	937	7366	29	483	10783	2751	660	541
10 Vest-Agder	22474	544	4997	279	-	11491	1469	3211	483
11 Rogaland	39198	2943	27043	150	357	5011	2851	79	764
12 Hordaland	100716	9221	45902	279	953	24282	17992	1585	502
14 Sogn og Fjordane	34739	3543	11705	56	3	12201	7231	-	-
15 Møre og Romsdal	61690	14686	34114	25	30	5763	6403	363	306
16 Sør-Trøndelag	49551	3066	25293	185	261	10992	7486	2015	253
17 Nord-Trøndelag	34183	2730	14435	438	30	4760	10525	520	745
18 Nordland	46446	10674	23199	34	168	8471	3583	166	151
19 Troms	52135	7980	33715	-	5	10366	29	20	20
20 Finnmark	14831	1309	5006	-	4	8417	92	-	3

[1] Permanent residents
Source: Statistics Norway

Table E4. Phosphorus (P) from waste water treatment plants and scattered settlements[1]

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
1995	601	364	1338	157	69	30
Counties 01-10						
1993	163	129	1091	110	87	46
1994	144	151	1056	105	88	41
1995	128	133	1036	114	89	46

[1] Differences in calculated discharge figures for 1993-1995 may be partly due to the quality of the data on which the calculations are based. [2] Shows the proportion of phosphorus removed from the waste water.
Source: Statistics Norway

Table F1. Agricultural area in use by type of production. Whole country and counties, in decares

	Agri-cultural area in use, total	Cereals and oil seeds	Vege-tables, field-grown	Potatoes, green fodder and silage	Culti-vated meadow	Surface-culti-vated meadow	Fertilized pasture	Other agri-cultural areas, fallow
Whole country								
1985	8960715	3176930	46791	574576	4074097	288884	657632	141805
1996*	10000284	3262727	50363	583112	4663517	266842	1028844	144879
Counties 01-10								
1985	4592700	2711339	32952	249028	1274817	81633	146173	96759
1996*	5071294	2780090	38279	289158	1536025	81412	242024	104306
01 Østfold								
1985	719086	606346	3825	25403	57993	4099	10421	10999
1996*	756170	623083	4722	22842	74826	5494	14234	10969
02/03 Akershus/Oslo								
1985	731326	602875	2218	21660	77351	5782	12582	8858
1996*	797223	642987	2206	18526	95085	5086	20581	12752
04 Hedmark								
1985	948160	550225	4808	70132	271635	8558	23099	19703
1996*	1054271	577348	4623	94533	318003	8529	35099	16136
05 Oppland								
1985	865331	261724	3534	65660	459266	20818	47648	6680
1996*	982311	247757	4678	83094	529121	24478	86726	6457
06 Buskerud								
1985	445976	258076	6512	17161	119417	11330	19543	13938
1996*	503127	267952	7058	18148	152005	10342	33084	14538
07 Vestfold								
1985	401152	316750	7348	21048	26963	2586	4874	21582
1996*	426088	306815	10097	26767	45756	3001	5961	27691
08 Telemark								
1985	217468	92904	1275	11081	83125	11993	8164	8926
1996*	246650	96371	1009	10917	105170	10726	13261	9196
09 Aust-Agder								
1985	99329	14427	2489	7914	63152	3580	3891	3878
1996*	113282	10593	3047	5909	80440	2473	6316	4504
10 Vest-Agder								
1985	164874	8013	944	8969	115915	12887	15951	2195
1996*	192174	7184	839	8422	135619	11283	26762	2065
11 Rogaland								
1985	745612	36721	4497	75362	373877	15841	235101	4214
1996*	904036	33022	5192	85321	428262	15608	332582	4049

Table F1 (cont.). Agricultural area in use by type of production. Whole country and counties, in decares

	Agri-cultural area in use, Total	Cereals and oil seeds	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
1996*	456916	763	188	6531	264018	54354	118942	12120
14 Sogn og Fjordane								
1985	408825	1615	1449	10823	271728	47649	65100	10462
1996*	459786	1077	804	6260	296337	38249	107986	9073
15 Møre og Romsdal								
1985	545761	19566	1325	22336	435837	21333	41370	3995
1996*	599048	15672	304	11413	479410	20850	67905	3494
16 Sør-Trøndelag								
1985	665756	132685	646	47938	445828	12054	23023	3582
1996*	737698	144735	444	37804	491110	14094	46388	3123
17 Nord-Trøndelag								
1985	774425	269681	3285	90699	374675	10121	20909	5055
1996*	867440	284729	4133	72818	452711	12161	35733	5155
18 Nordland								
1985	489187	4012	1285	43895	377502	25067	34667	2759
1996*	545650	2627	779	37066	427340	19281	56467	2090
19 Troms								
1985	230886	74	590	18050	190465	12435	8507	766
1996*	261341	4	214	28389	207987	7910	15835	1002
20 Finnmark								
1985	89575	12	96	6147	75807	4412	2287	816
1996*	97074	8	26	8352	80317	2923	4982	466

Source: Applications for production subsidies, Norwegian National Grain Administration

Table F2. Cereal and oil seed acreage by type of tillage. Autumn-sown cereals. Decares

	Total[1]	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
1994/95	3497349	305713	1970362	120306	1375906	30775	..
1995/96*	3459217	268143	2014683	105330	1308141	31063	..
Counties 01-10							
1989/90	3071938	107853	2563424	..	..	8829	499749
1994/95	2991838	303916	1690883	117426	1154998	28532	..
1995/96*	2962512	265751	1748588	102077	1082050	29796	..
01 Østfold							
1989/90	660337	35139	604733	..	..	3371	52212
1994/95	658961	128728	420093	21077	210757	7035	..
1995/96*	667832	120865	433303	19406	208063	7059	..
02/03 Akershus/Oslo							
1989/90	699503	25012	626148	..	..	1203	72168
1994/95	672340	94180	411180	23379	231186	6595	..
1995/96*	648012	74445	417455	18512	202414	9630	..
04 Hedmark							
1989/90	657356	7082	496208	..	..	470	160710
1994/95	632297	15436	362680	38237	227886	3494	..
1995/96*	633488	14143	366200	39539	223818	3878	..
05 Oppland							
1989/90	287309	7548	214449	..	..	1081	71814
1994/95	271101	4858	145377	13662	108827	3235	..
1995/96*	263949	4060	150335	8691	102153	2770	..
06 Buskerud							
1989/90	306307	10993	250370	..	..	447	55489
1994/95	293030	24176	126597	10938	152283	3212	..
1995/96*	298631	16325	154213	7333	134147	2938	..
07 Vestfold							
1989/90	327163	16923	275099	..	..	2236	49823
1994/95	336283	30129	169919	6874	156630	2861	..
1995/96*	330096	30669	177531	5858	144341	2367	..
08 Telemark							
1989/90	107438	4456	79454	..	..	20	27966
1994/95	106047	5604	45945	2718	55890	1494	..
1995/96*	100362	4166	40691	2389	56600	681	..

Table F2 (cont.). Cereal and oil seed acreage by type of tillage. Autumn-sown cereals. Decares

	Total[1]	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
1994/95	13688	227	6710	226	6182	570	..
1995/96*	11768	440	6912	78	4648	130	..
11 Rogaland							
1989/90	50788	32	4881	..	..	344	45553
1994/95	35671	212	4775	30	30865	-	..
1995/96*	37619	122	1322	47	35441	810	..
16 Sør-Trøndelag							
1989/90	165710	111	123439	..	..	105	42183
1994/95	151541	692	82600	487	67598	855	..
1995/96*	153354	1086	85342	688	67018	306	..
17 Nord-Trøndelag							
1989/90	327353	1371	268567	..	..	57	58706
1994/95	298586	724	184490	1946	110804	1347	..
1995/96*	284727	1133	173181	1815	109591	141	..

[1] Calculated on the basis of Sample Survey of Agriculture.
[2] Cereal and oil seed acreage where annual comparison of type of tillage is not possible.
Source: Statistics Norway

Table F3. Nutrient balance for agricultural areas. 1 000 tonnes as nitrogen and phosphorus

Year	Nitrogen				Phosphorus		
	Manure	Commercial fertilizer	Removed in crops	NH_3 losses	Manure	Commercial fertilizer	Removed in crops
1985	72.0	110.8	86.0	15.6	11.8	24.8	17.9
1986	71.7	106.0	80.5	15.6	11.8	22.8	16.7
1987	70.1	109.8	84.0	15.6	11.6	22.0	17.4
1988	68.6	111.2	81.9	15.6	11.3	19.7	16.7
1989	68.2	110.1	80.7	15.3	11.2	17.4	16.5
1990	69.0	110.4	96.8	15.4	11.4	16.0	19.9
1991	69.3	110.8	95.0	16.0	11.4	15.2	19.4
1992	70.4	110.9	79.6	16.5	11.6	14.8	16.0
1993	69.1	109.3	92.2	16.2	11.3	13.7	18.7
1994	70.1	108.3	83.1	16.4	11.5	13.7	16.7
1995*	70.7	110.9	86.7	16.5	11.6	13.3	17.5

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

Table G1. Forest balance 1995. 1 000 m^3, without bark

	Total	Spruce	Pine	Broad-leaved trees
Growing stock on 1/1[1]	633302	288418	207033	137851
Total losses	12384	8240	2452	1691
Of which total roundwood cut	10170	7127	1977	1066
Sales, excl. fuelwood	8874	6772	1871	231
Fuelwood, sales and private	1093	203	61	829
Own use	202	152	45	6
Other losses	2214	1113	475	626
Logging waste	653	428	119	107
Natural losses	1561	686	356	519
Total increment	22557	11431	5936	5189
Growing stock on 31/12	643475	291609	210517	141349

[1] Volume and percentage increment for 1994 and 1995 for all types of land use classes in counties inventoried.
Source: NIJOS (1996) (Figures from inventories supplemented by calculations by Statistics Norway for Finnmark, where no inventory has been carried out.)

Table G2. Growing stock under bark and annual increment. 1 000 m^3 without bark

	Growing stock				Annual increment			
	Total	Spruce	Pine	Broad-leaved trees	Total	Spruce	Pine	Broad-leaved trees
Whole country								
1933	322635	170960	90002	61673	10447	5835	2535	2077
1967	435121	226168	133972	74981	13200	7131	3364	2706
1990	578317	270543	188279	119495	20058	10528	5200	4330
1994/95[1]	633302	288418	207033	137851	22206	11306	5838	5061
Region, 1994/95								
Østfold, Akershus/Oslo, Hedmark	175844	95305	62790	17749	6712	3853	2092	767
Oppland, Buskerud, Vestfold	140868	83142	36936	20791	4864	3014	972	879
Telemark, Aust-Agder, Vest-Agder	106744	33372	48788	24585	3261	1191	1244	826
Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal	78117	17750	33549	26818	3066	1287	878	901
Sør-Trøndelag, Nord-Trøndelag	83679	49575	16990	17114	2600	1529	412	659
Nordland, Troms	45194	9274	5859	30061	1628	433	182	1013
Finnmark	2856	1	2122	733	75	0	59	16

[1] Volume and annual increment for all types of land use classes, average for 1994 and 1995 in counties inventoried.
Source: NIJOS (1996) (Figures from inventories supplemented by calculations by Statistics Norway for Finnmark, where no inventory has been carried out.)

Table G3. Crown density by 10% classes for spruce. Whole country. Percentages

Year	Crown density class										Average	No. trees
	90	80	70	60	50	40	30	20	10	0		
1989	57.3	18.7	9.7	5.6	2.7	2.4	1.1	1.1	0.8	0.8	85.1	4375
1990	57.0	17.7	9.7	5.1	3.2	2.4	1.9	1.2	0.8	1.1	84.8	4323
1991	52.6	18.2	10.2	6.2	4.1	3.2	2.7	1.5	0.8	0.5	82.6	4200
1992	47.9	19.2	12.4	7.4	4.4	3.8	2.2	1.4	0.8	0.6	81.8	4026
1993	48.3	21.1	12.1	6.5	3.1	2.8	2.3	1.7	1.3	0.7	81.9	3976
1994	47.6	20.9	11.2	6.8	4.0	3.4	2.6	2.0	1.1	0.5	81.1	3834
1995	43.1	22.0	12.4	7.8	4.4	3.1	2.6	2.3	1.7	0.5	79.6	3717
1996	45.5	20.3	10.1	7.4	4.0	4.0	3.4	2.5	2.0	0.8	79.0	3716

Source: NIJOS (1997)

Table G4. Crown density by 10% classes for pine. Whole country. Percentages

Year	Crown density class										Average	No. trees
	90	80	70	60	50	40	30	20	10	0		
1989	50.3	28.3	12.5	4.6	1.5	0.9	0.5	0.5	0.2	0.8	85.6	3052
1990	51.1	27.8	12.8	4.4	1.2	0.9	0.4	0.4	0.3	0.6	86.0	2991
1991	50.2	30.0	11.7	4.3	1.5	1.1	0.6	0.2	0.1	0.2	86.1	2926
1992	40.1	30.3	16.6	7.5	2.5	1.3	0.8	0.4	0.2	0.2	83.3	2963
1993	39.6	33.9	15.2	5.4	2.3	2.0	0.7	0.4	0.1	0.3	83.6	2896
1994	38.0	33.9	16.5	6.8	2.2	1.0	0.9	0.3	0.2	0.2	83.2	2845
1995	36.7	34.4	17.5	6.6	2.3	1.1	0.6	0.4	0.2	0.2	83.1	2832
1996	38.5	31.4	16.7	6.9	2.7	1.6	1.0	0.5	0.4	0.3	82.5	2813

Source: NIJOS (1997)

Table H1. Stock trends for some important fish species. 1 000 tonnes

Year	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arctic saithe[2]	Green-land halibut[1]	Barents Sea capelin[3, 6]	Norwegian spring-spawning herring[4]	North Sea herring[4]
1977	2130	240	480	120	5460	260	50
1978	1800	260	470	100	5890	340	70
1979	1490	320	480	130	5560	370	110
1980	1210	250	540	110	6970	450	140
1981	1200	190	530	120	4290	470	200
1982	1010	110	480	120	3750	470	280
1983	750	70	480	130	4230	560	430
1984	870	50	400	120	2860	610	710
1985	1000	150	370	120	820	550	740
1986	1240	290	350	130	120	480	750
1987	1080	250	370	120	100	1250	870
1988	780	160	350	120	430	4040	1120
1989	910	130	330	120	870	5120	1240
1990	970	120	390	110	5830	5210	1140
1991	1520	150	480	120	7100	5480	940
1992	2020	260	620	70	5150	4860	700
1993	2720	610	660	80	800	4460	460
1994	2620	700	530	70	200	4950	520
1995	2430	720	560	60	190	5040	500
1996	2540	660	520	60	500	5350	420

Year	North Sea cod[3]	North Sea haddock[3]	North Sea saithe[3]	North Sea whiting[3]	North Seai plaice[3]	North Sea sole[3]	Blue whiting (northern and southern stock)[5]
1977	820	570	530	1110	480	60	..
1978	810	670	440	770	470	60	..
1979	800	670	490	950	470	50	..
1980	1010	1250	440	830	490	40	..
1981	850	670	540	630	490	50	5350
1982	840	840	580	490	560	60	4230
1983	650	760	700	530	550	70	3750
1984	710	1500	650	500	560	70	3490
1985	490	860	570	440	550	60	3510
1986	670	720	530	660	650	50	3690
1987	550	1070	390	540	630	60	3190
1988	410	430	350	420	620	70	2850
1989	420	400	380	560	580	100	2820
1990	330	340	340	490	550	120	2840
1991	290	740	400	470	450	110	3900
1992	400	610	450	430	430	110	3360
1993	350	890	460	420	390	110	2490
1994	480	520	460	480	330	100	2050
1995	480	990	510	570	340	100	..
1996	470	720	540	580	350	60	..

[1] Fish aged 3 years and over. [2] Fish aged 2 years and older [3] Fish aged 1 year and older. [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 H2. Norwegian catches by groups of fish species. 1 000 tonnes

	1987	1988	1989	1990	1991	1992	1993	1994*	1995*	1996*
Total	1804	1686	1725	1519	1949	2372	2353	2290	2469	2589
Cod	305	252	186	125	164	219	275	373	366	359
Haddock	75	63	39	23	25	40	44	74	80	97
Saithe	152	148	145	112	140	168	188	189	219	222
Tusk	30	23	32	28	27	26	27	20	19	20
Ling/blue ling	25	24	29	24	23	22	20	19	19	20
Greeland halibut	7	9	11	24	33	11	15	13	14	17
Redfish	18	25	27	41	56	38	33	27	22	28
Others and unspecified	34	29	29	30	44	43	57	31	27	25
Capelin	142	73	108	92	576	811	530	113	28	206
Mackerel	159	162	143	150	179	207	224	260	202	137
Herring	347	339	275	208	201	227	352	539	687	758
Sprat	10	12	5	6	34	33	47	44	41	59
Other industrial fisheries[1]	500	526	696	655	447	527	541	587	746	642

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

Table H3. Consumption of antibacterial agents in fish farming, kg active substance

Year	Total	Oxytetra cycline chloride	Nifura-zolidone	Oxsolinic 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 H4. Exports of some main groups of fish products. 1 000 tonnes

Year	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	341.1	579.7	210.8	94.4	70.5	20.6	66.1	85.6
1996*	369.8	685.3	234.6	91.5	76.5	19.3	87.1	68.1

Source: Statistics Norway, External Trade Statistics

Table H5. Exports of fish and fish products by important recipient country. Million NOK

Year	Total	EU-countries, total	Of this: France	Of this: Denmark	Of this: United Kingdom	Of this: Germany	Other countries, total	Of this: Japan	Of this: 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	20088.6	13171.6	2137.9	2192.1	1590.6	1605.0	6917.0	1987.5	799.3
1996*	22470.3	13851.6	2171.0	2434.5	1770.3	1528.2	8618.7	2504.9	761.6

Source: Statistics Norway, External Trade Statistics

Table H6. Exports of fresh and frozen farmed salmon. 1 000 tonnes and million NOK

	Total		Fresh or chilled		Frozen			
Year	Quantity 1000 tonnes	Value Million NOK	Quantity 1000 tonnes	Value Million NOK	Quantity 1000 tonnes	Value Million NOK	Quantity 1000 tonnes	Value Million NOK
1981	7.5	301.4	5.5	211.4	1.9	81.5	0.1	8.5
1982	9.3	403.7	7.9	330.8	1.3	64.5	0.1	8.4
1983	15.6	724.5	13.0	582.6	2.4	126.5	0.2	15.4
1984	20.0	973.8	17.3	819.1	2.4	125.8	0.3	28.9
1985	24.5	1359.7	21.4	1160.6	2.6	147.8	0.5	51.4
1986	39.8	1756.9	34.4	1458.6	4.5	205.1	0.9	93.2
1987	44.2	2281.4	39.2	1967.3	4.0	207.1	1.0	107.0
1988	66.7	3155.9	56.0	2594.9	10.0	484.8	0.7	76.2
1989	96.8	3621.4	81.1	2954.6	14.4	531.5	1.3	135.3
1990	132.6	5019.0	92.8	3423.8	37.9	1411.1	1.9	184.1
1991	134.3	4968.00	91.3	3149.3	35.4	1300.3	7.7	518.4
1992	130.9	4991.9	107.1	3881.8	15.0	518.1	8.8	592.0
1993	141.0	5236.1	117.9	4087.4	13.1	466.0	10.0	682.9
1994	168.8	6383.5	140.7	4942.2	13.1	483.1	15.0	958.2
1995	206.3	6714.6	169.4	5007.1	19.7	653.7	17.2	1053.8
1996*	237.5	6932.2	191.4	5048.3	23.1	652.7	23.0	1231.2

Source: Statistics Norway, External Trade Statistics

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