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Natural Resources and the Environment 1998

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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 1998 contains updated resource accounts for energy and the latest figures for emissions to air. These are followed by articles and updated statistics on transport, waste management, water supplies and waste water treatment, agriculture, forests and forest damage, and fishing, sealing and whaling. New features in this year's edition are figures for land use in urban settlements and results from the surveys of living conditions showing the extent to which people consider themselves to be annoyed by noise and air pollution.

The book also describes results from Statistics Norway's research into resource and environmental economics. The 1998 edition includes articles on the eco-efficiency of various branches of industry, the benefits of voluntary environmental agreements, the environmental costs associated with waste management and various aspects of the Nordic energy market. Finally, the appendix 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 1998*.

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. The editorial committee also included Annegrete Bruvoll and Karin Ibenholt. Janet Aagenæs (Introduction, Chapters 1, 2.5-2.7, 5.5-5.6, 10 and 12) and Alison Coulthard (remainder) have translated the Norwegian version into English.

Statistics Norway,
Oslo/Kongsvinger 2 July 1998

Svein Longva

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Introduction

Natural Resources and the Environment 1998 provides information on important Norwegian natural resources and the natural environment in the form of statistics and analyses. The information is primarily based on Statistics Norway's own material, but data have also been obtained from other sources.

The publication describes the 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. The analyses look at the relationships between the use of resources, the environment and the economy. An appendix of tables provides more detailed statistics on natural resources and environmental conditions in Norway.

Chapter 1 deals with the *driving forces in the economy*, and discusses macroeconomic developments that are of importance to the state of the environment. In recent years Norway's economy has been characterized by a cyclical upturn, with higher production activity in the North Sea and higher demand in the public sector, in industry and commerce and in households. This has contributed to an increase in emissions to air and greater waste quantities.

Chapter 2 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. The chapter also includes analyses of the electricity market in the Nordic area and the environmental effects of Norwegian gas sales.

The extraction and use of fossil energy commodities are the most important causes of emissions of atmospheric pollutants, which may have local, regional or global effects. Chapter 4 on *emissions to air* deals with both emissions and pollution problems at these three levels. Emphasis is placed on developments in Norway's emissions as well as climate change, which is a global problem. The content of the Kyoto Protocol is discussed in particular.

According to *surveys of living conditions*, road traffic is the most important cause of exposure to noise and pollution. Chapter 11 looks further at those groups which are affected the most, and changes over time. Chapter 3 on transport quantifies the actual growth in *passenger and goods transport* in Norway during the past 50 years and the underlying reasons for this.

Chapter 5 on *waste* presents figures on the collection and treatment of household waste and other municipal waste. This waste has increased sharply in recent years. A separate study of industrial waste and data on delivered quantities of hazardous waste are also included in the chapter. The chapter also contains analyses of the costs associated with the recycling of materials.

According to the North Sea Declarations, Norway pledged 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 1998* presents the latest statistics and analyses of measures to reduce discharges of nutrients to the North Sea. The publication also provides an overview of drinking water resources and economic aspects of the waste water treatment and waste management sectors.

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

Chapter 10 discusses *land use in urban settlements* in Norway. Land areas are under considerable pressure in many urban settlements, and sound land-use management is therefore necessary. New and expanded statistics on the area of urban settlements will provide a better basis for sound land-use management.

The last chapter in the publication includes various analyses of the relationship between the environment and the economy. The first article deals with energy use and emissions to air in various industry sectors. The article discusses changes in the environmental efficiency, i.e. environmental impact per unit value added, of the various sectors. This chapter also presents analyses of how labour-market rigidities influence the environmental effects of green taxes, the democratic aspect of cost-benefit analyses and, finally, whether voluntary agreements may be more environmentally effective than taxes on environmentally harmful activities.

1. Economic driving forces

Economic activity is an important driving force behind the extraction of natural resources and changes in the state of the environment. Information concerning the most important features of economic developments is therefore important for understanding changes in the environmental situation. A cyclical upturn has been under way in Norway since 1993, with sharp growth in production and consumption. This has resulted in a deterioration in environmental quality in some areas. At the same time, clean-up measures and more stringent emission standards may have contributed to a more positive trend for other environmental conditions. With regard to the extraction of natural resources, the high level of activity in the North Sea has been particularly important in recent years.

1.1. General developments

The relationship between changes in the extraction of natural resources, environmental quality and economic activity is often complex. Economic activity results in the use of natural resources and various types of environmental stresses. The composition of economic growth has an important bearing on these effects as various sectors use different quantities of resources and have different levels of emissions per unit of production. For example, service sectors use fewer natural resources and have lower emissions per unit of production than manufacturing sectors. This is seen in the resource and national accounts compiled by Statistics Norway, see Chapter 12.1. Price changes can also influence the use of resources and environmental stresses. A higher price for a factor input may prompt producers to use less of this input, and price changes can also result in shifts in the composition of industries. The extraction of natural resources contributes to economic growth in two ways, partly in the form of investment activity and partly as a result of the income generated, which results in higher demand. Both these mechanisms contribute to higher production in other sectors. Consumption influences the environment, partly in the form of emissions to air from passenger transport and heating as well as waste generation. One example of the economy-environment feedback is air pollution which may damage health, which in turn can have a negative impact on labour productivity.

The most common method of measuring total economic activity in a country is gross domestic product (GDP). The figures for GDP show that economic growth in Norway has been fairly strong from 1993 to 1997 (table 1.1). In this period mainland GDP rose by an average 3.5 per cent

Table 1.1. **Average growth in some key macroeconomic aggregates. Periods 1989-1992, 1993-1996 and 1997*. Per cent**

	1989-1992	1993-1996	1997*
Gross domestic product	2.3	4.1	3.5
- Mainland Norway	0.7	3.4	3.9
Private consumption	0.9	3.6	3.0
General government consumption	4.0	1.6	2.5
Gross fixed investment	-5.3	5.1	15.1
- Mainland Norway	-6.7	8.6	9.2
- Petroleum activities	10.5	-3.4	27.1
Exports	7.7	6.3	4.1
- Traditional goods	4.6	7.7	7.4
- Crude oil and natural gas	14.4	10.4	2.0
Imports	1.4	5.7	11.9

Source: National accounts from Statistics Norway.

annually. In 1997, mainland GDP expanded by nearly 4 per cent (preliminary figure). The cyclical upturn has been broadly based, with growth in most demand components (household consumption, fixed investment and traditional merchandise exports) and has been accompanied by moderate price and wage inflation.

Table 1.1 shows the average growth in some key macroeconomic aggregates since 1989. The table shows changes in GDP for Norway as a whole and for mainland Norway. Gross fixed investment is an important demand component in the economy, generating production primarily in manufacturing industry and the construction sector. Table 1.1 shows growth in total gross fixed investment and growth in mainland Norway and petroleum activities. Mainland Norway accounts for about 70 per cent of total investment and the petroleum sector for about 25 per cent, while the ocean transport sector accounts for the remainder. In 1997, exports of crude oil and natural gas accounted for 36 per cent and traditional goods for 38 per cent of total exports.

1.2. Industries

Oil and gas production

Norway is very dependent on the use of fossil natural resources, and developments in international oil and gas markets have a considerable influence on the country's economy. In 1997, oil and gas production accounted for a good 14 per cent of GDP, a twofold increase since 1988. Oil and gas production, measured in constant prices, rose by 1.7 per cent in 1997, while oil and gas prices increased by an average 2.1 per cent. Measured in volume terms, oil and gas production grew by 3.2 per cent, primarily in the form of higher gas production. Average oil production in 1997 came to 3.2 million barrels per day. Gas exports rose by 11.4 per cent, while exports of oil remained virtually unchanged. As seen in table 1.1, investment in the petroleum sector showed a sharp growth from 1996 to 1997, and according to provisional calculations 1997 will represent a new peak, with investment amounting to NOK 63.1 billion (current NOK). This is NOK 5.5 billion higher than in 1993, which is the peak year so far.

Oil prices moved on a downward trend in 1997 after increasing the previous two years. 1997, however, was marked by substantial fluctuations in prices, particularly as a result of the situation in the Middle East[1] and variations in demand

[1] Examples include the implementation of Iraq's agreement with the UN on exports of oil provided the revenues were used for humanitarian purposes, increased tension in the area due to the conflict beween UN weapons inspectors and Iraq, and OPEC's decision to increase the cartel's quotas for 1998.

due to climatic conditions[2]. At the beginning of 1997, the spot price of Brent Blend was about USD 24 p/b, whereas one year later it was down to USD 16 p/b. For Norway, however, the fall in the oil price in USD has been more than offset by an attendant appreciation of the USD. The overall effect was a rise in the average crude oil price in NOK of NOK 2, to NOK 135 p/b in 1997. In the short term, price changes do not necessarily have an impact on the volume of production. In the longer term, prices – and expectations concerning price movements – will influence the level of investment, and thereby production.

Central government revenues from petroleum activities have risen substantially in recent years, and in 1997 the net cash flow from petroleum activities came to NOK 85 billion. About NOK 23 billion of petroleum revenues was used to cover the government budget deficit excluding petroleum activities, while about NOK 62 billion was allocated to the Government Petroleum Fund. General government consumption rose by 2.5 per cent from 1996 to 1997, and total general government expenditure amounted to 44 per cent of GDP in 1997. The industry profile for the general government sector calculated in the NOREEA project (Chapter 12.1) shows, however, that the sector has low energy use and low emissions to air compared with gross production.

Increased activity in the petroleum sector has resulted in a sharp rise in energy use in this sector. For example, the use of natural gas increased from 12 PJ in 1976 to 153 PJ in 1997, see Chapter 2. The sector accounts for a substantial share of atmospheric emissions of CO_2, NO_x and NMVOCs, and a high proportion of the rise in these emissions in Norway in recent years can be ascribed to expanded activity in the sector, see Chapter 4.

Electricity supply

Electricity production totalled 111.6 TWh in 1997, an increase of about 7 per cent from 1996, but a decline of 9.3 per cent compared with production in 1995. Electricity imports exceeded exports by 3.8 TWh in 1997 (imports of 8.7 TWh and exports of 4.9 TWh), see also Chapter 2.2.

Net domestic consumption rose by 0.4 per cent to 105 TWh. As a result of high prices at the beginning of the year and milder weather compared with 1996, consumption was particularly low in the first half of 1997. Adjusted for temperature fluctuations, consumption rose by 2 per cent.

In 1997, electricity consumption accounted for about 48 per cent of total energy consumption, which is approximately the same as in 1996. In the period 1989-1995 this share was on average a little more than 50 per cent. The decline in electricity consumption from 1995 to 1996 reflects a sharp rise in electricity prices in this period. The strong rise in prices was ascribable to low precipitation in 1996, which resulted in low water reservoir levels and low electricity production.

Manufacturing and mining

Production in manufacturing and mining rose in volume by 3.2 per cent in 1997, according to preliminary figures. Production of wood products, furniture and other manufacturing expanded at a faster pace than the average growth in manufactu-

[2] At the end of 1997 mild weather in northwest Asia, the east coast of the US and in large parts of Europe resulted in lower demand for heating oil.

Table 1.2. **Average growth in gross product, total energy use and electricity use in manufacturing. Periods 1989-1992, 1993-1996 and 1997*. Per cent**

	1989-1992			1993-1996			1997*	
	Gross product	Total energy use	Electricity use	Gross product	Total energy use	Electricity use	Gross product	Share of total GDP
Mining and quarrying	3.0	-8.4[1]	-8.5[1]	-1.6	2.0	-10.0	1.9	0.2
Manufacturing	-1.3	-1.7	-0.1	3.5	2.9	0.4	3.3	11.0
- Food products, beverages and tobacco	-1.8	3.5	8.3	2.7	2.6	-0.7	1.4	1.9
- Textiles, wearing apparel, leather	-1.0	-0.3	8.0	2.1	6.0	-2.2	0	0.2
- Pulp, paper and paper products	-0.4	-0.3	1.0	4.4	5.3	1.2	4.7	0.5
- Publishing, printing, reproduction	-1.6	1.6	5.1	4.1	5.0	1.5	1.3	1.2
- Refined petroleum products	9.6	-3.7	5.8	4.5	-12.2	-3.9	2.4	0.1
- Basic chemicals	-1.2	-2.6	-0.8	3.5	5.8	5.1	1.0	0.5
- Chemical and mineral products	-1.7	1.0	5.9	4.8	4.5	-2.0	2.9	1.0
- Basic metals	1.8	-2.3	-1.8	2.6	0.8	-0.5	3.2	0.7
- Machinery and building of ships	-0.9	1.3	3.6	4.3	14.3	1.8	3.0	3.9
- Wood products, furniture, manufacturing n.e.c.	-6.1	1.6	5.6	1.2	5.0	3.2	10.1	0.8

[1] Change 1991-1992.
Source: National accounts and Energy Statistics from Statistics Norway.

ring. For export-oriented industries, the growth was highest in the pulp and paper industry (4.7 per cent) and the basic metals sector (3.2 per cent).

Electricity consumption in power-intensive manufacturing sectors came to 29.2 TWh in 1997, a rise of 2.2 per cent from the previous year. As a result of the high output growth in the basic metals sector, this industry also recorded the sharpest rise in electricity consumption. Consumption of spot power in manufacturing was 4.4 TWh, an increase of as much as 36 per cent from 1996, but this must be viewed in connection with the unusually low level of consumption in 1996 due to high spot prices for electricity. Spot prices were on average NOK 0.13 per kWh in 1997 compared with NOK 0.25 per kWh in 1996.

Energy use in various manufacturing sectors in the periods 1989-1992 and 1993-1996 generally follows the same trends as activity in the industries. The average change per year in the first period was lower than corresponding figures for the second period (table 1.2). For manufacturing industry as a whole, energy intensity (energy use per unit of production) fell in the period 1989-1996, but there were considerable variations between sectors. Despite higher gross production, the oil refining sector recorded a relatively sharp reduction in total energy use. Total energy use in the machinery industry and shipbuilding, however, rose considerably more than gross production. The changes in energy intensity are ascribable to structural changes within the sectors as well as temperature and prices changes that influence energy use in the sectors to a varying extent.

With regard to electricity consumption as a share of total energy use in the various manufacturing sectors, it appears that electricity consumption fell less than total

Table 1.3. **Average growth in gross product, total energy use and electricity use in primary industries. Periods 1989-1992, 1993-1996 and 1997*. Share of GDP 1997*. Per cent**

	1989-1992			1993-1996			1997*	
	Gross product	Total energy use	Electricity use	Gross product	Total energy use	Electricity use	Gross product	Share of total GDP
Agriculture and hunting	1.1	-3.2	-9.2	4.2	5.2	29.0	4.0	1.5
Forestry and logging	-2.7	-2.4	..	-2.9	0.6	..	-3.1	0.2
Fishing and fish farming	5.1	-3.6	..	14.8	6.4	..	4.4	0.8

Source: National accounts and Energy Statistics from Statistics Norway.

energy consumption in the period 1989-1992, while it rose less in the period 1993 to 1996. Preliminary figures for 1997 show, however, that electricity as a share of total energy consumption in manufacturing has again risen. The rise was particularly strong in power-intensive manufacturing and the pulp and paper industry, with a rise of 2 and 6 per cent, respectively.

Construction

Gross production in the construction sector rose in volume by 7 per cent from 1996 to 1997, according to preliminary figures. Construction investment expanded by 11 per cent in the same period, with housing investment increasing by 8.9 per cent. Value added in the industry accounted for 3.2 per cent of total GDP in 1997.

Gross production in the construction sector showed an average annual decline of 2.4 per cent in the period 1989 to 1992. In the period 1993 to 1996, however, growth was positive, showing an average annual rise of 2.8 per cent. Energy use in this sector fell by an average 11 per cent a year in the period 1989-1992, but increased by an average 5.6 per cent a year in the period 1993-1996. It thus appears that the energy intensity in the industry has risen during the current cyclical upturn. In 1996, the industry accounted for a little more than 1 per cent of total energy consumption, excluding energy sectors.

The average borrowing rate for households fell by about 7 percentage points in the period from 1991-1992 up to 1997, entailing that the real interest rate after tax has fallen by more than 3 percentage points in the same period. Towards the end of the period the demand for dwellings has risen substantially, resulting in a pronounced rise in prices, an increase in housing starts and higher energy use.

Primary industries

Production in these industries (agriculture, forestry and fishing, including fish farming) rose by about 3.3 per cent in 1997. The fish farming industry recorded the highest growth, but production in traditional fisheries and agriculture also expanded. At the same time, employment, measured in man-hours, fell by about 1 per cent, indicating some productivity gains in these industries.

Energy use in primary industries is shown in table 1.3, compared with growth in gross product.

The International Council for the Exploration of the Sea (ICES) has recommended a reduction in quotas for herring and cod in

Table 1.4. **Average growth in gross product, total energy use and electricity use in private services. Periods 1989-1992, 1993-1996 and 1997*. Share of GDP 1997*. Per cent**

	1989-1992			1993-1996			1997*	
	Gross product	Total energy use	Electricity use	Gross product	Total energy use	Electricity use	Gross product	Share of total GDP
Totalt	-0.3	-0.4	2.7	3.7	5.7	2.9	4.7	32.0
Transport and communication	3.5			9.2	5.2		7.2	7.1
- Railway transport		-5.1	-10.0		-2.3	0.7		
- Other land transport		2.2	..		8.5	-8.2		
- Air transport		-3.7	..		11.6	..		
- Post and telecommunications		-7.9	-7.2		-1.6	-2.9		
- Inland water and coastal transport	-1.6	-0.9	..	2.4	2.9	..	7.0	0.2
Other private services[1]	-1.1	2.3	3.9	2.6	4.0	3.0	3.8	24.8

[1] Includes Wholesale and retail trade, Hotels and restaurants, Financial intermediation and insurance, Housing services, Business services and Private services.
Source: National accounts and Energy Statistics from Statistics Norway.

1998 in order to rebuild stocks[3]. A maximum catch of Norwegian spring-spawning herring of 1.3 million tonnes has been proposed for 1998 compared with a quota of 1.5 million tonnes for 1997. According to the ICES, the quota for cod in 1998 should be 550 000 tonnes, a reduction of as much as 340 000 tonnes from 1997. If the recommendations are adopted, the loss in catches for Norwegian and Russian fishermen will amount to NOK 3.3 billion in the short term.

Private services

Gross production in private services as a whole rose by 4.7 per cent from 1996 to 1997. This is noticeably higher growth than the average for mainland industries, and is also reflected in the rise in prices. In these sectors prices showed a rise of 3.7 per cent, while for mainland Norway as a whole prices increased by 2.7 per cent.

The highest growth was recorded by domestic transport[4] and business services, see table 1.4. Production in domestic transport rose by altogether 6.6 per cent at constant prices from 1996 to 1997, with other land transport and services linked to transport exhibiting the sharpest growth. Within transport sectors, however, both railway and tram transport have shown a slight decline. The number of passengers who travelled from Norwegian airports in January-November 1997 was about 6.3 per cent above the level in the same period one year earlier. The number of passengers travelling abroad increased by 12.8 per cent, while domestic travel rose by 4.0 per cent. Total production in

[3] The stock of herring in recent years has shown a very positive trend and the spawning stock of Norwegian spring-spawning herring is now estimated at more than 9 million tonnes (see Chapter 9). The sizeable increase is due to the recruitment of the two strong 1991 and 1992 year classes to the spawning stock. The recommended reduction in fish catches, however, may reflect a more long-term evaluation, as the year classes after 1992 have been weaker, and it is assumed that recruitment to the spawning stock may be low in the years ahead.

[4] Includes both passenger and goods transport.

the air transport sector, however, only increased by 3.0 per cent in 1997, as foreign airlines accounted for a considerable share of the increase in foreign travel. The increase in air transport is also reflected in this sector's emissions to air, with emissions of CO_2, CO, NO_x, particulate matter, VOCs and NH_3 rising by about 8 per cent from 1996 to 1997.

1.3. Households

Private consumption grew by 3.0 per cent in 1997, which is slightly lower than the average for the period 1993-1996. The slower growth rate is particularly due to lower car purchases in 1997 compared with one year earlier. In the years 1993-1996 household consumption increased at a moderately faster pace than the growth in real disposable income, resulting in a slight reduction in the household saving ratio. In 1997, however, real disposable income increased by 3.2 per cent, i.e. slightly higher than the growth in private consumption. For the period 1991-1997, the real interest rate after tax fell by more than 3 percentage points. As a result, it has become more economically advantageous to own dwellings and consumer durables[5] compared with saving in financial assets.

Table 1.5 shows changes in private consumption and household energy use for the years 1989 to 1997. In the period 1989-1992 energy use rose at a slower pace than consumption, while in the period 1993-1996 both components showed approximately the same trend. Shifts have taken place, however, in the composition of the various energy carriers. The consumption of heating oil has declined substantially since 1989. This is partly because the heating equipment installed in new dwellings in recent years has almost exclusively been based on the use of electricity. As with production sectors, the share for electricity increased in the period 1989-1992, while it declined slightly in the period 1993-1996. In 1993, electricity as a share of households' total energy use came to 80 per cent.

Table 1.5. **Average growth in household consumption, energy use and waste. Periods 1989-1992, 1993-1996 and 1997*. Per cent**

	1989-1992	1993-1996	1997*
Household consumption	0.9	3.6	3.0
- Consumption of goods	0.6	4.0	2.6
- Services	2.0	2.5	2.6
- Direct purchases abroad by resident households	-3.6	4.1	12.4
Energy use in households, housing purposes	0.1	3.4	-1.5
- Electricity	3.0	2.4	-2.4
- Oil	-17.3	-3.0	2.6[1]
- Other[2]	-4.1	9.7	..
Petrol and diesel	1.5	0.2	..
Household waste	3.2	3.7	..

[1] The figure refers to the consumption of fuel, which includes all types of fuel used for housing purposes.
[2] Other includes wood, kerosene, coal/coke, solar cells, etc.
Source: National accounts and Energy Statistics from Statistics Norway.

Energy consumption fell by a good 1.5 per cent in 1997, partly due to higher mean temperatures and higher prices that year compared with 1996. The consumption of heating fuel rose in 1997, whereas electricity consumption declined. This is partly related to movements in electricity prices, which rose considerably more than the price of fuel; electricity prices rose by

[5] Consumer durables include private means of transport, furniture, electrical equipment and durable leisure goods.

5 per cent, while fuel prices only increased by 1.4 per cent.

The consumption of goods accounted for about 54 per cent of total household consumption in 1997, and showed a rise in volume of 2.6 per cent from 1996. The consumption of goods exhibited a pronounced decline in the first quarter of 1997, but later increased during the remainder of the year. Household purchases of private cars are an important factor underlying this development. In 1996, car purchases rose by 42 per cent, while in 1997 they increased by only a little more than 6 per cent. These markedly different growth rates reflect the temporary increase in the refund for scrapped vehicles in 1996 and reduced car taxes, which combined had the effect of moving forward many car purchases. It is interesting to note, however, that the stock of cars fell by 1.4 per cent from 1995 to 1996 (see Chapter 3), which means that the number of scrapped vehicles was very high in 1996. In 1997, the stock of cars rose by 5.5 per cent. The consumption of clothing and footwear showed a fairly high rate of growth in 1997, increasing by 3.8 per cent. Other durables (furniture, electrical equipment, equipment for recreational activities and education) also exhibited vigorous growth. A favourable price trend for these commodity groups is one explanation for the sharp growth; prices for clothing and footwear fell by a little less than 0.5 per cent, while prices for other durables remained virtually unchanged. The higher consumption of goods is reflected, for example, in the form of higher waste quantities from households, see also Chapter 5.

Household consumption of services accounted for about 45 per cent of total consumption in 1997, with growth at approximately the same level as in 1996. Growth was recorded by all categories of services. However, services related to the operation of private means of transport showed little growth from 1996 to 1997, probably as a result of the weaker trend in car sales and the 7.5 per cent increase in prices for car insurance and repair services. The sharpest growth was recorded by the use of public transport services and post and telecommunication services. The reduction in telephone rates has resulted in lower prices for telecommunication services in recent years, which has contributed to boosting consumption of these services. If cheaper postal and telecommunication services prompts us to reduce our demand for other transport (we communicate by telephone instead of visiting each other), this might reduce emissions from the transport sector.

1.4. Outlook for 1998 and 1999

Norway is now experiencing its fifth year of economic expansion, and Statistics Norway projects that the upturn will continue in 1998. Growth in the economy, however, is expected to slow in 1999.

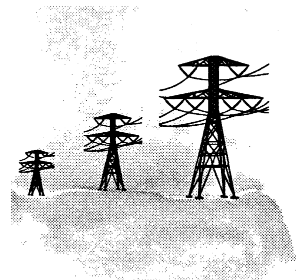
At the beginning of 1998, the Norwegian economy is characterized by a high level of activity and growing pressures in the labour market. Continued strong growth in real income may result in higher consumption of goods and thereby higher waste quantities. So far the high level of demand does not appear to have translated into rising inflation in retail markets. In the housing market, however, demand pressures are pushing up prices. A continued rise in production will probably result in a higher use of energy and increased emissions to air, depending on the composition of production growth.

For petroleum activities, it is likely – based on the oil companies' own estimates – that petroleum investment will expand substantially in 1998. Oil and gas production is also expected to increase considerably from 1997 to 1998 – 15 per cent for oil production and 10 per cent for gas production. The oil price is projected to fall considerably both in USD and NOK due to projected high production in OPEC along with lower growth in the world economy. In 1999, on the other hand, the oil price in USD is expected to rise slightly in line with a more normal cyclical trend in the world economy.

Documentation: Statistics Norway (1998a).

More information may be obtained from: Karin Ibenholt and Torstein Bye.

2. Energy



Energy use has an enormous environmental impact; for example, a very large proportion of global air pollution is generated by petroleum combustion. Energy extraction and conversion also have major environmental effects. The energy sector in Norway accounts for 30 per cent of Norwegian CO_2 emissions and 60 per cent of VOC emissions. In recent years, emissions from the energy sector in Norway have risen more than emissions from other sectors because of the growth in oil and gas extraction.

Norway has large energy reserves, and extracts far larger quantities of energy commodities than are needed for domestic use. In 1997, extraction of energy commodities was almost nine times consumption. This is mainly accounted for by oil and gas extraction. Norway has about 1 per cent of the known remaining petroleum reserves in the world, but accounted for almost 4 per cent of world production in 1997. This indicates that the rate of extraction is relatively high. Given the current rate of extraction and the petroleum reserves estimated to exist, Norway's oil reserves will be exhausted in 26 years and its gas reserves in 121 years. Petroleum extraction accounted for 14 per cent of GDP and 37 per cent of export income in 1997.

Even though Norway has the largest hydropower reserves in Europe, electricity consumption has risen faster than production in recent years. Norway's per capita energy use is almost four times higher than the average for the world as a whole, and 20 per cent higher than the average for the OECD countries.

2.1. Resource base and reserves

Crude oil and natural gas

At the end of 1997, Norwegian reserves of crude oil in fields that are already developed or where development has been approved totalled 1.86 billion standard cubic metres oil equivalents (Sm^3 o.e.), and corresponded to 1.1 per cent of the world's crude oil reserves (table 2.1). Reserves of natural gas totalled 1.17 billion Sm^3 o.e., or 0.8 per cent of total world reserves. Petroleum reserves are defined as the share of the total proven resources that can profitably be extracted given current prices and technology. Trends in the estimates of Norwegian reserves are shown in tables A1 and A2 in the Appendix.

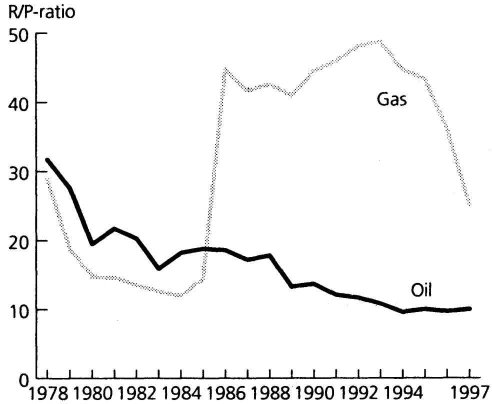
The Norwegian Petroleum Directorate has calculated that the remaining Norwegian petroleum resources total 4.8 billion Sm^3 o.e. crude oil (including wet gas) and 5.7

Table 2.1. **World reserves[1] of oil and gas as of 1 January 1998**

	Oil		Gas	
	Billion Sm^3 o.e.	Percentage	Billion Sm^3 o.e.	Percentage
World	162.3	100.0	143.7	100.0
North America	4.3	2.6	6.6	4.6
Latin America	20.1	12.4	8.1	5.6
Western Europe (incl. Norway)	3.1	1.9	4.5	3.1
Eastern Europe	9.4	5.8	56.7	39.5
Middle East	107.6	66.3	48.9	34.0
Africa	11.1	6.9	9.9	6.9
Asia and Australasia	6.7	4.1	9.1	6.3
OPEC	126.7	78.1	61.6	42.9
Norway	1.9	1.1	1.2	0.8

[1] For most countries, the reserves comprise proven resources which can be exploited using current technology and prices.
Sources: Oil & Gas Journal (1997) and Norwegian Petroleum Directorate (figures for Norway).

Figure 2.1. **Ratio between reserves and production (R/P ratio) for oil and gas. Fields already developed or where development has been approved**



Sources: Energy Statistics from Statistics Norway and Norwegian Petroleum Directorate.

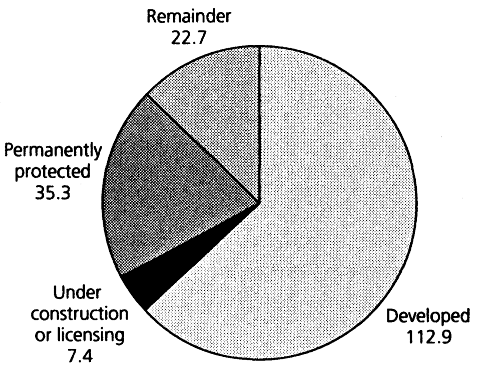
billion Sm^3 o.e. natural gas. These figures include uncertain estimates accounting for 42 and 45 per cent respectively of the total (estimates based on more efficient use of proven finds in the future and estimates of the size of reserves that are not yet definitely proven). Given the present rate of production and current technology, the calculated crude oil reserves on the Norwegian continental shelf will be exhausted after 26 years, and the natural gas reserves after 121 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. If only fields that are already developed or where development has been approved are included, the R/P ratio in 1997 was 10 years for oil and 25 years for gas. Historical trends in the R/P ratio are shown in figure 2.1. As a result of the high rate of extraction and a considerable reduction in the estimates of reserves, the R/P ratio for natural gas dropped sharply from 1995 to 1997 (for fields that are already developed or where development has been approved).

Norway's proven oil reserves are larger than those of any other European country except Russia (as of 1 January 1998). Russia also has Europe's largest 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, according to figures from the Oil & Gas Journal. At the end of 1997, the R/P ratio for the world's petroleum reserves was 43 years for crude oil and 63 years for natural gas.

Hydropower

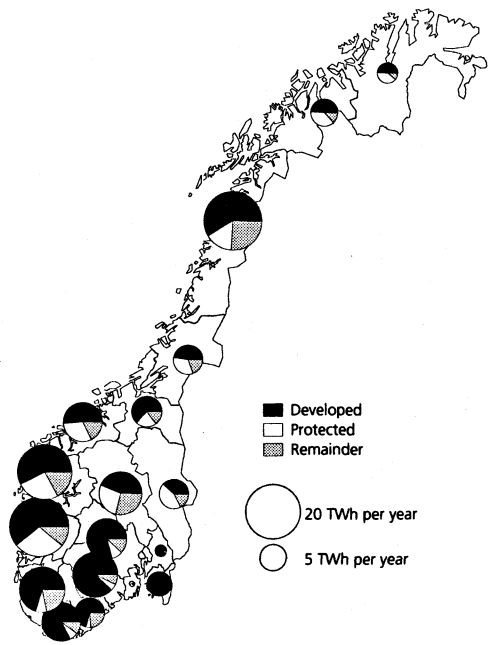
As of 1 January 1998, Norway's economically exploitable hydropower reserves totalled 178.3 TWh (expressed as mean annual production capability, i.e. the production capacity of the power stations in a year with normal precipitation).

Figure 2.2. **Hydropower potential as of 1 January 1998, in TWh per year**



Source: Norwegian Water Resources and Energy Administration.

Figure 2.3. **Norway's hydropower reserves by county, in TWh per year**



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

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 1998, 112.9 TWh was developed and 35.3 TWh permanently protected (figure 2.2). The counties Telemark, Hordaland, Sogn og Fjordane and Nordland account for 46 per cent of Norway's developed reserves, and Nordland also has 19 per cent of the country's remaining undeveloped production capacity (figure 2.3). In anticipation of a rise in electricity prices, there was growing interest in new hydropower development projects in 1997, and this is expected to continue in 1998 (Norwegian Water Resources and Energy Administration 1998).

Coal

At the end of 1997, Norway's proven coal reserves on Svalbard were about 5.8 million tonnes. Trends in the estimates of reserves are shown in table A3 in the Appendix. At the 1997 rate of extraction, the proven coal reserves will be exhausted in 14 years' time. However, this figure has varied widely as a result of large fluctuations in production level in recent years. In 1997, production rose steeply, partly because the Svea mine was re-opened. In addition to the proven reserves, a further 56.5 million tonnes are defined as probable coal reserves. These would last for 136 years given the same rate of extraction as in 1997. At the end of 1996, the world's exploitable coal reserves were 1 032 billion tonnes (BP 1997). At the current rate of extraction, they will last for 224 years. The largest reserves are found in the former Soviet Union, the USA and China.

2.2. Extraction and production

Total extraction of energy commodities in Norway has risen by an average of 11.2 per cent per year since 1976 as a result of

Box 2.1. Energy content, energy units and prefixes

Average energy content, density and efficiency of energy commodities[1]

Energy commodity	Theoretical energy content	Density	Fuel efficiency: Manufacturing and mining	Fuel efficiency: Transport	Fuel efficiency: Other
Coal	28.1 GJ/tonnes	..	0.80	0.10	0.60
Coal coke	28.5 GJ/tonnes	..	0.80	-	0.60
Petrol coke	35.0 GJ/tonnes	..	0.80	-	-
Crude oil	42.3 GJ/tonnes = 36.0 GJ/m³	0.85 tonnes/m³	..	..	..
Refinery gas	48.6 GJ/tonnes	..	0.95	..	0.95
Natural gas (1997)[2]	40.8 GJ/1000 Sm³	0.85 kg/Sm³	0.95	..	0.95
Liquefied propane and butane (LPG)	46.1 GJ/tonnes = 23.5 GJ/m³	0.51 tonnes/m³	0.95	..	0.95
Fuel gas	50.0 GJ/tonnes	..	..	..	..
Petrol	43.9 GJ/tonnes = 32.5 GJ/m³	0.74 tonnes/m³	0.20	0.20	0.20
Kerosene	43.1 GJ/tonnes = 34.5 GJ/m³	0.80 tonnes/m³	0.80	0.30	0.75
Diesel, gas- and fuel oil no. 1 and 2	43.1 GJ/tonnes = 36.2 GJ/m³	0.84 tonnes/m³	0.80	0.30	0.70
Heavy fuel oil	40.6 GJ/tonnes = 39.4 GJ/m³	0.97 tonnes/m³	0.90	0.30	0.75
Methane	50.2 GJ/tonnes	..	..	..	..
Wood	16.8 GJ/tonnes = 8.4 GJ/solid m³	0.5 tonnes/fm³	0.65	-	0.65
Wood waste (dry weight)	16.8 GJ/tonnes	..	..	..	..
Black liquor (dry weight)	14.0 GJ/tonnes	..	..	..	..
Waste	10.5 GJ/tonnes	..	..	..	..
Electricity	3.6 GJ/MWh	..	1.00	1.00	1.00
Uranium	430 - 688 TJ/tonnes	..	..	..	..

[1] The theoretical energy content of a particular energy commodity may vary. The figures therefore give mean values.
[2] Sm³ = standard cubic metre (15° C and 1 atmospheric pressure).
Sources: Energy Statistics from Statistics Norway, Norwegian Petroleum Institute, Norwegian Association of Energy Users and Suppliers, Norwegian Building Research Institute.

Energy units

	PJ	TWh	Mtoe	Mbarrels	MSm³ o.e. oil	MSm³ o.e. gas	quad
1 PJ	1	0.278	0.024	0.18	0.028	0.025	0.00095
1 TWh	3.6	1	0.085	0.64	0.100	0.088	0.0034
1 Mtoe	42.3	11.75	1	7.49	1.18	1.037	0.040
1 Mbarrel	5.65	1.57	0.13	1	0.16	0.14	0.0054
1 MSm³ o.e. oil	36.0	10.0	0.9	6.4	1	0.88	0.034
1 MSm³ o.e. gas	40.8	11.3	1.0	7.2	1.13	1	0.039
1 quad	1053	292.5	24.9	186.4	29.29	25.81	1

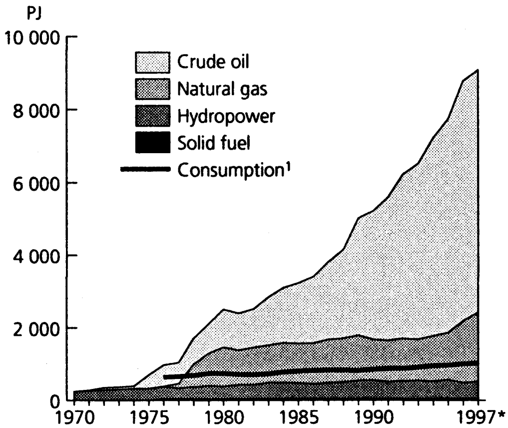
1 Mtoe = 1 mill. tonne (crude) oil equivalents
1 Mbarrel = 1 mill. barrels crude oil (1 barrel = 0.159 m³)
1 MSm³ o.e. oil = 1 mill. Sm³ oil
1 MSm³ o.e. gas = 1 billion Sm³ natural gas
1 quad = 10^{15} Btu (British termal units)

Sources: Energy Statistics from Statistics Norway and Norwegian Petroleum Directorate.

Prefixes

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

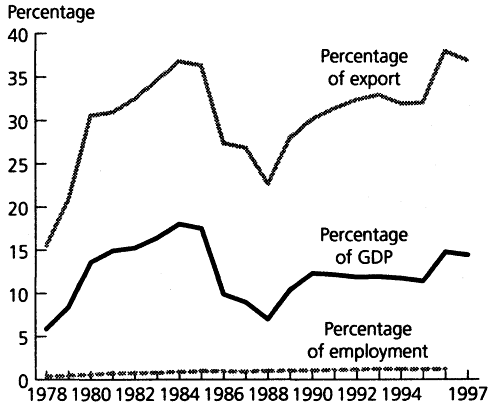
Figure 2.4. **Extraction and consumption[1] of energy commodities in Norway**



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

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

Figure 2.5. **Oil and gas extraction: percentages of exports, GDP and employment**



Source: National Accounts from Statistics Norway.

the growth in oil and gas extraction in the North Sea (figure 2.4). Total consumption has only 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 1997, extraction of primary energy commodities was 8.8 times consumption.

Crude oil and natural gas

Oil and gas extraction is Norway's most important industry measured in terms of export revenue and value added (proportion of GDP). In 1997, exports of crude oil and natural gas reached record levels and totalled NOK 163 billion, or 37 per cent of the country's total exports (figure 2.5).

The industry accounted for 14.4 per cent of GDP, and slightly more than 1 per cent of total labour input was directly related to oil and gas extraction.

According to production statistics compiled by the Norwegian Petroleum Directorate, production of crude oil and natural gas rose to 229.2 Sm³ o.e. in 1997, a rise of 3.2 per cent from 1996. Production of natural gas accounted for most of this, and rose by 14.0 per cent. Oil production was almost unchanged, and production of NGL[1] and condensate rose by 16.3 per cent. The figures from the Norwegian Petroleum Directorate show that the average oil production rate (including NGL and condensate) was 3.2 million barrels per day. Norway ranked as the world's seventh largest oil producer and ninth largest gas producer in 1997, and accounted for 4.8 and 1.9 per cent respectively of world production (table 2.2).

[1] Wet gas or NGL (natural gas liquids) is often split into the following fractions: ethane (C_2), propane (C_3), butanes (C_4) and condensates (C_{5+}). Butane and propane are known as LPG (liquefied petroleum gas).

Table 2.2. **World production of crude oil and natural gas in 1997*. Million Sm³ o.e.**

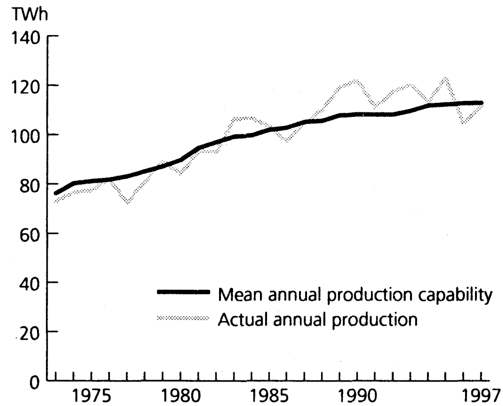
	Oil	Gas
World	3 798.0	2 301.1
North America	482.6	746.7
Latin America	537.5	123.5
Western Europe	364.9	273.8
Eastern Europe	425.6	707.7
Middle East	1 160.6	137.0
Africa	410.1	86.6
Asia and Australasia	416.7	225.8
OPEC	1 575.8	286.3
Saudi-Arabia	480.4	36.9
Former Soviet Union	412.5	675.1
USA	372.0	563.4
Iran	211.0	33.5
China	186.3	21.0
Venezuela	184.8	28.3
Norway[1]	182.9	42.6
Mexico	175.6	46.1
United Kingdom	147.5	91.8
Canada	110.6	183.3
Indonesia	79.2	66.1
Algeria	49.5	59.4
Netherlands	3.3	84.4

[1] Figures for Norway differ from newer figures from the Norwegian Petroleum Directorate that are used elsewhere in this chapter.
Sources: Oil & Gas Journal (1998).

Oil production was lower in 1997 than the year before on several fields, for example on the major oil fields Statoil and Gullfaks and on Oseberg, Brage, Tordis and Snorre. On Draugen, Statfjord East and Statfjord North, oil production rose by about 20 per cent from 1996 to 1997, and on Troll West and Heidrun by about 10 per cent.

Figures from the Norwegian Petroleum Directorate show that the drop in natural gas production on some fields, e.g. Heimdal and the Frigg area, was outweighed by the rise in production on the two largest fields on the continental shelf, Troll East and Sleipner East. Troll East was opened in June 1996 and accounted for more than 33 per cent of gas production on the Norwegian continental shelf in 1997.

Figure 2.6. **Mean annual production capability and actual hydropower production in Norway**



Source: Norwegian Water Resources and Energy Administration.

According to the Ministry of Petroleum and Energy, the production capacity of Troll East is 27 billion Sm³ o.e. gas per year, and it is expected that the production level on the field will rise when overall Norwegian sales of gas rise.

Electricity

Electricity production in Norway in 1997 totalled 111.6 TWh, which was 7 per cent higher than the year before but 9.3 per cent lower than in 1995. A total of 8.7 TWh was imported, and 4.9 TWh was exported, giving a net import of 3.8 TWh, compared with 9 TWh the year before (Appendix, table A7). More than 70 per cent of the total was imported in the period January-May, when production was lower than normal because the degree of filling of the reservoirs was low. From the end of May 1996 to the beginning of April 1997, the degree of filling of the reservoirs was lower than the minimum level in the period 1982-1991. During summer and autumn 1997, melting snow in the mountains and high precipitation levels brought the degree of filling up to above the median level for 1982-1991. As a result, electricity production in this period was markedly higher than in the same period in the previous year, and in the period July-October Norway was a net exporter of electricity. In week 1 in 1998, the degree of filling was 70.4 per cent, as compared with 53 per cent in the same week in 1997. Reservoir capacity was increased by about 2.3 TWh last year as a result of the Svartisen development in Nordland county, and is now 83.2 TWh. Regular updates of the degree of filling of the reservoirs can be found on Statistics Norway's website (www.ssb.no).

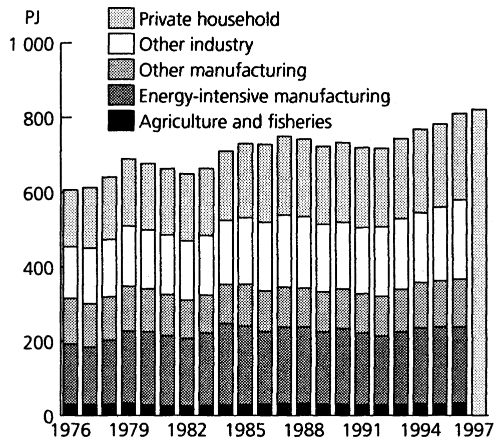
Coal

Coal production on Svalbard in 1997 was almost twice as high as the year before, and totalled about 11.7 PJ according to preliminary figures. The rise was due to the re-opening of the Svea mine. World coal production in 1996 was 4.6 billion tonnes, equivalent to about 96 EJ. The largest producers were China and the USA, which accounted for 30 and 25 per cent of the total respectively. Europe excluding the former Soviet Union accounted for 13 per cent of the total, and more than half of this was produced in Germany and Poland.

Biofuel

Wood, wood waste and black liquor (waste from chemical pulp production) are the most important biofuels in Norway. Production of these fuels, including production for own use, is more than 40 PJ per year. This is equivalent to roughly 9 per cent of energy production from hydropower. The figure is uncertain because the data are incomplete. In 1996, energy equivalent to about 4.8 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 327 000 tonnes (corresponding to an energy content of

Figure 2.7. **Domestic energy use by consumer group**



Source: Energy Statistics from Statistics Norway.

about 16 PJ) in 1996. In recent years, more and more of this gas has been used for energy purposes or flared. In 1996, 13 400 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.

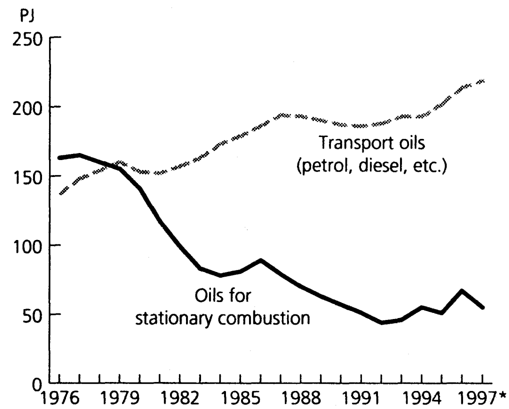
2.3. Energy use

Consumption of energy commodities in Norway, excluding the energy sectors and international maritime transport, totalled 811 PJ in 1996 and 822 PJ in 1997 (preliminary figures), which gives an increase of 1.3 per cent (figure 2.7 and Appendix, table A5). Energy use rose by an average of 1.3 per cent per year from 1978 to 1997. In the same period, GDP excluding the oil and gas sector rose by an average of 2.2 per cent per year.

Energy use in the energy sectors

In 1997, net energy use in the energy sectors (hydropower production, oil and gas extraction, oil refineries, etc.) accounted for about 20 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 205 PJ in 1997 (preliminary figure). The use of natural gas in the extraction of crude oil and natural gas accounted for 12 PJ of this in 1976 and 153 PJ in 1997 (see Appendix, table A6). This gives an average rise of almost 9 per cent per year. Almost all the gas is used for energy purposes, and only 1 per cent is 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, because the level of efficiency is low. However, the amount of energy used per unit of crude oil and natural gas produced has been reduced in the same period.

Figure 2.8. **Consumption of oil products**



Sources: Energy Statistics from Statistics Norway.

Energy use in the energy sectors results in large emissions to air. These are discussed in more detail in Chapter 4. See also Appendix, tables C3-C6.

Oil consumption

Total oil consumption, excluding international maritime transport, dropped by about 9 per cent from 1976 to 1997, despite the fact that oil consumption for transport rose by 60 per cent in the same period (figure 2.8). Transport now accounts for 79 per cent of total oil consumption, as compared with 46 per cent in 1976. Since 1976, the consumption of transport oils has risen by an average of 2.3 per cent per year, while goods and passenger transport have risen by 0.8 per cent and 2.2 per cent per year, respectively. Auto diesel and marine gas oil are the types of transport oils whose consumption has risen most. Consumption of aviation fuel has also risen, while consumption of heavy fuel oil has dropped during the past ten years.

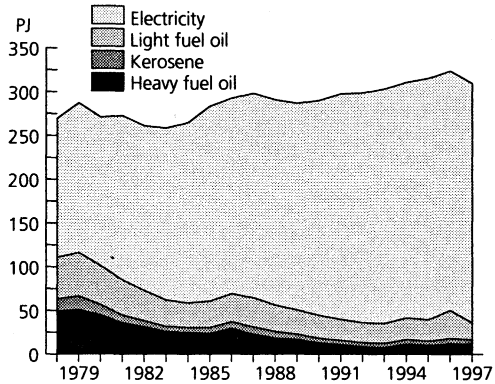
Sales of oil for stationary purposes had dropped to less than one third of the 1976 level by 1992. Since then, the figures have fluctuated, and there was a drop of 17 per cent from 1996 to 1997 (preliminary figures). Sales of heating kerosene and heavy fuel oil also fell by 8 and 9 per cent respectively from 1996 (figure 2.9).
The lower figures are explained by mild weather in 1997 and by a rise in fuel oil prices and somewhat lower electricity prices, partly because there was more water in the reservoirs (see section 2.4).

Emissions to air associated with oil consumption are discussed in Chapter 4. See also Appendix, tables C3-C6.

Electricity consumption

Net domestic consumption of electricity rose by 0.4 per cent from 1996 to 1997, and totalled 105 TWh (see Appendix, table A7). General consumption (net domestic consumption except spot power for electric boilers and consumption by

Figure 2.9. **Electricity consumption (excluding energy-intensive manufacturing) and sales of fuel oils and kerosene as utilized energy**



Source: Energy Statistics from Statistics Norway and Norwegian Petroleum Directorate.

power-intensive manufacturing) totalled 71.4 TWh, 2 per cent lower than in 1996. Consumption was particularly low in the first half of 1997, and this is presumably connected with the high electricity prices at the beginning of the year. The weather was also milder in 1997 than in 1996. General consumption corrected for temperature rose by about 2 per cent from 1996.

Electricity consumption in power-intensive manufacturing was 29.2 TWh in 1997, a rise of 2.2 per cent from the year before. As a result of the rapid growth in metal manufacturing, electricity consumption rose most in this sector. Consumption of spot power totalled 4.4 TWh in 1997, a rise of 36 per cent from the year before. However, in 1996 consumption of spot power was unusually low because of the high spot prices. In 1997, the price of spot power, excluding the charge for use of the grid and taxes, was on average NOK 0.136 per kWh, as compared with NOK 0.252 in 1996.

Since 1987, hydropower production in Norway has risen by an average of 0.7 per cent per year, and net domestic electricity consumption has risen by 1.1 per cent per year. If these trends continue, Norway will to an increasing extent become a net importer of electricity. However, Norway can meet any power deficit more easily than before because a common Nordic power market has been established, and transmission capacity between the countries has been substantially improved. These developments make it possible to utilize power resources in the Nordic countries more efficiently, and are advantageous to Norway as well. The need for investments to ensure that the demand for power is met in dry years will be reduced, and export opportunities after periods when precipitation is high will be improved. Some aspects of these issues are discussed in sections 2.5 and 2.6.

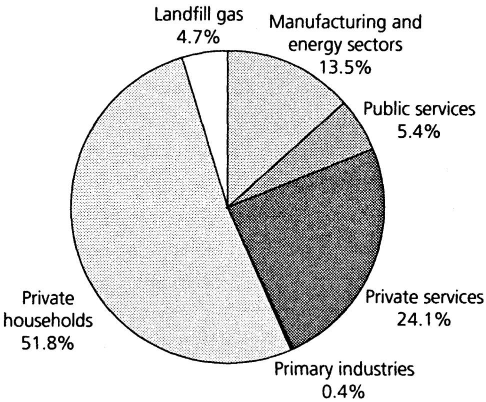
Energy use in the municipalities

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 2.10 and table A9 in the Appendix show energy use (theoretical energy content) in Oslo municipality in 1995.

World energy use

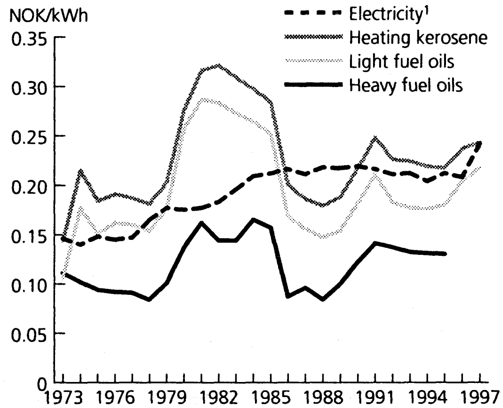
In 1995, Norway accounted for 0.29 per cent of total world energy use (Appendix, table A10), and the OECD countries for 56 per cent. Per capita energy use in Norway is 20 per cent higher than the average for the OECD countries and almost four times the world average. However, of the Nordic countries only Denmark has lower per capita energy use than Norway. Average per capita energy use in OECD member countries is almost six times higher than

Figure 2.10. **Energy use for stationary combustion in Oslo by branch of industry, 1995**



Source: Statistics Norway.

Figure 2.11. **Prices of fuel oils and electricity for heating (as utilized energy), in fixed 1980 prices including all taxes and tariffs**



[1] Electricity prices for 1996 and 1997 are as of 1 January; for earlier years, the average price for the whole year is given.
Source: Energy Statistics from Statistics Norway, Norwegian Water Resources and Energy Administration and Norwegian Petroleum Institute.

in the rest of the world. Energy intensity in Norway, measured as energy used per unit of GDP, is now about two-thirds of the average for the OECD countries. However, if these figures are adjusted for local purchasing power, the figure for Norway is close to the OECD average. Norway's high level of energy use compared with other OECD countries and other parts of the world is explained by several factors. Norway has a high proportion of power-intensive manufacturing industries, the climate is cold, and the pattern of settlement is scattered.

The energy mix varies between continents, but oil, coal and natural gas are important energy commodities in all continents.

2.4. Energy prices

Electricity

A mild winter and the increase in the degree of filling of the reservoirs resulted in lower spot prices in 1997 than in 1996. Many energy utilities therefore lowered their prices to the consumer during 1997. In addition, stronger competition between utilities resulted in lower prices and a smaller price range. The Norwegian Water Resources and Energy Administration investigated electricity prices among the 40 largest suppliers in July 1997, and found that the average price was NOK 0.29 per kWh, including the electricity tax and VAT. This was a drop of about 20 per cent from 1 January 1997. By October 1997, the price of electricity had risen slightly, but there was less variation in the prices offered by the various utilities. In March 1998, prices had dropped further, and were around NOK 0.27 per kWh. For energy prices in earlier years see figure 2.11.

The fee for changing power supplier was removed in 1997, and the media provided a great deal of information to consumers on how to change supplier. At the beginning of 1997, few households had changed supplier, but the number rose gradually during the year to 11 000 in the fourth quarter. By then, 27 000 households were using a supplier other than the local electricity utility. From 1998 onwards, it is possible to change energy supplier each week, and more people may now take the opportunity to do so.

Fuel oils

In 1997, the listed price of light fuel oil was NOK 3.72 per litre, a rise of 9 per cent from the year before. Measured as utilized energy (i.e. corrected for efficiency), the price was NOK 0.528 per kWh. The listed price of heating kerosene rose by 5 per cent in 1997, and was on average NOK 0.591 per kWh (table A8 in the Appendix shows the prices of heating products as energy supplied).

2.5. The Nordic electricity market: Gas-based power generation in Norway or new Nordic gas pipelines?

The production of electricity is capital intensive and has considerable environmental consequences. In recent years Finland, Norway and Sweden have deregulated their national electricity markets, and considerable interest has therefore been shown in future developments in the Nordic electricity market. Today there is sufficient production capacity to cover demand. The decommissioning of some Swedish nuclear power stations, the phasing out of older production facilities, demand growth and any measures to combat air pollution will increase the need for investment in new production capacity. Political decisions and initiatives linked to gas-based power generation in Norway and gas pipelines from Norway to other Nordic countries will have important consequences for developments in the Nordic electricity market.

An equilibrium model for the Nordic electricity market has been constructed in order to analyze the effects of various policy options. The model is based on an assumption of perfect competition. It has a detailed time disaggregation which allows studies of Nordic short-term power exchange. The model has been used to analyze the Nordic electricity market up to the year 2020 on the basis of different assumptions concerning the supply of gas for electricity production.

If a licence for gas-based power generation in Norway is not granted, and no measures are introduced to establish new gas pipelines in the Nordic area, our calculations show that new investments will be made in coal-fired power capacity in Sweden, Denmark and Finland. Some expansion of hydropower capacity will take place in Norway. Electricity production using biofuels will be profitable in combined heat and power generation, but the supply of fuel and fuel costs limit the potential for biofuel-based electricity generation. In this analysis wind power is not available as a potential technology in the model, and only existing wind power is included.

If a licence is granted for gas-based power generation in Norway, this will partly displace coal-fired power generation in the other Nordic countries. At the same time, electricity prices will fall, which in turn will stimulate the demand for electricity. All in all, the calculations indicate a slight reduction in Nordic CO_2 emissions. If a decision is made to construct new pipelines for the transport of Norwegian gas to the other Nordic countries, this will contribute to a far greater reduction in coal-fired power generation and thus emissions of CO_2. In this case the price of electricity also falls, which stimulates demand.

The model is based on a number of simplified assumptions and uncertain data. Sensitivity analyses show that the effect of a unilateral decision to permit gas-based power generation in Norway on Nordic CO_2 emissions is particularly uncertain, and emissions may just as well increase as decline. On the other hand, the conclusion that the construction of new gas pipelines in the Nordic area will result in lower emissions is more robust to changes in the assumptions underlying the calculations.

Project financed by: Nordic Energy Research Programme, Energy and Society Programme, The Research Council of Norway, Samram.

Project documentation: Johnsen (1998).

2.6. Coordination of energy and pollution taxes in the Nordic Electricity market

The introduction of a market-based electricity trading system in the Nordic countries provides a good basis for an efficient use of Nordic power resources. However, there are still many wedges in the markets which obstruct such efficient use.

Energy taxes in the Nordic countries are different both with regard to structure and tax level. In Denmark, all taxes are levied on the consumption of electricity, while in Sweden and Norway taxes are imposed on both producers and consumers. In Finland, all taxes are levied on electricity producers. There can be many arguments for taxing electricity production and electricity consumption. Hydropower production may be taxed to collect some of the economic rent in this sector or in order to take account of external environmental effects resulting from the development of watercourses. Economic rent is the profit accruing to older power stations with low production costs when the market is willing to pay a price equal to the cost of developing new capacity, and this cost is rising. Nuclear power may be taxed to take into account the socioeconomic risk of accidents and the consequences this production may entail. Electricity production using fossil fuels may be taxed based on the polluter pays principle. The arguments for taxing the consumption of electricity are considerably weaker since the use of electricity cannot be said to have indirect effects. It is naturally possible to apply general arguments for taxing consumption instead of production, or purely fiscal arguments.

This project looks at the various consequences of a possible harmonization of tax regimes in the Nordic countries on the Nordic electricity market, the pollution situation in the Nordic area and some distributional effects. We have in part examined the effects of a tax harmonization on electricity consumption and production between the Nordic countries Sweden, Denmark, Finland and Norway and in part the effects of improving the targeting of taxes in relation to pollution in electricity production.

The price effects of this reform vary depending on which alternative is studied. For many customer groups prices change by 30 per cent, whereas for others the price changes are more modest. In the most extreme cases, where all purchaser taxes are levied on households, electricity prices for households in Norway will rise by 50 per cent. For other alternatives, where the price discrimination of households is discontinued, the price for Danish households may decline by 30 per cent.

A tax reform in the direction of the alternatives studied in this article will result in a decline in Nordic electricity production and consumption in the order of 5-20 TWh in the years to 2010. (Total Nordic electricity consumption came to a little more than 300 TWh in the mid-1990s). The greatest decline is obtained in the case with taxes on fossil fuels and an energy tax on nuclear power and hydropower as well as a unilateral taxation of the household sector on the consumption side.

Due to strict constraints on the possibilities for establishing new cable capacity between countries, and exogenously determined limits for production and consumption in the baseline scenario in the calculations, electricity trade between countries is affected very little in this analysis. This also entails that changes in wholesale prices will be greater than they would have been in a situation with freer adaptation on both the production side in Sweden (where the supply is heavily regulated) and in the grid capacity between the Nordic countries.

Project financed by: Nordic Council of Ministers.

Project documentation: Aune and Bye (1997).

2.7. Environmental effects of Norwegian gas sales

In this project we have studied the impacts of a reduction in Norwegian gas sales on Western European CO_2 emissions. Norway is a large producer and exporter of natural gas to Europe, and is currently supplying about 10 per cent of the natural gas consumption in Western Europe. A change in Norway's energy policy through lower production and thereby a reduction in gas sales may therefore have an effect on CO_2 emissions in Western Europe. The effects of reduced gas sales may generally be classified in three different categories: demand effects, supply effects and effects via regulations.

The demand effects may be divided into two separate effects. The first is due to the substitution between different sources of energy. If Norwegian gas is not fully replaced by other gas, a reduction in Norwegian gas sales will result in a higher price of gas and consumers will shift their energy demand towards other sources of energy, such as coal and oil. This may result in higher emissions. More expensive gas will also result in a higher price level and thereby lower energy consumption and lower emissions given the same income (an income effect). A change in Norwegian gas sales may also have supply effects through supply reactions from other gas producers and producers of alternative energy sources. A higher gas price will result in higher demand for oil and coal. The impact of this substitution effect depends on the elasticity of supply for oil and coal, i.e., how much production is increased when the price rises. Finally, the existence of political regulations or institutional conditions may also influence the environmental effects. This may be the case, for example, if a country has committed itself to an environmental agreement or has the objective of maintaining coal production.

The dynamic oligopoly model of the European gas market DYNOPOLY is used to analyze the effects of a reduction in Norwegian gas sales on Russian and Algerian gas exports, while the effects on the demand side are analyzed with the help of the energy demand model SEEM. If

Western European countries are committed to fulfilling their announced CO_2 targets, reduced gas exports will not have an impact on emissions. The consumption of oil and coal will increase slightly, whereas total energy consumption will decline. A reduction in Norwegian gas sales will also have minimal effects on Western European CO_2 emissions when there are no regulations on emissions. The main reason for this is the considerable difference between the end-user price and the import price of gas. A change in the import price as a result of reduced Norwegian gas sales will therefore have minimal effects on the end-user price and therefore on the demand for gas and other fuels.

In addition to the aggregated effects, we have also focused on the sectoral changes in Western Europe for the four largest energy consumers, notably Germany, the UK, Italy and France. Emissions from the industry sector are significantly reduced in all four countries as a result of reduced Norwegian gas sales, while the emissions from the transport sector are unaltered. The first is largely due to energy savings, while the latter is due to low gas consumption and small substitution possibilities among the energy carriers in the transport sector. The effects on other economic sectors will to some extent vary considerably between the various countries. In Germany, for example, emissions in the household and service sectors will increase due to substitution towards oil and coal. In total, however, German emissions will decline somewhat.

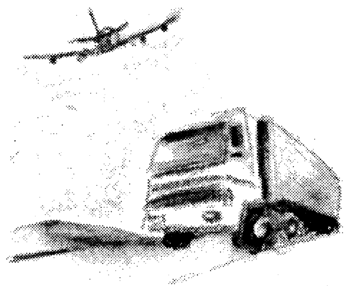
Project financed by: Ministry of the Environment.

Project documentation: Berg, Boug and Kverndokk (1997a), (1997b) and (1998).

Documentation, energy in general: Statistics Norway (1997a).

More information on energy in general may be obtained from: Lisbet Høgset, Trond Sandmo, Tor Arnt Johnsen and Bodil Merethe Larsen.

3. Transport



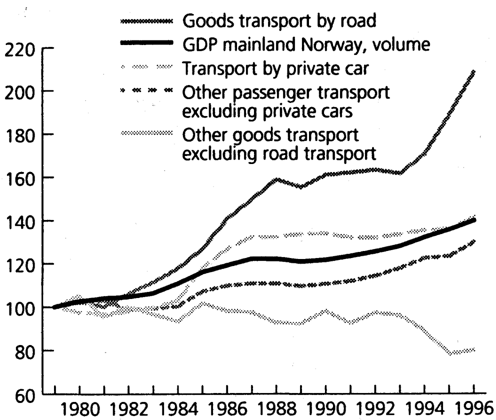
Economic growth and growth in transport activities are closely connected. Efficient transport and a growth in capacity are needed to make use of the rising production capacity, and rising incomes in themselves result in a growing demand for transport services. Since 1946, passenger transport in Norway has risen twelvefold, and goods transport fivefold. In 1996, every Norwegian travelled an average distance of 36 km per day. The large volume of traffic has a major environmental impact. A substantial proportion of all air pollution is generated by fuel combustion by various modes of transport, and according to the Surveys of Level of Living, road traffic is the main cause of perceived exposure to pollution and noise. In addition, traffic arteries occupy large areas of land and can act as barriers to other forms of access.

3.1. Introduction

The volume of domestic transport has grown steeply in recent decades. Since 1946, passenger transport has risen twelvefold and goods transport, including oil and gas transport from the North Sea, has risen ninefold. Transport by private car, transport from the North Sea to the Norwegian mainland and goods transport by road have contributed most to these developments. Since 1980, the transport industries[1] have accounted for a total of about 8-10 per cent of gross domestic product (GDP) and employment. Water transport accounts for the largest proportion of GDP, but much of this takes place outside Norway's borders. If both ocean transport and oil and gas transport from the North Sea are excluded, the transport industries account for about 6 per cent of GDP in mainland Norway. Figure 3.1 shows the growth in the volume of GDP for mainland Norway, together with developments in transport work (including transport on own account) for the most

[1] Excluding transport on own account.

Figure 3.1. Trends in GDP for mainland Norway and domestic passenger and goods transport. Index: 1979=100



Source: National accounts and Transport Statistics from Statistics Norway.

Box 3.1. Definitions

Goods transport work (tonne-km)	Sum of the quantities transported multiplied by the length of transport for each trip
Passenger transport work (passenger-km)	Sum of the number of kilometres each passenger has travelled
Occupancy rate	Ratio between the number of passenger-km and the number of km driven, i.e. the average number of persons in the mode of transport
Domestic transport	Transport which both starts and ends in Norway, including the North Sea

important modes of transport. The Ministry of Transport and Communications expects passenger transport to grow more slowly than GDP in the period 1995-2010. Goods transport by road and GDP are expected to grow at about the same rate during this period (Ministry of Transport and Communications 1997).

3.2. Transport networks and vehicles

At the end of 1996, the total length of public roads and streets in Norway was 91 300 km, or 282 m road per km² of land area in Norway excluding Svalbard and Jan Mayen. There are large variations between the counties; in Oslo, for example, the total length of public road per km² is 3 230 m, whereas in Finnmark it is only 87 m. National highways accounted for 29 per cent of the total, county roads for 30 per cent and municipal roads for 41 per cent. The total area of the various types of roads has been calculated to be about 480 km², or somewhat more than the area of the municipality of Oslo. The figures include the hard shoulder, but not embankments, ditches, noise zones, etc.

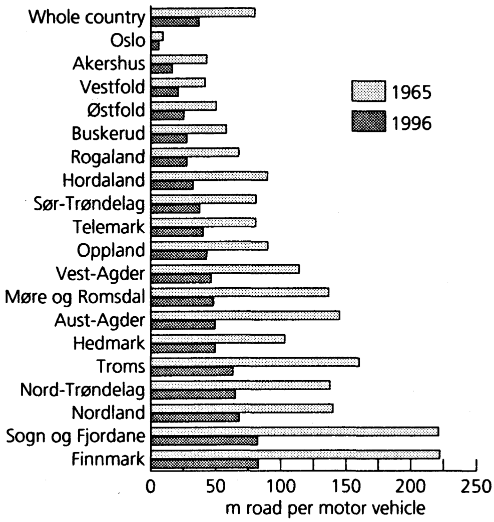
Car density, measured as the number of metres of public road available per vehicle, dropped steeply from 1945 to the mid-1980s (table 3.1). This is because the number of motor vehicles rose much faster than the total length of public roads, particularly during the first half of this period. However, a substantial proportion of investments in roads has been used to expand the existing road network. Car density has changed relatively little during the past ten years. At the end of 1996, there was an average of 37 m public road available per vehicle. Car density is highest in Oslo, where only 6 m public road is available per motor vehicle registered in Oslo, whereas in both Finnmark and Sogn og Fjordane the average figure is 82 m per vehicle (figure 3.2).

Table 3.1. **Length of public roads in metres**

	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
1996	37	282

Sources: Transport Statistics from Statistics Norway and Directorate of Public Roads.

Figure 3.2. **Length (metres) of public road per vehicle, by county**



Source: Directorate of Public Roads.

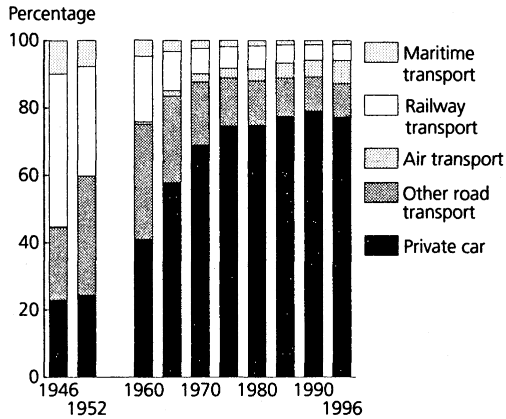
In 1996, the total length of cycle and footpaths along national highways was 2 667 km, an increase of about 1 000 km since 1990. In addition, Norway has an estimated 50 000 km year-round forestry roads (see Chapter 8.3).

The total length of the public railway network has remained fairly constant since the end of the Second World War, and is slightly more than 4 000 km. In 1945-1946, only 17 per cent of the lines were electrified, as compared with about 60 per cent today.

3.3. Passenger transport

In October 1960, import restrictions for private cars were lifted, and between 1960 and 1975 the proportion of total passenger transport work carried out by private cars rose from 40 to 76 per cent (figure 3.3 and Appendix, table B1). Since 1975, this proportion has changed very

Figure 3.3. **Domestic passenger transport work by mode of transport**



Sources: Transport Statistics from Statistics Norway and Institute of Transport Economics.

little (77.1 per cent in 1996). Other important trends in recent years are the substantial growth in air transport and a drop in the share of total passenger transport for other modes of transport.

Total transport work by scheduled buses has remained almost unchanged since 1970, and was about 3.8 billion passenger-km in 1996. The share of total transport work done by buses dropped from 16 to 7 per cent in the same period.

Rail transport, including suburban railways and trams, accounted for 2.8 billion passenger-km in 1996, and of this 0.4 million passenger-km was on suburban railways and trams. These figures have changed relatively little since 1980, although the share of total transport work carried out by the railways dropped by two percentage points to 5 per cent in 1996.

Although passenger transport by sea is important in some regions, the total

Box 3.2. Ownership and use of private cars

Statistics Norway was commissioned by the Ministry of Transport and Communications and the Directorate of Public Roads to study trends in the ownership and use of private cars in the period 1980-1995 (Monsrud 1997). The analysis is based on sample surveys in 1980, 1987 and 1995. The results show some major changes in this period, particularly as regards women's use of cars. In 1980, women accounted for an overall figure of only 2.4 billion km driven, but this doubled in the next seven years to 4.9 billion km driven. These figures correspond to 16 and 24 per cent, respectively, of the total distance driven by private cars. In 1995, this share had risen to 28 per cent or 6.3 billion km, i.e. an increase of 161 per cent in the 15-year period. The total distance driven by men rose by 33 per cent in the same period. Women typically use cars for relatively short trips in connection with journeys to and from school, day care facilities, shops, public offices, doctors, etc. The average occupancy rate is also lower for female than for male drivers; in 1995, the figures were 1.68 and 1.83 persons respectively. The main explanation of this is that men still account for about 80 per cent of trips categorized as weekend and holiday driving. These are long trips with a larger number of people in the car.

In 1995, private cars that were more than 10 years old accounted for 32 per cent of the total driven, or 7.3 billion km. The corresponding figures for 1980 and 1987 were 12.5 and 16.5 per cent, respectively. The studies also show that the total distance driven by the newest cars (0-4 years old) dropped from 9.9 billion km in 1987 to 5.5 billion km in 1995. This was because there were fewer new cars in 1995 than in 1987, and the distance driven per car was unchanged.

The study showed that driving to and from work accounts for a quarter of the total distance driven. Since the occupancy rate was low (1.23 in 1995), this corresponded to only 18 per cent of transport work measured in passenger-km. Driving in connection with outdoor recreation, sports and other leisure activities and visits accounted for 31 per cent of total transport work.

The total distance driven by private cars registered in Oslo was 1.8 billion km in 1980, greater than for any other county. In 1995, this figure had risen to 2.2 billion km, a rise of 22 per cent. The country average rose by 54 per cent in the same period. The greatest relative growth in the distance driven in this period was in Sogn og Fjordane, where it was 74 per cent, but the greatest absolute growth in the distance driven was found in Akershus. Here, the total distance driven by private cars was 2.7 billion km in 1995, as compared with 1.6 billion km in 1980. This correspon-ded to 4.6 billion passenger-km (1995).

volume is relatively limited. In 1996, 43 million passengers were carried on domestic routes. Ferry services accounted for 85 per cent of passenger transport.

Air transport accounted for only 2 per cent of domestic transport work, measured in passenger-km, in 1970, but this figure had grown to 7 per cent in 1996. Air transport accounted for a greater share of the total than rail transport for the first time in 1989 and for a greater share than scheduled buses in 1996. Although air transport is now the second most important mode of transport, accounting for 3.9 billion passenger-km in 1996, this is only 9 per cent of the figure for private cars. Since the average plane journey is 440 km per passenger, the number of persons transported by air is not very large. In 1996, about 9 million passenger journeys were made by plane.

Private cars are far and away the dominant mode of transport today, especially for short and medium-length journeys. Domestic transport work by private car in 1996 was calculated to total about 44 bil-

Table 3.2. **Number of passenger-km per person per day**

	Total	Private car	Other road traffic	Aircraft	Railway[1]	Ship
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
1996	35.71	27.55	3.58	2.46	1.73	0.38

[1] Including suburban railways and trams.
Source: Transport Statistics from Statistics Norway.

lion passenger-km, which is an increase of 1.7 billion passenger-km (4 per cent) from 1995. This corresponds to three-quarters of the total growth in domestic passenger transport in 1996. The steep increase occurred despite a drop of 1.4 per cent in the number of private cars from 1995 to 1996. This drop is related to the large number of cars scrapped against a refund. However, the average age of Norwegian private cars is still high, and was 9.9 years at the end of 1996. The average age was lowest in Oslo (8.4 years) and highest in Oppland (11.1 years). In 1970, the average age of private cars was 6.3 years. The rise in the average age of cars is mainly explained by the fact that the number of cars on the road ceased to rise after 1987 (low sales of new cars). However, in 1997 the number of private cars rose by almost 100 000 to 1.758 million, which is the steepest growth ever recorded in a single year. This was mainly because very few cars were scrapped in 1997.

In 1996, each Norwegian travelled an average of 36 km per day, nine times more than in 1946 (table 3.2). However, people travelled more both by boat and by train in 1946 than in 1996.

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 general economic growth. The general improvement in the economy of private households has strongly influenced the use of private cars. In particular, families with children give priority to car use. In 1995, 87 per cent of all married couples with children owned cars, as compared with 75 per cent of those without children. More than one in three of all couples with children owned more than one car. Long journeys to school, day care facilities, children's after-school activities, and the fact that both parents work are factors that help to explain why families with children give priority to car ownership at the expense of other benefits.

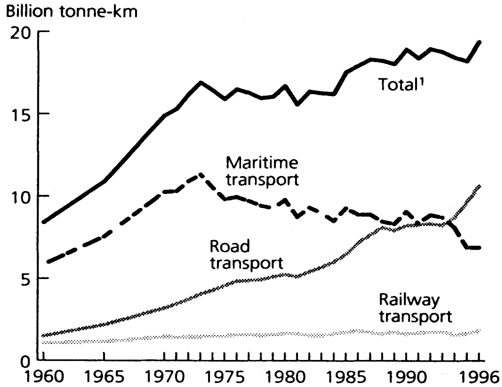
It is not only couples with children who find that the existing public transport system does not meet their daily needs. For most people, car ownership provides freedom and a greater choice of both jobs and housing. Cars also allow far more mobility and flexibility than that provided by public transport. Our many day-to-day activities can be carried out more quickly and easily with access to a private car. Social contacts are easier to maintain and develop, and cars open up more opportunities for holidays and leisure activities. A study of car ownership and use (see box 3.2) showed that in 1995, trips to and from outdoor recreation areas, sports and other activities and visits to family and friends accounted for 31 per cent of transport work. Statistics Norway's study of people's holiday activities 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 (Vaage 1995). Of the remaining 15 per cent, roughly equal proportions travelled by train, bus and ship/ferry.

The Government's Long-term Programme for 1998-2001 presents projections of traffic trends up to 2010 drawn up by the Institute of Transport Economics. In the period 1980-1995, the average rate of growth for private cars and public transport was 2.2 and 1.3 per cent respectively, but this is expected to drop to 1.3 per cent for private cars and 1.0 per cent for public transport in the period 1995-2010. 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. Assumptions about structural aspects of population size and composition are an important basis for the calculations. For example, the estimates are based on slower growth in the number of people holding driving licences, a slower increase in the number of cars and slower growth of the labour force. From 1995 to 1996, passenger transport work grew by over 4 per cent. In contrast, preliminary calculations show that there was no growth from 1996 to 1997.

3.4. Goods transport

In 1946, domestic goods transport work totalled 4.2 billion tonne-km. Fifty years later, this figure (excluding oil and gas transport from the North Sea) had grown to 19.4 billion tonne-km (figure 3.4 and Appendix, table B2). Growth was steepest up to and including 1973. Since then, it has been more moderate. Other important trends since 1960, measured in absolute figures, have been the lack of growth in railway and maritime transport and the growth in road transport. In recent years, the volume of transport from the North Sea to mainland Norway has grown steeply (cf. figure 3.5).

Figure 3.4. **Domestic goods transport[1] by mode of transport**



[1] Excluding oil and gas transport.
Sources: Transport Statistics from Statistics Norway and Institute of Transport Economics.

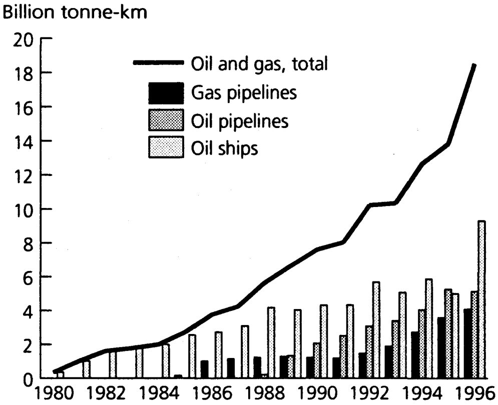
At the end of the 1950s, goods transport by rail and road totalled about 1 billion tonne-km each. In 1996, transport by rail had grown to 1.8 billion tonne-km and transport by road to almost 11 billion tonne-km. The railways have lost the greatest market shares for short journeys.

In 1960, traditional maritime transport (excluding oil transport by ship from the North Sea) accounted for 67 per cent of total domestic transport work. By 1996, this share had dropped to 36 per cent of the total. Whereas transport by rail has merely shown a lack of growth, water transport has shown a clear reduction even in absolute terms.

The volume of goods transported by air is moderate, and has not grown in recent years. Total transport work was the same in 1996 as in 1985, about 0.02 billion tonne-km.

Goods transport by road has shown steady growth throughout the period since 1960.

Figure 3.5. **Oil and gas transport from the Norwegian continental shelf to the mainland**



Sources: Transport Statistics from Statistics Norway and Institute of Transport Economics.

In 1994, the volume of road transport was larger than that of maritime transport for the first time, and in 1996, road transport accounted for about 55 per cent of domestic transport work (10.7 billion tonne-km). In 1960, the corresponding figure was 17 per cent. In 1996, a total of 244 million tonnes was transported by road. This was almost 82 per cent of total domestic goods transport.

Oil transport from the North Sea to Norway has grown dramatically, see figure 3.5, and by 1996 accounted for as large a volume as all other modes of goods transport together. Oil and gas transport totalled 18.5 billion tonne-km in 1996, and oil transport by ship accounted for 9.3 billion tonne-km of this, almost twice as much as in 1995. Gas and oil pipeline transport showed only small changes from the previous year.

A society's needs for transport services will inevitably alter with economic growth and change. Lorries appear to be best adapted to modern requirements and needs. Physical accessibility is important. Only lorries can transport goods from door to door without the need for expensive reloading. Time is also becoming an increasingly important consideration, partly because companies are minimizing their own stocks. As a result, smaller consignments are being sent more often. This increases the need for short-distance transport of small volumes, and lorries outcompete all other modes of transport over short distances. Studies carried out by the Institute of Transport Economics also show that lorries hold a strongly dominant position for transport distances of 30 to 150 km, despite the fact that for half the goods in the study, there were parallel rail or shipping routes. There is only any real competition for long-distance transport (more than 400 km), but even in this case lorries have a 50 per cent share of general cargo. Maritime transport has a particular advantage in cases where a low price per transport km is important and the transport time is less important, for example for bulk cargo.

Modern infrastructure is an essential prerequisite for effective transport. Road-building and improvement (higher permitted axle load) and the construction of bridges and tunnels have probably resulted in relatively greater improvements in infrastructure for road transport than for maritime and rail transport. Even though it is an express goal, both nationally and internationally, to promote intermodal transport, e.g. road/rail/road, all statistics both for Norway and for the rest of Europe show that goods transport by road is increasing. The inadequate capacity of the railway networks is presumably an important reason why rail transport has not gained a larger share of goods transport, particularly over long distances.

Although shipping accounts for a shrinking proportion of domestic transport, it dominates foreign-going transport. In 1996, shipping accounted for 72 per cent of total imports and exports, including oil transport from the North Sea to other countries. The total corresponded to 175 million tonnes, of which Norwegian ships carried 91 million tonnes. Goods transport by lorry (Norwegian and foreign) accounted for barely 3 per cent of the total or 6.6 million tonnes.

In the Government's Long-term Programme for 1998-2001 (Ministry of Finance 1997), it is assumed that the growth in goods transport in mainland Norway will be substantially lower in the period 1995-2010 than in the previous 15-year period (baseline alternative). The average annual growth rates in transport work for road and sea/rail in the period 1980-1995 were 4.3 per cent and 1.5 per cent respectively. From 1995 to 2010 inclusive, the projected average annual growth rate for road transport is 1.9 per cent, slightly lower than for sea/rail at 2.0 per cent. This is explained by the imposition of a CO_2 tax in addition to existing taxes. (The Long-term Programme 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.) The rate of growth in goods transport is expected to be about the same as for GDP. From 1995 to 1996, the general increase in goods transport work was between 2 and 3 per cent, and was somewhat weaker than the growth in GDP. However, goods transport by road rose by more than 10 per cent, and preliminary calculations show approximately the same rise from 1996 to 1997.

3.5. Emissions to air from transport

Holtskog and Rypdal (1997) discussed energy use and emissions to air from the commonest modes of transport. Calculations show that emissions of greenhouse gases per passenger-km are highest for local coastal services, and emissions per tonne-km (goods transport) are highest for air transport. These figures take into account actual utilization of capacity. See also Chapter 4 and Appendix, tables C5 and C6.

Documentation: Statistics Norway (1997b) and (1998b).

Further information may be obtained from: Jan Monsrud and Asbjørn Wethal.

4. Air

Emissions of pollutants to air cause some of the most serious environmental problems at both global and local level. Rising concentrations of greenhouse gases disturb the energy balance of the earth, causing positive radiative forcing (this is known as the enhanced greenhouse effect). Carbon dioxide (CO_2) is the greenhouse gas with the greatest overall impact on the earth's energy balance. According to the Kyoto Protocol, which is to be used as the basis for a worldwide agreement on greenhouse gas emissions, industrial countries are to cut their emissions by 5.2 per cent from 1990 levels during the period 2008-2012. However, Norway's emissions may rise by 1 per cent. Norwegian emissions of all greenhouse gases rose by 6.8 per cent from 1990 to 1996 as a result of large increases in emissions of CO_2 and methane. Emissions of these two gases rose further from 1996 to 1997.

Emissions of pollutants that cause injury to health dropped slightly from 1996 to 1997, with the exception of nitrogen oxides (NO_x). However, there have at times been high concentrations of pollutants such as particulate matter in the largest towns.

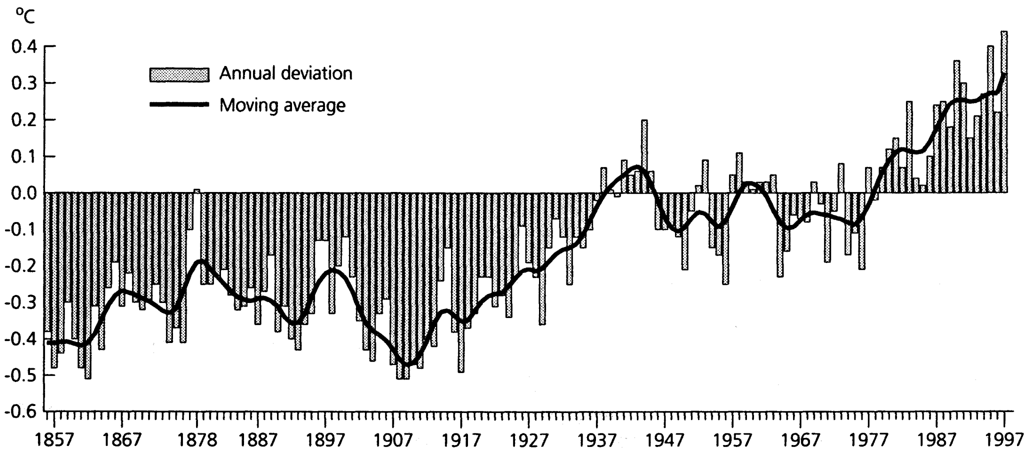
4.1. Introduction

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 most important components of such emissions are nitrogen oxides, particulate matter and volatile organic compounds. The major *regional* problems are acidification of water and soils and damage to vegetation, and the most important pollutants involved are sulphur dioxide, nitrogen oxides and ammonia. The *global* effects are depletion of the ozone layer and climate change. Compounds containing chlorine and bromine have the greatest impact on the ozone layer. Boxes 4.1 and 4.2 summarize the adverse effects of various air pollutants.

Global mean temperature

Many scientists view the possibility of climate change as a result of greenhouse gas emissions as the most serious environmental problem facing the world today. The most important measure of possible climate change is the global mean temperature, which has risen by 0.3-0.6° C during the past 100 years (figure 4.1). This is generally consistent with the trends predicted by climate models on the basis of rising concentrations of greenhouse

Figure 4.1. **Changes in global mean temperature compared with the normal value for 1961-1990**



Sources: University of East Anglia and Norwegian Meteorological Institute.

gases in the atmosphere. Nevertheless, the temperature rise is still within the limits that could be explained by natural variations. In 1997, the global mean temperature was 0.44° C higher than the average for 1961-1990. This was the warmest year since registration of the global mean temperature began in 1856 (Norwegian Meteorological Institute 1998). Calculations by the UN Intergovernmental Panel on Climate Change (IPCC 1996) 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 areas.

4.2. Trends in national emissions

Carbon dioxide (CO_2)

Norwegian emissions of the greenhouse gas carbon dioxide (CO_2) are rising, and according to preliminary figures, totalled 41.4 million tonnes in 1997. This is a rise of almost 17 per cent from 1990 (figure 4.2 and Appendix, table C1), which is the base year for the Kyoto Protocol. Norwegian emissions from practically all uses of fossil fuels have risen since 1990. The most important sources of CO_2 emissions in Norway are oil and gas production (21 per cent) and road traffic (21 per cent). From 1996 to 1997, CO_2 emissions rose by almost 1 per cent. Emissions were particularly high in 1996 because high electricity prices resulted in an extensive changeover from electricity to oil in manufacturing industries and other branches. Winter 1995-1996 was also cold in many parts of the country. In 1997, electricity prices were lower and the winter was mild, resulting in a reduction in fuel oil consumption. Nevertheless, consumption

Box 4.1. Harmful effects of air pollutants

Component	Important sources[1]	Effects
Ammonia (NH_3)	Agriculture	Contributes to acidification of water and soils.
Tropospheric ozone (O_3)	Formed by oxidation of CH_4, CO_2, NO_x and NMVOCs (in sunlight)	Causes respiratory complaints and vegetation damage. Recommended threshold value set by Norwegian Pollution Control Authority is 80 µg/m³ (8-hour mean).
Benzene (C_6H_6)	Combustion and evaporation of petrol and diesel, wood-firing	Carcinogenic, toxic effects on acute exposure to high concentrations.
Lead (Pb)	Road traffic, waste incineration, mineral production	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 (NMVOCs)	Oil and gas activities, road traffic, solvents	May include carcinogenic substances. Contribute to formation of tropospheric ozone.
Hydrofluorocarbons (HFCs)	Cooling fluids	Enhance the greenhouse effect.
Hydrochlorofluorocarbons (HCFCs)	Cooling fluids	Deplete the ozone layer.
Carbon dioxide (CO_2)	Combustion of fossil fuels, changes in land use and deforestation	Enhances the greenhouse effect.
Carbon monoxide (CO)	Combustion (wood-firing, road traffic)	Increases risk of heart problems in people with cardio-vascular diseases. Recommended threshold value set by Norwegian Pollution Control Authority is 10 mg/m³ (8-hour mean).
Chlorofluorocarbons (CFCs)	Cooling fluids	Deplete the ozone layer.
Nitrous oxide (N_2O)	Agriculture, fertilizer production	Enhances the greenhouse effect.
Methane (CH_4)	Agriculture, landfills, production and use of fossil fuels	Enhances the greenhouse effect and contributes to formation of tropospheric ozone.
Nitrogen oxides (NO_x)	Combustion (industry, road traffic)	Cause respiratory disease (particularly NO_2). Maximum concentrations recommended in Norwegian air quality guidelines are 75 µg/m³ (24 hour-mean) and 50 µg/m³ (six-monthly mean). Contribute to acidification, corrosion and formation of tropospheric ozone.
Perfluorocarbons (PFCs: CF_4 and C_2F_6)	Aluminium production	Enhance the greenhouse effect.
Polycyclic aromatic hydrocarbons (PAHs)	All incomplete combustion of organic material and fossil fuels	Several are carcinogenic.
Particulate matter ($PM_{2.5}$ and PM_{10})	Road traffic and wood-firing	PM_{10}: particle diameter less than 10 µm, $PM_{2.5}$: particle diameter less than 2.5 µm. Increase risk of respiratory complaints together with other components. Maximum concentrations recommended in Norwegian air quality guidelines are 35 µg/m³ (PM_{10}) 24-hour mean and 20 µg/m³ ($PM_{2.5}$) 24-hour mean. The $PM_{2.5}$ value is under revision.
Sulphur dioxide (SO_2)	Combustion, metal production	With other components, increases the risk of respiratory disease. Acidifies soil and water and causes corrosion. Recommended threshold values set by Norwegian Pollution Control Authority are 90 µg/m³ (24-hour mean) and 40 µg/m³ (six-monthly mean).
Sulphur hexafluoride (SF_6)	Magnesium production	Enhances the greenhouse effect.

[1] The table indicates important anthropogenic sources. There are also major natural sources for several of these components.
Sources: Norwegian Institute for Air Research 1996a and 1996b), Norwegian Pollution Control Authority (1992 and 1993), IPCC (1996) and Norwegian Institute for Water Research/Norwegian Institute for Air Research (1995).

Box 4.2. Environmental problems caused by air pollution

Enhanced greenhouse effect	As a result of the natural greenhouse effect, the global mean temperature is about 15°C instead of -18°C. But anthropogenic emissions of gases such as CO_2, CH_4, N_2O and fluorine-containing gases can cause further warming. 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 CO_2 is absorbed by sinks, which may be natural (e.g. forest, oceans, sediments) or anthropogenic (e.g. buildings, furniture, paper). In 1995, the natural sink in Norwegian forests was estimated to be 13.6 million tonnes CO_2 per year, which corresponds to about one third of total anthropogenic emissions in 1995 (Ministry of the Environment 1997a).
Climate change	Anthropogenic emissions of greenhouse gases, SO_2 and particulate matter can alter the natural composition of the atmosphere. 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 (IPCC 1996). (For variations in global mean temperature, see figure 4.1).
Depletion of the ozone layer	The atmospheric ozone layer is found in the stratosphere, 10-40 km above the earth, and prevents harmful ultra-violet (UV) radiation from the sun from reaching the surface of the earth. Episodes when the ozone content of the stratosphere is very low and the levels of UV radiation reaching the earth are high have been observed above Antarctica. Observations have also shown that the ozone content of the stratosphere above middle latitudes dropped by about 3 per cent in the 1980s (UNEP 1993). The causes of ozone depletion include anthropogenic emissions of CFCs, HCFCs, halons and other gases containing chlorine and bromine, all of which can break down ozone in the presence of sunlight. 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 (SSB/SFT/DN 1994). (For imports of ozone-depleting substances to Norway, see figure 4.7).
Formation of tropospheric ozone	Tropospheric ozone is formed by oxidation of CH_4, CO, NO_x and NMVOCs in the presence of sunlight. It may also be transported to Norway from other parts of Europe. In 1996 there were more pollution episodes[1] (26 days) than the average for the 10-year period 1986-1995 (19.1 days). The highest hourly mean concentration in 1996 was 172 $\mu g/m^3$ (Norwegian Pollution Control Authority 1997). No measuring station recorded above 180 $\mu g/m^3$, which is the EU population warning threshold (recommended threshold value in Norway is 100 $\mu g/m^3$).
Acidification	Total emissions of SO_2 and NO_x are lower in Norway than in most other European countries. Sulphur and nitrogen tend to acidify soils and water, and are also transported for considerable distances with air currents. The extent of the damage depends on the type of soil and vegetation. Lime-rich soil can for example withstand acidification better than other soil types because it weathers to release calcium. Many parts of Norway have lime-poor soils and sensitive vegetation, and the impact of acid rain is greater than in many other areas where deposition of acid components is higher. Fresh-water organisms have suffered the most serious damage, and the effects have been observed particularly in Southern Norway, the southern parts of Western Norway, and Eastern Norway. Sør-Varanger municipality in Finnmark suffers the effects of acid rain from sources in Russia. Acid rain increases leaching of nutrients and metals (especially aluminium) from soils and can cause corrosion damage to buildings. (For deposition of sulphur and nitrogen compounds in Norway, see Appendix, tables C10-C12 and Chapter 4.2).

[1] Number of days when one measuring station records a maximum hourly mean concentration of 200 $\mu g/m^3$ or several measuring stations record an hourly mean concentration of more than 120 $\mu g/m^3$.
Sources: IPCC (1996), Ministry of the Environment (1997a), Norwegian Pollution Control Authority (1997).

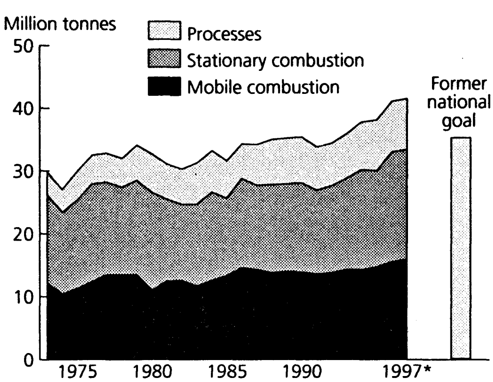
Box 4.3. Sources of emissions

Stationary combustion includes emissions from all combustion of energy commodities in various types of stationary sources. The most important of these are direct-fired furnaces where combustion of energy commodities provides heat for an industrial process, boilers where energy commodities are used to heat water to form steam, small stoves that use oil or wood to heat housing, or flaring (combustion of energy commodities without using the energy).

Mobile combustion includes emissions from all combustion of energy commodities in various modes of transport and mobile motorized equipment.

Processes includes all emissions not related to combustion. They include industrial processes, evaporation and biological processes, emissions from livestock, evaporation during petrol distribution, fermentation processes in the food processing industry, emissions from fertilizers and landfills, evaporation during use of solvents and particulate matter from road dust. Coal and coke used as reducing agents in metal production are included, but dust from industrial processes is not included in the calculations.

Figure 4.2. **Emissions of CO_2 by source**



Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

remained higher than in 1995. Despite the drop in fuel oil consumption, emissions from stationary combustion in 1997 were almost unchanged from the year before. One reason why there was no reduction in emissions was that consumption of gas and coal as fuel in the industrial sector rose in 1997 because production was higher in certain branches of industry.

Emissions from oil and gas production rose by 5.5 per cent from 1996 as a result of an increase in gas production. Emissions from mobile sources rose by 2 per cent from 1996 to 1997. The growth in emissions was largest for oil drilling, domestic shipping and air transport. Emissions from air transport rose by 8 per cent. This can be explained by the growth in scheduled traffic from Norway's largest airports. Emissions from oil drilling rose by 35 per cent as a result of a higher level of activity. Overall process emissions of CO_2 were more or less unchanged from 1996 to 1997.

Projections indicate that Norwegian CO_2 emissions will rise by about 42 per cent from 1990 to 2010 (see table 4.1). The most important reason for this rise is the growth in emissions from the petroleum sector. In addition, emissions from the transport sector and from the use of fuel oil are expected to rise (Ministry of the Environment 1998).

Methane (CH_4)

Methane emissions rose by about 11 per cent from 1990 to 1997, largely because of an increase in the amount of waste landfilled (see Chapter 5). The extraction of methane from landfills has limited the rise in these emissions. In 1996, methane emissions from landfills were reduced by 5 per cent in this way. The agricultural sector (domestic animals and manure) is

Box 4.4. GWP – Global Warming Potential

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 are used to convert emissions of greenhouse gases to CO_2 equivalents.

also an important source of Norwegian methane emissions. In 1997, methane emissions from biodegradation of waste accounted for 67 per cent of the total, and domestic animals and manure accounted for 22 per cent.

Nitrous oxide (N_2O)

Agriculture and the manufacture of commercial fertilizer are important sources of nitrous oxide emissions. These emissions were reduced by about 1 per cent from 1990 to 1997 as a result of technical improvements in fertilizer manufacture. However, there is a large degree of uncertainty associated with the level of emissions from the agricultural sector.

Other greenhouse gases

Emissions of PFCs (CF_2 and C_2F_6) and SF_6 were reduced by 50 and 76 per cent respectively from 1990 to 1996, mainly as a result of wide-ranging measures to reduce emissions from the process industry.

Emissions of hydrofluorocarbons (HFCs) rose by almost 70 per cent from 1990 to 1996, but these gases only constitute a very small proportion of total greenhouse gas emissions in Norway. HFC emissions are expected to rise in the next few years, mainly as a result of efforts to phase out CFCs and HCFCs. HFCs are being substituted for these substances in cooling equipment.

Table 4.1. **Norwegian emissions of greenhouse gases in 1990, 1996 and projections[1] for 2010. Million tonnes CO_2 equivalents**

	1990	1996	2010	% change 1990-2010
CO_2	35.5	41.1	50.6	42
CH_4	9.3	10.2	8.2	-12
N_2O	5.7	5.6	5.8	2
PFCs	2.5	1.3	1.2	-52
SF_6	2.2	0.5	0.5	-77
HFCs	0.0	0.3	1.8	..
Sum	55.2	58.9	68.1	23

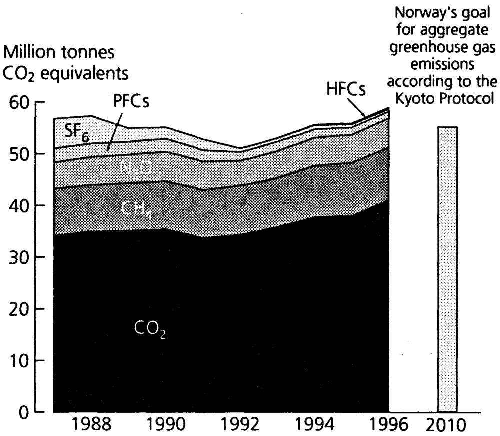
[1] The projections for emissions up to 2010 are based on the assumption that no new measures other than those already adopted will be introduced. It is also assumed that two gas-fired power plants will be built. For further details on the assumptions on which these figures are based, see Ministry of the Environment (1998).
Source: Ministry of the Environment (1998).

Total emissions of greenhouse gases

To allow a comparison of the extent to which different gases may enhance the greenhouse effect, their emissions are converted to CO_2 equivalents using GWP values (see box 4.4). In 1996, emissions of greenhouse gases in Norway totalled 59 million tonnes CO_2 equivalents (see figure 4.3 and Appendix, tables C1 and C3). This corresponds to a rise of about 7 per cent since 1990. From 1995 to 1996, total emissions rose by 5 per cent. Some of the rise can be attributed to the growth in oil consumption in manufacturing and other industries. Projections for the year 2010 suggest that emissions will total 68 million tonnes CO_2 equivalents (Ministry of the Environment 1998). This is 13 million tonnes CO_2 equivalents more than in 1990 (see table 4.1).

According to the December 1997 Kyoto Protocol, the industrial countries are to reduce their aggregate emissions of greenhouse gases by 5.2 per cent compared with the 1990 level between 2008 and 2012. Norway is one of the few countries

Figure 4.3. **Emissions of greenhouse gases in Norway**



Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority, IPCC (1996).

where a rise in total greenhouse gas emissions is permitted, in Norway's case by 1 per cent compared with the 1990 level. According to the Protocol, fixation of CO_2 by trees planted after 1990 on areas that were not previously forested, minus CO_2 emissions as a result of deforestation, may be subtracted from total CO_2 emissions. This is only expected to give a very small deduction from Norway's emissions. The large increase in the growing stock of forest in Norway is an important CO_2 sink, but may not be deducted from Norway's emissions because it is regarded as part of the natural increment.

The Kyoto Protocol provides for emissions trading between industrial countries using their allocated emissions quotas. Further details of the guidelines for conditions for such emissions trading will be discussed at the next Conference of the Parties in Buenos Aires in autumn 1998. Norway has recently entered into an agreement with China to contribute NOK 35 million to the improvement and modernization of a

Box 4.5. 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:

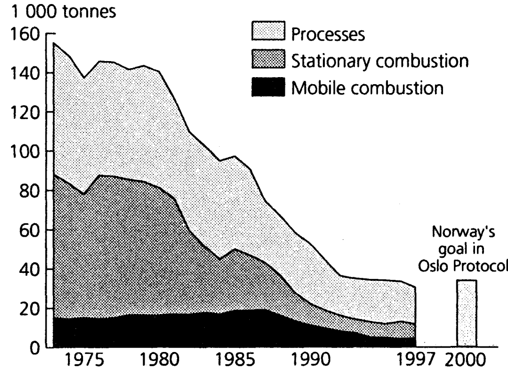
Sofia	Stabilization of NO_x emissions at the 1987 level by 1994.
Montreal	Eliminate consumption of ozone-depleting substances. In Norway, this means eliminating imports, since the country does not manufacture such substances. Most subtances have already been phased out, and the rest (HCFCs and methyl bromide) will be phased out in the next 15-30 years.
Genèva	30 per cent reduction of NMVOC emissions between 1989 and 1999. Applies to the mainland and the Norwegian 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.
Kyoto	Industrial countries are to reduce their overall greenhouse gas emissions by 5.2 per cent from 1990 levels during the period 2008-2012. Norway's emissions may rise by 1 per cent from the 1990 level. The agreement applies to CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. For the last three, parties may choose between 1990 and 1995 as the base year. Fixation of CO_2 in forests as a result of afforestation and reforestation since 1990 may be deducted from emissions. This will probably make only a small contribution in Norway. Further details will be decided at the coming Conference of the Parties in Buenos Aires 2-13 November 1998. The agreeement enters into force when it has been ratified by at least 55 countries which account for at least 55 per cent of total CO_2 emissions from industrial countries.

large coal-fired power plant. This will improve its energy efficiency and thus reduce CO_2 emissions (Cutter 1998). Norway, like a number of other industrial countries, has drawn up such agreements in the hope that the resulting emission reductions will be approved under the Kyoto Protocol.

A central element in implementation of the Kyoto Protocol in Norway is the Report to the Storting describing national measures that will be necessary to ensure that Norway meets its commitment. The Report to the Storting was submitted in spring 1998, and should be considered in conjunction with the new Report to the Storting on green taxes.

The CO_2 tax that was introduced in 1991 is Norway's most important climate policy instrument. Since 1991, the tax base has been expanded several times, and the tax now applies to almost 60 per cent of all CO_2 emissions, or 40-45 per cent of Norway's overall greenhouse gas emissions. Further expansion of the tax base will be an important instrument for the reduction of CO_2 emissions. Other instruments proposed to reduce greenhouse gas emissions are energy taxes, a tax on the final disposal of waste and licensing requirements under the Pollution Control Act (Ministry of the Environment 1998).

Figure 4.4. **Emissions of SO_2 by source**



Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

Sulphur dioxide (SO_2)

Norwegian emissions of sulphur dioxide (SO_2) were reduced by 80 per cent from 1973 to 1997 (figure 4.4), and by 78 per cent from 1980 to 1997. Both the goal set out in the Helsinki Protocol (30 per cent reduction from 1980 to 1993) and Norway's national goal (50 per cent reduction from 1980 to 1993) have thus been achieved. The Helsinki Protocol was renegotiated in summer 1994, and is now known as the Oslo Protocol. In this Protocol, Norway has undertaken to reduce its SO_2 emissions by 76 per cent from 1980 to 2000 (box 4.5). The drop in SO_2 emissions from combustion can be explained by a changeover to the use of electricity, the use of lighter oil products, a reduction in the sulphur content of oil products, and the installation of more and better equipment to control emissions. About 62 per cent of Norway's SO_2 emissions in 1997 were generated by industrial processes, particularly the manufacture of metals. The drop in process emissions has been particularly marked since the 1980s, mainly as a result of requirements to install equipment to control emissions at a number of plants and the closure of some of the plants that generated most pollution. Since 1975, Norway has used taxes on the sulphur content of oil products as an instrument for the reduction of SO_2 emissions (Statistics Norway 1997a). The tax rates have gradually been increased.

In 1996, sulphur deposition over Norway totalled slightly more than 80 000 tonnes.

Box 4.6. Emissions from gas-fired power plants

Naturkraft AS, which is owned by Norsk Hydro, Statkraft and Statoil, has received permission to start the construction of two gas-fired power plants in Norway, one at Kollsnes in Hordaland and one at Kårstø in Rogaland. The Norwegian Pollution Control Authority has received an application for discharge permits. Each of the two plants will have an installed capacity of 350 MW and a production capacity of about 2.8 TWh per year. Power from Norwegian gas can 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. The table below shows comparative figures from the Ministry of Industry and Energy for the efficiency of gas- and coal-fired power plants.

Table 4.2. **Efficiency[1] of gas- and coal-fired power plants and emissions 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

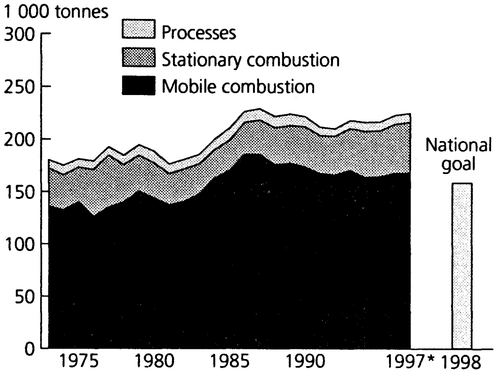
[1] Efficiency is a measure of the proportion of the energy supplied e.g. in the form of coal or gas actually converted to electrical energy.
Source: Ministry of Industry and Energy (1996).

This is more than 17 000 tonnes less than in 1995 (Appendix, table C12). About 3 200 tonnes of the total originates from Norwegian emissions, and 5 100 tonnes from sea water and other natural sources. Other large sources in 1996 were the United Kingdom (8 100 tonnes), Germany (8 300 tonnes) and Eastern Europe, Russia and the Baltic states (12 700 tonnes). About 35 000 tonnes of the total originates from unidentified sources. Of Norway's own sulphur emissions, a large proportion (about 48 per cent) was deposited over the North Sea and North Atlantic, and about 40 per cent in Sweden and over Norwegian territory. From 1985 to 1996, sulphur deposition over Norway was reduced by about 50 per cent as a result of reductions in emissions in Europe (Berge 1997).

Nitrogen oxides (NO_x)

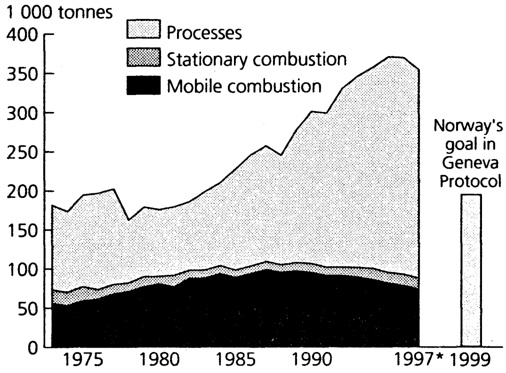
Emissions of nitrogen oxides (NO_x) are generated mainly by shipping, road traffic and oil and gas extraction. The growth in the use of private cars resulted in a steep rise in NO_x emissions until 1987 (figure 4.5). After this, emissions dropped somewhat until 1992, and then rose again. Preliminary figures for 1997 show that emissions rose by 1 per cent from 1996 (Appendix, table C2). Emissions from road traffic dropped by almost 9 per cent from 1996 to 1997, while emissions from shipping rose by a similar amount in the same period. All new cars now have three-way catalytic converters, which reduce NO_x emissions. High sales of new cars in 1996 and 1997, together with the large number of older cars scrapped in 1996, have brought down the average age of private cars. This may explain the reduction in emissions from road traffic in 1997. In 1997, 39 per cent of private cars were

Figure 4.5. **Emissions of NO_x by source**



Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

Figure 4.6. **Emissions of NMVOCs by source**



Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

fitted with three-way catalytic converters, as compared with 24 per cent in 1995 and 31 per cent in 1996.

Norway has achieved the goal of the Sofia Protocol, which was to stabilize NO_x emissions at the 1987 level by 1994. 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. However, the reduction achieved so far is less than 1 per cent. A new NO_x protocol is now being negotiated within the framework of the ECE Convention on Long-range Transboundary Air Pollution (ECE: UN Economic Commission for Europe). This will probably set out goals for emissions based on critical loads for acid rain and tropospheric ozone.

Total deposition of reduced nitrogen (e.g. ammonia) and oxidized nitrogen (e.g. nitrogen oxides) over Norway in 1996 was 96 200 tonnes (see Appendix, tables C10 and C11). This is a lower figure than in 1995. Of this, 21 000 tonnes originated from Norwegian emissions, and emissions from the United Kingdom and Germany together accounted for a further 19 300 tonnes (Berge 1997).

NMVOCs

Emissions of non-methane volatile organic compounds (NMVOCs) have risen steeply since the late 1970s (figure 4.6). The most important sources in Norway are evaporation during loading of crude oil (53 per cent in 1996) and emissions from petrol engines (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 petrol consumption. Emissions of NMVOCs dropped by 4 per cent from 1996 to 1997. Norway has undertaken to reduce these emissions by 30 per cent by 1999, using 1989 as the base year. Despite this, emissions have risen by 27 per cent since 1989. Most of the rise is explained by an increase in the volume of crude oil loaded on tankers at offshore installations and oil terminals. The reduction from 1996 to 1997 is explained by a reduction in the average age of cars and the introduction of a recovery facility for oil vapour at one of the terminals. The emission figures suggest that it will be difficult to achieve a 30 per cent reduction within the time limit. However, it may be possible to achieve this goal at a later date by implementing measures to recover oil vapour during loading and unloading from all crude oil ships at Norwegian continental shelf and the terminals, and at refineries and larger petrol stations, in combination with an increase in the proportion of cars fitted with three-way catalytic converters. A new NMVOC protocol is now being negotiated.

Ammonia (NH_3)
Emissions of ammonia (NH_3) rose by 14 per cent from 1990 to 1997. Ammonia emissions are generated mainly by commercial fertilizer and manure and by treatment of straw with ammonia.

Carbon monoxide (CO)
Carbon monoxide (CO) emissions rose from 1973 to the mid-1980s. However, there has been a marked drop after this. From 1990 to 1997, total emissions were reduced by almost 22 per cent, with a reduction of nearly 7 per cent from 1996 to 1997. The reduction since 1990 has been largely in emissions from mobile sources, and is mainly a result of improvements in technology and lower petrol consumption. In 1997, emissions from petrol engines and heating of dwellings accounted for 55 and 23 per cent, respectively, of total CO emissions.

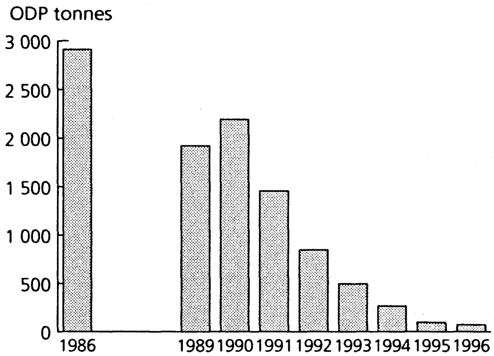
Particulate matter (PM_{10})
Emissions of particulate matter from stationary combustion were considerably reduced from 1973 to 1983. This can be explained by the drop in the use of heavy fuel oil for heating. However, from 1990 to 1997 emissions from stationary combustion rose by 11 per cent. Emissions from heating in private households rose by 22 per cent in this period, and accounted for 58 per cent of total emissions in 1997. Emissions of asphalt dust from the use of studded tyres, which have previously not been included in these figures, accounted for 7 per cent of the total. Emissions from processes (manufacturing, etc.) are not included in the calculations of total emissions.

Lead (Pb)
Emissions of lead have been reduced by 99 per cent from 1973 to 1996. In 1997, no leaded petrol was sold in Norway. Lead pollution in air is now well below the level believed to cause injury to human health. From 1990 to 1996 total emissions were reduced by 96 per cent. About 56 per cent of total lead emissions can be traced back to mobile combustion sources, and 22 per cent to stationary combustion sources.

Cadmium (Cd)
Emissions of cadmium dropped by 45 per cent from 1991 to 1996. Metal manufacturing accounted for the largest proportion of emissions in 1996. The reduction in emissions in this period was also largest in this sector (67 per cent).

Ozone-depleting substances
The consumption of ozone-depleting substances (HCFCs, CFCs and other gases containing chlorine and bromine) in Norway has dropped since the mid-1980s (figure 4.7). Most of these substances are used in products (e.g. fridges) which eventually result in emissions to air. There is a time lag between consumption and the resultant emissions. Only small amounts are collected and destroyed. In accordance with the revised Montreal Protocol, Norway has eliminated imports 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

Figure 4.7. **Import of ozone-depleting substances**



Source: Norwegian Pollution Control Authority.

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 (1996a).

Measurements of the thickness of the ozone layer have been made in Norway since the mid-1930s. In the period 1979-1996, the ozone layer was depleted by an average of 0.4 per cent per year, and there has been no decrease in the rate of depletion. The most marked ozone depletion episodes occur in March-April. Reductions of up to 30 per cent in the amount of ozone have been registered in Norway (Norwegian Institute for Air Research 1996c). The thickness of the ozone layer is measured daily in Oslo, Tromsø, Andøya and Ny-Ålesund (Svalbard) by the Norwegian Institute for Air Research and the Universities of Oslo and Tromsø.

Emissions in other countries

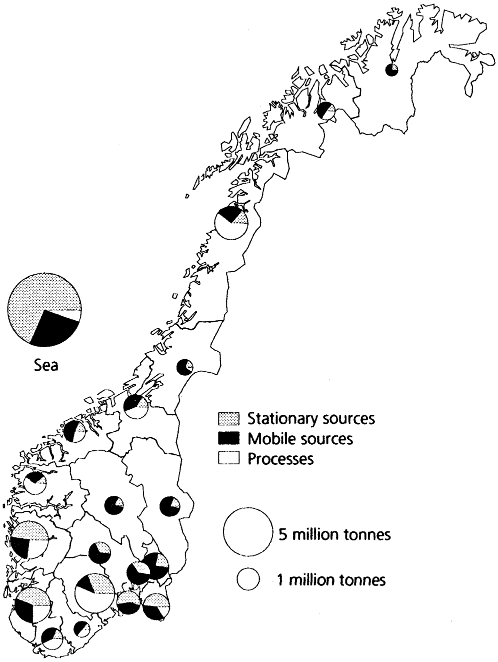
In the OECD countries, there has been a slight overall rise in CO_2 emissions during the period 1980-1995. CO_2 emissions per unit GDP (kg per USD 1 000) and per capita CO_2 emissions in Norway are lower than the average for all OECD countries (Appendix, table C9). This is mainly because hydroelectricity accounts for a large proportion of energy use in Norway. However, average per capita emissions for the world as a whole (including developing countries) are only half the Norwegian level. The production of electricity 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.

4.3. Emissions by county

Telemark and Hordaland are the counties with the highest CO_2 emissions (figure 4.8). 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.

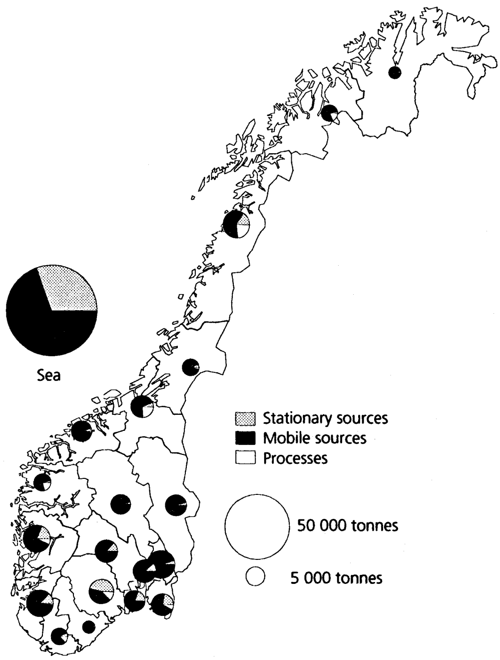
CO_2 emissions are high at sea, where almost one third of Norway's total emissions are generated (figure 4.8 and Appendix, table C7). Emissions at sea also make the largest regional contribution to Norwegian emissions of NO_x and NMVOCs. Shipping is the main source of NO_x, while loading of crude oil on tankers offshore is the most important source of NMVOC emissions.

Figure 4.8. **CO_2 emissions in 1995 by source and county**



Digital map data: Norwegian Mapping Authority.
Sources: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Figure 4.9. **NO_x emissions in 1995 by source and county**



Digital map data: Norwegian Mapping Authority.
Sources: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

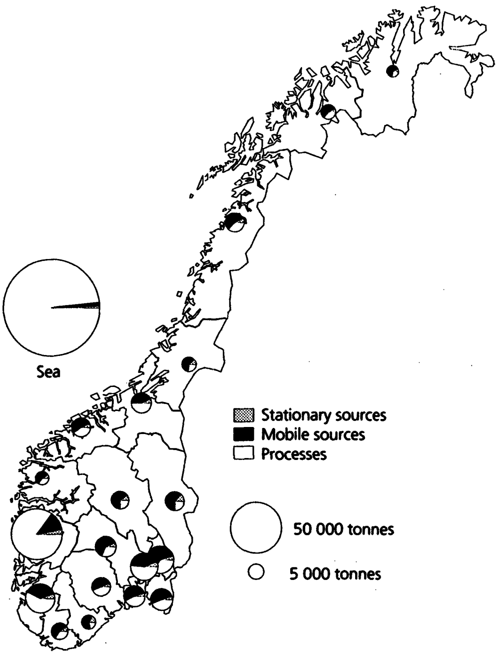
CH_4 and NH_3 emissions are highest in Rogaland, mainly because the county has large numbers of livestock and therefore large amounts of manure. On Svalbard, the coal mines are a major point source of CH_4 emissions. Process emissions from the manufacture of fertilizer in Telemark and Nordland account for 30 per cent of the country's total emissions of N_2O.

Østfold, Nordland, Aust-Agder and Sør-Trøndelag account for the largest SO_2 emissions from the mainland (Appendix, table C7). The manufacture of ferro-alloys and chemical industry are the main sources. In all counties, NO_x emissions are dominated by mobile sources (figure 4.9); 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, Telemark is also among the counties with the highest NO_x emissions.

Hordaland alone accounts for 27 per cent of total mainland emissions of NMVOCs (figure 4.10). The main sources are process emissions from loading of crude oil and oil refining.

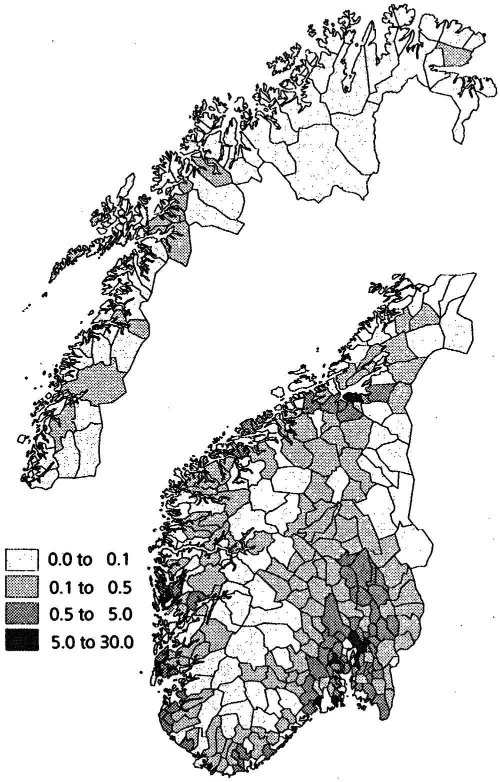
CO emissions are highest in Akershus, largely as a result of road traffic. Emissions of particulate matter are highest in Hordaland, which is followed by Hedmark, Akershus and Rogaland. The main sources are wood-firing and road traffic.

Figure 4.10. NMVOC emissions in 1995 by source and county



Digital map data: Norwegian Mapping Authority.
Sources: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Figure 4.11. NO_x emissions by municipality in 1995. Tonnes per km²



Digital map data: Norwegian Mapping Authority.
Sources: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

4.4. Emissions by municipality

In 1995, the municipalities of Oslo, Porsgrunn and Bergen accounted for the largest NO_x emissions, and emissions exceeded 4 000 tonnes in Oslo and Porsgrunn. If emissions per km² are compared, we find the highest values in Porsgrunn, Stavanger and Oslo (figure 4.11). As a general rule, emissions per km² are highest in municipalities with a high population density and where there are national highways.

Per capita NO_x emissions were highest in Tysfjord, followed by Sørfold, Bremanger 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 the Appendix shows emissions to air by municipality, and references for the calculation method are given in box 4.7. Emissions are calculated for the same number of components at municipal and national level.

4.5. 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_x, CO and particulate matter (the term particulate

Box 4.7. Emissions to air by municipality

These figures include emissions to Norwegian territory from international maritime and air transport and domestic activities in Norway. The figures for national emissions, on the other hand, only include domestic activities in Norway. The methods used to calculate emissions to air are described in Rypdal (1993 and 1995), Daasvatn et al. (1994) and Norwegian Pollution Control Authority (1998a). Emission figures may be found on Statistics Norway's website (www.ssb.no).

matter is used here as a synonym for PM_{10}, i.e. particles with a diameter less than 10 μm). Particulate matter from wear of asphalt (road dust) is most important locally when the roads are dry in the winter months, when the use of studded tyres is permitted. However, wood firing in private households may also make a significant contribution to the PM_{10} concentration. Industrial installations are the most important source of high SO_2 concentrations. In municipalities with major ports, shipping is also an important source of SO_2 and NO_x emissions.

Air quality in Oslo

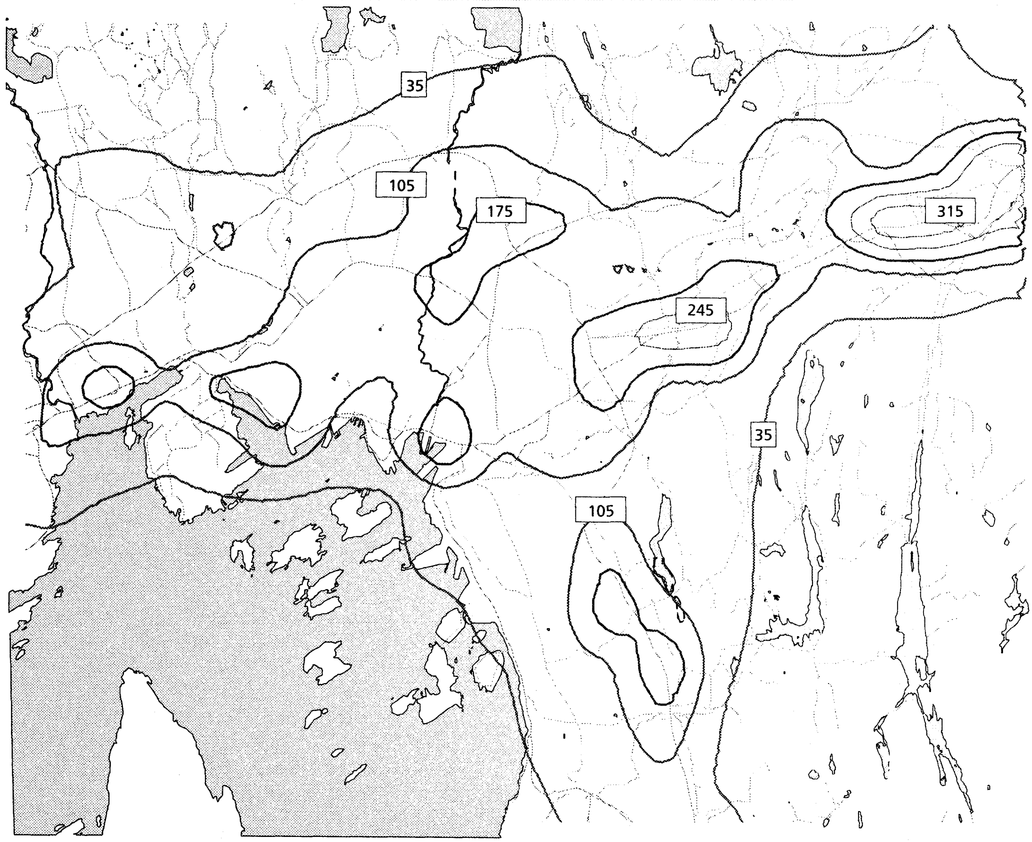
There has been frequent coverage of air quality in Oslo in both local and national Norwegian newspapers recently. The concentrations of pollutants specified in the authorities' recommended air quality guidelines have been exceeded several times in recent winters, and a large number of people are exposed to harmful substances. This section deals with conditions in Oslo, but other larger towns such as Bergen and Drammen have the same problems.

Air quality depends on topography and weather conditions in addition to the amounts of pollutants released. When air pressure is high and the weather is cold and clear, there is little air movement and dispersion conditions are poor. Cold air sinks towards the ground and a temperature inversion develops: the temperature increases with altitude in the lowest 50-200 m of the air masses. Under such conditions, the concentrations of air pollutants may continue to rise until the air masses are replaced, for instance by wind. Temperature inversions frequently develop in Oslo during the winter.

PM_{10}, NO_x, SO_2 and ozone (O_3) are the most important air pollutants in a description of air quality, see box 4.1. In Oslo, SO_2 is no longer regarded as a problem with respect to air quality because coal and coke are not used for heating today and because the sulphur content of most energy commodities has been reduced in recent decades. Road traffic (exhaust particles and road dust) and wood firing in private households are the most important sources of pollution by particulate matter in Oslo. Measurements made by the municipal authorities in winter 1996-97 show that the concentration of PM_{10} is not always lower at weekends, when road traffic is less heavy (Miljø- og næringsmiddeletaten 1997). This shows that air quality is also dependent on weather conditions and that other major sources of particulate matter such as wood firing may also be of importance when there is less traffic.

Calculations by Statistics Norway show that in 1995, emissions of particulate matter in Oslo totalled 1 609 tonnes. Of this, 1 057 tonnes was generated by heating in private households, mainly by wood firing. Emissions of particulate matter from wear of asphalt totalled 162 tonnes, and emissions from exhaust 262 tonnes. Emissions from heating in private households thus accounted for almost 66 per cent of total emissions of particulate

Figure 4.12. **Calculated concentration of particulate matter (PM_{10}) in Oslo on the most heavily-polluted day of the year (assuming that roads are dry and there is a temperature inversion and little wind). µg/m³**



[1] Maximum concentration of PM_{10} according to recommended air quality guidelines is 35 µg/m³. The (isoconcentration) lines are drawn at 1, 3, 5, 7 and 9 times this concentration.
Source: Oslo City Department of Environmental Health and Food Control.

matter in Oslo in 1995, and road dust for only 10 per cent. Nevertheless, road dust is the most important component of these emissions during certain periods. This is because emissions of road dust directly to the air take place only during the months when the use of studded tyres is permitted, and mainly when the roads are dry. Emissions from wear on roads are thus concentrated to a few episodes during each winter when road dust contributes significantly to the total concentration of particulate matter. Furthermore, emissions of road dust take place at ground level, where people are exposed directly, whereas particulate matter from wood firing is released some metres above ground. This means that on certain days, emissions of road dust contribute more to the concentration of particulate matter at ground level than emissions from heating, even though overall emissions from heating are larger. The Norwegian Institute for Air Research has calculated that on the five days when the mean concentration of PM_{10} was highest at four measuring stations in Oslo, dust worn off and whirled up from roads accounted for 84-92 per cent of the total PM_{10} concentration, and 60-78 per cent of $PM_{2.5}$ (Larssen and Hagen 1997).

Figure 4.12 shows the calculated 24-hour mean concentration of particulate matter (PM_{10}) over Oslo on a winter's day when the roads are dry and there is a temperature inversion and little wind. The emission data used are from 1994, and it is assumed that 20 per cent of the vehicles were using winter tyres without studs. The Oslo City Department of Environmental Health and Food Control estimates that there is one day each winter when concentrations are as high as this (i.e. an extreme situation). The concentrations are drawn at 1, 3, 5, 7 and 9 times the concentration of PM_{10} specified in the recommended air quality guidelines issued by the Norwegian Pollution Control Authority and the National Institute of Public Health (a 24-hour mean of 35 $\mu g/m^3$). The figure shows that under these conditions, the highest concentrations are generally found along the main roads where traffic is heaviest. The highest concentration shown on the map is nine times higher than the recommended maximum. The high concentrations found under conditions like those shown in figure 4.12 are mainly due to wear and tear on asphalt and road dust raised by the traffic. Emissions of road dust are proportional to the square of the vehicle's speed, and the high average speed of vehicles on some of the main roads thus contributes directly to the high level of emissions.

Wood firing accounted for almost 48 per cent of total emissions of particulate matter (including emissions related to the use of studded tyres) in Oslo in 1994. Figure 4.13 shows emissions from wood

Box 4.8. Calculation of air pollution per basic unit

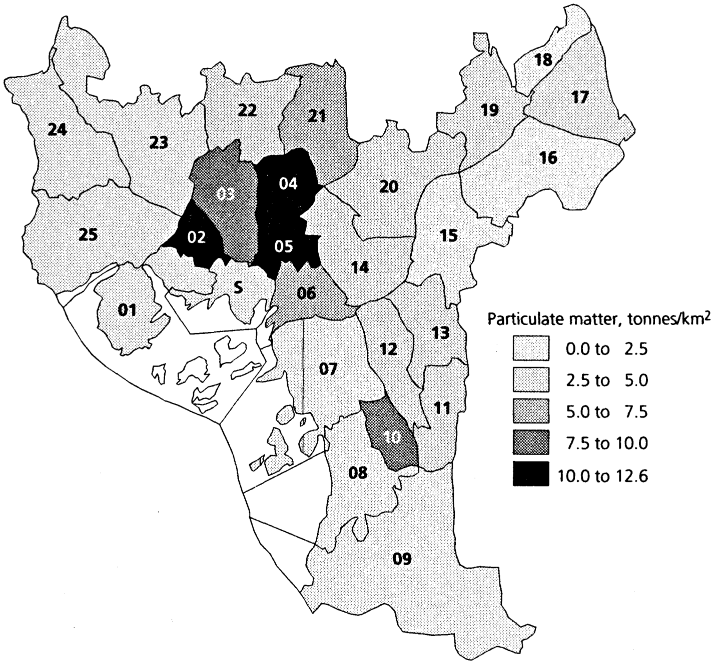
Statistics Norway calculates emissions to air per basic unit in 11 Norwegian municipalities (Flugsrud et al. 1996) for the Norwegian Pollution Control Authority. Basic units are the smallest geographical unit Statistics Norway uses for statistical purposes, and an urban district consists of several basic units. In 1994, emissions were calculated in the following municipalities: Oslo, Bergen, Trondheim, Drammen, Skien, Porsgrunn, Sarpsborg, Fredrikstad, Lier, Nedre Eiker and Bærum.

Figures are obtained from a model that calculates emissions of 11 components per municipality in Norway. The figures are divided into three main groups: stationary combustion (e.g. heating in housing and offices), process emissions (e.g. petrol distribution, solvents) and mobile sources (e.g. road traffic, shipping). Emissions are allocated to basic units using various methods (Flugsrud et al. 1996).

Emissions per basic unit are used in the air quality model AirQUIS (Air Quality Information System). AirQUIS was developed by the Norwegian Institute for Air Research. The Oslo City Department of Environmental Health and Food Control uses AirQUIS for daily monitoring of air quality and in impact assessment to evaluate measures to combat pollution. Figure 4.12 was drawn up using AirQUIS.

firing in that year in urban districts of Oslo, expressed as tonnes/km². From the map, it can be seen that emissions per unit area are highest in Uranienborg-Majorstua (2), Grünerløkka-Sofienberg (5) and Sagene-Torshov (4). One of the concentration maxima in figure 4.12 is also centred on urban district no. 4. These three districts have a large proportion of older town housing where wood can be used for heating, and are also the districts where

Figure 4.13. **Emissions of particulate matter from wood-firing in private households for urban districts in Oslo. Tonnes/km² in 1994**



Urban district no.	Name
1	Bygdøy-Frogner
2	Uranienborg-Majorstuen
3	St. Hanshaugen-Ullevål
4	Sagene-Torshov
5	Grünerløkka-Sofienberg
6	Gamle Oslo
7	Ekeberg-Bekkelaget
8	Nordstrand
9	Søndre Nordstrand
10	Lambertseter
11	Bøler
12	Manglerud
13	Østensjø
14	Helsfyr-Sinsen
15	Hellerud
16	Furuset
17	Stovner
18	Romsås
19	Grorud
20	Bjerke
21	Grefsen-Kjelsås
22	Sogn
23	Vindern
24	Røa
25	Ullern
S	Sentrum

Source: Material from Statistics Norway.

population density is highest. The urban districts where PM_{10} emissions of this type have least impact are Sentrum (S), Søndre Nordstrand (9) and Bygdøy-Frogner (1). In urban district no. 1, the low average level of emissions is explained by the large area of park and woodland on the Bygdøy peninsula.

The municipal authorities and the Oslo division of the Public Roads Administration measured PM_{10} concentrations at two measuring stations in Oslo in winter 1996-97 (Miljø- og næringsmiddeletaten 1997). At station A, the threshold limit for PM_{10} given in the recommended air quality guidelines (24-hour mean 35 μg/m³) was exceeded for 45 per cent of the time in the period September-March. For measuring station B, the corresponding figure was only 17 per cent. The difference is explained by the fact that at station A, measurements were taken 4 m above a road carrying heavy traffic, where there was direct exposure to road dust, whereas measuring station B is in a courtyard and therefore not directly exposed to road dust.

Injury to health caused by particulate matter

Several studies have shown a significantly higher risk of death on days (or during periods) when concentrations of particulate matter are high (e.g. Plagiannakos and Parker 1988, Lipfert et al. 1988 and Schwartz 1993). PM_{10} is considered to be harmful mainly to the lower respiratory passages. In the upper respiratory passages, larger particles may also be harmful. $PM_{2.5}$ (particles with a diameter of less than 2.5 μm) are believed to have a more serious effect on health because they penetrate more deeply into the lungs. Several articles have presented findings showing that particles with a diameter of less than 2.5 μm are particularly harmful, but few authors have measured PM_{10} and $PM_{2.5}$ at the same time (Vedal 1997). Schwartz et al. (1996) measured PM_{10} and $PM_{2.5}$ in eight American towns and compared the measurements with daily mortality. They found a strong correlation between mortality and short-term increases in the $PM_{2.5}$ concentration. Particles from diesel exhaust have been shown to enhance allergic reactions caused by pollen (National Institute of Public Health et al. 1998).

Rosendahl (1996) calculated that there are about 90 premature deaths per year in Oslo as a result of episodes involving high local concentrations of PM_{10}. Furthermore, 400 new cases of chronic lung disease per year are attributable to particulate matter. Hansen and Selte (1997) calculated that if the PM_{10} concentration in Oslo was reduced by 10 $\mu g/m^3$ (about 40 per cent of the average PM_{10} concentration in the measurement period), the total number of days of sick leave for a company with 1000 employees would be reduced by about 240, which is a reduction of about 2 per cent. This would reduce the company's costs by about NOK 288 000.

Injury to health is caused not only by episodes involving high concentrations of particulate matter, but also by long-term exposure to lower concentrations. American studies show that long-term exposure to low concentrations of particulate matter in air can result in a larger number of cases of bronchitis, reduced lung capacity and a reduction in life expectancy of 1-2 years (EU Commission 1997). Some effects are caused by other harmful substances carried by dust particles, such as PAHs (polycyclic aromatic hydrocarbons), sulphur and various metals (e.g. lead). Some PAHs are classified as carcinogenic.

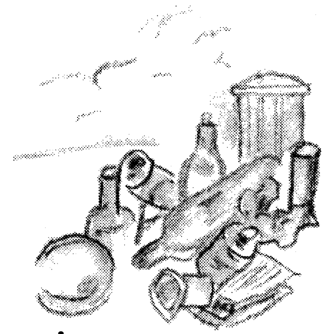
Larssen (1991) refers to a report by Davies and Sanner from 1983, which concluded that smoking and air pollution act synergistically in the development of lung cancer. This means that the total risk of developing cancer for the group that is exposed to both smoking and air pollution is larger than the sum of the probabilities of developing cancer after exposure to one of these factors. This is probably because the cilia in the respiratory passages are damaged in smokers, so that pollutants are not removed as efficiently as in non-smokers (Sanner 1998). Davies and Sanner also state that air pollution is a contributory factor in 5-25 per cent of cases of lung cancer in Oslo. According to Sanner (1998), even though the results are from 1983, there is nothing to suggest that they are not still valid. Emissions of carcinogenic substances are mainly generated by combustion processes. Road dust contains much less of such substances than particulate matter from wood firing and internal combustion engines, and therefore plays little part in the development of cancer.

Co-financed by: Ministry of the Environment and Norwegian Pollution Control Authority.

Documentation: Daasvatn, Flugsrud, Hunnes and Rypdal (1994), Holtskog and Rypdal (1997), Rypdal (1993 and 1995), Rypdal and Tornsjø (1997).

More information may be obtained from: Gisle Haakonsen, Kristin Rypdal, Bente Tornsjø and Solveig Glomsrød (projections).

5. Waste



The quantities of waste generated are increasing with rising consumption and economic growth. Per capita generation of household waste is now almost 300 kg per year, almost twice the figure 30 years ago. In addition, waste is generated by business and industry and by the public sector. The most important environmental problems associated with waste include emissions to air from landfills, incineration plants and waste transport, seepage from landfills and the large areas required by landfills. Projections drawn up by Statistics Norway indicate that the quantities of waste generated will continue to rise steeply unless patterns of consumption change.

5.1. Introduction

The strategy set out 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. Despite this, the volumes of waste generated have been rising. Waste entails socio-economic costs regardless of how it is treated. However, measures to prevent the generation of waste can produce a net socio-economic gain (Bruvoll 1998a).

Landfills emit substantial amounts of methane (CH_4), which account for 12 per cent of greenhouse gas emissions in Norway. These emissions have risen despite an increase in the amount of methane extracted and burnt. Incineration of waste also results in emissions of toxic gases. Stricter requirements have been introduced for emissions from incineration plants, and emissions of toxic gases have been reduced in recent years. Polluted seepage from landfills is still a problem at many sites.

Waste also contains materials and energy that can be recovered and used. In some cases, material recovery also reduces pollution problems. For example, energy consumption in aluminium production can be reduced by using aluminium scrap as feedstock instead of virgin raw materials. Energy recovery can also reduce greenhouse gas emissions in two ways. Firstly, waste can be used to replace fossil fuels, thus reducing CO_2 emissions. Ninety per cent of the energy obtained from waste incineration is considered to be bioenergy. Secondly, incinerated waste that is landfilled will not result in methane emissions in the long term, in contrast to non-incinerated waste.

However, a greater degree of material recovery, together with direct landfilling and incineration, may result in higher

Box 5.1. Waste and waste statistics – terminology and classification

Waste can be classified in many ways, for instance according to its 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: 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 economic activities, both private and public. Statistics Norway further subdivides industrial waste according to the branch of industry from which it originates (for example manufacturing waste). The degree of aggregation in the classification varies.

Municipal waste
All waste treated or administered in the municipal system, i.e. almost all household waste and a large proportion of industrial waste.

costs in the form of more transport and emissions during further treatment of the waste. Analyses suggest that both the environmental and the economic costs associated with certain types of material recovery have been underestimated. Further review of the environmental and economic costs of various types of waste treatment is needed.

5.2. Waste generation: more household waste, less manufacturing waste

It is not possible to give exact figures for the total quantity of waste generated each

Table 5.1. **Quantities of waste generated in Norway[1] in 1996, million tonnes**

Sector	Waste quantity	Source
Private households	1.3	Statistics Norway (1997c)
Manufacturing	2.9	Statistics Norway (1997d)
Construction[2]	14.2[3]	Hjellnes Cowi (1997)
Mining and quarrying except energy-producing materials	2.5	Norwegian Pollution Control Authority (1998b)
Parts of public sector[4]	0.4	Statistics Norway (1996a)
Fisheries[5]	0.6	Foundation RUBIN[6] (1996)

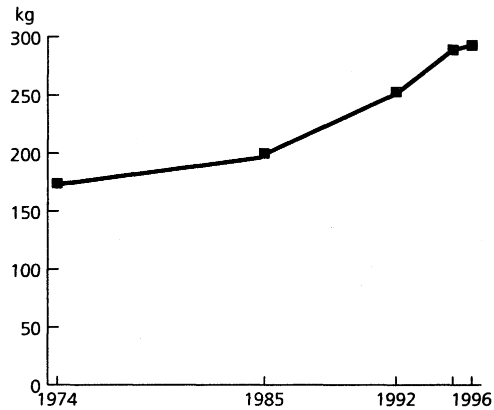
[1] Data lacking for several sectors. [2] Average for 1983-1996. [3]An estimated 13 million tonnes of this is stone waste from blasting and excavated soil and gravel. [4] Technical services in the municipalities, the health and social affairs sector of central government administration, educational institutions (agricultural sector, other colleges and universities), research activities, animal health and veterinary services and social services for the elderly. Figures are from 1994. [5] Figures are from 1995.
[6] RUBIN: Recycling and Utilisation of Organic By-product in Norway.

year in Norway. This is partly because it can be difficult to define precisely which materials are to be considered as waste (e.g. for much of the waste from construction activities) and partly because the quantities can be very difficult to measure. Calculation of the total mass of residuals in production sectors is discussed in section 5.6. Table 5.1 shows figures for the quantities of waste generated in Norway in 1996 for those sectors for which statistics and calculations from various sources are available.

Household waste

Household waste totalled 1.29 million tonnes in 1996. The amount of household waste generated has been rising ever since the first surveys were made in the early

Figure 5.1. **Per capita generation of household waste**



Sources: Waste Statistics from Statistics Norway and Halmø (1984:)

1970s. In 1974, each person generated an average of 174 kg household waste (figure 5.1). In 1996, this had risen to 293 kg (Ligård 1982, Statistics Norway 1989 and 1997c). Between 1974 and 1985, the average rise in the per capita quantity of household waste was 1.3 per cent per year. Between 1985 and 1992, the rate of growth rose to 3.4 per cent per year, and between 1992 and 1996 it was 3.7 per cent per year, corresponding to an average annual rise of 10 kg per capita. In recent years, the quantity of waste has grown faster than consumption of goods (see Chapter 1). Since consumption has risen more rapidly than was expected and the quantities of waste generated have grown faster than consumption, the volume of household waste has in recent years increased faster than in the projections for 1992-2010 drawn up by Statistics Norway (Bruvoll and Ibenholt 1995). Per capita quantity waste generation reached the level predicted for 2010 in 1996. Updated projections based on the same economic assumptions as the Long-term Programme 1998-2001 indicate that per capita waste

Table 5.2. **Composition of household waste in 1997, percentages by weight**

Paper/Cardboard	33
Plastic	8
Glass	4
Food	28
Metals	4
Wood	2
Park and garden waste	2
Other combustible waste	8
Sanitary articles	4
Electrical/electronic waste	1
Other non-combustible waste	1
Hazardous waste	0
Dust, including vacuum cleaner bags	5

Source: Heie (1998).

generation will rise by an average of 1.8 per cent up to 2010 if current waste policy is continued. According to these calculations, per capita generation of household waste would be 380 kg in 2010.

Differences in per capita waste generation have been analysed both in Norway and in other countries. These analyses show a relationship between general welfare trends in a country, expressed as gross domestic product, and per capita waste generation (Beede and Blom 1995). Per capita waste generation is also higher in urban municipalities than in rural municipalities (Halmø 1984, Ligård 1982, Beede and Blom 1995).

Analyses show that household waste in Norway contains about 33 per cent paper and cardboard, 28 per cent food waste and 8 per cent plastic (including waste delivered for material recovery), see table 5.2. Other fractions account for less than 8 per cent of the total each (Heie 1998).

Table 5.3. **Composition of waste from manufacturing industries in 1996, percentages by weight**

Paper and cardboard	7
Plastic (including EPS)	2
Glass	1
Food, slaughterhouse and fish waste	15
Iron and other metals	10
Processed wood	32
Park and garden waste	1
Textiles	0
Rubber (including car tyres)	0
Stone, gravel, earth and other minerals waste	9
Asphalt, ash and dust	3
Sewage sludge (dry matter)	6
Slag	8
Chemicals	0
Mixed/unknown/other	6

Source: Statistics Norway (1997d).

Production and consumer waste from manufacturing industries

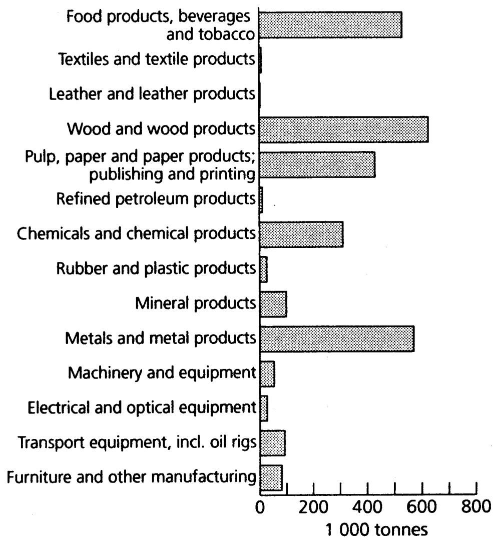
In 1996, Norwegian manufacturing industries generated 2.5 million tonnes production and consumer waste (Statistics Norway 1997d, 1998c). This is 0.5 million tonnes less than in 1993. The drop is mainly a result of changes in production processes that reduce waste generation. Waste management entails substantial costs for industrial enterprises, and many of them have implemented measures to reduce waste generation.

Even though manufacturing industries generated less production and consumer waste in 1996 than in 1993, the quantities delivered to external waste treatment and disposal plants rose from 1.6 to 1.7 million tonnes. The quantity treated on-site was reduced from 1.4 to 0.8 million tonnes. These figures do not include on-site material recovery.

In 1996, the largest fraction of manufacturing waste, 32 per cent, was wood waste (table 5.3). Food, slaughterhouse waste and fish waste accounted for 15 per cent, iron and other metals for 10 per cent and paper and cardboard for 7 per cent. It is therefore not surprising that in the same year, the largest quantities of waste were generated by the pulp and paper industry, metal manufacturing and manufacturing of food products, beverages and tobacco (figure 5.2). They accounted for 37, 20 and 18 per cent respectively of the total quantity of waste from manufacturing industries.

Section 5.6 describes projections of the residuals generated by manufacturing industries, assuming that waste forms a constant proportion of the residual mass. These projections indicate substantial growth up to 2010 (Ibenholt and Wiig 1998).

Figure 5.2. **Production, consumer and hazardous waste from manufacturing industries in 1996, by source**



Source: Statistics Norway (1997d).

Hazardous waste

Because of its high toxicity, hazardous waste represents a serious threat to health and 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 were the largest category of hazardous waste, and made up 36 per cent of the total. The next largest categories were environmentally hazardous metals (29 per cent) and waste oil (11 per cent).

The quantities of hazardous waste generated by manufacturing industries rose from 320 000 tonnes in 1993 to 400 000 tonnes in 1996 (Statistics Norway 1997d, 1998c). Most of this originated from the manufacture of chemicals and chemical products (56 per cent) and metal manufacturing (37 per cent). The rise from 1993 to 1996 can be partly explained by an improvement in the quality of the data needed for the calculations and partly by greater awareness of what should be classified as hazardous waste. However, the increase in the quantity of hazardous waste is not sufficient to explain the entire drop in the amount of production and consumer waste.

5.3. Waste management: More recycling

Once waste has been generated, some form of treatment or disposal is necessary. This may be re-use, material recovery, incineration with or without energy recovery, composting or landfilling. The objective of waste management is to dispose of the waste and at the same time minimize the associated environmental problems and costs. Some forms of treatment, such as material recovery and incineration combined with energy use, utilize the resources in the waste.

Box 5.2. Waste accounts for paper and cardboard

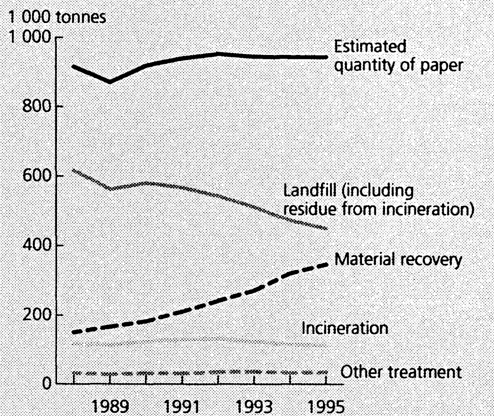
Statistics Norway's main aim in developing waste accounts is to provide more complete information on waste quantities and waste streams in Norway. The first results of this work were waste accounts for paper and cardboard, which were published in 1997.

The method assumes that all paper and cardboard entering the economy ends up as waste after use. Thus, the quantity of waste can be found using the quantity of paper supplied (supply of goods) calculated according to the following equation:

Waste = Supply of goods = primary production + imports - exports + changes in stocks

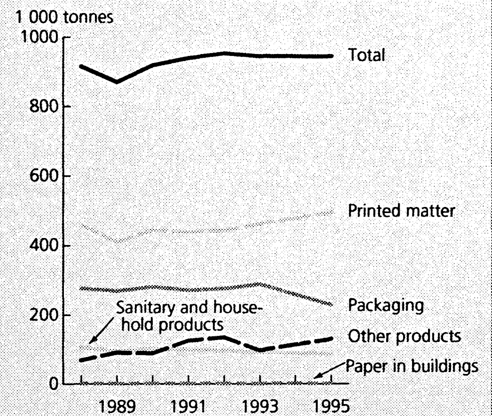
According to these calculations, 943 000 tonnes of waste paper was generated in Norway in 1995, and 37 per cent of this was delivered for material recovery. From 1988 to 1995, the quantity of waste paper recycled rose from 150 000 to 346 000 tonnes (figure 5.3). The quantity of printed matter rose and the quantity of packaging fell in the same period (figure 5.4). See Skogesal (1997) and Statistics Norway (1997e) for more information on the waste accounts.

Figure 5.3. **Waste paper by method of treatment**



Sources: Statistics Norway (1997e) and Skogesal (1997).

Figure 5.4. **Waste paper by category**



Sources: Statistics Norway (1997e) and Skogesal (1997).

In recent years, the authorities, often in cooperation with business and industry, have taken steps to recover a larger proportion of waste. Several analyses have been carried out to compare the economic performance and environmental impact of different types of treatment; see for example ECON (1995) and Norwegian Pollution Control Authority (1996). Many of these conclude that there is no straightforward answer to the question of which type of treatment is best that applies to all types of waste. Section 5.5 describes a review of the literature and an analysis showing that the scientific literature does not appear to provide clear support for the strong emphasis on material recovery (Bruvoll 1998a and 1998b). For example, an analysis of waste paper and plastic shows that material recovery does not necessarily result in lower environmental costs than incineration and landfilling.

Table 5.4. **Environmental and economic effects of various methods of waste treatment and disposal in Norway today**

Treatment	Positive effects	Adverse effects
Landfilling[1]	Low treatment costs	Greenhouse gas emissions Seepage Requires large areas of land Unpleasant smells Infection risk
Incineration without energy use[1]	Low treatment costs	Emissions of pollutants to air Investment costs
Incineration combined with energy use[1]	Use of energy in waste cuts use of other energy sources	Emissions of pollutants to air Investment costs
Material recovery[2]	Use of materials saves virgin raw materials May also save energy[2]	Emissions of pollutants to air and economic costs of sorting, transport, cleaning and treatment of materials

[1] Technological improvements will reduce emissions but raise economic costs.
[2] For certain materials, material recovery saves energy. Remelting aluminium requires only about 5 per cent as much energy as production of the same quantity of primary aluminium. For other materials, material recovery may use energy, e.g. removal of printers' ink from waste paper and cleaning plastics.

Table 5.4 summarizes the commonest types of waste treatment and disposal in Norway and their positive and negative environmental and economic effects at present. The table shows the general situation and is therefore not necessarily accurate for a particular plant or scheme.

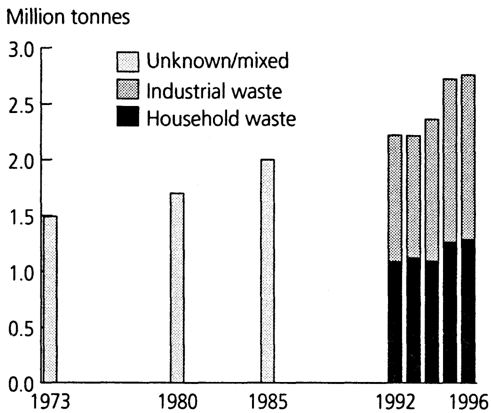
Municipal waste management
Statistics Norway's figures for municipal waste management include almost all household waste and a proportion of industrial waste. Industrial waste that is recycled is only included in these statistics if the municipalities administer the collection scheme. In 1992 and 1995, Statistics Norway obtained reports from all municipalities and waste treatment and disposal plants, and in 1993, 1994 and 1996 from a sample of municipalities. Data from the municipalities in the sample were used as a basis for calculating figures for the whole country.

In 1996, municipal waste collection systems dealt with almost 2.8 million tonnes waste (figure 5.5). This is an increase of more than 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 5.6), the quantities landfilled and incinerated are also increasing. In 1996, 63 per cent of municipal waste was dumped in landfills, 16 per cent was incinerated, 20 per cent was delivered for material recovery and 1 per cent was treated biologically.

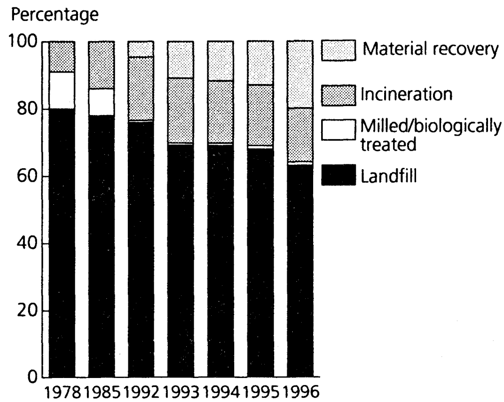
Figures for recent years show a steep increase in the amount of waste recycled. In 1996, about 550 000 tonnes waste was delivered for material recovery from municipal collection schemes. The proportion of household waste recycled has risen from 9 per cent in 1992 to 22 per cent in 1996 (figure 5.7). The proportion of industrial waste that is recycled has

Figure 5.5. **Total quantities of municipal waste[1]**



[1] Figures for 1993, 1994 and 1996 calculated on the basis of sample surveys.
Source: Waste Statistics from Statistics Norway.

Figure 5.6. **Municipal waste according to method of treatment**



Source: Waste Statistics from Statistics Norway.

risen from 8 per cent to 18 per cent during the same period (municipal waste collection schemes only).

Almost half of the household waste delivered for material recovery was collected where it was generated (sorting and collection at source). The rest was collected at recycling centres (38 per cent) or waste treatment and disposal plants (16 per cent). In 1996, schemes for sorting and collection at source were in operation for more than 1 million households, or 56 per cent of the population.

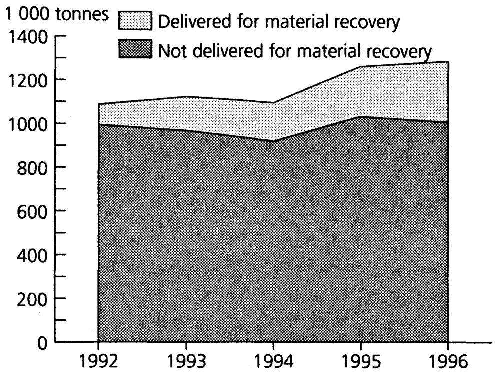
Half the household waste delivered for material recovery is paper and cardboard (figure 5.8). Other important fractions are waste from parks and gardens (15 per cent), food, slaughterhouse waste and fish waste (10 per cent), iron and other metals (8 per cent) and glass (7 per cent). The total quantity of paper and cardboard delivered was 130 000 tonnes, more than twice as much as in 1992.

A proportion of industrial waste is also processed through municipal waste collection schemes. In 1995, this totalled 1.47 million tonnes, a rise of 0.34 million tonnes since 1992.

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

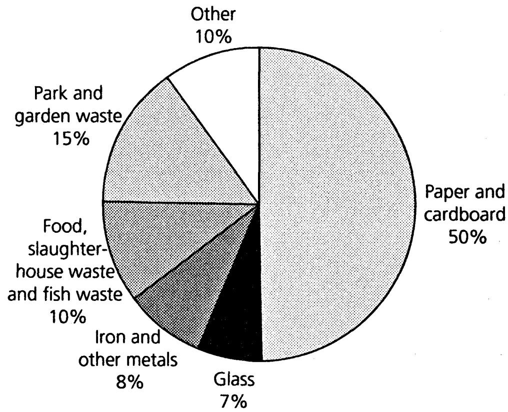
Emissions of the greenhouse gas methane as a result of decay in landfills constitute one of the most serious environmental problems associated with waste management. These emissions were calculated to total 327 000 tonnes in 1996, as compa-

Figure 5.7. **Household waste delivered for material recovery**



Source: Waste Statistics from Statistics Norway.

Figure 5.8. **Household waste delivered for material recovery[1], by material, 1996**



[1]Park and garden waste is composted: this is not strictly speaking material recovery, but is classified as biological treatment.
Source: Waste Statistics from Statistics Norway.

red with 302 000 tonnes in 1990. In 1996, an estimated 13 500 tonnes of the gas were flared or used for energy purposes, as compared with 800 tonnes in 1990. Thus, the increase in the amount of methane extracted has not been sufficient to prevent a rise in methane emissions from landfills. In 1996, methane emissions from landfills accounted for almost 12 per cent of total Norwegian greenhouse gas emissions.

Emissions from waste incineration constitute only a very small proportion of overall emissions of pollutants. This applies to all components of emissions (for more details about emissions to air, see Chapter 4 and Appendix, tables C5 and C6).

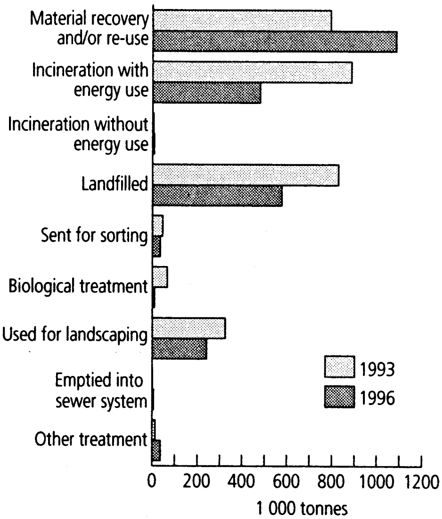
Management of waste from manufacturing industries

The proportion of production and consumer waste from manufacturing industries delivered for material recovery and/or re-use rose considerably from 1993 to 1996 (figure 5.9, Statistics Norway 1998c). In 1996, 44 per cent was delivered for material recovery and/or re-use, as compared with 27 per cent in 1993. At the same time, the proportion incinerated and used as an energy source dropped from 30 to 19 per cent. Incineration of waste and use of the energy is particularly widely used in the manufacture of wood and wood products, pulp and paper manufacture, and printing and publishing. These industries have introduced changes that have entailed more material recovery and re-use and less incineration. The proportion of waste landfilled dropped from 28 to 23 per cent.

Iron and other materials was the waste fraction of which the largest proportion was recycled in 1996 (93 per cent). The proportion was also high for food, slaughterhouse waste and fish waste (89 per cent). These are materials which have been recycled for many years. There were only small changes in the figures from 1993.

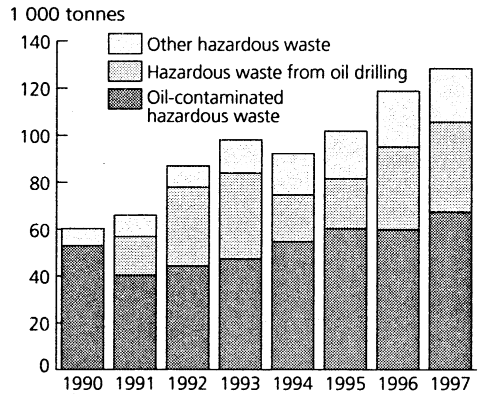
There have been considerable changes in the treatment of waste wood and plastic,

Figure 5.9. **Manufacturing waste. Quantities, generated[1], by method of treatment**



[1]Does not include hazardous waste.
Source: Statistics Norway (1997d).

Figure 5.10. **Quantities of hazardous waste delivered to the hazardous waste management system, main fractions**



Source: Norsas.

of which 33 and 39 per cent respectively were delivered for material recovery in 1996. The corresponding figures in 1993 were 7 and 15 per cent. For waste glass and paper, the proportions recycled in 1996 were 75 and 69 per cent respectively. This was slightly less than in 1993.

Excluding hazardous waste, only 14 per cent of the waste from manufacturing industries was dealt with by municipal waste collection schemes in 1996. Fifty-five per cent was delivered to private waste management companies, and the remaining 31 per cent was dealt with on-site. The general pattern was that waste delivered to municipal schemes was landfilled (72 per cent of the total delivered), whereas waste delivered to private waste management companies was used for material recovery or re-used (77 per cent of the total). For waste dealt with by companies on-site, incineration combined with energy use accounted for 52 per cent, and 37 per cent was landfilled.

Almost all the waste that companies delivered for material recovery and/or re-use (97 per cent) was dealt with by private waste management companies.

Hazardous waste management

Waste which comes within the scope of the hazardous waste regulations must be delivered to approved reception or treatment centres. Norsas (Norwegian Resource Centre for Waste Management and Recycling) is responsible for establishing and administering the system of hazardous waste management. Treatment of hazardous waste includes material recovery, energy recovery and final disposal. Special collection systems have been established for certain categories of hazardous waste, see below.

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 1997 it had risen

Table 5.5. **Exports and imports of hazardous waste, tonnes**

	Exports	Imports
1989	16 576	..
1990	21 766	..
1991	14 643	2 419
1992	14 533	6 262
1993	18 208	15 222
1994	32 811	4 358
1995	37 257	8 958
1996	29 250	34 441

Source: Norsas.

to almost 130 000 tonnes (figure 5.10, Norsas 1998a). In 1997, various categories of oily waste made up 52 per cent of the total and waste from oil drilling about 30 per cent.

The hazardous waste management system originally included all companies that were licensed to deal with hazardous waste. The EU list of hazardous waste categories has since been taken into use in Norway, and this resulted in the definition of more categories of waste as hazardous waste. The "new" hazardous waste is largely dealt with by approved facilities in Norway, but these have not yet been incorporated into the hazardous waste management system. This is true, for instance, of the firm Norwegian Waste Management (NOAH). This means that there will be discrepancies between statistics compiled by Norsas and those from Statistics Norway on hazardous waste generated by Norwegian industry.

According to Statistics Norway's investigations of industrial waste, the quantity of hazardous waste delivered to approved facilities rose from 240 000 tonnes in 1993 to 270 000 tonnes in 1996 (Appendix, table D12). However, the total quantity generated rose so much that the proportion delivered to such facilities sank from 74 to 69 per cent. At the same time, the quantity of hazardous waste treated on-site rose. On-site treatment includes treatment by the enterprise with or without a licence and temporary storage of waste.

For seven of 22 categories of hazardous waste, more than 95 per cent of the total was delivered to facilities approved for the type of waste in question. These were waste oil, oil emulsions, organic solvents containing halogens, lead accumulators, acids, photographic chemicals and asbestos.

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 1997, almost 217 000 tonnes of waste paper was exported (Prosessindustriens landsforening 1998). 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 1997, just under 42 000 tonnes of waste paper was imported, which is less than in the three preceding years.

With permission from the 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. The quantities vary widely from year to

Table 5.6. **Quantities of waste collected in special return schemes**

Year	Material/product	Tonnes collected[1, 2]	Per cent collected	Goal in agreement with sector (per cent)	Source
1997	Total packaging	240 000	ca. 70	..	Materialretur AS
1997	Glass	44 500[2]	85[3]	..	Norsk glassgjenvinning AS
1997	Paper	432 000	57[4]	..[5]	Prosessindustriens landsforening
1997	Cardboard (transport packaging)	135 000	70	80 by 1999	Materialretur AS
1997	Plastic	ca. 40 000	ca. 40	80 by 1999	Plastretur AS
1997	Car tyres	1 800 000[1]	..	..	Norsk Dekkretur
1996	Scrap iron	346 000	..	..	Stålverkenes skrapjernkontor
1996	Scrap aluminium	67 000	..	..	Skanaluminium
1997	Scrapped cars	45 082[1]	100	..	Statistics Norway
1997	Lead accumulators	12 350	113[6]	95	AS Batteriretur
1996	Waste oil	41 000	47	..	Norsas[7]

[1] For car tyres and cars, numbers scrapped. [2] Some categories overlap, so that the figures cannot be added together. [3] Includes 6 000 tonnes of bottles replaced by the breweries in addition to 38 500 tonnes collected through the normal channels. [4] Percentage of paper returned calculated by Treforedlingsindustriens bransjeforening in accordance with international paper statistics. Statistics Norway calculates the supply of paper differently in its waste accounts, and found rather lower return percentages for 1988-1995. [5] No agreement for the paper fraction as a whole, but agreements on the collection of drinking cartons (60 per cent by 1997) and cardboard packaging (60 per cent by 1999). [6] Return percentage exceeds 100 because figures include accumulators in store after collection in previous years. [7] Norsas: Norwegian Resource Centre for Waste Management and Recycling.

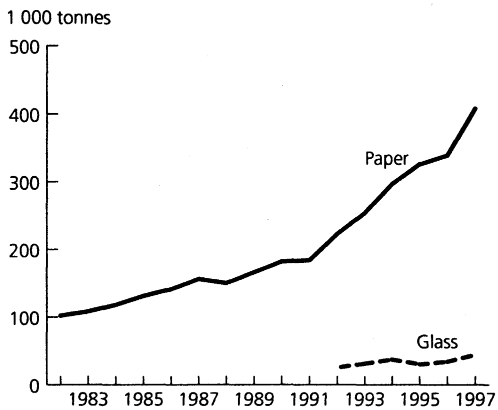
year. In recent years, lead accumulators have made up about half of total exports. Imports of hazardous waste are registered in the same way as exports. These figures also show considerable variation from year to year. The large rise in import quantities from 1995 to 1996 is explained by the import of about 20 000 tonnes ash from waste incineration in Denmark. This is delivered at a landfill run by Norwegian Waste Management. Imports of ash will continue for the next few years (Norsas 1998b).

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 secondary 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. Table 5.6 shows some of the most important return and recycling schemes and the quantities collected through them.

Packaging waste: The company Materialretur AS was established to register, collect and provide reports on collection and recycling fees for packaging waste. According to the company, a total of 240 000 tonnes of packaging waste was collected in Norway in 1997, and the goal is to collect 300 000 tonnes (Materialretur AS 1998). The company estimates that between 360 000 and 370 000 tonnes packaging waste is generated per year in Norway. The Norwegian Pollution Control

Figure 5.11. **Quantities of paper and glass collected**



Sources: Norsk Glassgjenvinning AS and Prosessindustriens landsforening.

Authority and Statistics Norway are developing new statistics on packaging that will give a better basis for estimates of the total quantities of packaging waste generated annually in Norway.

Glass: The amount of glass recycled 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 1997, 38 480 tonnes of glass was collected through the normal system. In addition, 6 000 tonnes of glass bottles were collected directly from the breweries. The percentage returned is 85 per cent if glass subject to packaging duty is included in the figures, and 72 per cent if such glass is excluded (Norsk Glassgjenvinning 1998).

The deposit and return schemes for beer, mineral water, wine and spirits bottles are long-established re-use schemes in Norway. Between 95 and 100 per cent of all beer and mineral water bottles are returned, and 71 per cent of wine and spirits bottles were returned in 1996 (Statistics Norway 1997f).

Paper: Prosessindustriens landsforening (PIL) compiles statistics for paper and cardboard waste. These show a steady increase in the amounts collected during the past ten years (figure 5.11). In 1997, almost 432 000 tonnes of waste paper was collected in Norway (Prosessindustriens landsforening 1998).

A collection scheme for drinking cartons has been established, and is available to about 85 per cent of the population. By the end of 1997, 60 per cent of all drinking cartons were being returned after use. This is in line with the goal set out in the agreement with the authorities (Norsk Returkartong 1998).

Similar agreements have been drawn up for other types of paper and cardboard packaging. In 1997, 70 per cent of all board used for transport packaging was recycled. This corresponds to about 135 000 tonnes corrugated and other board. The goal is to recover 80 per cent of the packaging waste generated by 1999. At least 65 per cent of this is to be delivered for material recovery and the rest for energy recovery (Materialretur AS 1998).

Plastics: The company Plastretur AS is responsible for developing, running and administering return schemes for plastic packaging. It estimates that about 95 000 tonnes plastic packaging waste[1] was generated in Norway in 1997. Of this, about 7 000 tonnes was returned for material recovery and more than 30 000 tonnes

[1] This does not include plastic packaging such as soft drink bottles covered by deposit and return schemes.

was used for energy recovery. The goal is to use 30 per cent of the total for material recovery and 50 per cent for energy recovery by 1999 (Plastretur AS 1998).

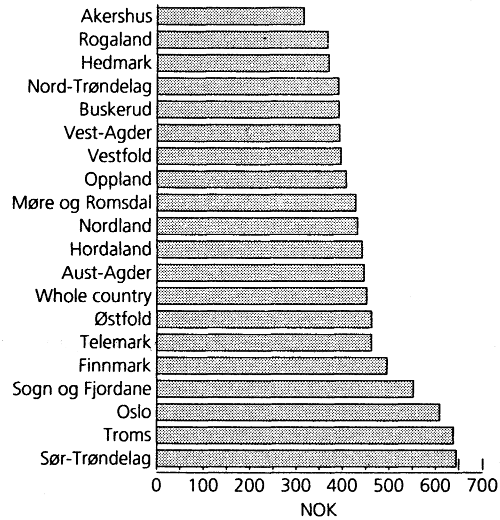
Car tyres: Since 1 January 1995, sales of tyres for passenger cars and lorries have been subject to a fee intended to cover the costs of a collection and recycling scheme. Since 1997, tyres for industrial vehicles and tractors have also been included in the scheme. In 1997, most of the 1.8 million tyres collected were used for energy recovery in cement production. About 100 000 tyres were re-used after retreading. A substantial number of tyres (estimated at 700 000) were collected with scrapped cars and were therefore not utilized in the same way as those collected through the recovery scheme. Arrangements to remove tyres when cars are scrapped should have been in place from 1997, but are not yet in operation (Norsk Dekkretur 1998).

Iron and other metals: In 1996, 346 000 tonnes of scrap iron was collected in Norway (Stålverkenes skrapjernkontor 1997). A substantial proportion of this consisted of scrapped cars. In 1996 the number of cars collected rose to more than 223 000 from 64 000 in 1995. This was because the amount payable to a person who delivered a scrapped car to a breaker's yard was temporarily raised in 1996. In 1997, 45 082 cars were scrapped.

According to Skanaluminium, 67 000 tonnes of aluminium was remelted in 1996. The quantity of aluminium collected for material recovery has risen in recent years (Skanaluminium 1998).

As for other types of packaging, an agreement has been drawn up to encourage

Figure 5.12. **Per capita municipal waste management costs, by county. 1995**

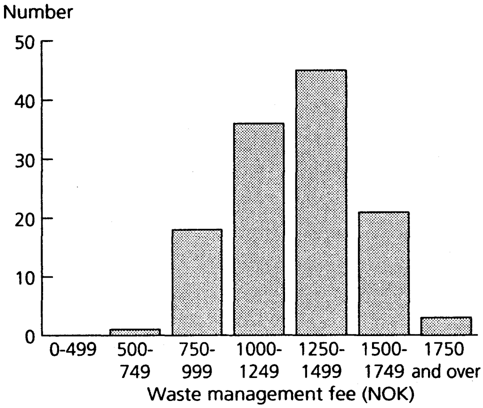


Source: Waste Statistiscs from Statistics Norway.

recycling of metal packaging. The company Norsk Metallgjenvinning was established on 1 January 1998. The goal is to collect 60 per cent of all metal packaging waste by 1999. It is estimated that about 10 000 tonnes metal packaging waste is generated per year in Norway, mainly in the form of foil, tin cans and screw tops (Materialretur AS 1998).

Lead accumulators (hazardous waste): The scheme for the delivery and recycling of lead accumulators is organized by the company Batteriretur A/S. The goal is to collect 95 per cent of all accumulators that are scrapped for recovery. In 1996, the rate of collection was 113 per cent, because the figures include accumulators in store after collection in previous years. After collection, the accumulators are exported. The lead is extracted and recycled, the plastic is used for material or energy recovery and the sulphuric acid is

Figure 5.13. **Waste management fees in municipalities. Number of a sample of 124 by price groups, 1997**



Source: Statistics Norway and Huseiernes landsforbund.

neutralized and landfilled. In 1997, 12 350 tonnes of lead accumulators were collected under this scheme (AS Batteriretur 1998).

In 1996, 41 000 tonnes of waste oil was collected. This is 47 per cent of the sales volume of lubricating oils subject to a sales tax. The quantity collected rose to 43 000 tonnes in 1997. Waste oil is now used solely for heating purposes. (Norsas 1998a, Statistics Norway 1997f).

5.4. Economy of the municipal waste management system

Investments

In 1995, the municipalities invested NOK 196 million in municipal waste management. Investments in waste treatment and disposal plants[2] accounted for 37 per cent of this, and collection and transport for 36 per cent.

Costs

In 1995, the costs incurred by the municipalities in connection with waste management totalled NOK 1.98 billion. The cost per capita differs between counties (figure 5.12),but on average it is NOK 452 per person. The average cost per tonne of waste was NOK 726. Operating costs accounted for most of the total, or about NOK 1.8 billion.

Fees for municipal waste collection systems

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 5.13).

In 1997, Statistics Norway carried out a sample survey commissioned by the Norwegian Homeowners' Association (Huseiernes landsforbund), dealing with the prices of municipal services in 124 municipalities (Huseiernes landsforbund 1997). The average annual waste collection fee per subscriber[3] was NOK 1 285 in the municipalities in the sample. This was 9 per cent higher than in the same sample in 1996.

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[4] of 95 per cent, and the ratio was between 90 and 110 per cent in 70 per cent of the municipalities.

[2] The term waste treatment and disposal plant includes milling, shredding, incineration, composting and rendering plants as well as landfills.

[3] Based on refuse collection once a week.

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

By 1996, sorting and collection at source were available to more than one million households, or just over half the population. Paper and cardboard were sorted by most of these, and sorting of wet organic waste at source had been introduced for about 210 000 households. The average refuse collection fee in a municipality where there was some form of sorting and collection at source was NOK 931, while the corresponding figure for municipalities without such a system was NOK 905. Section 5.5 presents an analysis of the relationship between waste collection fees and the degree of recycling for municipal waste.

See also Natural Resources and the Environment 1997 for a more detailed discussion of investments, costs and fees in the municipal waste management system.

5.5. Three analyses of optimal waste policies

In recent years the focus in waste policy has shifted from incineration and landfill to increased emphasis on recycling. At the same time, there is a fourth policy option, i.e. waste minimization. The conceptual and empirical basis for the choice between these alternatives is deficient, which complicates efficient decision-making. The following three analyses attempt to improve the basis for waste policy planning. The first analysis is a review of international studies in the area, the second compares the various policy choices for two specific materials, while the third looks at factors which explain recycling rates in Norway.

Effective use of instruments in waste policy

There are a number of empirical studies of the effect of various policy alternatives and theoretical analyses of effective waste policies. A review of the literature shows that the assumed positive gains derived from mandated recycling have probably been overestimated. On the contrary, it can be seen from a vast number of studies that recycling is often economically and environmentally costly compared with the alternatives incineration and landfill. This is partly because the costs of collection, transport and production processes associated with recycling have been underestimated and new technology has made incineration and landfill considerably less harmful to the environment.

One conclusion is that there are greater advantages in using economic instruments instead of regulations. Predetermined recycling targets create artificial markets and hamper cost-effective recycling. The use of taxes to reduce waste amounts results in lower social costs and provides greater incentives to develop new technology. The international literature contains many examples showing that economic instruments are also well suited for influencing the choice of treatment.

Incorrect pricing of input factors is an important reason for the sharp growth in waste amounts. A subsidized use of virgin materials and the lack of internalized environmental costs increase the use of materials and thereby waste amounts. Sooner or later materials that are extracted from nature end up as emissions to air, land or water. Virgin material taxes can be levied to correct the market when it fails to function in an environmentally optimal way, thereby reducing the flows of material in the economy. If the environmental damage increases with the use of natural resources, virgin material taxes can be used to reduce the use of resources and thereby emissions, cf. CO_2 tax on fossil fuels.

Table 5.7. **Marginal costs (environmental and economic) of recycling, incineration and disposal of paper and plastic waste, selected estimates. Costs based on cost interval in parenthesis. NOK per tonne waste fraction**

	Paper waste		Plastic waste	
	from households	from businesses	from households	from businesses
Recycling	2400 (1700-3100)	800	6700 (6000-7400)	5000
Incineration	1300 (1200-1300)	1500 (1300-1500)	2700 (1700-4500)	2900 (1900-4700)
New landfills	2300 (1100-2900)	2400 (1200-3000)	2600 (2100-2900)	2800 (2300-3100)
Old landfills	3300 (1000-4500)	3400 (1100-4600)	2700 (1900-3100)	2900 (2100-3300)

Source: Bruvoll (1998a).

As an alternative to virgin material taxes, variable tax rates may be levied on products or the waste itself. Under the existing solid waste management policy, one does not pay more if one produces more waste. Taxes unrelated to the delivered waste amount provide an incentive to generate more waste than the marginal costs imply. A number of studies support the notion that variable tax rates for end treatment reduce waste amounts and increase the recycling rate. If it is considered desirable to influence the choice of end treatment, the tax can be directed towards special targets at the final stage. For example, taxes on greenhouse gases may contribute to reducing emissions of methane from landfills.

Project financed by: The Research Council of Norway and Ministry of the Environment. The project was carried out during a stay at the University of Colorado at Boulder. Support was also provided by Professor Wilhelm Keilhaus' Memorial Fund.

Project documentation: Bruvoll (1998b) and (1998c).

The costs of alternative policies for paper and plastic waste

In recent years there has been a sharp increase in the recycling rate for paper and plastic waste in Norway. The goal is to reduce the negative environmental effects of incineration and landfills and to extend the lifetime of materials. However, recycling also has environmental consequences, partly as a result of increased transport. This analysis attempts to compare the various cost components of different measures for paper and plastic waste, with a view to improving the basis for future waste policy planning.

In addition to the treatment options recycling, incineration and landfill, the consequences of waste minimization in the form of a tax on paper and plastic are evaluated. The two types of waste are further divided into household waste and commercial waste. The study looks at both environmental costs and the conventional economic costs of collection, transport and treatment of waste. The study includes time costs linked to sorting by source. When sufficient data from Norway were lacking, estimates were obtained from US sources. Data are still lacking, however, to obtain a complete picture of the total costs of the various alternatives. The environmental cost associated with the further processing of waste for recycling is the most important component that is lacking. The estimates on the environmental costs of collecting and treating emissions are based on a number of studies. The environmental costs are shown as intervals as the estimates vary considerably between different studies and estimation methods.

The study supports the advantages of using economic instruments; waste minimization carried out as a tax on virgin materials is the best alternative for all of the waste types studied. The cost of a tax reform is that private consumption and production are reduced. This is more than offset, however, by the advantages of reduced waste amounts and emissions to air, measured by treatment costs saved and environmental costs.

Whereas a tax on waste generating materials involves social gains, net costs arise for all the alternatives for the treatment of waste that has already been generated. Moreover, the study shows that recycling as a method of treatment is not always the best alternative. The figures show that for paper and plastic both the environmental and economic costs in most cases exceed the costs of incineration and landfill (even when account is not taken of the environmental costs from the further processing of recycled waste). This is ascribable to higher collection costs for recycling compared with traditional waste collection.

Recycling is the best alternative for commercial paper due to relatively low collection costs and high paper quality, and thereby high prices. Our data show that incineration is the best alternative for household paper, see table 5.7. Recycling and modern landfills with the collection of environmentally harmful emissions rank about equal, while old landfills result in higher costs due to emissions of methane. Recycling is the most costly alternative for plastic due to high transport costs. Incineration and landfills rank about equal.
The figures must be looked upon as "average results", whereas in practice there are considerable variations between regions, waste fractions and recycling levels. Transport costs depend on the distance to the recycling and treatment facilities and many of the environmentally harmful emissions vary with population density.

The recommendations concerning future waste planning in this analysis point to an emphasis on reducing waste generation, and in the case of plastic and to some extent paper a reduction in recycling rates. The analysis shows that there is no general rule for ranking the various alternatives; the costs of each alternative must be calculated for the various types of waste to ensure positive results for political decisions.

Project financed by: The Research Council of Norway.

Project documentation: Bruvoll, A. (1998a).

What factors influence household recycling rates?

It is important to understand the factors that influence household recycling rates. The starting point was an assumption that there was a clear relationship between household recycling rates and solid waste collection fees. The primary source of data for the analysis was the 1995 municipal solid waste survey.

The main conclusion of the study is that there is no clear and obvious relationship between the current levels of solid waste collection fees and the amount of material collected for recycling from households. In general, municipalities with high collection fees do not have higher recovery rates than municipalities with low fees.

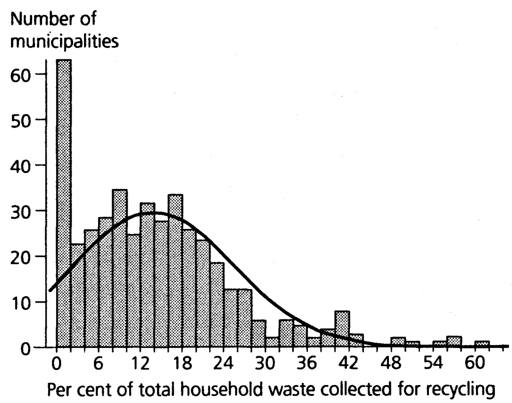
Regression analysis is used to attempt to identify other factors that might explain recycling rates. Relationships between structural variables from the various municipalities and recycling rates were therefore included in the analysis. The following variables were included:

- municipal collection fee income per person
- time variable: whether the municipality had/did not have a curbside collection system for newspaper and cardboard in 1992 and/or in 1995
- centrality variable: the closeness of the municipality to major cities
- the per cent of households that have a source separation curbside collection system for newspaper and cardboard
- the population density
- the per cent of the total municipal budget spent on the solid waste sector
- municipalities' cost per tonne of solid waste treated

The only variables which were found to be significantly related to the recycling rates of households were the length of time that a municipality had a system for curbside collection of paper and the closeness of the municipality to major cities. However, the analyses show that the time variable alone explains 25-28 per cent of the variation in recycling rates. When both the time variable and the centrality variable are included, 27-31 per cent of the variation in recycling rates is explained.

The length of time that a municipality has a system for curbside collection of recyclable materials, as the most important explanatory variable for municipal recycling rates, may be explained on the basis of the adoption of technical innovation, such as source separation and recycling, which takes place over time (adoption of innovation theory, Rogers 1996). It takes time before municipalities develop a source separation system and it takes time before households learn to sort by source. The average recycling rate for households in 1995 was 14.4 per cent, but 24 municipalities (5.5 per cent) had a recycling rate that was higher than 37 per cent (mean plus two standard deviations, see figure 5.14), which is the boundary for the first two adoption groups, referred to as innovators and early adopters. The figure shows that many municipalities have zero or very low recycling rates, but some municipalities have a recycling rate which is higher, although it is not possible using the data in the analysis to provide a reasonable explanation for this.

Figure 5.14. **Histogram of per cent of total household waste collected for recycling (normal distribution added). 1995**



Source: Hass (1997a).

Based on this analysis, we find that recycling is still at an early stage of development in many municipalities, and that some municipalities are more innovative than others in encouraging increased recycling.

Project financed by: The Research Council of Norway, MILFOR programme.

Project documentation: Hass (1997a).

5.6. Residuals in production based on mass balance

Statistics Norway has previously made projections of waste quantities generated in manufacturing industry in Norway based on the macroeconomic model MSG-EE (Bruvoll and Ibenholt 1995). These projections have explained the generation of waste by assuming a fixed relationship between waste and production volume and/or the use of material inputs in production. The fixed relationships are calculated by using waste statistics. In this analysis we have studied the generation of residuals up to the year 2010 using a different approach, i.e. the principle of mass balance. This is based on a law of physics which states that mass cannot disappear but only alter form. It then follows that materials going into the production process must be equal to the materials coming out of the process. Ingoing materials consist of, for example, virgin materials (crude oil, minerals) and more or less processed goods. Outgoing materials consist of finished products and emissions to air, water and land, including solid waste. By calculating the mass which comes out in the form of finished products and emissions to air, waste and other discharges to land and water may be calculated residually.

The macroeconomic model MSG-EE projects the use of material inputs and production in monetary units. These units (NOK) have been converted to weight units (tonnes) by calculating kg per NOK for virgin materials and processed goods. An additional module to the MSG-EE model was used to compute emissions to air for the 10 most important components in tonnes. Our analysis is based on the same baseline scenario for MSG-EE as earlier waste projections, which in principle is the one used in the Long-Term Programme 1994-1997.

Residuals consist of any emissions to air which are not included in this model, margins of error for weight and virgin material coefficients as well as discharges to water and land. Residuals thus comprise more than solid waste, and cannot be directly compared with earlier waste projections. Changes over time in the form of growth rates are, however, comparable, provided that the solid waste constitutes a constant share of the residuals.

We find that residuals for all production sectors increase by 69 per cent from 1988 to 2010. Earlier projections of waste show changes in the manufacturing sector separately for the period 1993 to 2010. In our analysis, residuals for these sectors increase in the same period by 84 per cent, compared with 64 per cent in earlier waste projections. The higher growth shown in our analysis was expected inasmuch as a general result in the baseline scenario of MSG-EE is that the use of material inputs (ingoing materials) increases at a faster pace than production (outgoing materials). This development is a result of the assumption that material inputs will be relatively cheaper than labour and that in some production sectors it is possible to replace steadily more expensive labour with material inputs, for example by accepting greater shrinkage of materials in production. Projections based on changes in material inputs or production do not entirely capture this, while our analysis, which is based on residuals being equal to material inputs minus production, does illustrate this trend.

The absolute figures in the mass balance can provide us with an indication of the quantity of materials which must be in circulation in society in order to maintain production. It is possible, for example, to project the consumption of natural resources, which is particularly relevant in the debate on sustainable consumption and production.

Project financed by: The Research Council of Norway.

Project documentation: Ibenholt and Wiig (1998).

Partial funding, waste statistics: Ministry of Environment, Norwegian Pollution Control Authority and Research Council of Norway.

More information on waste statistics and waste analyses may be obtained from: Olav Skogesal, Øystein Skullerud, Annegrete Bruvoll and Anders Falnes.

6. Water supplies and waste water treatment

Even though natural conditions mean that Norway has plentiful water supplies, population growth, urbanization and industrialization have resulted in a shortage of water of satisfactory quality in certain parts of the country. Discharges of waste water, which contains nutrients such as phosphorus and nitrogen, often result in nutrient enrichment (eutrophication) of rivers, lakes and coastal waters. This leads to a deterioration in water quality, and creates various problems for user interests and for many of the plant and animal species associated with the recipients. To reduce discharges to an acceptable level, large sums are expended each year on the construction and operation of waste water treatment plants and the sewer system. The costs are covered largely through municipal fees. Nutrients and organic material are removed from waste water to form sewage sludge, which is widely used in integrated plant nutrient management on agricultural areas and parks and other green spaces.

6.1. Introduction

Water resources are so closely linked with almost all forms of economic activity that they are vulnerable to over-exploitation and degradation. In many parts of the world, there is a growing shortage of clean water supplies, brought about by withdrawal for industrial, household, agricultural, mining and other purposes and discharges of waste water and environmentally hazardous substances. The overall situation in Norway is much more satisfactory than in many other countries, but there can nevertheless be severe local problems.

Discharges of the nutrients phosphorus (P) and nitrogen (N) to Norwegian river systems and coastal waters have been a matter of concern for many years. There are large discharges of these substances from agriculture and industry as well as in waste water. In order to reduce discharges to rivers, lakes and coastal areas with a heavy pollution load, it is therefore important to cooperate across both sectors and national borders.

In recent years, both Norway and other countries that drain to the Skagerrak and the North Sea basin have invested substantial resources in waste water treatment in response to the North Sea Declarations and serious pollution in the various recipients. According to the declarations, the countries around the North Sea have undertaken to halve inputs of phosphorus and nitrogen compared with the 1985 level as soon as possible. Norway has achieved a satisfactory level of treatment efficiency for phosphorus, mainly by building waste water treatment plants providing chemical or chemical/biological treatment. However, nitrogen is not as successfully removed from waste water. Despite the improvements in waste water treatment, there are still signs of poor water quality in the outer Oslofjord. An attempt will be made to improve this situation by constructing nitrogen removal facilities at two large treatment plants in the catchment area of the river Glomma in the next few years.

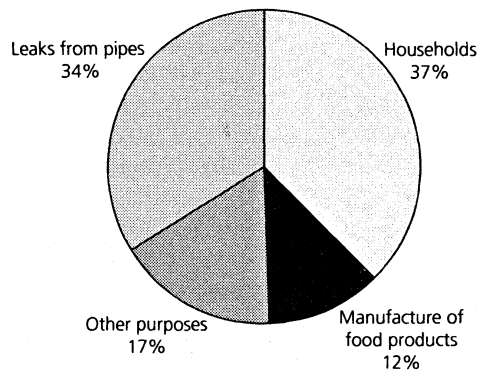
6.2. Water supplies and water consumption

The National Institute of Public Health collects data from Norwegian water works. In 1994, about 1 600 water works[1] were registered, of which about 500 were private. These supplied about 3.82 million people, or 88 per cent of the Norwegian population. The remaining 12 per cent of the population are supplied by smaller water works or take water from their own wells, rivers and lakes.

In Norway, both ground water and surface water are commonly used as water supplies. Water production at Norwegian water works was calculated to total 1 110 million m^3 in 1994. Ground water accounted for 12 per cent of this and surface water for 88 per cent. Although it only provides a small proportion of total consumption, ground water is often a better alternative than surface water. Factors in favour of greater use of ground water are its high, stable quality, good protection against pollution, and the fact that only limited technical facilities are required, so that investment and operating costs are low.

Figure 6.1 shows how water production from Norwegian water works is utilized. Private households account for the largest proportion of consumption, 37 per cent. It should however be noted that more than one third of the water supplied by water works is lost by leakage from pipes and joints. If the water that is lost between the water works and the consumer is subtracted, average per capita consumption is found to be 480 l/day, of which 260 l is consumption by private households. Note that there is some uncertainty as to these figures, and particularly that the quantity of water lost through leakages may be somewhat higher than shown here.

Figure 6.1. **Water consumption from Norwegian water works. Whole country, 1994**

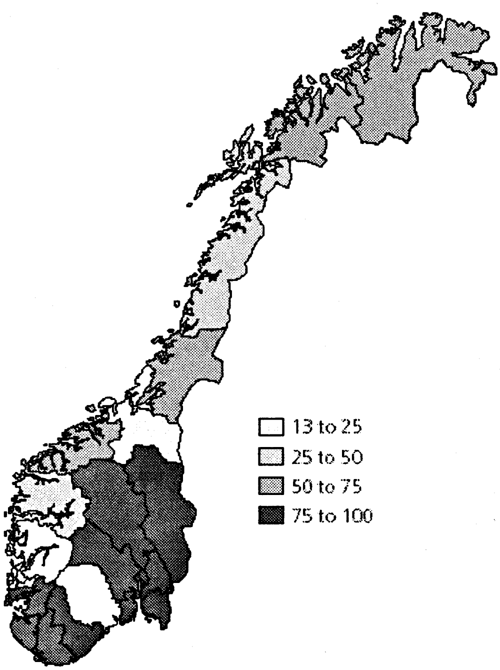


Source: National Institute of Public Health.

An investigation of the quality of the water supplied by Norwegian water works (National Institute of Public Health 1997) showed that much remains to be done here. In 1994, only 38 per cent of the water works supplied water of satisfactory quality according to criteria for water intake, hygiene, water treatment and water quality. These water works supplied 66 per cent of the population connected to a water works, or 58 per cent of Norway's total population. The worst figures were for Telemark, Hordaland and Sør-Trønde-

[1] Only facilities supplying at least 100 persons are registered.

Figure 6.2. **Percentage of the population connected to water works providing satisfactory water supplies, by county. 1994**



Digital map data: Norwegian Mapping Authority.
Source: National Institute of Public Health.

lag counties, where less than a quarter of the population were supplied with water of satisfactory quality (figure 6.2). In Oslo, on the other hand, water supplies to the entire population were of satisfactory quality. The most important measures for improving the quality of water supplied by a water works are removal of humus and disinfection.

6.3. Total inputs of nutrients to Norwegian coastal waters

Discharge figures for municipal waste water 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 1996, 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 2 400 tonnes of phosphorus and 45 000 tonnes of nitrogen (Norwegian Institute for Water Research 1997). Table 6.1 shows how inputs are split between the North Sea counties and the rest of the country.

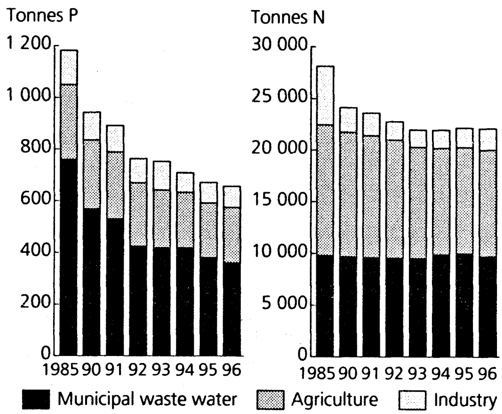
Inputs of phosphorus from the North Sea counties are much lower than those from the rest of the country. This is a result of the investment of substantial resources in treatment of waste water and industrial discharges (sections 6.10 - 6.12) and measures to reduce runoff from agriculture in these counties (Chapter 7). These steps were taken in response to poor conditions in recipients. Highest priority

Table 6.1. **Inputs of phosphorus (P) and nitrogen (N) to Norwegian coastal waters from agriculture, industry and municipal waste water**

Area	Phosphorus			Nitrogen		
	Total input, tonnes	Per cent of total input	Per capita input	Total input, tonnes	Per cent of total input	Per capita input
Whole country	2 383	100	0.55 kg	45 266	100	10.4 kg
- North Sea counties	657	28	0.28 kg	22 065	49	9.2 kg
- Rest of country	1 726	72	0.87 kg	23 201	51	11.7 kg

Sources: Material from Statistics Norway and Norwegian Institute for Water Research.

Figure 6.3. **Norwegian anthropogenic inputs of phosphorus (P) and nitrogen (N) to the coastal zone from Østfold to Vest-Agder (the North Sea area)**[1]



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

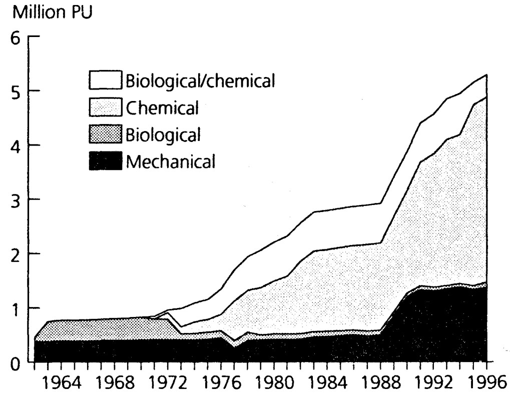
has been given to the removal of phosphorus.

Figure 6.3 shows how the different sectors have contributed to inputs of phosphorus and nitrogen to the North Sea from 1985 to 1996. Inputs of phosphorus and nitrogen from municipal waste water were reduced by 53 per cent and 1 per cent respectively from 1985 to 1996. The reductions in total discharges from all sectors were 44 and 22 per cent respectively.

6.4. Waste water treatment plants

Most waste water treatment plants in Norway have been built within the last 20 years. In the 1950s and 1960s, most of the plants built 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 6.4. **Hydraulic capacity by treatment method. Whole country**



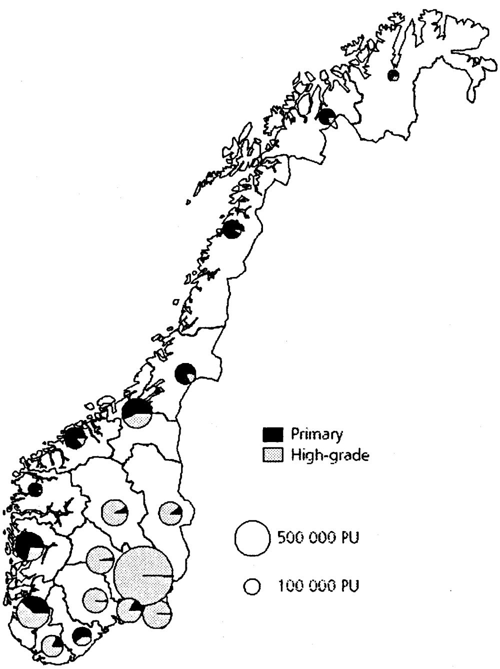
Source: Waste water treatment statistics from Statistics Norway.

Figure 6.4 shows a sharp increase in mechanical treatment capacity from 1988 to 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.

From 1995 to 1996, total treatment capacity rose for mechanical (3 per cent), biological (39 per cent) and chemical (2 per cent) treatment plants, but remained unchanged for chemical/biological plants.

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.

Figure 6.5. **Hydraulic capacity at primary and high-grade treatment plants. By county, 1996**



Digital map data: Norwegian Mapping Authority.
Source: Waste water treatment statistics from Statistics Norway.

In 1996, 2 210 municipal waste water treatment plants with a treatment capacity of at least 50 population units (PU) were registered in Norway. Their total treatment capacity was 5.4 million PU. The 17 largest plants each had a treatment capacity of 50 000 PU 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 6.5). Such plants account for 94 per cent of total treatment capacity in this area. Along the coast from Rogaland county and northwards, most waste water is only mechanically treated, and high-grade treatment plants account for only 34 per cent of total treatment capacity. See also Appendix, tables E1 and E2.

6.5. Sewer systems

The total length of sewer systems in 1996 was reported to be 33 700 km (data from 49 municipalities are lacking). The population of the municipalities for which data are available is about 4.1 million, giving an average of 8.2 m sewers 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 1996, the total length of new sewers laid was at least 1 162 km (data from two counties are lacking). This is about 40 per cent more than was laid the year before. Combined sewer systems accounted for 31 per cent of this, waste water sewers for 48 per cent, and storm water sewers for 21 per cent.

The data available on types of sewer systems, length, age and materials are incomplete in both this year's and earlier reports. It is therefore difficult to say anything definite about the current situation and trends. Almost 80 per cent of investments in 1996 were used on the sewer system (section 6.12).

6.6. Discharges from 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 1996 were calculated to be about 560 tonnes, and the average treatment efficiency of these plants was 72 per cent (figure 6.6 and Appendix, table E4).

Box 6.1. Definitions

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** (PU) in an area is given by the sum of the number of permanent residents and the number of population equivalents in the area.

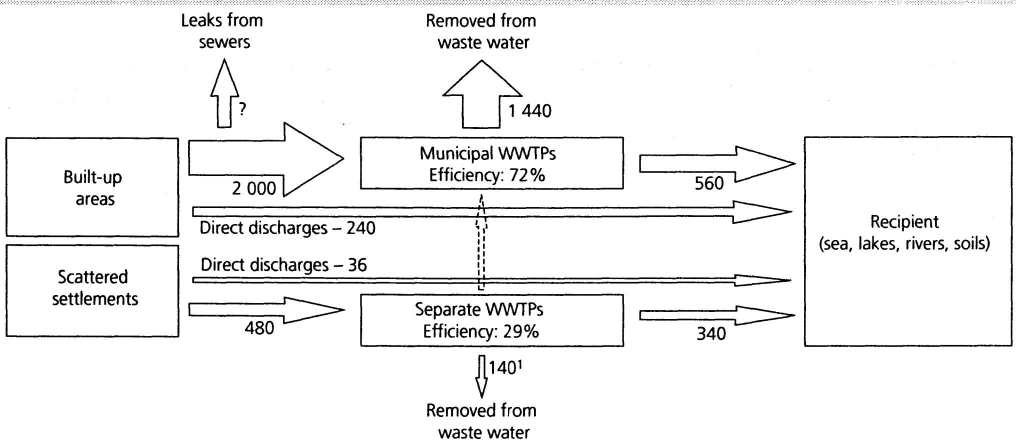
The **hydraulic capacity** of a treatment plant is the amount of waste water it is designed to receive.

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.

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.

Figure 6.6. **Material flow diagram for phosphorus in waste water, 1996. Tonnes**

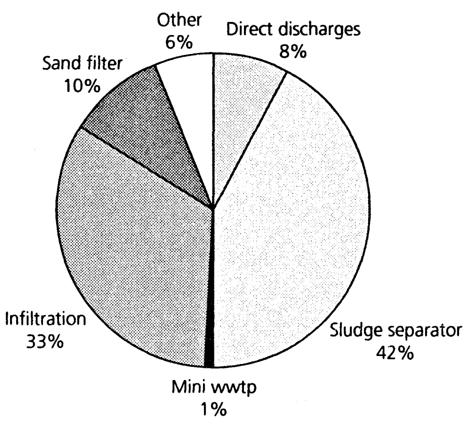


[1] Also includes sludge from septic tanks delivered from separate waste water treatments plant to municipal plants (dotted arrow).
Source: Waste water treatment statistics from Statistics Norway.

Calculations show that in 1996, the average treatment efficiency for phosphorus in municipal waste water treatment plants in the North Sea counties was 91 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 116 tonnes of phosphorus, or about 21 per cent of the country's total discharges from municipal waste water treatment plants. About 1 170 tonnes phosphorus was removed by treatment in this area of the country.

Because conditions in the recipients are generally better along the coast from Rogaland and northwards, a larger proportion of the treatment plants use relatively simple means of waste water treatment, such as screens, strainers, sludge separators and sand traps, and these retain phosphorus less efficiently. A total of 447 tonnes phosphorus was discharged from these plants in 1996. The average treatment efficiency was calculated to be 37 per cent, which means that about 260 tonnes phosphorus was removed.

Figure 6.7. **Treatment methods for waste water from scattered settlements in 1996. Percentage of all plants**



Source: Waste water treatment statistics from Statistics Norway.

Thus, of a total quantity of about 2 000 tonnes phosphorus entering waste water treatment plants, about 1 440 tonnes was removed. This is retained as a component of sewage sludge, and is subsequently used e.g. in integrated plant nutrient management. Figure 6.6 summarizes material flows for phosphorus.

6.7. Discharges from 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 1996, total discharges from these were calculated to be 342 tonnes of phosphorus (figure 6.6). The average treatment efficiency was about 29 per cent, which means that about 140 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 6.7).

6.8. Other sources of discharges

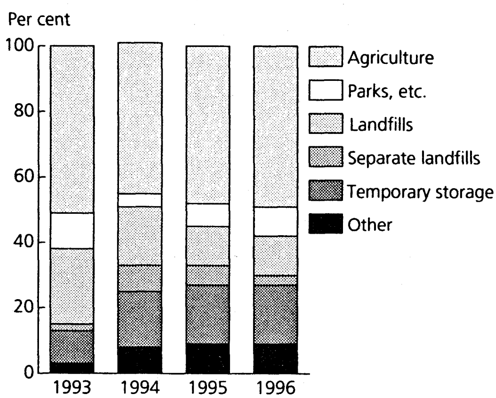
In addition to discharges from small separate waste water treatment plants in scattered settlements and treatment plants in built-up areas, there are also some direct discharges of untreated waste water from municipal sewer systems in certain areas. In 1996, 632 discharge points for untrea-

Table 6.2. **Heavy metals in sewage sludge as mg per kg dry weight in 1996 and annual percentage change 1993-1996**

Heavy metal	No. of plants reporting in 1996	mg per kg dry weight: Mean value per plant	Minimum value	Maximum value	Standard deviation	Annual per cent change in mean value per plant 1993-1996[1]
Cadmium	201	1.0	0.1	9.0	0.9	- 6.8
Lead	203	24.6	0.3	78.0	13.5	- 5.8
Mercury	200	1.2	0.2	5.1	0.8	- 4.3
Nickel	189	12.5	0.3	74.0	9.3	+ 5.3
Zinc	190	376.0	98.0	2 540.0	272.6	+ 1.8
Chromium	190	29.9	3.7	976.0	84.1	+ 17.5
Copper	190	271.2	3.4	1 186.0	189.1	- 5.7

[1] Calculated by regression analysis. Extreme values (the five highest and five lowest values each year for each metal) are omitted from the analysis.
Source: Waste water treatment statistics from Statistics Norway.

Figure 6.8. **Disposal of sewage sludge, whole country**



Source: Waste water treatment statistics from Statistics Norway.

ted waste water were registered, most of them in the counties from Rogaland and northwards to Finnmark. Discharges of phosphorus from these in 1996 are calculated to be about 240 tonnes. Of this, 98 per cent is discharged to marine recipients such as fjords and open coastal waters.

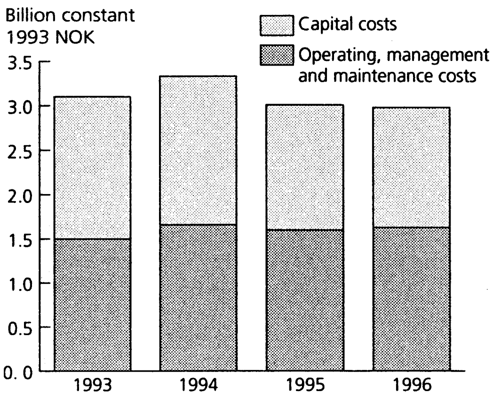
Leaks from the sewer system can also make up a substantial proportion of total discharges. It is very difficult to give an exact figure for such losses, but as a rough approximation it is assumed that about 10 per cent of the pollutants generated in the district served by a treatment plant is lost from pipes and joints. This will vary widely from one municipality to another depending on the type of sewer system and its age.

6.9. 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 1996, the total amount of sludge produced, expressed as dry weight, was calculated to be 95 300 tonnes. This is 2 400 tonnes more than in 1995. Of this, 58 per cent was used in integrated plant nutrient management on agricultural areas and green spaces (figure 6.8 and Appendix, table E5).

The remainder of the sludge is used in landscaping landfills, is temporarily stored until a decision is made on final use, or is stored permanently on separate sludge landfills.

Figure 6.9. **Total costs in the municipal waste water treatment sector, whole country. Constant 1993 NOK**



Source: Waste water treatment statistics from Statistics Norway.

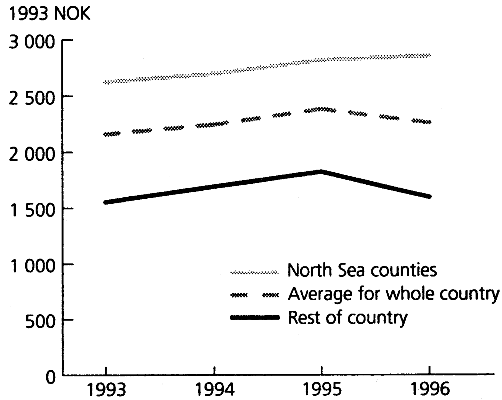
The composition of the sewage sludge produced, including its content of heavy metals, varies substantially from one plant to another depending on the type of treatment used and the amount and type of waste water. From 1993 to 1996, a drop in the content of some heavy metals (lead, mercury, cadmium and copper) has been registered, whereas the content of zinc, nickel and chromium has risen (table 6.2).

6.10. Costs

In 1996, the total costs of municipal waste water treatment were about NOK 3.25 billion. Operating, management and maintenance costs accounted for NOK 1.78 billion of the total, and capital costs for NOK 1.47 billion. There were only small changes in these figures from 1995 (figure 6.9).

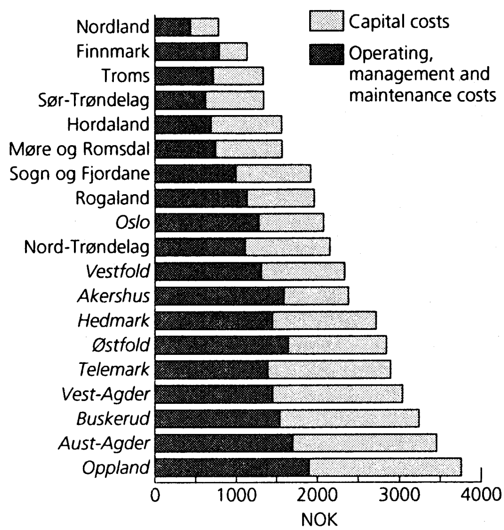
Since such substantial resources have been invested in the removal of phosphorus in the North Sea counties, the costs per subscriber were highest here, NOK 2 629 as compared with NOK 1 469 in the rest of the country.

Figure 6.10. **Annual costs per subscriber. Constant 1993 NOK**



Source: Waste water treatment statistics from Statistics Norway.

Figure 6.11. **Annual costs per subscriber in 1996, by county (North Sea counties in italics)**



Source: Waste water treatment statistics from Statistics Norway.

Measured in constant 1993 NOK, the average annual cost per subscriber dropped for the first time for four years in 1996 (figure 6.10). The main reason for

Box 6.2. Definitions

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

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

The **average cost per subscriber** for the whole country or by county may be calculated in two ways:
1. Total costs divided by number of subscribers.
2. Sum of annual costs per subscriber for each municipality divided by number of municipalities.

In this chapter, the first method is used, whereas the Norwegian Pollution Control Authority and the Ministry of the Environment use the second method for defining cut-off levels for grants.

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.

Capital costs are calculated by assuming a depreciation period of 20 years and an annual interest charge of 6.5 per cent. This is in accordance with the model used by the municipalities to calculate the basis for their fees.

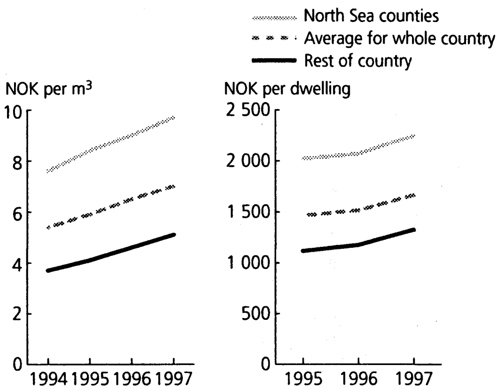
this was that capital costs dropped as a result of lower interest rates. Operating, management and maintenance costs remained almost constant. Another reason for the drop in costs was that the level of investments has been falling steadily during the past three years because a rising proportion of the planned investments have not in fact been made (see section 6.12). A third factor is that the number of subscribers connected to municipal systems has risen in recent years. In 1995, there was a total of 1.44 million subscribers in the whole country, and in 1996 this figure had risen to 1.56 million. A fourth reason for the drop in the average annual cost per subscriber is that updated and more accurate data on the number of subscribers are now available from the municipalities.

There were large variations between the counties in costs per subscriber. Costs are much higher in the North Sea counties than in other parts of the country (figure 6.11 and Appendix, table E7). This is because the proportion of high-grade waste water treatment plants is much higher (see section 6.4). Figure 6.11 also shows capital costs as a proportion of the total for each county.

6.11. Fees

The municipalities are authorized to levy connection fees and annual fees to cover the capital and operating costs of waste water treatment. In 1996, the municipalities collected a total of NOK 3.09 billion in waste water treatment fees, which was NOK 0.14 billion less than their total costs. Annual fees accounted for NOK 2.86 billion of the total and connection fees for about NOK 238 million.

Figure 6.12. **Average annual fee based on water consumption in m³ and on the area of an average dwelling (140 m²). Current NOK**



Source: Waste water treatment statistics from Statistics Norway.

A municipality may not collect fees exceeding its annual waste water treatment costs (Ministry of the Environment 1996b). Calculations show that for the whole country, income in the form of fees covered 95 per cent of total costs in 1996. The corresponding figure in 1993 was 80 per cent. This trend shows that the municipalities are adjusting their fees so that they cover more or less the entire actual costs of waste water treatment.

The income-to-cost ratio[2] varies widely from one municipality to another, from 11 to 325 per cent. Twenty-two per cent of all municipalities had an income-to-cost ratio of less than 50 per cent, and 16 per cent had an income-to-cost ratio exceeding 110 per cent. An income-to-cost ratio close to 100 per cent means that the municipality has managed to budget its waste water treatment costs accurately. Income-to-cost ratios for the counties are shown in table E7 in the Appendix.

The municipalities fix annual fees on the basis of either the area of the subscriber's dwelling or measured water consumption, based on the assumption that the volume of water in equals the volume of waste water out. In the period 1993-1996, both types of fee rose by between 5 and 13 per cent. For the whole country, the average annual fee per m³ water was NOK 7.02 in 1997. The corresponding figures for the North Sea counties and the rest of the country were NOK 9.71 and NOK 5.08, respectively. This corresponds to a rise of 8 per cent in the average fee in the North Sea counties and 11 per cent in the rest of the country since 1996 (figure 6.12 and Appendix, table E8).
There are similar variations in fees set on the basis of the area of the subscriber's dwelling.

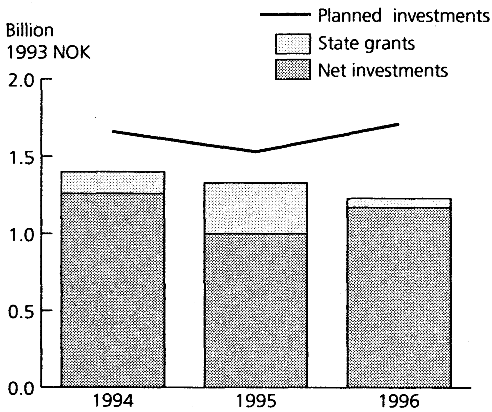
6.12. Investments

In 1996, gross investments in municipal waste water treatment totalled just over NOK 1.3 billion (Appendix, table E9). This is 7 per cent less than the year before. Some projects have been postponed because they have not received state support and because of uncertainty surrounding investments in nitrogen removal facilities (figure 6.13).

For an overview of investment trends in the waste water treatment sector, it can be useful to study investment patterns for the whole country over some years. Gross investments in 1996 were the lowest in the 1990s, and state grants for investments in this sector totalled NOK 68.6 million (measured in constant 1993 NOK), the lowest level for 20 years. In recent years, there has been a drop in gross investments and a lower proportion of the

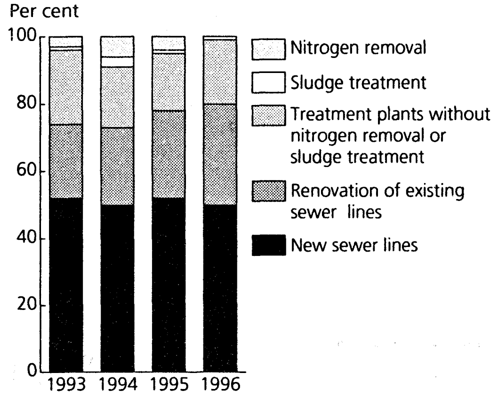
[2] The income-to-cost ratio is the ratio between income from fees and annual costs.

Figure 6.13. **Investments planned and carried out, divided into net investments and state grants. Constant 1993 NOK**



Source: Waste water treatment statistics from Statistics Norway.

Figure 6.14. **Gross investments by category, whole country**



Source: Waste water treatment statistics from Statistics Norway.

planned investments have in fact been carried out (figure 6.13). In 1996, only 71 per cent of the planned investments were carried out. The planned level of investments has always been higher than the actual level, but the difference was greater in 1996 than in previous years. If the difference continues to increase, this may mean that the municipalities are finding long-term planning in this sector increasingly difficult, and as a result, national and local commitments may not be achieved.

In 1996, 79.3 per cent of total investments were used for laying sewers and renovation of sewer systems, while investments in plants without nitrogen removal facilities accounted for 19.3 per cent of the total. The proportion of investments in nitrogen removal dropped from 4 per cent in 1995 to 0.4 per cent in 1996, and only 2.5 per cent of the investments in nitrogen removal planned for 1996 were carried out. Such investments are necessary to meet Norway's commitments under the North Sea Declarations.

Investment patterns in the waste water treatment sector vary a good deal from year to year. Almost all municipalities invest in new sewers every year. Such investments have accounted for the largest proportion of the municipalities' investments in each of the past four years. Municipal sewer systems are continually being expanded, so that a rising proportion of the population is connected to sewer systems.

The second largest proportion of municipal investments in 1996 was used for renovation of existing sewer systems. Such investments are necessary because existing sewers must be repaired and replaced after a certain number of years. A more extensive sewer system also requires more maintenance to ensure that the entire system is kept in good repair. With a more extensive and better-maintained sewer system, less untreated sewage will be discharged.

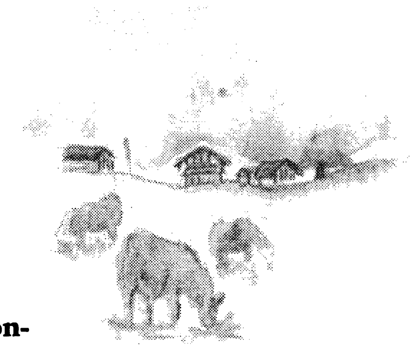
The last category of investments, in waste water treatment plants, sludge treatment and nitrogen removal, improves treatment efficiency for waste water that reaches treatment plants. Such investments often take the form of projects, and investments may therefore be very high in some years and very low in others. The uneven pattern of investments makes it difficult to compare the level of investments in different regions. Table E9 in the Appendix shows investments by county since 1993.

Co-financed by: Norwegian Pollution Control Authority.

Documentation: Hass (1997b) and Mork (1997).

Further information may be obtained from: Kjetil Mork (sections 6.1-6.9), Julie Hass (sections 6.10-6.12).

7. Agriculture



The agricultural sector has a significant environmental impact because farmland occupies large areas and greatly influences their character. Agricultural activities also contribute to certain types of pollution, and nutrient enrichment of water bodies has been the focus of much attention. 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. Despite the decline in the economic importance of agriculture, the area of agricultural land is growing.

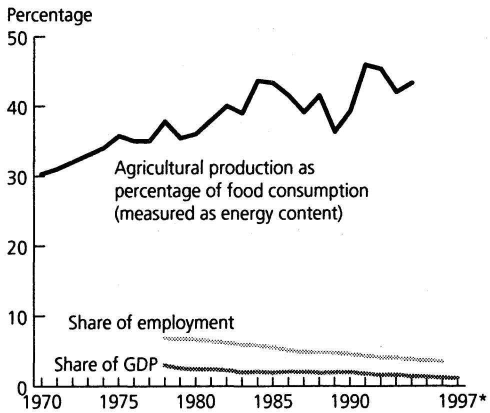
7.1. Principal economic figures for agriculture

The importance of agriculture in economic terms is declining. From 1978 to 1996, the agricultural sector's share of total employment (measured as full-time equivalent persons) sank from 6.8 to 3.5 per cent (figure 7.1). In absolute figures, the drop was from 111 500 to 64 700 full-time equivalent persons. The share of gross domestic product (GDP) derived from agriculture dropped from 3.0 per cent to 1.1 per cent in the period 1978-1997. Agricultural production expressed as a percentage of food consumption by the population (measured as energy content and corrected for import of animal feedstuffs) rose from 30 to 43 per cent in the period 1970 to 1994[1] (National Nutrition Council 1996). Norway has a trade surplus in certain animal products at times, while the degree of self-sufficiency is lowest for sugar, fruit and berries.

7.2. Land suitable for agriculture

The total area of land potentially suitable for agriculture in Norway has been calcu-

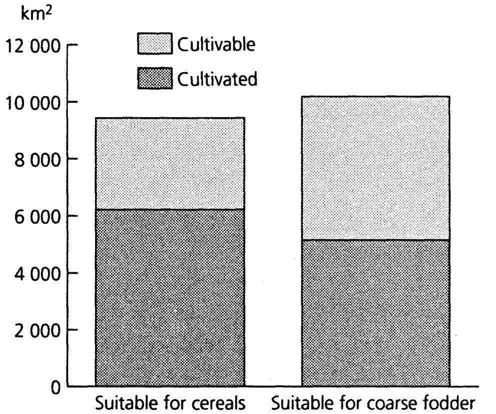
Figure 7.1. **Economic importance of the agricultural sector as a percentage of employment and GDP, and degree of self-sufficiency**



Sources: National Nutrition Council and National Accounts from Statistics Norway.

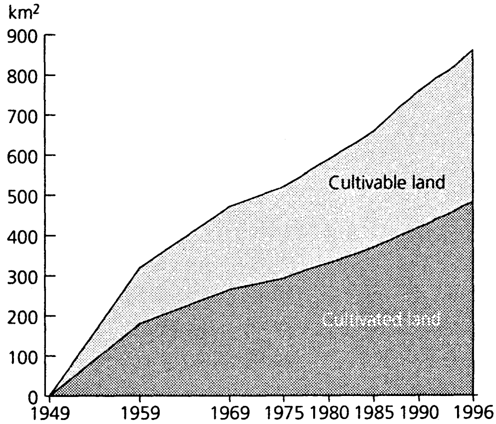
[1] This method of calculating the degree of self-sufficiency, i.e. corrected for imported feedstuffs, cannot be used after 1994 because the import monopoly for cereals was abolished.

Figure 7.2. **Agricultural land in Norway**



Source: Grønlund (1997).

Figure 7.3. **Conversion of cultivated and cultivable[1] land for other purposes since 1949**



[1] For 1949-1976, only data for cultivated areas is available. The area of cultivable land is estimated on the basis of the ratio between cultivable and cultivated land developed in the period 1976-1996.
Sources: Agricultural Censuses from Statistics Norway and Ministry of Agriculture.

lated to be about 19 000 km² (Grønlund 1997), of which about 10 000 km² is in use. In general, the best soils are cultivated, so that other cultivable land is normally of poorer quality. According to Grønlund (1997), 66 per cent of the best class of soils (suitable for cereals) is in use, but only about 50 per cent of the poorest quality class (figure 7.2).

Conversion of cultivated and cultivable land for other purposes

Because Norway has a cold climate and limited areas suitable for agriculture, its capacity for self-sufficiency is limited. At present, the self-sufficiency rate is just under 50 per cent. It is an explicit policy goal to maintain the country's capacity for self-sufficiency, so that the degree of self-sufficiency can be increased at need, for example in a trade crisis (Proposition No. 8 (1992-93) to the Storting). One of the most important means of ensuring this is to maintain areas that are suitable for agricultural purposes. The greatest threat to agricultural land is its conversion for purposes that prevent agricultural production in the future, e.g. development for roads and housing. Since 1949, an estimated 840 000 decares[2], or about 4.4 per cent of the total area suitable for agriculture, have been used for such purposes (figure 7.3).

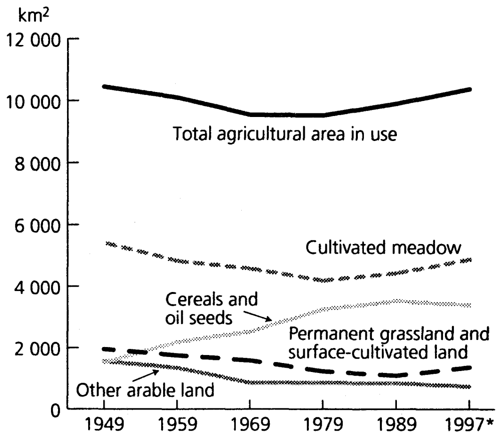
The rate at which agricultural land was lost in this way was particularly high in the 1950s and lower in the 1970s, but has risen again more recently.

Agricultural land in use

Since 1949, the area of agricultural land in use has varied between 9 500 and 10 500 km² (figure 7.4). Since the late 1980s, the area has gradually increased, and was 10 400 km² in 1997 (see Appen-

[2] 1 decare = 0.1 hectare.

Figure 7.4. **Agricultural areas in use**



Source: Agricultural Statistics from Statistics Norway.

dix, table F1). Some of the increase recorded in recent years is probably due to a reorganization of the grants system, from support based on production to support based on the areas farmed. For instance, the acreage and cultural landscape support scheme was introduced in 1989. Grants under this scheme have made it more worthwhile for farmers to use marginal areas that were previously of little economic importance (Budget Committee for Agriculture 1997). One of the reasons for the reorganization of the grants system is the goal of maintaining the country's capacity for self-sufficiency, which means that agricultural areas must not be converted to other uses.

In 1997, cereal and oil-seed acreage made up 33 per cent of the agricultural area in use, and cultivated meadow 47 per cent. The acreage of cereals reached a peak in 1991, and has since dropped by 10 per cent. The area of cultivated meadow was at its lowest level in 1980, since when it has risen by about 16 per cent. In recent years, there has been a particularly large increase in the area of fertilized pasture, which is included in the area of permanent grassland, which has risen by 64 per cent since 1985. This is probably related to the introduction of acreage and cultural landscape support.

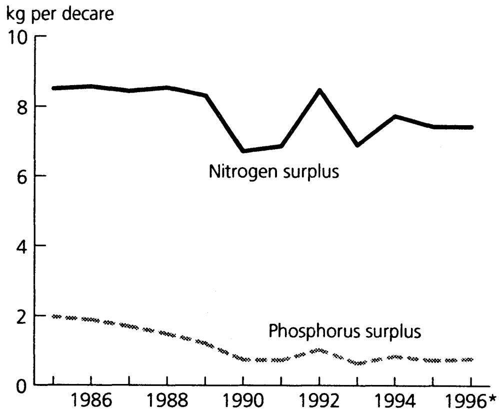
7.3. Environmental impacts

The negative environmental impacts of agriculture are pollution and alteration of biotopes (or landscape changes). Few systematic and nationwide figures are available for the latter. However, there are better statistics on pollution since this problem has been given priority in several contexts, for instance in the North Sea Declarations (see Chapter 6.1).

The most serious type of pollution from agriculture is considered to be runoff of nutrients (nitrogen and phosphorus). Agriculture accounts for about 30 per cent of phosphorus inputs and 50 per cent of nitrogen inputs to the coast (Norwegian Institute for Water Research 1997) (see figure 6.3). Nutrient enrichment (eutrophication) is a particularly serious problem locally in water recipients where much of the surrounding land is agricultural.

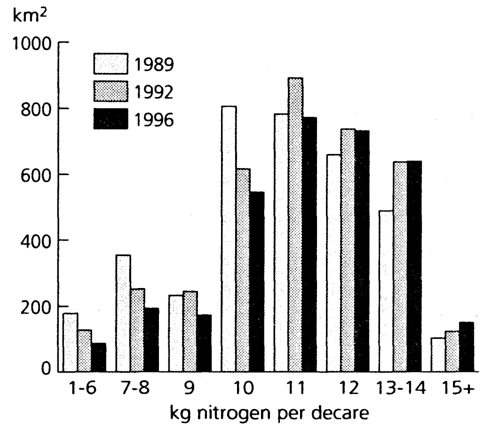
The agricultural sector is also responsible for significant emissions of greenhouse gases. About 9 per cent of Norway's total greenhouse gas emissions, measured as CO_2 equivalents, are generated by agricultural activities. Emissions of methane (CH_4) and nitrous oxide (N_2O) are particularly high (see Chapter 4 and Appendix, tables C3-C5). No measures have as yet been implemented to reduce greenhouse gas emissions from the agricultural sector.

Figure 7.5. **Surplus of nutrients (nitrogen and phosphorus) on agricultural areas: average figures per decare and year**



Sources: Agricultural Statistics from Statistics Norway and Norwegian National Grain Administration.

Figure 7.6. **Area of cereals and oil seeds by intensity of fertilizer application (kg nitrogen per decare in commercial fertilizer)**



Source: Agricultural Statistics from Statistics Norway.

Measures to limit runoff of nutrients can be divided into three main groups:

- better fertilizer management to reduce the surplus of nutrients in soils
- better cultivation systems to protect soils against erosion, such as reducing or postponing tillage, the use of catch crops, etc.
- technical facilities (hydrotechnical facilities, improvement and expansion of manure storage facilities, etc.).

Balance between fertilization and yields

Good fertilizer management involves maximizing the uptake of the nutrients added by crop plants. Heavy applications of fertilizer in relation to the yields obtained may result in a large surplus of nutrients, which raises the risk of loss of nutrients. The size of the surplus can be calculated by means of a nutrient balance for agricultural areas.

In this context, the nutrient balance for agricultural areas is defined as the difference between the quantities of nutrients added in commercial fertilizer and animal manure, and the quantities removed in the form of crops. Figure 7.5 shows changes in the nitrogen and phosphorus balance from 1985 to 1996. Nitrogen losses in the form of NH_3 emissions from commercial fertilizer and animal manure have been subtracted.

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 (denitrification).

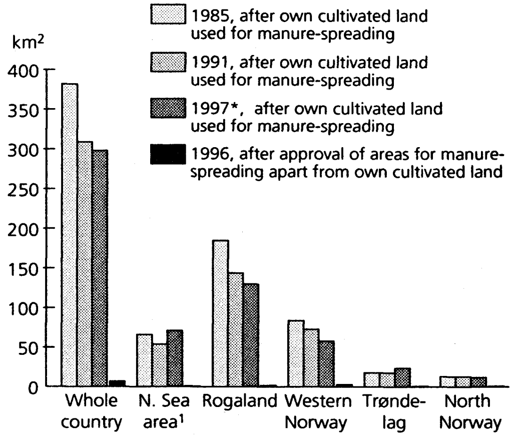
Using this method of calculation, we find that in 1985, the surplus per decare of agricultural land was 8.5 kg nitrogen and 2.0 kg phosphorus. By 1996, these figures had dropped to 7.4 kg nitrogen and 0.75 kg phosphorus. The phosphorus surplus per decare dropped steeply from 1985 to 1990 because farmers reduced the amount of phosphorus applied in commercial fertilizer. Otherwise, both fertilizer application and yields have been relatively stable, except for fluctuations in yields caused by variable weather conditions. These explain the large fluctuations in nutrient surplus from year to year. Some of the data on which figure 7.5 is based are given in table F2 in the Appendix.

Application of commercial fertilizer

Sales of phosphorus in commercial fertilizer dropped by more than 50 per cent from the early 1980s to the early 1990s, and have totalled about 13 000 - 14 000 tonnes per year for the past four years. Sales of nitrogen in commercial fertilizer have been stable at around 110 000 tonnes since 1980. The sales figures are shown in table F3 in the Appendix. 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.

According to figures from the annual Sample Survey of Agriculture, nitrogen fertilization of cereals rose from 10.6 to 11.3 kg/decare from 1989 to 1996, while nitrogen fertilization of meadow has remained stable at 13.7 kg/decare. In recent years, there has been a clear trend towards more uniform fertilization of meadow, i.e. less and less of the total area is either intensively or lightly fertilized. This may be connected with the more widespread use of fertilization plans, which means that the amount of fertilizer applied is determined on the basis of soil samples and recommended standards. In 1990, 25 per cent of all holdings had fertilization plans, and by 1996 this figure had risen to 56 per cent. However, intensive fertilization of cereals has become

Figure 7.7. **Shortfall in areas for manure spreading**



[1] Counties to which the North Sea Declarations apply, see box 6.1.

Sources: Statistics Norway and Norwegian National Grain Administration.

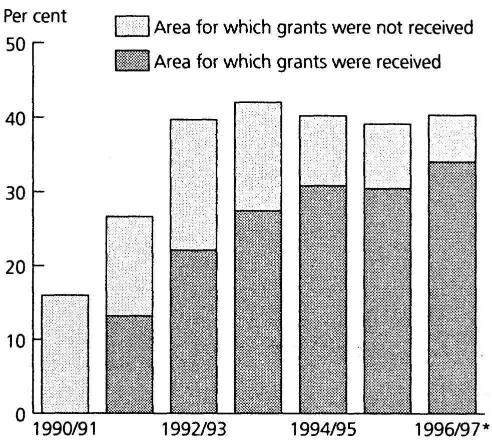
more widespread in recent years (figure 7.6). This may be because the split application of fertilizer became considerably more common from 1989 to 1993 (no statistics available after 1993). The overall effect of more widespread use of fertilization plans is uncertain, since this results in heavier fertilization of some areas and lighter fertilization of others.

Application of animal manure

Livestock numbers, and therefore the amount of manure produced, have changed little since 1985. The proportion of the manure applied during the growing season, expressed as nitrogen, was 80 per cent in 1989 and has been about 87 per cent in recent years. Application during the growing season is important to ensure efficient utilization of the manure.

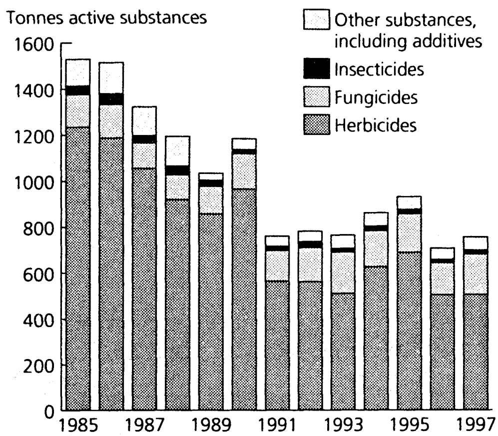
If livestock numbers are high in relation to the agricultural area in use, there may be an excess of manure and thus a risk of

Figure 7.8. **Proportion of cereal acreage under stubble in autumn**



Sources: Agricultural Statistics from Statistics Norway and Ministry of Agriculture.

Figure 7.9. **Sales of pesticides expressed as tonnes active substances**



Source: Norwegian Agricultural Inspection Service.

pollution. To prevent this, the authorities introduced the requirement that a farm must have at least four decares suitable for manure spreading per animal manure unit (manure from various types of livestock is expressed in terms of the manure produced by one cow). If there is too little cultivated land on the farm to meet this requirement, the farmer must fertilize land that is not cultivated, sell the manure or use it on other farms. Use of manure on 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 1997 was 298 000 decares, as compared with 380 000 decares in 1985. Nevertheless, in 1996 the actual shortfall after the approval of other areas for manure spreading was only 6 900 decares (figure 7.7). This means that farmers have been able to find enough land for manure spreading without reducing livestock numbers or cultivating more of their own land. Manure spreading on land belonging to others is the most important means of solving this problem.

Soil management

A large proportion of pollution from the agricultural sector is a result of erosion, i.e. transport of soil with surface water runoff from fields. Most erosion takes place on fields that are ploughed in autumn. Such areas are left for up to three-quarters of the year with no plant cover to protect the soil from rain and melt-water. In the long term, erosion also reduces the production capacity of the soil.

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. Support is provided

Box 7.1. Ecological agriculture

Ecological agriculture is a collective term for various farming systems based on some common principles:

- no use of commercial fertilizer or chemical/synthetic pesticides
- cultivation of a variety of crops and diversified crop rotation
- cultivation systems should have a preventive effect on disease and pests
- organic material recycled as far as possible
- balance between livestock numbers and areas of farmland with respect to fodder production and use of manure

Ecological agriculture has certain environmental advantages over conventional farming systems:

- often higher product quality
- less loss of nutrients and thus less pollution
- more varied agricultural landscape and therefore greater species diversity in and around agricultural areas
- no pesticide residues in soils or products

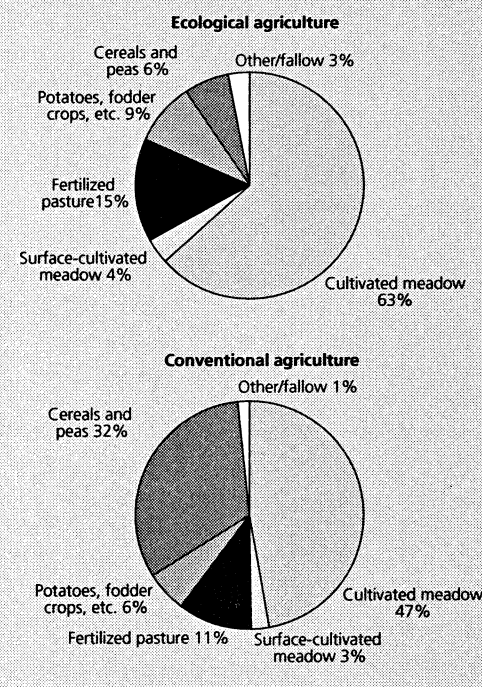
Ecological agriculture is considerably more labour-intensive than conventional agriculture, and yields are generally lower. This makes it more difficult to obtain earnings that are as high as those from ordinary agriculture, despite higher product prices.

The Agricultural Agreement has included support schemes for ecological farming practices since 1990. Conversion and acreage support is provided, as well as funds for control, research, information and marketing. The rules for ecological agricultural production are laid down in regulations issued by the Ministry of Agriculture, and the organization DEBIO is responsible for inspection and control. Each holding run on ecological principles must be approved by DEBIO and must be inspected at least once a year.

Ecological agriculture has been expanding in Norway in recent years. Areas approved for ecological agriculture have been registered since 1991, and the total area rose from 18 km^2 in 1991 to 74 km^2 in 1997 (see Appendix, table F6). Thus, only just above 0.7 per cent of the total agricultural area in use is farmed ecologically.

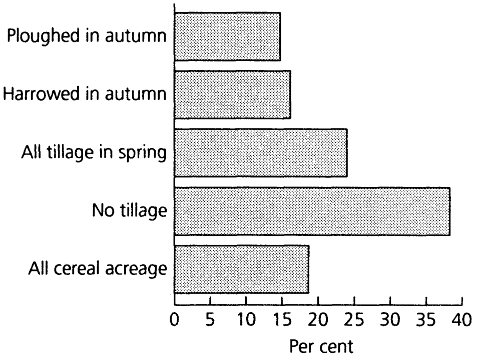
Ecological agriculture is based on coarse fodder production to a larger extent than conventional agriculture. Figure 7.10 shows land use by crop in ordinary and ecological agriculture.

Figure 7.10. **Crops on agricultural areas in use in ecological and conventional agriculture in 1996**



Sources: Agricultural Censuses from Statistics Norway, DEBIO and Norwegian National Grain Administration.

Figure 7.11. **Proportion of cereal acreage sprayed against perennial weeds according to soil management regime. Average for the period 1992-93 to 1996-97**



Source: Bye and Mork (1998).

because crop yields are expected to be lower without autumn tillage. The proportion of areas 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 7.8 and Appendix, table F4). However, the proportion of the area under stubble for which support is granted has risen steadily throughout the period, and was 85 per cent in 1996-97. A growing proportion of the grants is being provided for areas that are particularly vulnerable to erosion.

Technical facilities to improve environmental conditions

In autumn 1988, a grants scheme for technical facilities to improve environmental conditions was introduced, with the aim of reducing point discharges, runoff and erosion from agriculture. The most important measures included in the scheme are improvements of silos, manure storage facilities and various hydrotechnical facilities (surface water basins, etc.). Payments under this scheme reached a peak of NOK 92 million in 1993. In 1997, grants totalled NOK 67 million.

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 further after this (figure 7.9 and Appendix, table F5). The degradation rates of different pesticides vary widely, as do their selectivity and toxicity. These properties are very important for their impact on the environment. Over the years, there has been a changeover to low-dose pesticides. This means that even when sales (expressed as kilograms of active substances) are lower, the area sprayed is not correspondingly reduced. Nevertheless, changes in the total consumption of pesticides do give some indication of whether their environmental impact is increasing or decreasing.

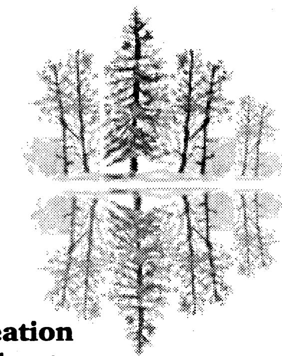
Perennial weeds, especially couch-grass, are the most serious problem in cereal production. They are controlled either by tilling or using herbicides. During the past five years, an average of 19 per cent of the area under cereals has been sprayed against perennial weeds each year. Although the extent of the spraying varies widely from year to year depending on conditions during harvesting, there is a clear relationship in all years 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, 38 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 7.11). Thus, when tillage is reduced, erosion and pollution by nutrients is reduced, but larger amounts of pesticides are used. This means that given current agricultural practice, the environmental cost of reducing erosion by limiting tillage is greater use of pesticides.

Co-financed by: Ministry of Agriculture.

Documentation: Bye and Mork (1998).

Further information may be obtained from: Henning Høie.

8. Forest



Forests contain many types of natural resources. Their direct benefits to people are primarily related to recreation and the harvesting of timber, game and berries. This chapter focuses on the timber resources of forests. Ever since the first forest inventory was made in 1925, the annual increment has been larger than the harvest. As a result, the volume of the growing stock has more than doubled since 1925. The net increment in 1996 was 12 million m^3, which means that the uptake of CO_2 from the atmosphere by forests corresponded to about 40 per cent of Norway's anthropogenic CO_2 emissions.

Forest damage still appears to be on the increase, as shown by the fact that average crown density, which is one of the indicators used, dropped for the seventh year in a row. The economic importance of forestry has been reduced in the last few years by low timber prices and moderate harvesting.

8.1. 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, or 0.3 per cent of total employment (figure 8.1). Forestry's share of Norway's GDP has dropped from 0.57 to 0.29 per cent in the same period. The gross value of the roundwood cut for sale and industrial production in 1995-96 was calculated at NOK 2.6 billion, which is 24 per cent less than the year before in current NOK (Statistics Norway 1997g). The average roundwood price dropped by NOK 38 to NOK 335 per m^3 in 1995-96.

8.2. Resources and reserves

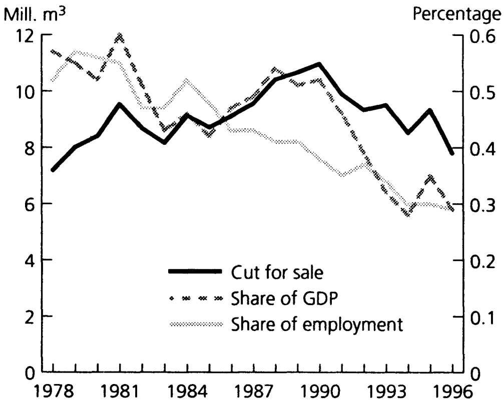
Areas and ownership structure

Productive forests cover about 72 000 km^2 in total, or 24 per cent of the area of Norway excluding Svalbard. This is 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 managed in combination with agricultural operations.

Volume of the growing stock and annual increment

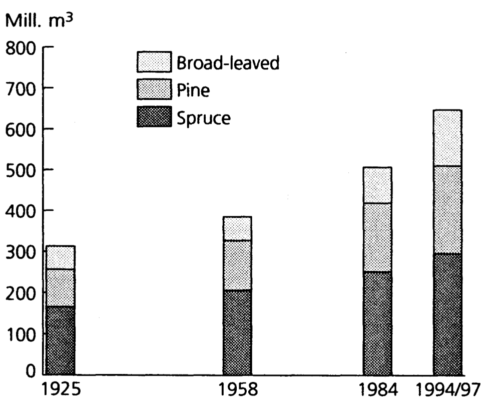
Forest inventories and calculations of volume show that the volume of the growing stock below the coniferous forest line more than doubled from 1925 to 1995-96 (figure 8.2). The increase was particularly rapid towards the end of the

Figure 8.1. **Forestry: share of employment and GDP. Roundwood cut**



Source: National Accounts and Forestry Statistics from Statistics Norway.

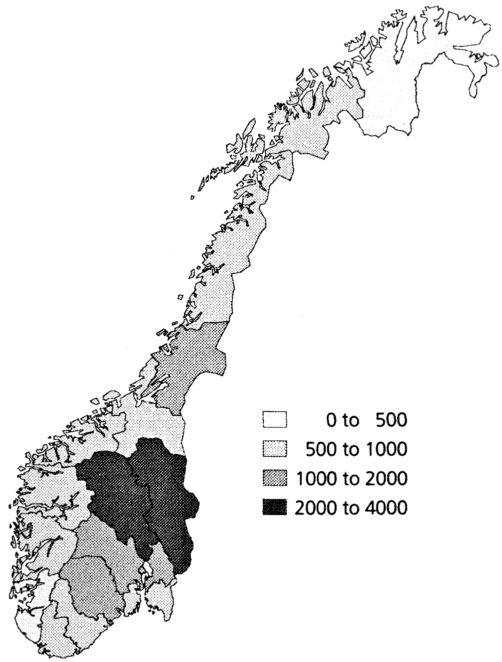
Figure 8.2. **Volume of the growing stock without bark**



Sources: Material from Statistics Norway and National Forest Inventory.

period. The annual gross increment varies from one part of the country to another, depending on the distribution of forest and the climate (figure 8.3). Annual figures for the volume of the growing stock, the forest balance, show the calculated

Figure 8.3. **Annual gross increment in forests by county. Average for 1986-1993 in 1 000 m³**



Source: Norwegian Institute for Land Inventory (1994). Digital map data: Norwegian Mapping Authority.

figures for the growing stock at the beginning and end of the year. The most recent data from inventories carried out by the Norwegian Institute for Land Inventory (NIJOS) show that the total volume of the growing stock, without bark, below the coniferous forest line was on average 648 million m³ in the period 1994-1997. This total consisted of 46 per cent spruce, 33 per cent pine and 21 per cent broad-leaved trees. In 1996, the net increment (annual increment minus roundwood cut and calculated natural losses) in the growing stock was 11.6 million m³, or 1.8 per cent of the total volume (figure 8.4. and Appendix, tables G1 and G2). The net increment was highest for broad-leaved trees and pine.

A positive net increment shows that the timber harvest is smaller than the gross increment. This means that the biomass of forests is increasing, and that they are assimilating CO_2 from the atmosphere. In recent years, the net uptake of CO_2 by productive forests has been rising and now corresponds to more than 40 per cent of Norway's anthropogenic CO_2 emissions. This includes CO_2 assimilated in bark, roots and other biomass. According to the Kyoto Protocol (see Chapter 4), Norway may not deduct net accumulation of CO_2 in forests from its CO_2 emissions. Only CO_2 accumulation resulting from afforestation of new areas, which will account for a very small proportion of the total in Norway, may be deducted. The Kyoto Protocol is formulated in such a way that the annual increment and harvest will be of very little importance in Norway's efforts to meet its commitment under the Protocol.

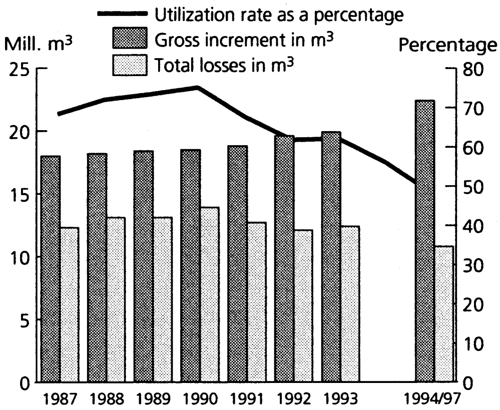
8.3. Roundwood cut and silviculture

Roundwood cut

In 1995-96, the total volume of the roundwood cut for sale and industrial production was 7.8 million m³. This is 16 per cent less than the year before, and the lowest figure since 1977-78. The drop in the volume harvested was largest for spruce (17 per cent lower than the year before). The decrease in the volume harvested varied somewhat between tree species and types of timber. The harvest included 3.7 million m³ special timber and sawlogs and 3.6 million m³ pulpwood.

The annual utilization rate for timber can be calculated as the total annual losses in the volume of the growing stock expressed as a percentage of the gross increment in volume. The utilization rate has been decreasing since 1990, and was 48 per cent in 1996 (figure 8.4). The low utilization rate has resulted in a substantial net increment in forests in recent years (see section 8.2).

Figure 8.4. **Gross increment, total losses and utilization rate of the growing stock**



Source: Forestry Statistics from Statistics Norway.

Silviculture

From 1980 to 1991, an area of about 300 km² was planted with forest every year. More recently, the level of activity has dropped somewhat, and in 1996 the annual area planted was calculated to be about 218 km² (Ministry of Agriculture 1998). In 1996, a total area of about 481 km² was subjected to clearance and weed control. Chemical weed control was used on about 6 per cent of this area.

The annual costs of afforestation fell from NOK 160 million in 1989 to NOK 145 million in 1996. The costs of clearance and weed control in forestry dropped from NOK 135 million in 1989 to NOK 93 million in 1996.

The registered level of silviculture activities has been dropping for several years. This may be partly explained by the fact that thinning accounts for a rising proportion of the roundwood cut, and partly by the fact that clear-cutting and replanting are to some extent being replaced by logging techniques that ensure natural regeneration to a larger degree. A reduction in the extent of other silviculture measures, such as clearance and weed control, may in the long term result in less efficient use of resources.

Forestry roads

The construction of forestry roads can entail a number of adverse environmental impacts, and has for many years been an important cause of the reduction in the size and number of undisturbed areas of natural habitat in Norway (SSB/SFT/DN 1994). According to the Agricultural Census for 1989, Norway then had 45 000 km of forestry roads suitable for lorries and 48 000 km of forestry tracks suitable for tractors, all for year-round use. A further 4 785 km of forestry roads for year-round use were built from 1990 to 1996. Construction of forestry roads is no longer proceeding at such a high tempo. The annual length of road constructed was roughly halved between 1990 and 1996, from 739 to 303 km for roads suitable for lorries and from 2 081 to 832 km for tracks suitable for tractors (Statistics Norway 1997h).

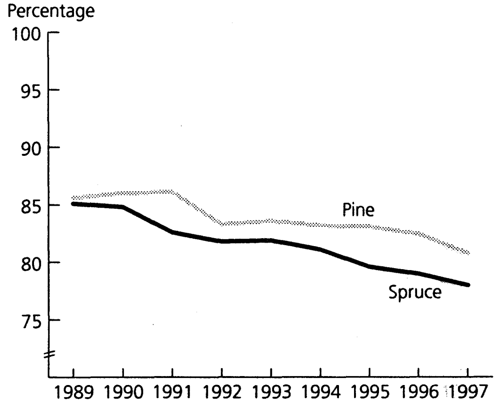
Expenditure on the construction and maintenance of forestry roads and tracks dropped from NOK 305 million in 1990 to NOK 170 million in 1996. In recent years, investments in road construction have increasingly been used to alter and improve already existing roads. In 1996, 327 km of existing forestry roads was improved.

8.4. Forest damage

Forest damage in Norway

The causes of forest damage are often complex. Unfavourable climate and

Figure 8.5. **Mean crown density of spruce and pine**



Source: Norwegian Institute for Land Inventory (1998).

weather conditions, insect and fungal attacks, forest fires and air pollution are important factors for the health of forests. Results from the Norwegian monitoring programme for forest damage (Norwegian Institute for Land Inventory 1998) show the current state of health of forests, measured as mean crown density and crown colour for the country as a whole. Crown density is measured as the leaf or needle mass of the tree compared with the theoretical mass for the same tree with a completely healthy crown (100 per cent). The mean crown density for spruce dropped from 85 per cent to 78 per cent in the period 1989 to 1997 (figure 8.5). The mean crown density for pine fell from 86 per cent in 1991 to 83 per cent in 1992, and remained at about this level up to 1996. In 1997, the average crown density for pine had dropped to 81 per cent.

There are regional differences in the results, which may be explained by variations in weather conditions and fungus and insect attacks, in addition to variations in pollution load.

In 1997, every fifth spruce tree in southern and central Norway showed discoloration of the crown (i.e. discoloration of more than 10 per cent of the crown). This figure was lower than in 1996. Discoloration of the crown is related to various factors, including the age of the tree. The proportion of spruce trees aged over 60 years showing discoloration of the crown was 29 per cent in 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. In southern Norway, average crown density dropped from 78 per cent in 1992 to 76 per cent in 1997. In North Norway, the average crown density has risen from 68 to 71 per cent in the same period. Broadleaved trees respond rapidly to natural stresses such as drought and insect attacks, and observations over many years are needed to give a complete picture of national and regional trends.

Forest damage in Europe

Since 1985, European countries have been cooperating to register and monitor the effects of air pollution on forests. In 1995, 30 countries took part in the programme, and a total of 117 035 trees were sampled.

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 to 13 per cent from 1994 to 1995.

According to the report from Bundesministerium für Ernährung, air pollution is considered to be the most important inciting factor in forest damage (in the form of crown thinning, discoloration of leaves and needles, and death of trees) in those countries where there is most severe air pollution. However, there are also clear regional differences within these countries; for example, proximity to towns is an important factor. Most scientists in Europe consider air pollution to be only one of a number of causes of forest damage. Long-term changes in the chemical and physical properties of forest soils, periods of drought, forest fires, insect attacks, wind damage, etc. all also affect the health of forests.

Further information may be obtained from: Per Schøning and Ketil Flugsrud.

9. Fisheries, sealing, whaling and fish farming

The fisheries are based on conditionally renewable natural resources. Sound management of fish stocks is therefore of crucial importance for a high, stable long-term yield. Stocks of several important fish species in the North Sea are now low. In the Norwegian and Barents Seas, the situation varies more between stocks. The capelin stock is still very low, but the spawning stock of Norwegian spring-spawning herring has almost returned to its size in the 1950s, and catches of herring have therefore risen steeply in recent years.

Sound management of fish resources is also important because of the economic importance of the fisheries, which account for about 15 per cent of exports of traditional goods from Norway. The fisheries and fish processing and fish farming industries also provide employment and substantial economic growth in outlying districts.

9.1. Principal economic figures for the fisheries

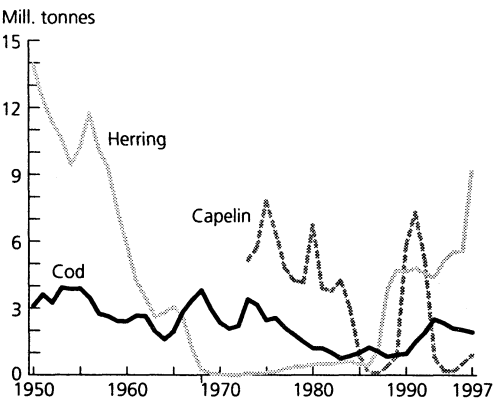
According to the national accounts, the share of Norway's gross domestic product (GDP) derived from fishing, sealing and whaling decreased from 0.8 per cent in 1978 to 0.7 per cent in 1997. The share of total employment decreased from 1.1 per cent to 0.9 per cent from 1978 to 1996. At the end of 1997, 22 900 fishermen were registered in Norway, and fishing was the main occupation of 73 per cent of these.

9.2. Trends in stocks

Barents Sea and Norwegian Sea

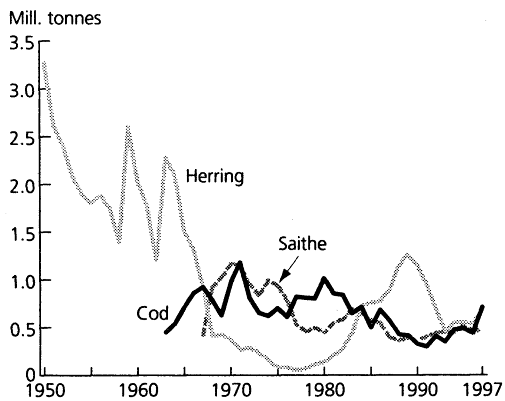
Norwegian spring-spawning herring, capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Since the end of the 1960s, all three of these stocks have at some time reached a historical low (figure 9.1). The herring stock was severely depleted by overfishing at the end of the 1960s, but has been recovering very satisfactorily in recent years (see also Appendix, table H1). The spawning stock of Norwegian spring-spawning herring is now calculated to be more than 9 million tonnes. The large increase in the stock is explained by the fact that the two strong year-classes from 1991 and 1992 have now become part of the spawning stock. The capelin stock in the Barents Sea collapsed in 1986-87, partly as a result of overfishing, but also from natural causes, It recovered rapidly after this, but dropped sharply again in 1993. The latest development is a result of a significant increase in the natural mortality of both

Figure 9.1. **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 9.2. **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.

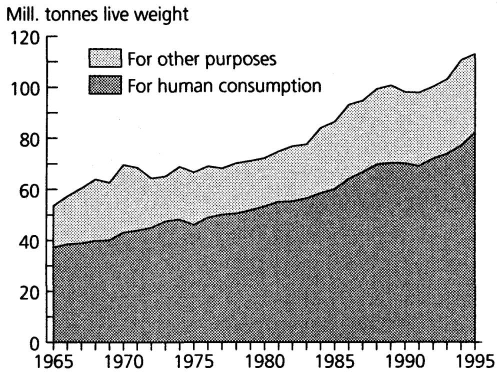
larvae and older capelin. This is explained by predation; cod and marine mammals in particular feed on adult capelin, and juvenile herring feed on capelin larvae. The capelin stock will remain low for the next few years, but better recruitment and faster individual growth are signs of positive developments after this (Institute of Marine Research 1997a). The cod stock was low throughout the 1980s, but has risen again in the 1990s. There is some uncertainty as to how this stock will develop, and the stock estimate has recently been reduced.

North Sea

The stock of North Sea herring rose steadily from 1980 onwards, but the spawning stock has dropped considerably during the 1990s (figure 9.2 and Appendix, table H1). One reason for this is that recruitment to the stock has been generally poor, partly because of the large annual harvest of juvenile herring. The fishing pressure on adult herring has also been high. Stocks of demersal fish in the North Sea are now showing signs of growth, but are still lower than they were in the early 1970s. This suggests that the natural mortality of juvenile herring is probably not as high as it was formerly. In 1996 and 1997, fishing pressure on both juvenile and adult herring was substantially reduced compared with preceding years. This allowed for some growth of the spawning stock in 1997 (figure 9.2).

For management purposes, the spawning stocks of mackerel from the three spawning grounds (the North Sea, south-west of Ireland and off Spain and Portugal) are now considered as one stock. The total spawning stock dropped somewhat until 1994 and has since been around 2.5 million tonnes. The largest component of the stock is found off Ireland, where the spawning biomass is about 2 million tonnes. The North Sea component is about 0.1 million tonnes. The component that spawns in southern waters is between

Figure 9.3. **World fish production by main uses**



Source: FAO.

0.3 and 0.4 million tonnes, and it is estimated that this has dropped by half since 1992. Mackerel can make lengthy migrations in a short space of time. There is therefore some exchange of individuals between all three components of the stock, and catches of all three are taken on Norwegian fishing grounds (Institute of Marine Research 1997a).

9.3. Fisheries and fish farming

World catches

World fish production, including both fresh-water and marine catches and fish farming, has increased substantially from slightly more than 50 million tonnes in 1965 to about 113 million tonnes in 1995 (figure 9.3). More than 80 per cent of the total is from marine areas. According to the FAO, the most important cause of the rise in recent years is the growth in aquaculture production, particularly in China, and in catches of pelagic species off the west coast of South America. As a result, both fish meal production and fish supplies for human consumption have reached record levels (FAO 1997a and b).

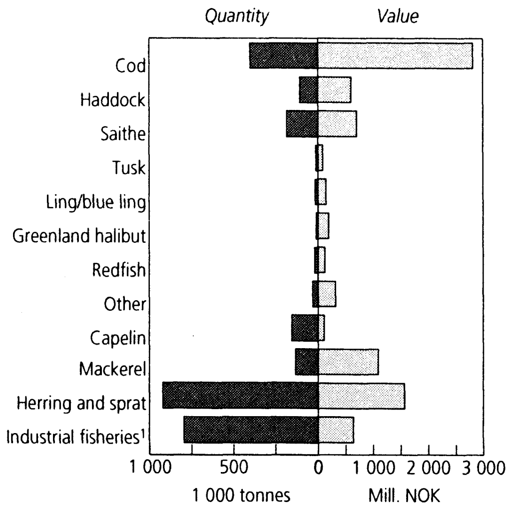
Norway's fisheries rank as number 10 in the world with a total catch of 2.8 million tonnes in 1995. The countries at the head of the list are China (24.4 million tonnes), Peru (8.9 million tonnes), Chile (7.6 million tonnes), Japan (6.8 million tonnes) and the USA (5.6 million tonnes) (Appendix, table H7).

The proportion of world fish production used for human consumption has remained relatively constant at about 70 per cent for the entire period after 1965. In Norway, the proportion used for human consumption was 66 per cent in 1995. However, in 1966 and 1975, when there were large catches of herring and capelin respectively, the proportion was less than 30 per cent.

Norwegian catches

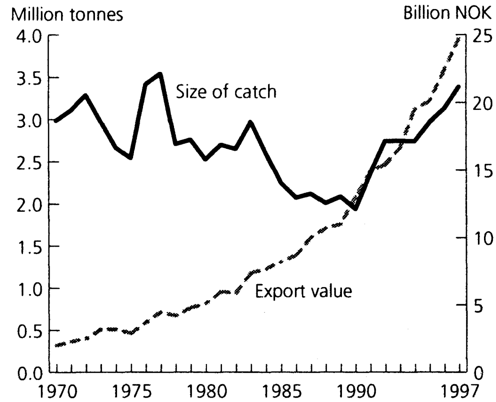
The total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) in 1997 was 3 million tonnes, and the first-hand value was NOK 9 billion. The total catch was the highest since 1977 and about 220 000 tonnes higher than in 1996. Its value rose by about NOK 350 million. The catch of herring rose by more than 150 000 tonnes in 1997, and its value increased by nearly NOK 80 million to NOK 1.55 billion. The catch of mackerel was about the same as in 1996. The catch of cod rose by about 40 000 tonnes from 1996, and its value rose by about NOK 300 million to NOK 2.81 billion. There has also been a considerable increase in the catch and its value in industrial fisheries (fish as raw material for meal and oil). This is explained by a large increase in the catches of sandeel and horse mackerel, which outweighed the halving of the Norway pout catch. First-hand values and catches in 1997 are shown in figure 9.4 (see also Appendix, table H2). Figure 9.5 shows trends in

Figure 9.4. **Norwegian catches by groups of fish species, 1997**



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

Figure 9.5. **Catches[1] and export value[1]**



[1] Salmon farming included.
Sources: External Trade Statistics from Statistics Norway and Directorate of Fisheries.

catches in Norwegian fisheries and in the export value of fish and fish products.

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 292 000 tonnes in 1996 to 315 000 tonnes in 1997 (figure 9.6). More than 80 per cent of the farmed salmon is exported. In 1996, Norway accounted for 51 per cent of total world production of farmed Atlantic salmon (Institute of Marine Research 1997b). The production of rainbow trout has also risen and was about 35 000 tonnes in 1997. Production in the Norwegian fish farming industry is now higher than total meat production in Norwegian agriculture, which was about 250 000 tonnes in 1996.

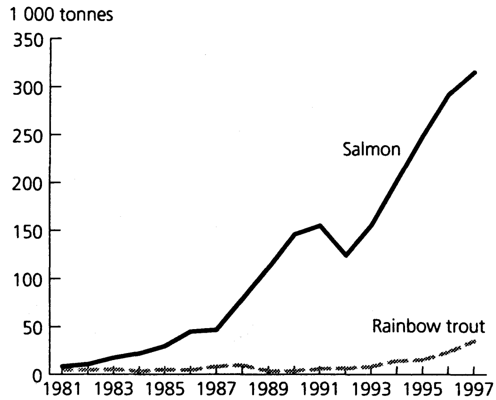
The health of farmed salmon

According to figures from the National Veterinary Institute, the most important diseases affecting salmon farming are:

- Furunculosis, caused by the bacterium *Aeromonas salmonicida* (diagnosed at three fish farms in 1996);
- Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum* (diagnosed at 15 fish farms in 1996);
- Vibriosis and cold-water vibriosis, caused by the bacteria *Vibrio anguillarum* and *Vibrio salmonicida* (diagnosed at 16 and eight fish farms respectively in 1996);
- Infectious salmon anaemia (ISA), a virus disease (diagnosed at seven fish farms in 1996);
- Infectious pancreatic necrosis (IPN), a virus disease (diagnosed at 221 fish farms in 1996).

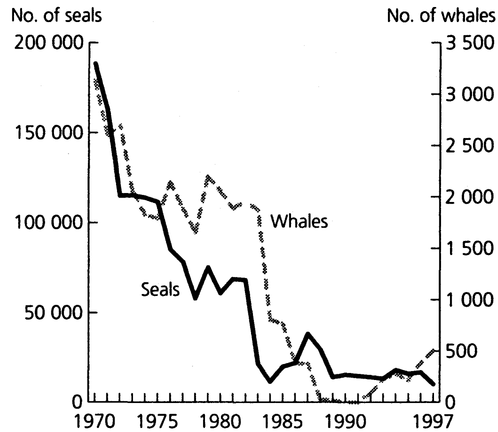
The health of farmed fish has been considerably improved, and the use of medicines by the fish farming industry has been

Figure 9.6. **Fish farming. Slaughtered quantities of salmon and rainbow trout**



Sources: Fishery Statistics from Statistics Norway, Directorate of Fisheries and Kontali AS.

Figure 9.7. **Norwegian catches of seals and small whales**[1]



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

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 (Appendix, table H3). 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 1997, consumption had been reduced to 746 kg, corresponding to 0.002 g per kg fish produced. 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.

The salmon louse (a parasitic crustacean) is still the most important cause of losses in the salmon farming industry. Estimated losses caused by the parasite are NOK 100-500 million per year (Institute of Marine Research 1997b). It is controlled either by chemical means or biologically, using wrasses (goldsinny, corkwing and ballan wrasse and rock cook are commonly used species). Salmon lice can cause poor growth, injure salmon and cause secondary infections followed by outbreaks of disease.

9.4. Sealing and whaling

Since the early 1980s, catches of seals have been small, varying between 10 000 and 40 000 animals per season (figure 9.7). In 1997, the total catch was 10 114 animals (7 180 harp seals and 2 934 hooded seals). Catches of seals for research purposes (a little over 300 animals) are included in these figures. Since 1983, Norwegian sealing has taken place only in the West Ice (off Jan Mayen) and in the East Ice (the White Sea). The catch in the West Ice includes both hooded seals (2 934) and harp seals (2 161), whereas that in the East Ice consists entirely of harp seals (5 019).

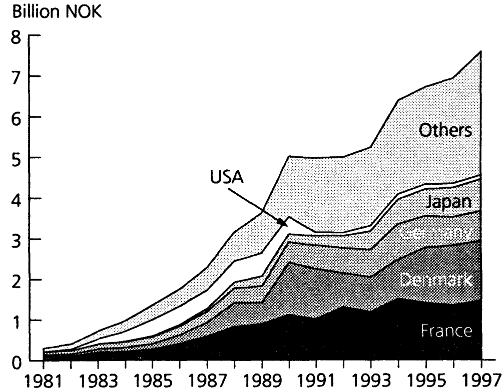
Until the early 1980s, the annual value of the seal catch was between NOK 10 and 40 million. In 1997, the value was just under NOK 2 million. Difficult market conditions as a result of international opposition, particularly to catches of seal pups, and restrictions on sealing are the main reasons for the large drop in the value of the catch. In the mid-1920s, about 150 boats took part in Norwegian sealing, but only a small number has been involved since about 1980. In the 1997 season, only two trips were made to the sealing grounds in the West Ice and one to the East Ice.

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 1997, 503 minke whales of a total quota of 572 animals were caught. The traditional hunt was discontinued and later quotas were much reduced in response to international opposition to whaling and resolutions adopted by the International Whaling Commission (IWC). The IWC has adopted a temporary moratorium on commercial whaling, and in 1985 classified the North East Atlantic minke whale stock as a protected stock. Norway lodged reservations against both these decisions, but discontinued the traditional hunt in 1987 pending more reliable estimates of the stock.

After the sighting survey carried out by the Institute of Marine Research in 1995, the North East 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. If the Jan Mayen area is included, the stock is calculated to number 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 1997, the value of the catch was about NOK 22 million.

Figure 9.8. **Exports of farmed salmon to the main purchasing countries**



Source: External Trade Statistics from Statistics Norway.

The Norwegian authorities have prohibited the export of whale products. The minke whale is listed in the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which entered into force in 1975.

Both harp seals and minke whales are important consumers in the Barents Sea ecosystem. It has been calculated that the total biomass consumed by the minke whale stock along the Norwegian coast, in the Barents Sea and off Svalbard is about 1.4 million tonnes, of which 0.9 million tonnes consists of fish (mainly herring, cod, capelin and haddock). Consumption by harp seals totals about 1.1 million tonnes, 0.7 million tonnes of which consists of fish (Institute of Marine Research 1997a).

9.5. Exports

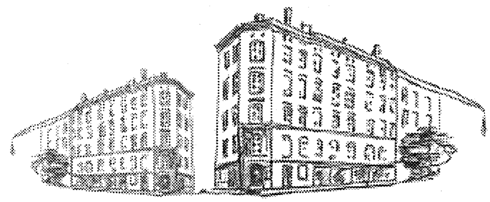
Preliminary figures show that in 1997, exports of fish and fish products rose to about 2 million tonnes, with a value of NOK 24.7 billion (figure 9.5 and Appendix, tables H4 and H5). Exports to EU countries accounted for 59 per cent of the total. Salmon exports totalled NOK 7.6 billion in 1997 (figure 9.8 and Appendix, table H6). This corresponds 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 14.7 per cent of exports of traditional goods from Norway in 1997 (i.e. exports excluding crude oil, natural gas, ships and oil platforms).

According to the FAO, in 1995 Norway ranked third in the list of the world's largest fish exporters, after Thailand and the USA and followed by China and Denmark (FAO 1997c). The value of Norway's fish exports (3 123 million USD) corresponded to about 6 per cent of the value of total world fish exports (52 035 million USD).

More information may be obtained from: Frode Brunvoll.

10. Land use in urban settlements



About three-fourths of Norway's population today lives in towns and urban settlements, and both urban settlements and adjacent land are under considerable development pressure. A sound use of urban settlement areas is therefore important for people's local environment, and may also be of substantial economic importance. Information and an overview are required to achieve sound land use planning and management. In order to improve the information in this field, Statistics Norway is now working to expand and standardize land use statistics for urban settlements. The first results are presented here.

10.1. Introduction

The tendency for a greater share of the population to live in urban settlements has created pressures and increased the need to control the development of land use. In the Ministry of the Environment's report on regional planning and land use policy (Ministry of the Environment 1997b), emphasis is therefore placed on environmentally friendly development patterns by e.g. strengthening town centres, planning environmentally friendly transport systems and securing green spaces. The development of land use statistics for urban settlements in Statistics Norway is based on this report.

10.2. Population trends in urban settlements

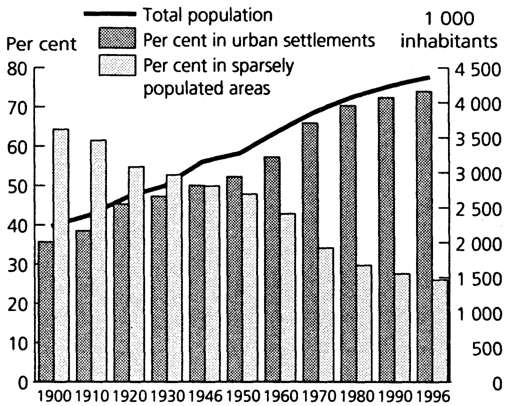
There has been a shift in Norway from relatively scattered settlements at the beginning of this century, when 35 per cent of the population lived in urban settlements, to the current situation where about three-fourths of the population lives in towns and urban settlements (figure 10.1).

In 1995, there were about 890 urban settlements in Norway with at least 200 inhabitants. Most urban settlements must be considered small by European stan-

Box 10.1. Definition of an urban settlement

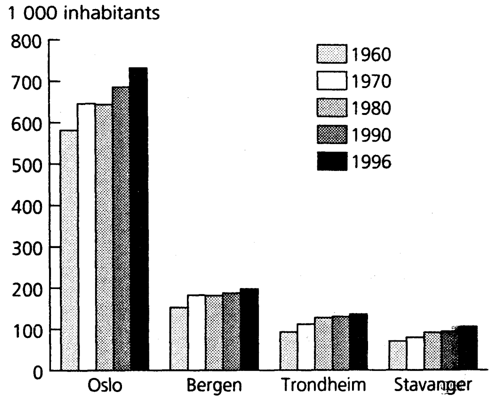
Urban settlement boundaries, as the term is used here, do not depend on administrative boundaries such as town, county or municipal limits. An urban settlement is defined as an agglomeration having at least 200 residents and where the distance between houses as a rule does not exceed 50 metres. Discretionary deviations are permitted for areas in which buildings shall not or cannot be erected, such as parks, sports facilities, industrial areas or natural barriers like rivers and tillable land. House clusters which form a natural part of the urban settlement are included up to a distance of 400 metres from the urban settlement core (Statistics Norway 1992).

Figure 10.1. **Total population and per cent of population living in urban settlements. 1900-1996**



Source: Population Statistics from Statistics Norway.

Figure 10.2. **Population growth[1] in Oslo, Bergen, Trondheim and Stavanger. 1960-1996**



[1] Refers to urban settlements and not urban municipality.
Source: Population Statistics from Statistics Norway.

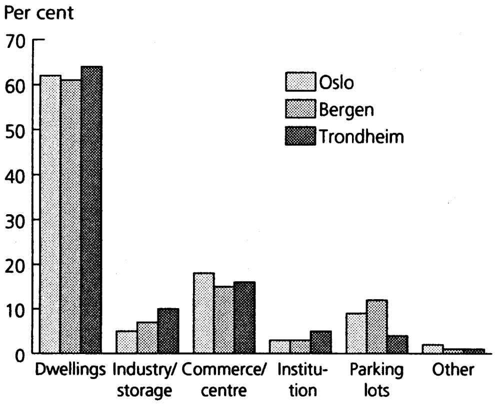
dards. Only four urban settlements, Oslo, Bergen, Trondheim and Stavanger, had more than 100 000 inhabitants in 1996 (note: urban settlement boundaries are not necessarily the same as municipal or town limits). That same year 27 per cent of the total population resided in these four urban settlements. Figure 10.2 shows population trends from 1960.

10.3. Previous land use statistics for urban settlements

Official statistics primarily cover commercial, demographic and settlement aspects of the urbanization process. Detailed information on land use in urban settlements is only found in unrelated project-oriented studies.

Land use statistics for urban settlements have previously been produced in Statistics Norway as part of the Norwegian resource accounts and covered the period 1955-1975. According to these statistics, housing accounted for 57 per cent of the built-up area in urban settlements. Area for transport purposes accounted for 19 per cent, area for commerce and urban settlement centre 3 per cent and area for industry and storage 10 per cent. Lyssand Larsen and Saglie (1995) compiled statistics on land use and population growth for 22 larger urban settlements for the period 1970 to 1990. The survey shows, for example, that the area available per inhabitant in 21 of these urban settlements had increased from 450 m^2 in 1970 to 554 m^2 in 1990, i.e. the area had increased at a higher rate than the population. The same 21 urban settlements lay claim to 41 per cent more land in 1990 than in 1970. The largest growth in urban settlements, measured by the expansion of area, took place in the 1970s. A slower expansion of urban settlements towards the end of the survey period is partly due to the decline in building volume, a greater degree of higher density housing and the development of satellites outside urban settlements (buildings outside the urban settlement boundary closely connected to the urban settlement which are

Figure 10.3. **Developed land in urban settlements: Oslo, Bergen and Trondheim in the period 1984-1992. Total developed area in towns distributed by various purposes**



Source: Engebretsen (1993).

not included as an independent urban settlement).

An analysis of changes in land use in urban settlements in Oslo, Bergen, Trondheim, Fredrikstad and Sarpsborg (Engebretsen 1993) shows that the area for the construction of dwellings dominates in the development of urban settlements in the period 1984 to 1992 (figure 10.3). In all the urban settlements studied, however, the expansion of commercial activity has accounted for a growing share of land development area in the 1980s. Throughout the entire survey period development in Bergen and Trondheim has taken place further and further from the centre. Development in Oslo, on the other hand, has during the last part of the period taken place to a greater extent closer to the centre of town so that the total urban settlement area increased at a slower pace.

10.4. Delimitation of urban settlements

Definitions

Urban settlements are land units where delimitation takes place continuously as a result of changes in the built-up area and the number of residents. The concept "urban settlement" was originally defined in connection with the Population and Housing Census in 1960. The term "urban settlement" was then chosen to make a clear distinction between this concept and the administrative concept "town".

The original definition of an urban settlement from 1960 included associated criteria such as the number of residents, minimum distance between houses and the number employed in industries other than primary industries. In 1970, the definition was developed further by introducing the concept cluster of urban settlements for urban settlements with a common labour market. Both in 1960 and in 1970 the delimitation of densely built-up areas was linked to the division of census districts. An urban settlement therefore consisted of one or more densely built-up districts. In the 1980 and 1990 Population and Housing Censuses, however, urban settlements were only delimited on the basis of the criteria for distance between buildings and the number of people living in the urban settlement, thereby separating the delimitation from the division of census districts.

Adjustments of criteria for the delimitation of urban settlements entail that it is difficult to compare figures on area and changes in land use in urban settlements over time. The definition from the 1990 Population and Housing Census was used as a basis in this project (box 10.1).

Method for delimiting urban settlements and aggregating statistics on area

In connection with the 1980 and 1990 Population and Housing Censuses urban settlement boundaries were delimited and drawn manually on maps. The work was carried out in each municipality and then digitalized centrally. Extensive manual work and the great number of participants provided possibilities for a considerable degree of subjective judgement and thus differing practices as to how urban settlement boundaries were drawn.

Statistics Norway is now developing a method for register-based and automatic delimitation and aggregation of land use statistics for urban settlements. The aim is to be able to delimit urban settlements in a cost-effective way and produce land use statistics which capture the dynamics of developments in urban settlements. The method for delimiting urban settlements is based on the use of information from the National Population Register and the GAB register, the official Norwegian register for property, addresses and buildings. Digital information from the Norwegian Mapping Authority's map series and road database are also used for the production of some land use statistics. So far the method has been used to delimit and produce simple land use statistics for a selection of larger urban settlements (chapter 10.5).

Statistics produced on the basis of GAB records on buildings do not provide information on areas without buildings. Thus in the autumn of 1997 a separate project was initiated in cooperation with the Norwegian Mapping Authority, the Environmental Section, for testing high-resolution satellite images for aggregating supplementary statistics, particularly for "green" and "grey" areas without buildings. Efforts are being made to combine data from the register and satellite image information into a coherent and dynamic statistical system which can provide information on land use as well as areas classified according to e.g. morphological and structural criteria.

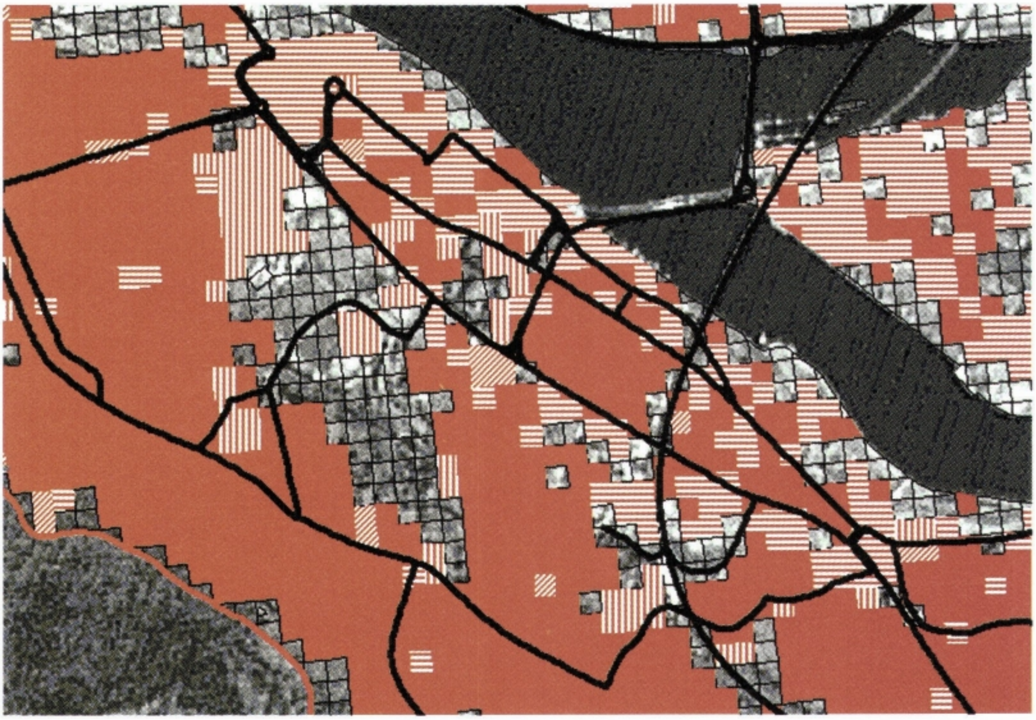
Figure 10.4 shows the basis for preparing land use statistics for urban settlements when coordinate-defined building information from GAB, information on roads and supplementary information from satellite images are used to assign land use categories.

Comparison of the various methods for delimiting urban settlements

The experience of the urban settlement project shows that when urban settlements are delimited strictly according to the definitional requirement of a maximum distance of 50 metres between houses, the result of this delimitation will differ substantially from the work carried out in the municipalities in 1994/1995. This demonstrates that local assessments have been made to a considerable extent and that the use of subjective judgement has been important in connection with earlier delimitations of urban settlements.

Figure 10.5 shows automatically aggregated urban settlement boundaries for Tromsø (see Chapter 10.3). Previously, the entire island (Tromsøya) was considered an urban settlement, while with automatic urban settlement delimitation large forest and park areas located centrally on the island, as well as the airport area, are not included. The area of urban settlements is divided into areas with an open (red colour) and dense structure.

Figure 10.4. **Satellite image[1] combined with digitalized data from registers. Section of Drammen urban settlement. 1997**



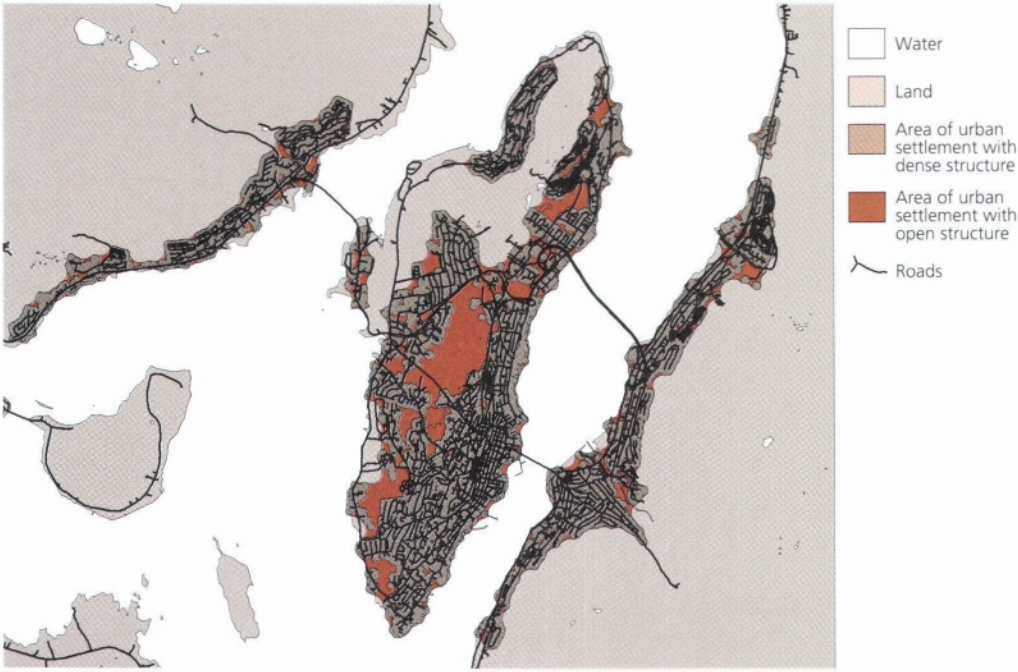
The mouth of the Drammen River which splits up around Holmen is seen in the upper right-hand section of the figure. Europe, national and county roads are added. All red and red-shaded areas can be classified by area based on the GAB register. The underlying satellite image is shown where it is not possible to classify areas based on information in the register, such as area covered by water, parks and port areas without buildings.

[1] IRS 1-C pan-chromatic image with a dissolution of 5.8 m.
Source: Statistics Norway.
Digital map data and satellite image: Norwegian Mapping Authority.

10.5. Land use in environmental towns

The Ministry of the Environment has initiated a special Environmental Town Programme, which has the aim of developing models for sustainable urban development. A number of specific goals for environmentally friendly urban settlements and accompanying indicators have been developed. For example, land use for expansion and transport purposes shall be reduced while the share for environmentally friendly transport shall be increased. Air pollution and noise levels shall be reduced. Nature and nearby recreational areas shall be preserved for biological diversity and recreation. The town centre shall be enhanced as the most important meeting place in towns for commerce and culture. The programme was started in 1993 and will be concluded in 2000. The Environmental Town Programme is partially funding the work in Statistics Norway on developing land use statistics

Figure 10.5. **Tromsø urban settlement. 1996**



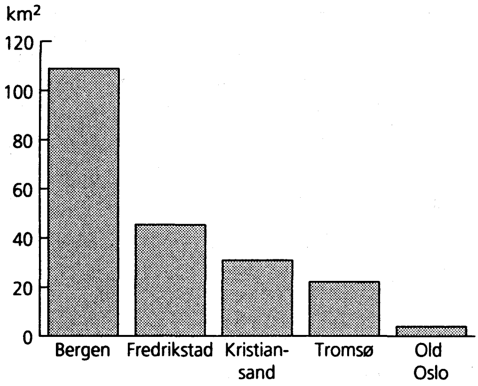
Source: Statistics Norway (1997i).
Digital map data: Norwegian Mapping Authority.

for urban settlements, and the environmental towns have therefore been selected as trial areas for developing these statistics. Fredrikstad, Kristiansand, Bergen, Tromsø and Old Oslo have been selected as environmental towns.

In addition to the information on total land and water areas in urban settlements, the urban settlement project has so far assigned priority to quantifying some key land use indicators, such as area available per inhabitant, built-up area and area for transport purposes. Methods for producing more detailed land use statistics for the built-up parts of the urban settlement are also being studied.

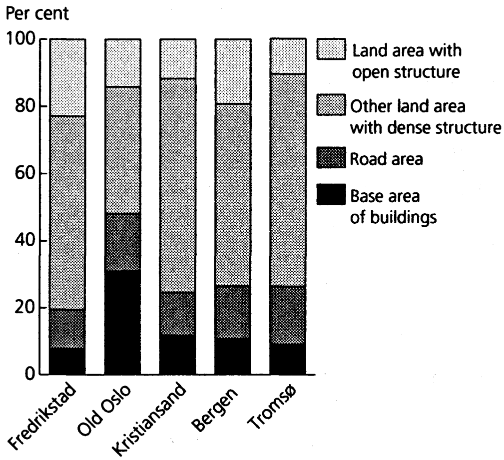
Only one contiguous area of urban settlement is included for Fredrikstad and Bergen. In Bergen, the area of a larger body of water, forests and mountains enclosed by the densely built-up area (Nordåsvatnet and Løvstakken) is included in the gross area of urban settlement. In Kristiansand, the area of urban settlement on both sides of the Topdals fjord is included. In both Fredrikstad and Kristiansand, the area of rivers running through the urban settlements is included. For Tromsø, the area of urban settlement includes Tromsøya as well as the connected area of urban settlement on the island of Kvaløya and the mainland. For total area of urban settlements in the environmental towns see figure 10.6.

Figure 10.6. **Total area of urban settlements. Environmental towns. 1996***



Source: Statistics Norway (1997i).

Figure 10.7. **Land area in urban settlements by land use categories. Environmental towns. 1996***



Source: Statistics Norway (1997i).

In the selected urban settlements there are to some extent considerable land areas without buildings, roads, etc. In order to separate these areas in the land use statistics, it was decided to divide the total land area in urban settlements into the main categories: area with dense structure (area with roads, railways or located up to 50 metres from buildings) and area with an open structure (area without roads, railways and located more than 50 metres from buildings).

Results

When land use statistics are used for comparing urban settlements, the figures must be interpreted with caution. Variations in land use in urban settlements may have complex causal relationships because the urban settlements have developed under very different economic and natural conditions. Varying statistical uncertainty also exists between the various urban settlements because the underlying records are of varying quality. Statistics Norway has therefore, particularly for the base area of buildings, made generalizations based on the available data. The area of roads is computed by multiplying road lengths from the Norwegian Mapping Authority's road database by a selected set of road widths. In particular, the choice of road widths for municipal roads will have an impact since this type of road dominates within urban settlement boundaries. Preliminary figures for 1996 show that the environmental town Old Oslo, which is in a unique position since it only comprises inner city areas, has the highest share of land used for housing and roads (figure 10.7). The land area used for buildings and roads is about 25 per cent in both Bergen and Tromsø, followed closely by Kristiansand. Fredrikstad and Bergen have the highest share of land area with an open structure. Fredrikstad also has the most land area per inhabitant (table 10.1). The environmental towns are of varying size and have a different history and geographical location. Land use

Table 10.1. **Number of people living in urban settlements and area per inhabitant. Environmental towns. 1996***

	Number living in urban settlement	m²		
		Total land area per inhabitant	Land area in urban settlement per inhabitant	Land area with dense structure per inhabitant
Fredrikstad	50 523	897	832	642
Gamle Oslo	20 857	184	184	159
Kristiansand	49 088	630	589	520
Bergen	194 934	559	497	401
Tromsø	45 992	480	458	410

Source: Population Statistics from Statistics Norway and Statistics Norway (1997i).

within the urban settlements is nevertheless very similar.

As land use in additional urban settlements is studied further and time series are established for them, the statistics may become an important source for following changes in land use in urban settlements.

Financed in part by: Ministry of the Environment and Norwegian Pollution Control Authority.

Documentation: Dysterud and Engelien (1997), Rogstad (1996), Rogstad and Dysterud (1996), Schøning, Dysterud and Engelien (1998), Statistics Norway (1981a), (1982) and (1986).

More information may be obtained from: Per Schøning, Marianne Vik Dysterud and Erik Engelien.

11. Perceived levels of noise and air pollution

Air pollution can cause injury to health and environmental damage. However, the way people perceive levels of noise and pollution is also an important aspect of environmental problems, for instance because this clearly affects their well-being. The 1997 Survey of Living Conditions shows that more than 200 000 people in Norway have sleep problems caused by noise, and that an estimated 23 000 people in Oslo consider that they are exposed to "highly annoying" pollution.

11.1. Introduction

The way people experience pollution and noise at home, in the local environment and at work has been studied by means of interviews with a representative sample of the Norwegian population (surveys of living and working conditions, see Barstad 1994). In most of these surveys, people have been asked whether they are "exposed to" noise and pollution, but in certain cases they have also been asked how "annoying" they find them. The answers to both types of questions are influenced by other factors than the actual level of noise or pollution. Attitudes to sources of noise and pollution, previous experience, and the length of time a person spends at home or work and at what time of day, all influence the answers given. Thus, it cannot be assumed that changes in the answers received only reflect the changes that can objectively be seen to have taken place in the environment. Changes in the level of awareness concerning general environmental issues, experience of local action, etc. may also have an effect on people's answers.

Data collected in this way, particularly those on pollution levels, are not suitable

Box 11.1. About the surveys of living conditions

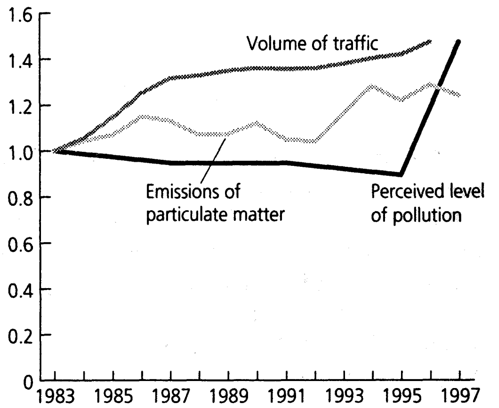
Surveys of living conditions (the title "Surveys of level of living" was used in English up to 1995) were carried out in 1980, 1983, 1987, 1991 and 1995, and are being carried out annually from 1996 onwards, the main topics varying from year to year. These are sample surveys based on interviews with a representative sample of 5 000 persons aged 16 years and over (before 1987: 16-79 years). All the surveys include questions on noise and pollution from various sources. The questions on noise were unchanged in all surveys up to 1995, and the questions on pollution were the same from 1983 to 1995. The main topics in the 1997 Survey of Living Conditions were housing and leisure activities. This survey also included more questions on noise and pollution than earlier surveys. People were first asked whether they were exposed to noise and pollution, and then how annoying they found this. This chapter focuses on exposure to noise and pollution, since this is directly comparable with previous surveys.

for investigating adverse effects on health. This is because the answers do not provide precise data on the substances or the concentrations of pollutants to which people are exposed. However, people's perception of noise and pollution levels is also an important aspect of environmental problems. The levels of annoyance caused by noise and pollution are an expression of how these factors can reduce people's well-being, which is an important consideration in itself. Moreover, this can in turn result in adverse effects on health.

11.2. Main distribution patterns and changes in environmental problems

The pollutants that have the greatest adverse effect on local air quality are particulate matter (PM_{10})[1], nitrogen oxides (NO_x) and sulphur dioxide (SO_2). These are discussed in more detail in Chapters 4.2 and 4.5. In the period 1983-1996, emissions of NO_x and particulate matter have risen by about 20 and 30 per cent respectively, while emissions of SO_2 and CO_2 have been reduced (Appendix, tables C1 and C2). In the same period, the volume of traffic on Norwegian roads has risen by 47 per cent (Rideng 1997). The surveys of living conditions show that despite these trends, people's perception of the degree to which they are exposed to air pollution changed little up to 1995. There was in fact a weak downward trend in the number of people who considered themselves to be exposed to pollution up to 1995, whereas there was a substantial rise from 1995 to 1997 (figure 11. 1 and table 11.1). The proportion exposed to one or more sources of air pollution rose from 17 to 28 per cent from 1995 to 1997.

Figure 11.1: **Trends in emissions of particulate matter (all sources), volume of road traffic and the proportion of the population exposed to pollution. Index, 1983=1**



Sources: Surveys of living conditions from Statistics Norway, emissions inventory from Statistics Norway and Norwegian Pollution Control Authority and Institute of Transport Economics.

Table 11.1. **Percentage of the population exposed to pollution from various sources near their homes**

	1983	1987	1991	1995	1997
Dust, smells, exhaust from road traffic	13	12	12	11	21[1]
Smoke, dust or deposits from industry or other sources	5	6	5	4	5
Smells from industry or other sources	6	6	5	5	7
Exposed to only one pollution source	15	14	14	14	23[1]
Exposed to 2 or 3 pollution sources	4	4	4	3	5[1]

[1] This figure is not directly comparable with other years. In 1997, the question on road-traffic pollution was split into two separate questions on smells and noise. An increase in the level of detail can influence the answers given.
Source: Surveys of living conditions from Statistics Norway.

[1] PM_{10} are particles with a diameter of less than 10 μm.

Table 11.2. **Percentage of the population exposed to noise from various sources in their homes**

	1980	1983	1987	1991	1995	1997
Neighbours, stairways, water pipes, etc.	7	6	5	6	7	..
Road traffic	14	13	12	13	13	16
Railways	2	2	2	3	3	..
Aircraft	6	5	6	8	7	12
Industry or construction	2	2	3	2	3	..

Source: Surveys of living conditions from Statistics Norway.

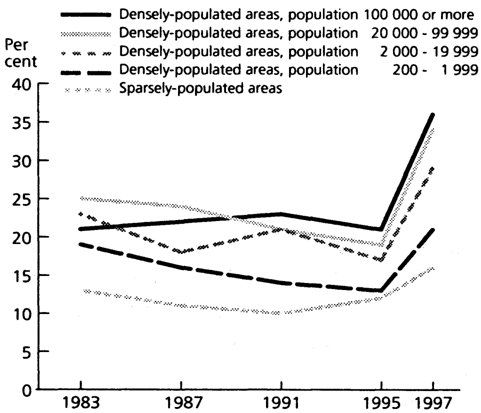
A growing proportion of the population reports exposure to noise from aircraft (table 11.2). The number of departures and arrivals rose by 25 per cent from 1980 to 1996, and more than one third of the increase took place from 1995 to 1996. The number of departures and arrivals at Fornebu Airport (Oslo) rose by 79 per cent in the period 1980-1996 (Statistics Norway 1981b, 1996c and 1998b). However, quieter planes have been introduced in recent years (Civil Aviation Administration 1996). The noisiest planes are to be phased out by 2002. This process has already begun, but given the rapid growth in air traffic in recent years, it is difficult to say whether the total noise level from aircraft has risen or been reduced.

These results suggest that people's perception of noise and pollution levels is not directly proportional to actual emissions and the volume of traffic. There are probably several reasons for the perceived rise in pollution levels. Part of the explanation may of course be the real changes that have taken place: emissions of particulate matter are higher than a few years ago, and the volume of traffic on Norwegian roads is still growing rapidly. This may explain part of the rise in perceived air pollution levels and road-traffic noise. There has been frequent coverage of air pollution in the media recently, and noise problems have also been discussed, for instance in connection with Oslo's new Gardermoen Airport. The focus on these problems may result in lower tolerance levels, so that people define themselves as being "exposed to" lower levels of noise and pollution.

The degree of "annoyance" caused by noise or pollution is often regarded as a better indicator of pollution and noise problems than perceived "exposure". Sixteen per cent of the sample in the survey stated that they were exposed to road noise, and almost half of these also reported that such noise was annoying or highly annoying. This means that about 700 000 people in Norway are exposed to noise from road traffic in their homes, and that 330 000 of these find the noise annoying or highly annoying. About 531 000 people are exposed to aircraft noise, and a third of these, or 176 000 people, find the noise annoying or highly annoying.

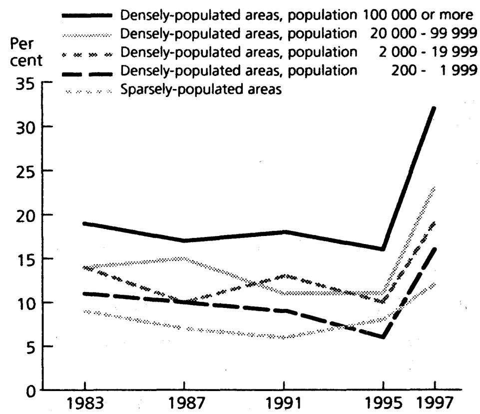
Twelve per cent of the sample say that they are exposed to smells or exhaust from road traffic near their homes. Rather more than half of these, or 270 000 people, consider this to be highly annoying or annoying. Eighteen per cent of the sample are exposed to dust from road traffic, and 63 per cent of these (485 000 people) consider this to be highly annoying or annoying. If the answers to these two questions are pooled, we find

Figure 11.2. **Percentage of the population exposed to both industrial and road-traffic pollution, according to type of residential area**



Source: Surveys of living conditions from Statistics Norway.

Figure 11.3. **Percentage of the population exposed to road-traffic pollution, according to type of residential area**



Source: Surveys of living conditions from Statistics Norway.

that 21 per cent of the people in the sample are exposed to dust, smells or exhaust from road traffic (table 11.1). In 1995, 8 per cent of the population were exposed to smells or pollution from industry and similar sources. In 1997, this had risen to 10 per cent.

11.3. Geographical distribution of pollution problems

In the period before 1995, there was a drop in the number of people living in small and medium-sized towns who considered themselves to be exposed to pollution, whereas there was little change in sparsely-populated areas and the largest towns (figure 11.2 and Statistics Norway 1996d). However, from 1995 to 1997 there has been a steep rise in the proportion who state that they are exposed to air pollution in all categories (figures 11.2 and 11.3). The rise in pollution from road traffic in this period may partly explain this (figure 11.1). However, pollution from traffic did not increase to the same extent as the perceived pollution load, and it is therefore likely that other factors are also involved in the rise. A general change in attitudes and greater awareness of pollution problems are possible explanatory factors. Another explanation may be that at times, the perceived pollution load does indeed rise faster than noise levels and emissions. It is possible that a rise in noise or in emission levels does not result in higher levels of annoyance until a certain threshold is passed.

Problems related to road-traffic pollution are most widespread in the larger towns, while industrial pollution is most widespread in densely-populated areas with 20 000 - 100 000 inhabitants. This pattern has been unchanged since 1983. From 1995 to 1997, the proportion of people in densely-populated areas who are exposed to industrial pollution has risen considerably, but has been greatly reduced in the largest towns.

The steep increase in the proportion of the population who consider themselves to be exposed to air pollution can also be found at county level. In 1995, 25 per cent of Oslo's population stated that they were exposed to pollution, while in 1997, this had risen to 43 per cent, or 215 000 people. Of these, 11 per cent or about 23 000 people found pollution highly annoying.

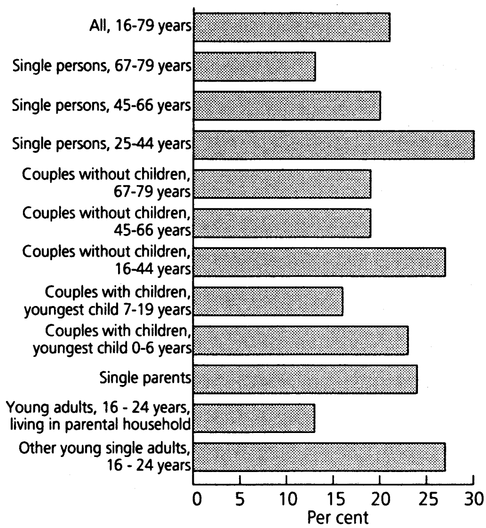
It is a little surprising that the proportion of people who state that they are exposed to pollution is highest in Aust-Agder (48 per cent). This is perhaps explained by the fact that two of the 10 largest sources of sulphur emissions in Norway are located in the county. One of these was the focus of media interest in connection with a campaign by the environmental organization Bellona in the period when the 1997 Survey of Living Conditions was being carried out. The figures for Aust-Agder are also statistically uncertain, since the sample consisted of only 77 people.

Exposure to air pollution from industry and road traffic was lowest for people living in Hordaland and Rogaland in 1997. In these counties, one in five inhabitants stated that they were exposed to such pollution. There were only small differences between the other counties.

11.4. Pollution experienced by different groups of the population

The 1995 Survey of Level of Living showed that there are only small differences between the exposure of different types of families to pollution, but that single parents were among the groups where exposure to both road-traffic and industrial pollution was highest. From 1995 to 1997, exposure to pollution rose for all types of families, the differences between groups increased, and single parents were no longer the group most exposed to pollution.

Figure 11.4. **Proportion of the population exposed to road-traffic pollution in 1997, by type of family**



Source: Surveys of living conditions from Statistics Norway.

In this connection, pollution from road traffic is very important, since heavy traffic near housing may have particularly adverse effects on living conditions for children and adolescents. Figure 11.4 shows perceived pollution from this source for different groups of the population in 1997. In general, exposure is highest for people under 45 years of age without children. Under the age of 67, single persons are more exposed than couples. Exposure is also higher for single parents than for couples with children, and higher for couples with small children than for those with older children. The categories least exposed to pollution from road traffic were young adults (16-24 years) living in the parental household and single persons aged 67-79 years.

There was a marked increase in exposure to road-traffic pollution for all groups in 1997. In addition, the clear improvement in the situation for some groups in the period 1987-1995 (Statistics Norway 1996d) has been reversed since 1995. The rise in exposure levels is particularly large for younger groups, which may be explained by their greater awareness of environmental issues. The survey of living conditions also included questions on the financial position of the respondents, and the younger groups most often stated that they had problems in meeting their current expenses. This suggests that exposure to pollution varies more strongly with family type and finances than has previously been the case. This result could of course be explained by random statistical variation, but it seems probable that economic developments may be one explanation. The groups who experienced the highest levels of exposure to road-traffic pollution in 1997 are also those who are normally in the process of setting up their own households. The steep rise in house prices in recent years has meant that at the time of buying their own homes, this group has had lower purchasing power than corresponding groups in previous surveys. Since housing prices are lower in areas with heavy traffic than in those with little traffic, it is reasonable to assume that the proportion of this group settling in areas with heavy traffic has been higher than previously. Thus, a larger proportion of the group will be exposed to road-traffic pollution. A change in general attitudes resulting in a greater aversion to pollution in the population in general will also result in greater perceived differences between areas with heavy and light traffic.

It should also be noted that the marked improvement in the situation for old people, particularly old couples, that was registered from 1983 to 1995 has been reversed between 1995 and 1997. Since 1995, exposure has risen for these groups as well. Exposure is highest for elderly couples.

Exposure to road-traffic pollution was lowest for young adults (16-24 years) living in the parental household. This result is unchanged from earlier years, but the level of exposure has risen for this

Table 11.3. **Percentage of the population exposed to various problems as a result of noise and air pollution. Whole country and Oslo, 1997**

Problem	Whole country	Oslo
Sleep problems because of noise	5	7
Disturbed by noise when resting	6	10
Conversations indoors disturbed by noise	2	5
Disturbed when listening to radio or watching TV	3	9
Air rooms less than would like to because of noise	5	12
Use of outdoor areas restricted because of noise	5	8
Window, frames and curtains dirtied by air pollution	22	46
Laundry dirtied by air pollution	6	8
Unpleasant smells inside the home from air pollution	4	5
Air rooms less than would like to because of air pollution	6	11
Use of outdoor areas restricted because of air pollution	4	8

Source: Surveys of living conditions from Statistics Norway.

group as well. In previous surveys, exposure was highest for single parents. In 1997, exposure levels for both single persons aged 16-44 years and couples aged 16-44 years rose above that for single parents. However, the latter group also experienced a substantial rise in exposure to pollution.

11.5. Relationships between geographical and social distribution of pollution problems

If the findings of the survey of living conditions for the geographical and social distribution of exposure to pollution are considered together, we find that young, single people living in towns clearly experience greater pollution problems than other groups. According to the survey, this group is also in the most difficult financial position, which may partly explain the findings regarding pollution. Couples aged 45-66 years without children are in the most favourable financial position. Figure 11.4 shows that this is also the group that experiences the lowest level of pollution problems. This supports our hypothesis that when the housing market is tight, groups with the poorest economy settle in the most heavily polluted areas, while those in a better financial position tend to choose less polluted areas.

Parents with small children are an interesting group in this context. They are in a relatively poor financial position, but both in Oslo and in the country as a whole they are in a relatively favourable position as regards exposure to pollution. This indicates that even though people's finances are important in determining the quality of their residential environment, other factors, such as living conditions for children, also play a role here.

11.6. Perceived effects of pollution and noise

Table 11.3 shows that 5 per cent of the population, or an estimated 206 000 people, experience sleep problems as a result of noise. Furthermore, windows, window-frames and curtains dirtied by air pollution are a problem for 22 per cent of the population, or about 944 000 people.

Not surprisingly, people in Oslo experience more problems than the rest of the population. In Oslo, more than 10 per cent of the population are disturbed by noise when resting, 12 per cent are not able to keep doors and windows open as much as they would like because of air pollution, and almost half the population (46 per cent) state that air pollution results in dirty windows, window-frames and curtains. About 35 000 people in Oslo have sleep problems caused by noise.

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Documentation: Statistics Norway (1996d and e).

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12. Other analyses

12.1. NOREEA – Norwegian Economic and Environmental Accounts

Environmental data in the national accounts

Both national accounting and environmental statistics have fairly long traditions in Norway. Proposals for combining these two sets of data were made as early as the 1970s (Peskin 1972), but it was not until 1997 that environmental data were integrated into the national accounts through a separate project. Through its research activities, however, Statistics Norway has long traditions in analyzing relationships between the economy and the environment with the help of other methods than the one presented here.

In the 1990s national accounting institutions throughout the world have renewed their commitment to the work on developing environmental accounts. Such accounts shed light on environmental issues such as emissions, waste water, etc. by linking economic activity and the associated environmental consequences. One example of this is de Haan and Keuning (1996), who describe a national accounting matrix that has served as a standard for similar efforts in many European countries, and which has also been the approach applied by NOREEA (*NOR*wegian *E*conomic and *E*nvironmental *A*ccounts). Developments in Europe have resulted in a greater emphasis on co-ordinating and harmonizing statistics, and this also applies to environmental accounts. Our project is one of many that shall prepare environmental accounts with a comparable content based on standardized methods for all countries in Europe.

At the moment, emissions to air are the only environmental parameter which is linked to the national accounts. Future plans include expanding the system to cover data on waste water and solid waste. The sets of data from the national accounts and emission and energy accounts are, for the most part, co-ordinated in terms of definitions and industry categories. This co-ordination makes it possible to present results based on existing data sources at such an early stage of the project.

Linking emissions data to the national accounts

The national accounts contain figures measured in monetary units, and there is no international agreement on which method is the most appropriate for calculating monetary units for such environmental variables as emissions, solid waste, etc. Nor is there any agreement on how such variables should be dealt with in the accounting system, cf. discussion concerning a "Green GDP" (Aaheim and Nyborg 1995). Our approach is that it is not necessary to measure these in monetary units in order to shed light on relationships between the economy and the environment. In the NOREEA project, no attempt has therefore been made to assign monetary values to emissions, and emissions are given in physical rather than monetary units.

For each industry, emissions have been linked to production in the industry (see Box 12.1). So, in the accounts, each industry produces various types of emissions in addition to ordinary products. Emissions from households are linked to household consumption.

Atmospheric emissions from ocean transport are normally not included when national emissions are reported, cf. for example the Kyoto Protocol (chapter 4, section 4.2 and Box 4.5). These emissions are, however, included in the NOREEA accounts. The reason is that value added in ocean transport is included in the figures for total value added in Norway, and emissions for the same Norwegian entities should also be incorporated in the integrated environmental accounts.

Acidification of soil and freshwater is a major environmental problem in Norway. It is therefore important to acquire knowledge about emissions of gases that are deposited on Norwegian territory. In addition to linking emissions to production in the various industries, we have therefore distinguished between emissions

Box 12.1. The NOREEA matrix

The NOREEA matrix has two main sections: One which includes data from the national accounts and one which presents figures from the emissions accounts. The two matrices are integrated so that it is possible to find along a row both the production of different products from an industry and the emissions produced by this industry. Emissions from households are linked along the row which shows household consumption. A complete numerical matrix for the year 1993 is presented in Hass and Sørensen (1998).

Even though the national accounts generally include information in monetary units, some components – such as employment – are also measured in physical units. Moreover, one of the main objectives of the national accounts is to show changes over time at constant prices (prices measured in a base year), which in principle represent changes in volume. The rise in these constant-price figures is therefore largely comparable to the increase in physical emissions data.

Emissions are measured in physical units (tonnes, acid equivalents, etc.), with the result that questions which can be raised for monetary units cannot be answered or have no meaning for emissions. The national accounts provide information about the value of the production of each product in an industry. This can be added up to calculate total production. The sum means something, partly because the purchasing power generated by the sale of production can be used irrespective of the properties of the products that are produced. There is no simple figure which tells us how large total emissions are because the various types of emissions have very different chemical compositions, and thereby have varying environmental consequences. Emissions of one tonne of carbon dioxide (CO_2) from an industry is not likely to alarm anyone, but emissions of one tonne of cadmium would constitute a very serious environmental problem.

Special aggregates of physical emissions data have nevertheless been developed for some purposes, i.e. the environmental themes. The various emissions are weighted so that they have the same impact on the environment with regard to a specific environmental problem irrespective of the type of emission. The Norwegian emissions data cover two such themes: Global warming (emissions of greenhouse gases) and acidification (emissions of acid forming gases) (see also chapter 4).

and depositions of acid forming gases. This is based on data from an international programme, EMEP (European Monitoring and Evaluation Programme), see Barrett and Berge (1996, page B:39). Air pollution from other countries contributes significantly to the acidification of Norwegian recipients. So far we have disregarded the net effect of Norwegian activities abroad and foreign activities in Norway. This will be examined more closely in a later phase of the project. The results presented here only relate to emissions and not depositions.

This initial integration of environmental data into the national accounts will permit renewed efforts to achieve better co-

Box 12.2. Concepts in NOREEA

Value added, GDP
Value added in basic values consists of value added and earned gross income from domestic production in an industry (or the total for all industries), derived and defined as output less intermediate consumption. Gross domestic product (GDP) is total value added plus net taxes on products minus an adjustment for the value of indirectly measured financial services.

Environmental consequences
Environmental consequences are the results of the economic activity of industries which have consequences for the environment, such as atmospheric emissions, noise, solid waste, discharges to water, restrictions on land area, etc. Only emissions to air have been included in this first phase of the project.

Industry profiles
The industry profile for an industry provides an overall picture of the use of important input factors, the economic results and environmental consequences of the industry's activities.

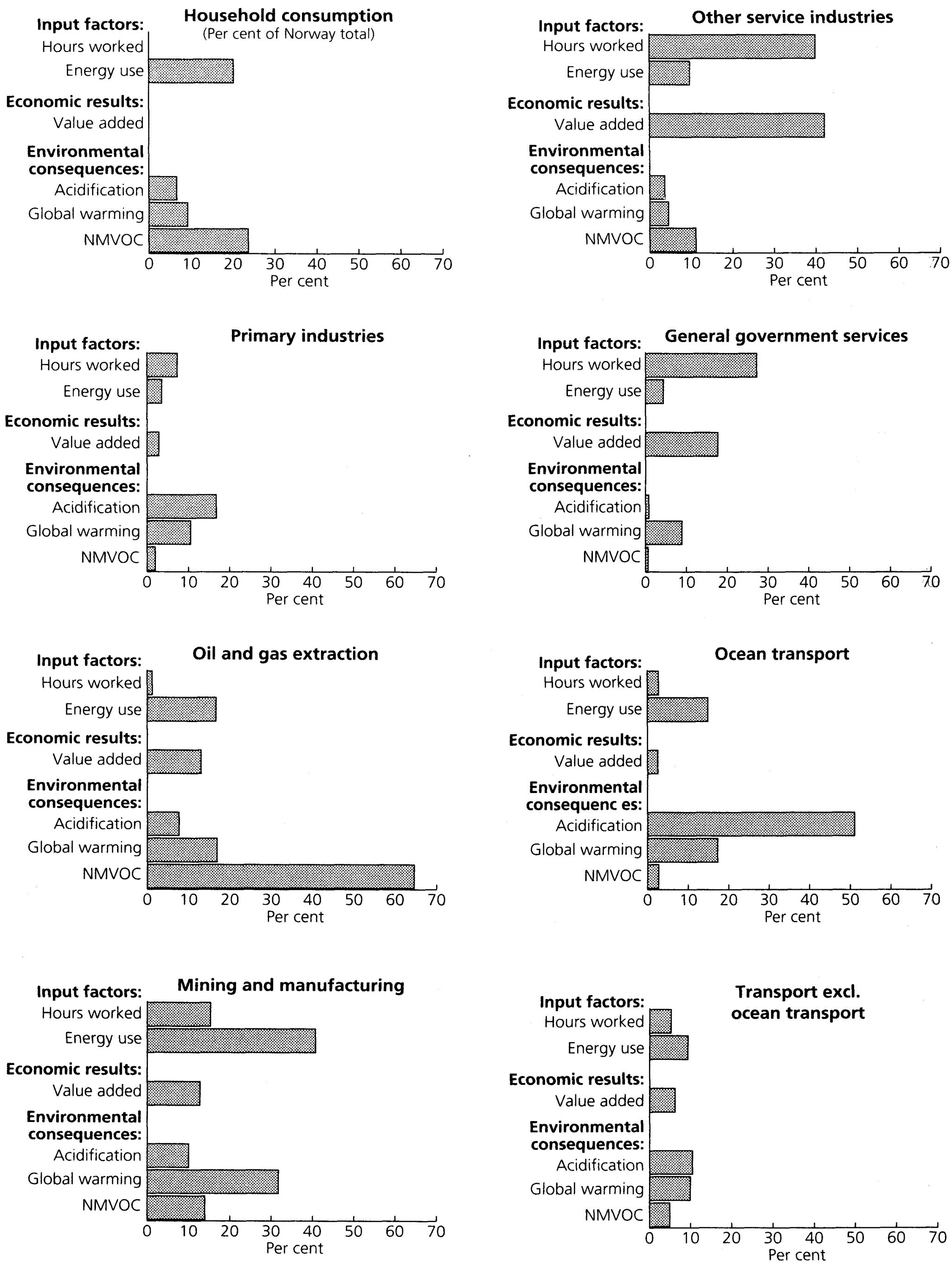
Environmental efficiency
A measure of the level of activity in industries in relation to the environmental consequences, as e.g. the industry's value added in relation to emissions of greenhouse gases. A higher level of economic activity unaccompanied by higher emissions means that the environmental efficiency of industries is increasing.

Acidification
Emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3) are aggregated (expressed in acid equivalents) according to their acid forming potential based on their chemical properties. The measure indicates the quantity of substances necessary to form an acid with a certain number of H^+ ions. The factors may be found e.g. in de Haan and Keuning (1996).

Global warming (GWP)
Greenhouse gas emissions are combined into a weighted aggregate according to the potential damage of the emissions. The damage from each type of emission is assigned a conversion factor known as Global Warming Potential (GWP). Each type of emission is converted into carbon dioxide (CO_2) equivalents in tonnes CO_2 using the GWP factor. The Norwegian calculations include not only the conventional greenhouse gases, CO_2, methane (CH_4) and nitrous oxide (N_2O), but also cover hydrofluorocarbons (HFCs), perfluorocarbons (CF_4 and C_2F_6) and sulphur hexafluoride (SF_6). The weights are determined by the Norwegian Pollution Control Authority based on a review of international climate research, see e.g. IPCC (1995).

NMVOC
Emissions which consist of non-methane volatile organic compounds.

Figure 12.1. **Industry profiles: Input factors, economic contribution and emissions. Per cent of Norwegian industry total, 1993**



Source: Hass and Sørensen (1998).

ordination and consistency between monetary and physical data. This will provide an opportunity to market the environmental data and make the figures more transparent for traditional users of the national accounts. Adopted national accounting methods can be applied to environmental statistics.

Results

We have selected some results from NOREEA which shed light on the relationship between economic activity and industry emissions (Figure 12.1). The concepts applied are explained in Box 12.2.

Figure 12.1 shows indicators of economic activity along with emissions data. We have also included emissions stemming from household consumption in the figure. In the national accounts, however, employment and value added cannot be directly linked to consumption.

For households, we find that they account for a lower proportion of total greenhouse gas and other emissions than their share of energy use, primarily because energy use is to a great extent based on electricity. Household emissions are otherwise higher than industries with regard to carbon monoxide (CO), particulate matter and lead, largely as a result of the use of cars by households.

With regard to other industry profiles in the figure, the percentages are calculated in relation to the Norwegian industry total for energy use and emissions, i.e. excluding household consumption. The various columns for an industry can therefore be compared. If the industry's value added contribution is higher than its share of emissions, the industry's environmental efficiency is greater than the overall industry average.

Primary industries have a higher share of emissions than their contribution to gross domestic product would imply. Carbon dioxide emissions are largely a result of diesel fuels used by the fishing industry, while methane emissions stem from livestock and manure spreading.

The oil and gas extraction industry includes both extraction and support services such as drilling. A relatively high energy use is due to the flaring of gases on the shelf. The high share of NMVOC emissions is a result of the loading and discharging of oil.

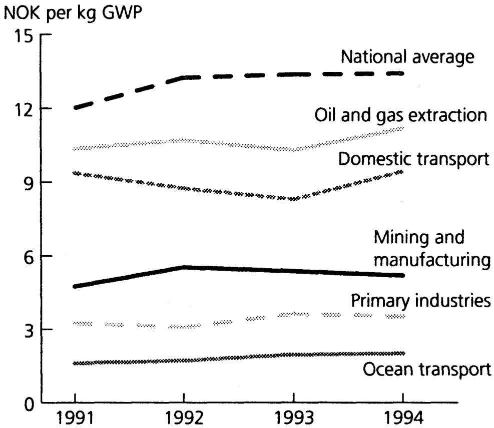
Mining and manufacturing in Norway is an energy-intensive industry which also contributes to high greenhouse gas emissions. The figure shows that this sector accounts for over 40 per cent of the total industry energy use and is also responsible for 30 per cent of the total industry contribution to atmospheric emissions which contribute to global warming. This industry's contribution to value added is only 13 per cent.

Because most of Norway's electricity production is based on hydropower, pollution from the electricity supply industry in Norway is less than in most other countries. In Norway, emissions from this industry are negligible.

The transport industry includes both domestic and ocean transport and support services. Post and telecommunication services are included in "other services". The use of high sulphur-containing fuels by international shipping makes a significant contribution to atmospheric emissions resulting in acidification.

Other service industries account for 40 per cent of the hours worked in Norway and have a share of total value added that is

Figure 12.2. **Changes in environmental efficiency 1991-1994 for industries with high emissions**



Source: Hass and Sørensen (1998).

even higher. Emissions from these industries are relatively modest. Emissions from general government services are also limited in relation to this sector's share of value added and employment. Government services, however, account for a major portion of the country's methane emissions due to emissions from municipal landfills.

Figure 12.2 shows changes in the environmental efficiency of industries. Efficiency is measured as GWP per NOK value added at constant 1993-prices. As the figure indicates, average efficiency has increased slightly in the period. Limited space only permits us to list those industries that have the highest emissions. The national average is high because the two sectors which contribute over 60 per cent to total gross value added, i.e. the government and services sectors, have fairly low greenhouse gas emissions. On average, these service industries had value added of more than NOK 60 per kg GWP in 1993.

The percentage increase in emission efficiency was particularly high in the transport industry as a whole from 1991 to 1994. In 1994, however, this industry still recorded relatively low value added compared with emissions. The entire improvement is ascribable to ocean transport. The change in level, from NOK 1.60 to 2.00 per kg GWP, results in a substantial percentage rise in efficiency even though the improvement in level was modest. Ocean transport, however, accounts for a high portion of the emissions in the transport industry in NOREEA. Other transport sectors had approximately the same efficiency in 1994 as in 1991, following a period of decreased efficiency in 1992 and 1993. For mining and manufacturing, the increase in value added in relation to emissions was substantial from 1991 to 1992, but emission efficiency has declined somewhat since then.

Efficiency in the primary industries has moved on a divergent trend for the two categories fishing and fish farming and agriculture and forestry. The level of greenhouse gas emissions in 1994 was about the same in 1992 for both categories. Value added, however, showed a pronounced change during the period. Measured at constant prices, value added in fishing and fish farming grew by more than 60 per cent, while value added in agriculture and forestry fell by 7.5 per cent. Such a sharp growth in value added unaccompanied by a substantial increase in emissions resulted in a considerable improvement in environmental efficiency in fishing and fish farming. Measured at constant prices, value added in fish farming grew at a substantially faster pace than value added in traditional fishing. As emissions from fish farming are modest, this contributed to a sharp increase in efficiency. Traditional fishing, however, also recorded a strong improvement in efficiency, possibly because the yield from the fisheries was relatively poor at the beginning of the 1990s. Changes for agriculture and forestry were more erratic, but this category shows declining environmental efficiency following a temporary improvement from 1992 to 1993.

The oil and gas extraction industry is in a class by itself with regard to growth in both value added and emissions, primarily as a result of the increase in activity in the industry. Measured at constant 1993-prices, value added grew by nearly 10 per cent annually during the period. The increase in value added was slightly higher than the increase in greenhouse gas emissions, entailing that environmental efficiency with respect to global warming has improved. The industry's emissions of NMVOC, however, have increased sharply due to emissions resulting from the transfer and loading of oil. These emissions doubled from 1991 to 1994, entailing that the industry's efficiency with respect to NMVOC fell by 12.6 per cent during the period.

Calculations of various environmental consequences in relation to the use of input factors and economic results in the industries provide an indication of the environmental efficiency of industries and how this efficiency changes over time. During the next phase of the project we will try to expand the coverage of environmental consequences by including solid waste and waste water. Future plans also include figures for more detailed industries. This will give us a basis which can not only be used to compare aggregated industries, as demonstrated in this article, but also to construct a set of key figures that may be useful e.g. for enterprises that want to compare their own environmental efficiency with the industry average.

What do the results tell us?
This article has described changes in environmental efficiency in industries based on figures in the NOREEA accounts. Our measure of environmental efficiency is influenced by many factors both of an economic and more technical nature. A greater in-depth analysis of causes underlying changes in environmental efficiency must focus on such factors as energy use, changes in oil product prices in relation to electricity, etc. Organizational changes also influence measured environmental efficiency in an industry, e.g. transport can either be organized as own transport or be a hired service from the transport industry.

Emissions in some industries are closely related to production activity in the industry such as in the transport sector. Emissions connected to fuel use are an integrated part of the transport sector even though environmental efficiency can be improved through e.g. technical measures which enhance the energy efficiency of engines, or through e.g. economic measures which result in a change to other forms of transport which have lower emissions. In other industries, such as some service industries, emissions may be more closely linked to heating, own transport, etc. without a direct connection to the services or products that are produced. The fact that the emission link to the activity in the industries differs considerably entails that environmental efficiency in the various industries cannot automatically be compared.

Project financed by: Eurostat and Ministry of the Environment.

Project documentation: Hass and Sørensen (1998).

12.2. Welfare implications of labour market rigidity for an environmental tax reform

Analyses of an environmental tax reform, which entails higher carbon dioxide taxes combined with a lower payroll tax, have shown that there is a potential in the Norwegian economy for achieving a welfare gain as a result of such a tax reform, see e.g. Bye (1996) and Håkonsen and Mathiesen (1997). Welfare is here measured as the utility of material consumption and leisure, while the utility of environmental improvements is not included. The welfare gain is achieved due to a reallocation of resources in the economy to activities where the social return is higher than in the initial use. This particularly applies to the reallocation of time, from leisure to paid employment. Because the taxation of labour is initially high, the social marginal value of labour is considerably higher than the private marginal value of leisure. An important source of the welfare gain as a result of a lower payroll tax is therefore higher employment. Previous analyses of such environmental tax reforms have demonstrated that it is precisely the positive effect on employment which makes the strongest contribution to the welfare gain.

These analyses show, however, that the carbon dioxide tax has a severe impact on the production of metals, industrial chemicals and the refining of oil products, and both production and employment are reduced substantially in these sectors, while they increase in other manufacturing sectors and in private services. The analyses have been criticized because they assume full mobility of factor inputs as labour and capital between sectors. Enterprises that are most affected are often located in one-industry towns, and it has therefore been asserted that adjustment costs are underestimated in the macroeconomic model-based calculations. In the short term both real capital and labour will have limited mobility.

This project analyses how immobile labour combined with wage rigidity in these production sectors affect welfare as a result of an environmental tax reform. The assumption of immobile labour can be justified on the grounds that there are considerable removal or other adjustment costs associated with finding other employment. Unemployment will then arise as a result of the tax reform. The analysis of the tax reform has been carried out using a version of Statistics Norway's intertemporal general equilibrium model MSG-6 with immobile labour and wage rigidity. The analysis of the tax reform applies a carbon dioxide tax of NOK 700 per tonne CO_2 emissions, which is the same for all types of fossil fuels and uses. Tax revenues from the higher CO_2 tax are used to reduce the payroll tax, entailing that the government budget balance remains unchanged. The effects of the tax reform are measured in relation to a reference path where there is no unemployment and an unchanged CO_2 tax.

CO_2 emissions fall by 13.3 per cent. Welfare, measured as total discounted utility of material consumption and leisure, ignoring positive economy-environment feedback, is reduced by 0.4 per cent. The estimated positive welfare effect of this environmental tax reform is therefore overestimated when account is not taken of immobility and wage rigidity in the labour market. In a model which includes unemployment, leisure will be the sum of voluntary leisure and involuntary unemployment. The difference between wages received and the price of leisure the unemployed actually face (shadow price of leisure) will then be a virtual tax on labour which further amplifies the existing gap between the cost of labour and the price of leisure. This results in a welfare loss (in an economic sense) which offsets any other redistributional gains of the tax reform. However, the positive environmental effects are still present.

Project financed by: Tax Research Programme, Research Council of Norway.

Project documentation: Bye (1997).

12.3. Cost-benefit analysis and the democratic ideal

It is sometimes claimed that strong lobbying groups have too much influence on political processes and that alternative methods for assigning priorities to public projects should be considered. One possible alternative is cost-benefit analysis in which projects are ranked according to their net social benefits, defined as the population's net willingness to pay for the projects. In 1995, the Republican Party introduced a bill in the US Congress, which in practice would mean that cost-benefit analysis would have a decisive influence on the adoption of new, major rules and regulations. Even though the bill was never approved by Congress, it illustrates that cost-benefit analysis in some circles is regarded as a realistic mechanism for government decisions. It may therefore be of interest to study more closely the properties of this decision-making mechanism. In this project we have evaluated whether cost-benefit analysis can be considered a *democratic* way of making decisions.

The starting point for this study is the seminal work of Robert Dahl (1989). Dahl sets out four main criteria for democratic decision-making procedures, which may be summarized as *effective participation, voting equality at the decisive stage, enlightened understanding,* and *control of the agenda*.

Cost-benefit analysis as a decision-making criterion conflicts with this democratic ideal on several points. Because the willingness to pay is used as the instrument of measure, the number of "votes" is in practice distributed according to the income of individuals. This constitutes a violation of the fundamental democratic principle of one vote per person. Another important problem relates to the principle of effective participation. In principle, analyses do take account of the utility of *all* individuals, including those who do not have strong spokespeople. It is not given, however, that "utility" coincides with the individual's views concerning what is best for society as a whole, and it is primarily the latter which the theory of democracy is concerned with. Individual views concerning this, however, have no place in cost-benefit analysis.

Usually, cost-benefit analysis is not used to make final decisions, but as *informational input* to a political process. We have also assessed whether such use of these analyses conflict with Dahl's criteria. Here, it is particularly the criterion of "enlightened understanding", i.e. that each citizen should have adequate and equal opportunities to evaluate the social desirability of alternatives, that is relevant.

Traditional cost-benefit analysis is based on a utilitarian approach: Society's interests are defined as the sum of individual utility, and one additional dollar is assumed to result in the same utility for everyone, irrespective of the individual's income or preferences. One may claim that those who accept this view have access to better information than others unless analyses based on the ethical views of every other participant in the debate are carried out. However, this is not necessarily a democratic problem if the access to alternative information is satisfactory. The ranking of projects in cost-benefit analysis may in this respect be regarded as the views of a fictitious, well-informed, but not neutral, "political actor"; and based on the principle of freedom of speech, there is no reason to censor such views.

Based on this line of reasoning, one would expect cost-benefit ratios to be looked upon as interesting, but not decisive, by citizens taking part in the public debate. This is consistent with findings from an interview survey we conducted among Norwegian politicians (Nyborg and Spangen 1996, Nyborg 1998a and Statistics Norway 1996d). Most of the politicians stated that cost-benefit analysis was useful, but they nevertheless placed limited emphasis on this analysis when they actually ranked projects. Politicians on the right, however, were far more positive about cost-benefit analysis than those on the left, which may indicate that the analyses are not perceived as politically neutral.

Project documentation: Nyborg and Spangen (1997) and (1998).

12.4. Voluntary agreements or environmental taxes?

In Norway, agreements concerning the reduction and recycling of packaging waste were entered into by several industry organizations and the Ministry of the Environment in the period from 1994 to 1996. According to these agreements, the industry pledged to collect and recycle 60 to 80 per cent of several categories of packaging materials, such as plastic, cardboard and metals. The Government indicated that it would consider introducing a tax on certain types of packaging materials if the agreements did not have the intended effect. In recent years, similar "voluntary agreements" have become increasingly popular as an environmental policy instrument in a number of countries.

It is reasonable that firms prefer agreements to taxes, but it is less obvious why this solution should also be in the interest of the policy makers. It has also been asserted that "voluntary agreements" are in reality only a special type of direct regulation because the authorities can threaten to introduce penal mechanisms if the agreements are not complied with. One argument provided by the Norwegian Government for not introducing such taxes right away was that it would be difficult to provide an *unambiguous definition of the tax base*. Even though it is intuitively clear what "packaging materials" are, it is difficult to construct a formal definition that cannot be circumvented by, for example, changing the packaging appearance or chemical composition. This project shows that if it is impossible to specify a precise and unambiguous definition, it may be in the interest of both parties to enter into an agreement, and in such an event there will be a genuine difference between regulation and agreements.

Assume that we have one *firm* which produces a good, where this production leads to emissions of pollutants, and a *regulator*, which represents the environmental authorities. The regulator is concerned about both environmental quality and production, and can impose a tax on emissions. It is assumed, however, that delimitation problems make it impossible to include all emissions in the formal definition of the tax base. Packaging waste covered by the formal definition can be thought of as the "verifiable emissions", while waste not covered by the formal definition corresponds to the "non-verifiable emissions". We will assume that both these types of emissions are *observable* for both the firm and the regulator (the authorities may e.g. observe whether packaging waste accumulates at municipal landfills). However, the authorities cannot impose an emission tax or a direct regulation on non-verifiable emissions that are not included in the formal definition, since observations of these emissions cannot be verified by a third party, such as a legal court.

The regulator can impose a tax on verifiable emissions, but must then take into account that the firm can avoid the tax by replacing verifiable emissions with non-verifiable emissions. If this substitution between emission types is inexpensive for the firm, and non-verifiable emissions are more harmful to the environment, the regulator must keep the tax at a low level; it may even be best to set the tax at zero.

Provided that the regulator can actually gain by introducing the tax, the potential tax represents a credible threat, which may be used to arrive at an agreement. One possible type of agreement is that the authorities refrain from imposing a tax, while the firm agrees to reduce total emissions. In this solution both parties will be better off, and the environmental quality will be better than in a tax-based solution. Because the emissions are observable, the regulator can determine whether the firm is complying with the agreement even though the observations cannot be proved to a third party.

One example might be that Norwegian industry organizations find it in their interest to reduce *all* types of packaging materials to avoid a future tax, not just the types of packaging materials which would presumably be covered by the tax. While industry avoids the imposition of a tax, the authorities achieve a reduction of broader waste categories than would otherwise be achieved. In this situation there is a distinct difference between regulation and agreements because industry – in order to achieve an economic advantage – agrees to implement measures which the regulator does not have the statutory authority to impose. In a certain sense it may therefore be maintained that the word "voluntary" is meaningful for such agreements. This reasoning can naturally not be used as an argument in favour of voluntary agreements in situations without ambiguity problems in terms of the tax base definition.

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Project documentation: Nyborg (1998b).

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Appendix A

Energy

Table A1. **Reserve accounts for crude oil. Fields already developed or where development has been approved. Million Sm³ o.e.**

	1990	1991	1992	1993	1994	1995	1996	1997
Reserves as of 1.1	1 189	1 340	1 354	1 496	1 473	1 477	1 654	1 795
New fields	126	114	117	5	34	131	315	84
Re-evaluation	123	12	152	107	124	212	11	166
Extraction	-98	-112	-127	-136	-154	-166	-186	-187
Reserves as of 31.12	1 340	1 354	1 496	1 473	1 477	1 654	1 795	1 858
R/P ratio	14	12	12	11	10	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 Sm³ o.e.**

	1990	1991	1992	1993	1994	1995	1996	1997
Reserves as of 1.1	1 261	1 230	1 274	1 381	1 356	1 346	1 352	1 479
New fields	17	54	138	1	2	32	195	12
Re-evaluation	-20	17	-2	2	18	5	-27	-271
Extraction	-28	-28	-29	-28	-30	-31	-41	-47
Reserves as of 31.12	1 230	1 274	1 381	1 356	1 346	1 352	1 479	1 173
R/P ratio	45	46	48	49	45	43	36	25

Sources: Norwegian Petroleum Directorate and Statistics Norway.

Table A3. **Reserve accounts for coal (proven reserves). Million tonnes**

	1990	1991	1992	1993	1994	1995	1996	1997
Reserves as of 1.1	13.3	13.0	4.5	4.1	4.0	6.1	6.1	5.8
Re-evaluation	-	-8.2	-	0.2	2.4	0.3	-0.1	0.4
Extraction	-0.3	-0.3	-0.4	-0.3	-0.3	-0.3	-0.2	-0.4
Reserves as of 31.12	13.0	4.5	4.1	4.0	6.1	6.1	5.8	5.8
R/P ratio	43	15	11	15	20	20	25	14

Source: Store Norske Spitsbergen Kulkompani.

Table A4. **Extraction, conversion and use[1] of energy commodities. 1996*. 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 1976-1996	Average annual change, per cent 1995-1996
Extraction of energy commodities	6	-	6 323	1 702	271[3]	374	-	8 676		
Energy use in extraction sectors	-	-	-	-150[4]	-13	-6	-	-168		
Imports and Norwegian purchases abroad	53	0	56	-	276	48	-	433		
Exports and foreign purchases in Norway	-9	0	-5 787	-1 570	-617	-15	-	-7 998		
Stocks (+decrease, -increase)	-1	.	-27	.	-8	.	.	-36		
Primary supplies	50	0	565	-18	-91	401	-	907		
Oil refineries	7	-	-601	-	562	-2	-	-35		
Other energy sectors or supplies	-1	43	-	-	15	2	6	65		
Registered losses, statistical errors	2	0	36	19	-7	-30	-2	18		
Registered use outside energy sectors	57	43	0	1	479	370	5	956	0.8	3.2
Domestic use	57	43	-	1	335	370	5	811	1.5	3.6
Agriculture and fisheries	0	-	-	-	28	5	0	33	0.6	9.7
Energy-intensive manufacturing	44	-	-	1	56	103	0	205	1.2	-1.5
Other manufacturing and mining	13	17	-	0	40	58	1	129	0.3	4.3
Other industry	-	0	-	-	136	74	2	213	2.2	7.2
Private households	0	26	-	-	75	129	1	231	2.1	3.9
International maritime transport	-	-	-	-	144	-	-	144	-2.0	1.0

[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 gas terminals.
Source: Statistics Norway.

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

Energy commodity	1976	1985	1990	1991	1992	1993	1994	1995	1996*	1997*	Average annual change, per cent 1976-1996	1996-1997
Total	606	731	733	723	718	745	768	783	811	822	1.5	1.3
Electricity	241	329	349	356	358	363	366	374	370	372	2.2	0.4
Firm power	232	312	324	330	330	335	347	348	356	356	2.1	0.2
Spot power	9	17	24	27	28	28	19	26	15	16	2.5	5.8
Oil, total	299	259	243	236	232	239	247	253	280	274	-0.3	-2.2
Oil other than for transport	163	81	57	51	44	46	55	51	67	55	-4.4	-17.4
Petrol	13	4	0	0	0	0	0	0	0	0	.	-
Kerosene	17	9	7	7	7	7	7	7	8	7	-3.6	-8.6
Middle distillates	66	43	36	31	28	28	31	30	41	32	-2.4	-22.4
Heavy fuel oil	66	25	14	13	10	11	17	14	18	16	-6.3	-10.1
Oil for tranpsort	137	179	187	186	188	193	193	202	214	219	2.3	2.5
Petrol, aviation fuel, jet fuel	70	88	99	97	96	97	98	101	105	106	2.1	0.5
Middle distillates	64	83	84	87	90	96	94	100	108	112	2.7	4.1
Heavy fuel oil	3	7	4	2	1	1	0	1	1	1	-8.9	67.0
Gas[1]	1	52	52	47	47	54	54	53	56	71	19.9	28.0
District heating	-	2	3	4	4	4	4	4	5	5	.	1.2
Solid fuel	64	89	86	79	78	86	97	100	100	100	2.3	-0.5
Coal, coke	47	57	50	45	45	48	54	58	57	58	1.0	1.0
Wood, wood waste, black liquor, waste	17	31	36	34	32	37	42	42	43	42	4.7	-2.5

[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	1985	1987	1989	1990	1991	1992	1993	1994	1995	1996*	1997*
Total	34	66	75	82	96	122	154	164	172	188	185	197	205
Of this:													
Electricity	4	6	8	7	7	7	8	8	8	11	10	8	12
Natural gas	12	30	45	55	68	79	113	118	125	137	140	150	153

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

Table A7. **Electricity balance. TWh. Percentage change**

	1975	1980	1987	1990	1994	1995	1996*	1997*	Average annual change, per cent 1975-1987	1987-1997
Production	77.5	84.1	104.3	121.8	113.2	123.0	104.7	111.6	2.5	0.7
+ Imports	0.1	2.0	3.0	0.3	4.8	2.3	13.2	8.7	34.8	11.3
- Exports	5.7	2.5	3.3	16.2	5.0	9.0	4.2	4.9	-4.4	3.9
= Gross domestic consumption	71.9	83.6	103.9	105.9	113.1	116.3	113.7	115.4	3.1	1.1
- Consumption in pumped storage power plants	0.1	0.5	0.7	0.3	1.5	1.4	0.4	1.7	15.5	9.2
- Consumption in power plants, losses and statistical differences	7.1	8.0	9.5	7.9	8.7	10.0	8.7	8.8	2.5	-0.8
= Net domestic consumption	64.7	75.1	93.8	97.7	102.9	105.0	104.6	105.0	3.1	1.1
- Spot power	3.2	1.2	4.1	6.7	5.4	7.5	3.2	4.4	2.0	0.7
= Net firm power consumption	61.4	73.9	89.7	91.0	97.6	97.5	101.4	100.6	3.2	1.2
- Energy-intensive manufacturing	26.2	27.9	28.9	29.6	28.2	28.4	28.6	29.0	0.8	0.0
= General consumption	35.2	46.0	60.8	61.5	69.4	69.1	72.8	71.6	4.6	1.7
General consumption, corrected for temperature	36.3	45.1	59.0	65.4	69.8	69.6	71.6	73.3	4.1	2.2

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**

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996*	1997*
Heating products[3]											
Price in øre[4]/kWh											
Electricity	37.9	41.7	43.5	45.7	46.5	46.6	47.8	46.8	49.7	49.3	59.0
Heating kerosene	25.0	25.7	28.3	33.9	40.1	37.4	37.8	37.6	38.2	42.1	44.3
Fuel oil no.1/light fuel oils[5]	19.6	19.7	21.6	26.6	31.9	28.3	28.0	28.2	29.6	34.0	37.0
Fuel oil no.2	18.3	18.8	20.7	25.7	30.8	27.2	26.9	27.1	..[5]	..	..
Heavy fuel oil	13.1	12.3	15.2	19.4	23.2	23.0	22.4	22.5	22.8	..	..
Transport products											
Price in øre/liter											
Petrol, leaded, high oct.	510.0	536.0	578.5	642.8	741.0	795.0	836.2	851.0	893.0	.	.
Petrol, unl. 98 octane	.	.	.	622.1	705.0	747.0	787.1	791.0	838.0	880.0	909.0
Petrol, unl. 95 octane	489.0	503.0	540.5	594.4	677.0	717.0	757.4	761.0	807.0	849.0	888.0
Auto diesel	210.0	214.0	233.0	285.9	341.0	326.0	403.0	649.0	701.0	757.0	779.0

[1] Including all taxes. [2] Households and agriculture. For 1987-1992, firm power only. For 1993-1997, both firm power and spot power. For 1996 and 1997: prices as of 1 January. [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 and Norwegian Petroleum Institute.

Table A9. **Consumption of energy commodities[1] for combustion. Oslo. 1995. MWh theoretical energy content**

	Fossil energy	Bioenergy
Total	3 916 276	562 409
Stationary combustion	1 295 737	562 409
Manufacturing and energy sectors	236 465	14 863
Public services	100 810	-
Private services	444 823	3 166
Primary industries	7706	-
Private households	497 194	465 726
Waste and landfill gas	8739	78 654
Mobile combustion	2 620 539	-
Road traffic	2 413 248	-
- Private households	762 816	-
- Public transport	161 936	-
- Other transport	1 488 496	-
Motorized equipment and tractors	128 331	-
- Private households	27 953	-
- Other sectors	100 378	-
Railways	9 119	-
Shipping, in port	69 841	-
Ships in international trade, in port[2]	80 598	-

[1] Waste incineration for district heating not included.
[2] Ships in international trade are not included in the total.
Source: Statistics Norway.

Table A10. **Total primary energy supply[1]. World total and selected countries. Million toe**

	1972	1980	1985	1990	1994	1995	Per unit GDP (1995) (toe/1000 1990-USD)	Per unit GDP (1995) (toe/1000 1990-USD PPP[2])	Per capita (1995) (toe per capita)
World total[3]	5 180.4	6 470.2	6 935.3	7 781.1	8 005.2	8 198.8	0.35	0.28	1.47
OECD	3 424.3	3 882.2	3 925.5	4 290.8	4 521.2	4 606.1	0.25	0.27	4.60
Norway	14.5	18.8	20.3	21.5	23.4	23.7	0.17	0.26	5.44
Denmark	20.1	19.7	19.9	19.7	20.6	20.5	0.14	0.20	3.92
Finland	19.7	25.0	26.2	28.6	30.5	28.7	0.22	0.36	5.62
Sweden	37.2	41.0	47.6	47.8	50.4	50.7	0.22	0.33	5.73
Iceland	1.0	1.4	1.8	2.1	2.1	2.1	0.33	0.44	8.03
Belgium	43.7	46.1	44.7	48.4	51.9	52.4	0.25	0.29	5.17
France	163.7	190.1	200.2	240.2	232.2	241.3	0.19	0.23	4.15
Greece	10.6	16.0	18.6	22.2	23.6	23.7	0.26	0.22	2.27
Italy	121.8	138.6	135.5	153.3	153.5	161.4	0.14	0.16	2.82
Netherlands	58.8	65.0	61.6	70.1	70.6	73.3	0.23	0.27	4.74
Portugal	6.7	10.3	11.4	16.4	18.1	19.2	0.27	0.17	1.94
Spain	45.4	68.6	71.8	90.6	98.6	103.5	0.20	0.20	2.64
United Kingdom	12.8	201.2	203.0	218.7	220.0	221.9	0.21	0.22	3.79
Switzerland	17.8	20.8	22.9	25.0	25.5	25.1	0.11	0.17	3.55
Turkey	22.0	31.3	38.9	52.5	56.8	62.2	0.35	0.16	1.01
Germany	319.2	359.0	359.6	337.7	336.3	339.3	0.19	0.24	4.15
Hungary	20.8	28.6	29.7	28.4	24.5	25.1	0.82	0.41	2.44
Austria	20.1	23.5	23.2	25.7	25.9	26.4	0.15	0.18	3.28
Canada	154.0	192.9	193.2	210.0	228.4	233.3	0.38	0.42	7.88
Mexico	50.1	98.9	111.2	124.2	137.1	133.4	0.47	0.21	1.41
USA	1 660.9	1 801.4	1 772.3	1 915.0	2 045.8	2 078.3	0.34	0.34	7.90
Japan	288.2	346.6	367.0	438.8	483.3	497.2	0.16	0.20	3.96
Australia	53.8	70.4	73.9	92.4	92.6	94.2	0.28	0.30	5.22
Non-OECD	1 709.5	2 579.4	3 036.4	3 538.2	3 502.4	3 613.8	0.72	0.28	0.79
Poland[4]	85.1	124.6	126.5	97.9	92.6	94.50	1.45	0.44	2.45
Romania	42.2	63.8	63.5	43.7	41.1	44.0	1.26	0.60	1.94
Russia	..	..	..	722.4	619.6	604.5	1.68	0.88	4.08
Egypt	8.0	15.2	24.5	31.4	32.7	34.7	0.91	0.22	0.60
Ethiopia	0.5	0.6	0.7	1.1	1.1	1.2	0.12	0.04	0.02
Nigeria	2.6	9.9	12.3	14.3	21.5	18.4	0.50	0.14	0.17
South Africa	42.1	59.1	79.2	80.1	85.0	88.9	0.81	0.52	2.14
Argentina	32.0	39.7	39.3	50.1	52.1	53.0	0.29	0.23	1.53
Brazil	40.0	73.0	82.0	101.6	119.9	122.9	0.23	0.14	0.77
Guatemala	0.9	1.4	1.2	1.8	2.1	2.2	0.24	0.07	0.21
Venezuela	21.2	35.0	36.8	42.7	40.5	47.1	0.84	0.29	2.19
Bangladesh	1.3	2.8	4.0	7.0	7.6	8.1	0.29	0.06	0.07
India	66.3	93.9	130.0	184.0	227.5	241.3	0.65	0.22	0.26
Indonesia	10.0	25.9	36.0	76.0	75.2	85.8	0.52	0.13	0.44
China	252.2	413.2	517.0	655.8	795.2	850.5	1.34	0.26	0.71
South Korea[4]	17.8	41.4	53.6	124.0	132.5	145.1	0.40	0.29	3.24
Thailand	7.4	12.1	15.6	39.9	44.4	52.1	0.41	0.14	0.89

[1] Whole world and non-OECD countries: figures do not include biofuel and waste. [2] PPP (purchasing power parity): GDP adjusted for local purchasing power. [3] Including international shipping. [4] Poland and South Korea joined the OECD at the end of 1996, but are included with non-OECD countries here.
Sources: OECD/IEA (1997a and b).

Appendix B

Transport

Table B1. **Domestic passenger transport. Million passenger-km**

	Total	Total road transport	Car	Car as share of total, per cent	Bus	Taxi, hired car	MC, moped	Air trans-port	Rail trans-port	Water trans-port
1946	4 591	2 051	1 053	22.9	687	218	93	3	2 081	456
1952	6 524	3 893	1 584	24.3	1 847	291	171	9	2 115	507
1960	11 646	8 739	4 758	40.9	2 776	376	829	93	2 254	560
1961	12 721	9 846	5 676	44.6	2 929	386	855	103	2 199	573
1962	13 893	10 998	6 675	48.0	3 093	396	834	144	2 186	565
1963	14 642	11 824	7 724	52.8	2 866	403	831	185	2 093	540
1964	16 017	13 207	8 875	55.4	3 108	402	822	232	2 035	543
1965	17 384	14 512	10 053	57.8	3 263	398	798	280	2 020	572
1966	18 836	15 893	11 304	60.0	3 426	395	768	295	2 071	577
1967	20 185	17 088	12 495	61.9	3 452	399	742	423	2 088	586
1968	22 244	19 140	14 414	64.8	3 600	407	719	484	2 029	591
1969	23 939	20 833	16 001	66.8	3 707	423	702	558	1 932	616
1970	25 824	22 631	17 781	68.9	3 726	429	695	632	1 930	631
1971	28 734	25 344	20 452	71.2	3 770	441	681	758	1 970	662
1972	30 514	26 946	21 969	72.0	3 867	447	663	858	2 021	689
1973	32 826	29 218	24 207	73.7	3 907	463	641	916	1 991	701
1974	33 792	29 980	24 842	73.5	4 058	452	628	915	2 221	676
1975	35 305	31 353	26 311	74.5	3 963	475	604	1 021	2 271	660
1976	37 310	33 135	28 200	75.6	3 916	481	538	1 139	2 338	698
1977	39 172	34 824	29 760	76.0	3 987	538	539	1 286	2 377	685
1978	39 837	35 326	30 287	76.0	3 930	562	547	1 395	2 449	667
1979	41 229	36 458	31 169	75.6	4 124	613	552	1 482	2 636	653
1980	40 705	35 819	30 436	74.8	4 257	625	501	1 475	2 751	660
1981	40 518	35 582	30 146	74.4	4 297	621	518	1 535	2 767	634
1982	40 443	35 641	30 504	75.4	3 952	635	550	1 626	2 575	601
1983	41 100	36 160	31 112	75.7	3 811	665	572	1 797	2 530	613
1984	42 137	37 066	32 050	76.1	3 712	712	592	1 929	2 525	617
1985	47 657	42 300	36 884	77.4	3 948	838	630	2 147	2 567	643
1986	50 534	45 013	39 488	78.1	3 878	949	698	2 301	2 582	638
1987	52 404	46 704	41 243	78.7	3 743	1 002	716	2 505	2 563	632
1988	52 381	46 734	41 230	78.7	3 901	912	691	2 548	2 463	636
1989	52 707	47 136	41 684	79.1	3 956	792	704	2 469	2 459	643
1990	52 844	47 113	41 717	78.9	3 890	801	705	2 665	2 430	636
1991	52 473	46 547	41 218	78.6	3 935	760	701	2 699	2 573	654
1992	52 634	46 561	41 130	78.1	3 945	782	704	2 946	2 511	616
1993	53 503	47 094	41 644	77.8	3 927	815	708	3 204	2 588	617
1994	54 538	47 804	42 211	77.4	3 956	928	709	3 397	2 703	634
1995	54 774	47 912	42 365	77.3	3 752	1 071	724	3 567	2 676	619
1996	57 111	49 783	44 052	77.1	3 752	1 211	768	3 938	2 767	623

Sources: Statistics Norway and Institute of Transport Economics.

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 continental shelf
1946	4 091	2 679	687	481	0	244	-
1952	6 662	4 202	1 186	807	0	467	-
1960	8 741	5 854	1 056	1 493	1	337	-
1965	11 107	7 550	1 160	2 183	2	212	-
1970	14 984	10 253	1 448	3 194	5	84	-
1971	15 296	10 303	1 440	3 455	6	92	-
1972	16 186	10 918	1 445	3 736	7	80	-
1973	16 919	11 321	1 454	4 069	8	67	-
1974	16 449	10 537	1 536	4 297	8	71	-
1975	16 014	9 836	1 508	4 569	9	92	-
1976	16 519	9 980	1 587	4 858	10	84	-
1977	16 287	9 731	1 588	4 894	12	62	-
1978	15 970	9 447	1 539	4 930	13	41	-
1979	16 054	9 279	1 593	5 112	14	56	17
1980	16 761	9 794	1 657	5 252	14	44	348
1981	15 581	8 751	1 650	5 115	15	50	1 018
1982	16 368	9 323	1 554	5 424	16	51	1 609
1983	16 276	9 003	1 529	5 695	17	32	1 778
1984	16 231	8 518	1 640	6 022	17	34	1 992
1985	17 610	9 300	1 771	6 485	19	35	2 718
1986	17 942	8 897	1 833	7 192	20	-	3 752
1987	18 327	8 908	1 747	7 652	20	-	4 234
1988	18 250	8 481	1 628	8 122	19	-	5 618
1989	18 052	8 331	1 763	7 940	18	-	6 636
1990	18 960	9 078	1 632	8 231	19	-	7 603
1991	18 402	8 380	1 718	8 286	18	-	8 030
1992	18 995	8 883	1 746	8 348	18	-	10 226
1993	18 796	8 735	1 774	8 266	21	-	10 350
1994	18 464	8 131	1 599	8 714	20	-	12 662
1995	18 222	6 900	1 647	9 654	21	-	13 843
1996	19 401	6 895	1 835	10 651	20	-	18 514

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

Appendix C

Air

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

	CO_2	CH_4	N_2O	HFC 125	HFC 134	HFC 143	HFC 152	CF_4	C_2F_6	SF_6	CO_2 equi-valents
	Mtonnes	ktonnes	ktonnes								Mtonnes
GWP	1	21	310	2 800	1 300	3 800	140	6 500	9 200	23 900	
1950		131	7								
1960		175	10								
1973	29.8	216[1]	12[1]	..	..	..	..	..	..	..	..
1974	26.9	..	..	..	..	..	..	..	..	..	..
1975	29.9	..	..	..	..	..	..	..	..	..	..
1976	32.5	..	..	..	..	..	..	..	..	..	..
1977	32.8	..	..	..	..	..	..	..	..	..	..
1978	32.0	..	..	..	..	..	..	..	..	..	..
1979	34.1	..	..	..	..	..	..	..	..	..	..
1980	32.7	407	16	..	..	..	..	..	..	..	..
1981	31.1	..	..	..	..	..	..	..	..	..	..
1982	30.3	..	..	..	..	..	..	..	..	..	..
1983	31.2	..	..	..	..	..	..	..	..	..	..
1984	33.1	..	..	..	..	..	..	..	..	..	..
1985	31.6	..	..	0	0	0	0	409	18	199	..
1986	34.3	..	..	0	0	0	0	401	18	240	..
1987	34.2	432	16	0	0	0	0	388	17	240	57
1988	35.0	427	17	0	0	0	0	371	16	223	57
1989	35.2	440	18	0	0	0	3	360	16	107	55
1990	35.5	442	18	0	0	0	3	369	16	92	55
1991	33.8	443	18	0	1	0	3	313	14	86	53
1992	34.4	454	15	0	2	0	3	242	11	29	51
1993	35.9	454	17	0	31	0	1	254	11	30	53
1994	37.8	475	17	11	40	4	1	231	11	35	56
1995	38.1	492	17	31	47	25	5	209	9	24	56
1996*	41.1	485	18	38	51	26	5	187	6	22	59
1997*	41.4	492	18	..	..	..	..	..	..	..	..

[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 equivalents[1]	NMVOCs	CO	Particulates[2]	Heavy metals Pb	Cd
								Tonnes	kg
1973	155	180	..	..	182	737	25	882	..
1974	149	175	..	..	174	698	23	826	..
1975	137	181	..	..	195	751	23	919	..
1976	146	179	..	..	197	797	22	756	..
1977	145	192	..	..	203	846	23	758	..
1978	142	185	..	..	163	857	22	781	..
1979	144	195	..	..	179	905	23	825	..
1980	140	189	22	9.8	176	896	21	680	..
1981	127	176	..	..	180	896	23	572	..
1982	110	181	..	..	186	903	21	647	..
1983	103	186	..	..	199	899	21	555	..
1984	95	200	..	..	210	952	22	398	..
1985	97	211	..	..	228	943	23	403	1 143
1986	91	226	..	..	246	979	24	339	..
1987	74	229	23	8.7	257	870	23	296	..
1988	67	222	21	8.2	245	894	23	291	..
1989	58	224	23	8.0	278	867	23	278	1 212
1990	53	222	23	7.8	301	858	24	230	1 193
1991	44	212	24	7.4	299	794	22	184	1 163
1992	36	210	25	7.2	330	784	22	150	1 063
1993	35	218	25	7.3	346	788	25	107	1 107
1994	34	216	25	7.2	357	791	27	22	628
1995	34	217	26	7.3	371	748	26	15	636
1996*	34	223	26	7.4	369	720	27	8	635
1997*	30	225	26	7.4	354	672	26	..	..

[1] Total acidifying effect of SO_2, NO_x and NH_3.
[2] Process emissions calculated for road dust only.
Sources: Statistics Norway and Norwegian Pollution Control Authority.

Table C3. **Emissions of greenhouse gases to air by sector. 1995. Tonnes unless otherwise specified**

	CO_2	CH_4	N_2O	HFC 125[1]	HFC 134[1,2]	HFC 143[1,2]	HFC 152[1,2]	CF_4	C_2F_6	SF_6	CO_2 equi-valents
	Mtonnes	ktonnes	ktonnes								Mtonnes
Total	38.1	492.1	17.5	31.1	46.9	25.2	4.5	208.5	8.9	23.5	56.1
Energy sectors	11.3	31.9	0.2	-	-	-	-	-	-	2.4	12.1
- Extraction of oil and gas[3]	9.3	27.6	0.1	-	-	-	-	-	-	-	10.0
- Extraction of coal	0.0	4.1	0.0	-	-	-	-	-	-	-	0.1
- Oil refining	1.7	0.1	0.1	-	-	-	-	-	-	-	1.8
- Electricity supplies[4]	0.2	0.1	0.0	-	-	-	-	-	-	2.4	0.3
Manufacturing and mining	10.9	101.6	6.1	0.3	0.5	0.3	0.05	208.5	8.9	21.2	16.9
- Oil drilling	0.3	0.2	0.0	-	-	-	-	-	-	-	0.3
- Manufacture of pulp and paper	0.6	50.2	0.4	-	-	-	-	-	-	-	1.7
- Manufacture of chemical raw materials	2.5	1.0	5.4	-	-	-	-	-	-	-	4.2
- Manufacture of minerals	1.9	0.0	0.1	-	-	-	-	-	-	-	2.0
- Manufacture of iron, steel and ferro-alloys	2.7	0.0	0.0	-	-	-	-	-	-	-	2.7
- Manufacture of other metals	1.9	0.0	0.0	-	-	-	-	208.5	8.9	21	3.8
- Manufacture of metal goods, boats, ships and oil 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	0.3	0.5	0.3	0.05	-	-	-	1.3
- Manufacture of consumer goods	0.6	0.0	0.1	-	-	-	-	-	-	-	0.6
Other	15.9	358.6	11.2	30.8	46.4	24.9	4.5	-	-	-	27.1
- Construction	0.6	0.1	0.0	-	-	-	-	-	-	-	0.6
- Agriculture and forestry	0.7	108.6	9.4	-	-	-	-	-	-	-	5.9
- Fishing, whaling and sealing	1.3	0.1	0.0	-	-	-	-	-	-	-	1.4
- Land transport, domestic	2.7	0.2	0.1	-	-	-	-	-	-	-	2.7
- Sea transport, domestic	1.3	0.1	0.0	-	-	-	-	-	-	-	1.3
- Air transport, domestic	1.3	0.0	0.0	-	-	-	-	-	-	-	1.3
- Other private services	2.0	0.5	0.3	30.8	46.4	24.9	4.5	-	-	-	2.3
- Public sector, municipal	0.2	234.1	0.4	-	-	-	-	-	-	-	5.2
- Public sector, state	0.5	0.0	0.0	-	-	-	-	-	-	-	0.5
- Private households	5.3	14.9	0.9	-	-	-	-	-	-	-	5.9

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

Table C4. **Emissions to air by sector, 1995. 1 000 tonnes unless otherwise specified**

	SO_2	NO_x	NH_3	Acid equivalents[1]	NMVOCs	CO	Particulates[2]	Heavy metals Pb	Heavy metals Cd
								Tonnes	kg
Total	34.1	216.6	25.8	7.3	370.6	748.5	25.7	15.5	636
Energy sectors	3.1	44.3	0.0	1.1	223.6	7.9	0.5	1.4	38
- Extraction of oil and gas[3]	0.5	40.4	-	0.9	203.9	6.5	0.2	0.0	1
- Extraction of coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
- Oil refining	1.9	2.5	0.0	0.1	19.1	0.0	0.1	0.0	0
- Electricity supplies[4]	0.7	1.3	0.0	0.1	0.5	1.4	0.2	1.3	37
Manufacturing and mining	25.1	27.3	0.3	1.4	24.3	61.1	2.0	2.4	433
- Oil drilling	0.1	4.5	-	0.1	0.4	0.3	0.0	0.0	0
- Manufacture of pulp and paper	2.5	1.8	0.0	0.1	0.3	2.0	0.5	0.2	19
- Manufacture of chemical raw materials	9.3	4.4	0.3	0.4	2.7	39.8	0.1	0.0	3
- Manufacture of minerals	2.5	7.1	0.0	0.2	1.6	0.8	0.3	1.4	63
- Manufacture of iron, steel and ferro-alloys	7.5	4.6	0.0	0.3	1.4	0.0	0.0	0.1	12
- Manufacture of other metals	2.1	1.4	0.0	0.1	0.0	10.2	0.1	0.5	303
- Manufacture of metal goods, boats, ships and oil platforms	0.2	0.8	0.0	0.0	2.6	0.8	0.1	0.0	1
- Manufacture of wood, plastic, rubber, and chemical goods, printing	0.3	0.8	0.0	0.0	14.0	5.3	0.8	0.0	30
- Manufacture of consumer goods	0.7	1.8	0.0	0.1	1.2	1.9	0.2	0.1	2
Other	5.8	145.0	25.4	4.8	122.7	679.5	23.2	11.7	164
- Construction	0.2	6.5	0.0	0.1	12.6	5.9	0.7	0.1	2
- Agriculture and forestry	0.3	6.4	24.6	1.6	2.6	5.3	0.8	0.1	1
- Fishing, whaling and sealing	0.7	29.6	0.0	0.7	0.8	6.5	0.2	0.1	3
- Land transport, domestic	1.1	25.0	0.0	0.6	4.7	20.7	3.2	0.3	6
- Sea transport, domestic	1.2	26.5	-	0.6	1.5	1.3	0.2	0.1	3
- Air transport, domestic	0.2	3.7	-	0.1	1.9	5.0	0.2	1.5	-
- Other private services	0.6	12.5	0.1	0.3	19.6	87.2	0.8	1.8	2
- Public sector, municipal[5]	0.1	0.3	0.0	0.0	0.7	0.3	0.0	0.0	0
- Public sector, state	0.1	3.1	0.0	0.1	2.2	2.7	0.1	0.0	0
- Private households	1.4	31.6	0.6	0.8	76.2	544.6	17.0	7.7	146

[1] Total acidifying effect of SO_2, NO_x and NH_3.
[2] Process emissions calculated for road dust only.
[3] Includes gas terminal, transport and supply ships, plants.
[4] Includes emissions from waste incineration.
[5] Includes water supplies.
Source: Statistics Norway and Norwegian Pollution Control Authority.

Table C5. **Emissions to air by source[1], 1995. 1 000 tonnes unless otherwise specified**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Million tonnes									Ton-nes	kg
Total	38.1	492.1	17.5	34.1	216.6	25.8	370.6	748.5	25.7	15.5	636
Stationary combustion	15.3	16.5	1.5	7.0	43.6	-	13.4	161.0	16.9	1.8	302
Oil extraction	7.6	2.6	0.1	0.2	28.3	-	1.1	5.7	0.1	0.0	-
- Natural gas	6.2	2.4	0.1	-	16.6	-	0.6	4.5	-	-	-
- Flaring	1.1	0.1	0.0	-	5.2	-	0.1	0.7	-	-	-
- Diesel combustion	0.4	0.1	0.0	0.2	6.4	-	0.4	0.5	0.1	0.0	-
Gas terminal and oil refineries	2.3	0.4	0.1	0.1	2.8	-	0.8	0.5	0.1	0.0	0
Other industry	3.3	0.4	0.8	5.0	8.9	-	0.8	7.2	1.7	0.4	126
Dwellings, offices, etc.	2.0	13.0	0.5	1.5	2.6	-	10.3	147.0	14.6	0.1	149
Waste incineration	0.1	0.1	0.0	0.2	0.9	-	0.3	0.2	0.0	1.3	27
Process emissions	8.1	472.5	15.0	22.2	8.4	25.0	275.4	49.7	1.9	1.9	316
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
Manufacture of cement and other minerals	0.8	-	-	0.9	-	-	-	-	-	1.3	-
Manufacture of metals	4.8	-	-	12.7	7.1	-	1.8	10.0	-	0.6	316
- Ferro-alloys	2.6	-	-	10.3	6.3	-	1.5	-	-	-	5
- Aluminium	1.5	-	-	1.5	0.6	-	-	-	-	0.4	102
- Other metals	0.8	-	-	0.8	0.2	-	0.3	10.0	-	0.2	209
Agriculture	0.2	108.6	9.3	-	-	24.6	-	-	-	-	-
Landfills	0.0	333.9	-	-	-	-	-	-	-	-	-
Solvents	0.1	-	-	-	-	-	44.9	-	-	-	-
Road dust	-	-	-	-	-	-	-	-	1.9	-	-
Other process emissions	0.0	0.1	0.4	0.1	-	-	0.8	-	-	-	-

Table C5 (cont.). **Emissions to air by source[1]. 1995. 1 000 tonnes unless otherwise specified**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Million tonnes									Ton-nes	kg
Mobile combustion	14.7	3.0	1.0	4.9	164.6	0.8	81.8	537.8	6.8	11.7	18
Motor vehicles	8.4	2.5	0.8	1.9	67.3	0.8	64.0	474.3	4.0	9.6	8
- Petrol engines	5.0	2.2	0.8	0.4	36.6	0.8	56.3	446.1	0.5	9.4	-
- Light vehicles	4.9	2.2	0.8	0.4	35.9	0.8	55.7	442.6	0.5	9.3	-
- Heavy vehicles	0.0	0.0	0.0	0.0	0.7	0.0	0.6	3.4	0.0	0.1	-
- Diesel engines	3.4	0.2	0.1	1.5	30.6	0.0	3.9	16.3	3.5	0.1	8
- Light vehicles	1.0	0.0	0.0	0.4	2.9	0.0	1.0	3.8	1.2	0.0	2
- Heavy vehicles	2.5	0.1	0.0	1.1	27.7	0.0	2.9	12.5	2.2	0.1	5
- Motorcycles, mopeds	0.1	0.1	0.0	0.0	0.1	0.0	3.8	11.9	0.0	0.1	-
- Motorcycles	0.0	0.0	0.0	0.0	0.1	0.0	1.2	7.0	0.0	0.1	-
- Mopeds	0.0	0.0	0.0	0.0	0.0	0.0	2.6	4.9	0.0	0.0	-
Snow scooters	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.5	0.0	0.0	-
Small boats	0.2	0.1	0.0	0.0	0.9	-	8.5	19.7	0.3	0.2	0
Motorized equipment	0.8	0.1	0.0	0.3	11.9	0.0	3.8	25.5	1.4	0.1	2
- Motorized, petrol	0.1	0.0	0.0	0.0	0.2	-	2.6	20.9	0.0	0.1	-
- Motorized: petrol two-stroke	0.0	0.0	0.0	0.0	0.0	-	0.7	1.0	0.0	0.0	-
- Motorized: petrol four-stroke	0.1	0.0	0.0	0.0	0.2	-	1.8	19.9	0.0	0.1	-
- Motorized: diesel	0.7	0.1	0.0	0.3	11.7	0.0	1.3	4.6	1.4	0.0	2
Railways	0.1	0.0	0.0	0.0	1.5	-	0.1	0.4	0.1	0.0	0
Air traffic	1.6	0.1	0.1	0.2	4.9	-	1.3	7.1	0.2	1.5	-
- Air traffic < 1000m	0.4	0.1	0.0	0.1	1.4	-	0.4	2.1	0.1	0.3	-
- Air traffic > 1000m	1.2	-	0.0	0.2	3.5	-	0.9	5.0	0.1	1.2	-
Shipping	3.6	0.3	0.1	2.4	78.2	-	2.6	8.3	0.7	0.2	8
- Coastal traffic etc.	2.1	0.2	0.1	1.6	44.5	-	1.6	1.8	0.4	0.1	5
- Fishing vessels	1.3	0.1	0.0	0.7	29.5	-	0.7	6.3	0.2	0.1	3
- Mobile oil rigs, etc.	0.2	0.0	0.0	0.1	4.2	-	0.3	0.2	0.0	0.0	0

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

Table C6. **Emissions to air by source[1]. 1996. 1 000 tonnes unless otherwise specified**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Million tonnes									Ton-nes	kg
Total	41.1	485.0	18.1	33.6	222.8	26.3	369.3	719.8	27.1	8.3	635
Stationary combustion	17.5	17.8	1.7	8.7	46.8	-	14.6	173.8	18.5	1.8	350
Oil extraction	8.2	2.8	0.1	0.2	30.3	-	1.2	6.1	0.1	0.0	-
- Natural gas	6.6	2.6	0.1	-	17.7	-	0.6	4.8	-	-	-
- Flaring	1.1	0.1	0.0	-	5.5	-	0.1	0.7	-	-	-
- Diesel combustion	0.4	0.1	0.0	0.2	7.2	-	0.5	0.5	0.1	0.0	-
Gas terminal and oil refineries	2.7	0.5	0.1	0.1	3.6	-	1.0	0.6	0.1	0.0	0
Other industry	4.0	0.4	0.9	6.5	8.7	-	0.9	7.5	1.9	0.5	129
Dwellings, offices etc.	2.6	14.1	0.6	1.7	3.1	-	11.1	158.9	15.8	0.1	161
Waste incineration	0.1	0.1	0.0	0.2	0.9	-	0.3	0.1	0.0	1.2	59
Process emissions	8.1	464.3	15.0	20.5	8.4	25.4	276.5	40.3	1.9	1.9	266
Oil and gas sector	0.7	23.9	-	1.6	0.0	-	219.3	-	-	-	-
- Venting, leaks, etc.	0.0	8.8	-	-	-	-	3.6	-	-	-	-
- Oil loading	0.6	14.8	-	-	-	-	198.8	-	-	-	-
- Gas terminal and oil refineries	0.1	0.3	-	1.6	0.0	-	16.8	-	-	-	-
Petrol distribution	0.0	-	-	-	-	-	6.2	-	-	-	-
Manufacture of pulp and paper	-	-	-	0.7	-	-	-	-	-	-	-
Manufacture of chemicals	1.2	1.0	5.2	5.3	1.3	0.3	0.8	38.8	-	-	0
Manufacture of cement and other minerals	0.8	-	-	0.9	-	-	-	-	-	1.4	-
Manufacture of metals	4.9	-	-	11.9	7.1	-	1.8	1.5	-	0.5	266
- Ferro-alloys	2.6	-	-	9.4	6.2	-	1.5	-	-	-	5
- Aluminium	1.5	-	-	1.7	0.7	-	-	-	-	0.4	102
- Other metals	0.9	-	-	0.8	0.2	-	0.3	1.5	-	0.1	159
Agriculture	0.2	109.2	9.4	-	-	25.0	-	-	-	-	-
Landfills	0.0	326.9	-	-	-	-	-	-	-	0.0	-
Solvents	0.1	-	-	-	-	-	47.5	-	-	-	-
Road dust	-	-	-	-	-	-	-	-	1.9	-	-
Other process emissions	0.0	0.1	0.4	0.1	-	-	0.9	-	-	-	-

Table C6 (cont.). **Emissions to air by source[1]. 1996. 1 000 tonnes unless otherwise specified**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Million tonnes									Ton-nes	kg
Mobile combustion	15.5	3.0	1.3	4.4	167.7	1.0	78.3	505.7	6.7	4.6	19
Motor vehicles	8.9	2.4	1.1	1.8	65.0	1.0	60.2	441.6	3.9	2.7	8
- Petrol engines	5.0	2.1	1.0	0.4	33.4	1.0	52.3	412.4	0.5	2.5	-
- Light vehicles	5.0	2.1	1.0	0.4	32.7	1.0	51.7	409.1	0.5	2.5	-
- Heavy vehicles	0.0	0.0	0.0	0.0	0.7	0.0	0.6	3.3	0.0	0.0	-
- Diesel engines	3.8	0.2	0.1	1.4	31.5	0.0	4.0	16.4	3.4	0.1	8
- Light vehicles	1.1	0.0	0.1	0.4	3.2	0.0	1.1	4.4	1.3	0.0	3
- Heavy vehicles	2.6	0.1	0.0	1.0	28.4	0.0	2.9	12.0	2.1	0.1	6
- Motorcycles, mopeds	0.1	0.1	0.0	0.0	0.1	0.0	3.9	12.8	0.0	0.0	-
- Motorcycles	0.0	0.1	0.0	0.0	0.1	0.0	1.3	8.0	0.0	0.0	-
- Mopeds	0.0	0.0	0.0	0.0	0.0	0.0	2.5	4.8	0.0	0.0	-
Snowscooters	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.6	0.0	0.0	-
Small boats	0.2	0.1	0.0	0.0	0.9	-	8.5	19.7	0.3	0.1	0
Motorized equipment	0.8	0.1	0.0	0.3	12.0	0.0	3.9	25.6	1.4	0.1	2
- Motorized, petrol	0.1	0.0	0.0	0.0	0.2	-	2.6	20.9	0.0	0.0	-
- Motorized: petrol two-stroke	0.0	0.0	0.0	0.0	0.0	-	0.7	1.0	0.0	0.0	-
- Motorized: petrol four-stroke	0.1	0.0	0.0	0.0	0.2	-	1.8	19.9	0.0	0.0	-
- Motorized, diesel	0.8	0.1	0.0	0.3	11.9	0.0	1.3	4.7	1.4	0.0	2
Railways	0.1	0.0	0.0	0.0	1.0	-	0.1	0.2	0.1	0.0	0
Air traffic	1.7	0.1	0.1	0.3	5.2	-	1.4	7.2	0.2	1.6	-
- Air traffic < 1000m	0.5	0.1	0.0	0.1	1.5	-	0.5	2.2	0.1	0.3	-
- Air traffic > 1000m	1.3	-	0.0	0.2	3.7	-	0.9	4.9	0.2	1.3	-
Shipping	3.8	0.3	0.1	2.0	83.5	-	2.8	8.8	0.7	0.2	9
- Coastal traffic etc.	2.1	0.2	0.1	1.2	44.7	-	1.6	1.9	0.4	0.1	5
- Fishing vessels	1.5	0.1	0.0	0.7	33.0	-	0.8	6.7	0.2	0.1	3
- Mobile oil rigs, etc.	0.3	0.1	0.0	0.1	5.7	-	0.4	0.3	0.0	0.0	1

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

Table C7. **Emissions to air[1] by county, 1995. 1 000 tonnes unless otherwise specified**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particulates	Pb	Cd
	Mtonnes									Tonnes	kg
Total	38.2	492.1	17.5	34.8	218.6	25.8	370.6	748.6	25.7	15.5	636
Of this, national emission figures	38.1	492.1	17.5	34.1	216.6	25.8	370.6	748.5	25.7	15.5	636
Of this, international maritime and air transport[2]	0.1	0.0	0.0	0.7	2.0	0.0	0.1	0.1	0.0	0.0	0
Østfold	1.5	38.2	0.9	4.5	6.5	2.0	9.4	36.2	1.2	2.2	17
Akershus	1.5	31.8	1.0	0.6	9.8	1.6	14.7	74.1	1.8	1.3	14
Oslo	1.1	3.6	0.2	0.6	6.8	0.1	14.9	54.1	1.6	1.5	15
Hedmark	0.8	31.9	1.0	0.4	6.0	2.3	7.1	43.6	2.0	0.6	23
Oppland	0.7	31.0	1.0	0.3	5.3	2.0	6.2	36.3	1.5	0.6	15
Buskerud	1.0	36.0	0.7	0.9	6.6	1.0	8.3	42.4	1.5	0.8	23
Vestfold	1.1	20.5	0.5	1.5	5.6	1.0	8.7	32.5	1.0	0.6	17
Telemark	3.2	18.5	3.8	1.3	7.8	0.8	6.7	37.4	1.0	0.5	42
Aust-Agder	0.5	14.2	0.2	3.7	2.4	0.3	4.1	58.6	1.3	0.3	11
Vest-Agder	1.0	16.7	0.3	1.9	4.0	0.5	5.7	27.8	1.1	0.5	19
Rogaland	2.7	50.1	1.3	1.4	9.0	2.9	16.5	53.3	1.8	0.9	52
Hordaland	3.0	41.5	0.7	2.5	9.3	1.2	50.7	54.3	2.1	0.9	219
Sogn og Fjordane	1.1	15.3	0.5	1.4	4.1	1.1	3.5	18.1	0.8	0.3	16
Møre og Romsdal	1.0	21.7	0.7	0.7	5.6	1.3	7.1	31.7	1.2	0.7	55
Sør-Trøndelag	1.2	19.3	0.8	3.4	6.4	1.6	8.1	38.1	1.2	0.7	20
Nord-Trøndelag	0.5	23.1	0.9	0.7	3.9	1.8	4.2	24.6	1.1	0.3	9
Nordland	2.3	27.4	2.4	4.6	9.2	1.4	6.9	32.5	1.2	0.7	42
Troms	0.7	11.8	0.3	1.2	3.8	0.9	4.2	21.0	0.8	0.3	8
Finnmark	0.3	8.5	0.2	0.4	2.2	2.1	2.6	12.1	0.5	0.2	4
Svalbard	0.1	4.1	0.0	0.5	0.2	0.0	0.1	0.3	0.1	0.0	9
Continental shelf	11.2	26.6	0.1	2.1	92.1	0.0	179.7	12.9	0.7	0.2	7
Air space[3]	1.4	0.0	0.0	0.2	4.3	0.0	1.1	5.9	0.2	1.5	0
Open sea[4]	0.3	0.0	0.0	0.2	7.5	0.0	0.2	0.8	0.1	0.0	1

[1] Process emissions calculated for road dust only.
[2] Includes emissions from international maritime transport in Norwegian ports and from foreign aircraft below 100 m.
[3] Includes emissions from Norwegian aircraft more than 100 m above Norwegian territory.
[4] Includes emissions from Norwegian fishing vessels outside the Norwegian Economic Zone.
Sources: Statistics Norway and Norwegian Pollution Control Authority.

Table C8. **Emissions to air by municipality. 1995. Tonnes, CO_2 in 1 000 tonnes**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Total	38 232	34 816	218 590	370 643
Of this, national emissions	38 123	34 101	216 575	370 565
Of this, international maritime and air transport[1]	109	715	2015	78
Østfold	1 452	4 544	6 460	9 356
Halden	118	291	504	669
Moss	166	316	773	747
Sarpsborg	535	2 627	1 688	1 637
Fredrikstad	332	1 219	1 475	3 424
Hvaler	14	3	87	361
Aremark	6	2	48	48
Marker	16	4	118	134
Rømskog	2	1	13	15
Trøgstad	17	5	120	142
Spydeberg	17	8	133	155
Askim	39	9	193	311
Eidsberg	40	11	282	450
Skiptvet	9	2	61	73
Rakkestad	28	9	187	213
Råde	35	9	270	310
Rygge	46	18	272	426
Våler	14	4	98	113
Hobøl	18	5	138	129
Akershus	1 511	583	9 835	14 743
Vestby	52	14	407	487
Ski	66	18	429	820
Ås	68	18	515	560
Frogn	34	10	226	443
Nesodden	26	8	158	473
Oppegård	44	13	285	474
Bærum	312	82	1792	3621
Asker	150	42	982	1443
Aurskog-Høland	43	12	312	423
Sørum	57	15	427	451
Fet	30	8	211	262
Rælingen	57	103	347	219
Enebakk	16	5	111	154
Lørenskog	59	18	365	771
Skedsmo	154	119	887	1116
Nittedal	49	16	293	459
Gjerdrum	10	3	70	101
Ullensaker	116	29	808	1016
Nes	53	16	375	466
Eidsvoll	84	25	613	701
Nannestad	21	6	144	193
Hurdal	10	3	76	92

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Oslo	1 123	589	6 797	14 948
Hedmark	815	352	6 004	7 115
Kongsvinger	65	27	463	572
Hamar	72	28	429	648
Ringsaker	137	61	901	1181
Løten	31	11	237	249
Stange	92	31	680	717
Nord-Odal	15	6	115	186
Sør-Odal	42	14	290	348
Eidskog	24	22	214	286
Grue	24	9	186	223
Åsnes	31	11	241	285
Våler	20	7	141	167
Elverum	67	23	471	615
Trysil	34	26	292	370
Åmot	27	28	185	228
Stor-Elvdal	34	11	306	231
Rendalen	17	6	150	125
Engerdal	9	7	83	103
Tolga	9	3	74	71
Tynset	31	10	255	234
Alvdal	17	6	154	119
Folldal	8	3	66	79
Os	8	3	70	78
Oppland	719	271	5 259	6 158
Lillehammer	70	28	461	636
Gjøvik	102	38	655	927
Dovre	23	7	195	167
Lesja	17	6	155	118
Skjåk	14	4	114	108
Lom	12	4	93	111
Vågå	18	5	141	151
Nord-Fron	27	9	201	212
Sel	34	10	245	281
Sør-Fron	15	5	121	119
Ringebu	26	8	208	192
Øyer	30	9	235	236
Gausdal	19	6	145	171
Østre Toten	45	23	301	402
Vestre Toten	47	13	287	336
Jevnaker	17	5	111	177
Lunner	28	32	271	310
Gran	44	14	324	387
Søndre Land	23	8	156	189
Nordre Land	23	7	176	216
Sør-Aurdal	15	5	127	123
Etnedal	8	2	62	70

Table C8 (cont.). **Emissions to air by municipality. 1995. Tonnes, CO_2 in 1 000 tonnes**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Nord-Aurdal	30	9	228	275
Vestre Slidre	10	4	71	65
Øystre Slidre	13	4	105	107
Vang	8	3	70	71
Buskerud	996	945	6 557	8 258
Drammen	164	58	905	1 469
Kongsberg	72	42	420	671
Ringerike	122	88	955	1 128
Hole	29	8	214	230
Flå	15	4	128	109
Nes	17	5	133	138
Gol	22	7	165	164
Hemsedal	12	4	87	104
Ål	20	20	144	176
Hol	23	7	173	183
Sigdal	16	5	119	133
Krødsherad	21	6	164	164
Modum	49	49	285	351
Øvre Eiker	87	94	517	477
Nedre Eiker	46	16	265	863
Lier	127	73	742	922
Røyken	30	10	186	331
Hurum	92	442	686	360
Flesberg	13	4	106	109
Rollag	8	2	67	74
Nore og Uvdal	12	3	96	103
Vestfold	1 132	1 461	5 620	8 678
Borre	56	18	381	554
Holmestrand	82	13	267	293
Tønsberg	431	898	1 450	2 897
Sandefjord	115	65	707	1 070
Larvik	171	210	1 151	1 363
Svelvik	44	5	99	141
Sande	70	201	454	448
Hof	13	4	85	96
Våle	30	14	243	275
Ramnes	10	3	77	99
Andebu	12	3	87	120
Stokke	37	11	262	312
Nøtterøy	36	10	197	628
Tjøme	12	3	69	291
Lardal	12	3	89	91
Telemark	3 244	1 256	7 829	6 658
Porsgrunn	2 329	754	4 344	1 118
Skien	152	342	719	1 097
Notodden	44	12	303	422

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Siljan	6	2	43	60
Bamble	502	18	928	1674
Kragerø	44	47	264	709
Drangedal	13	4	100	128
Nome	27	39	152	195
Bø	13	4	90	165
Sauherad	16	4	118	145
Tinn	19	6	139	209
Hjartdal	8	2	65	82
Seljord	14	4	106	125
Kviteseid	12	3	93	111
Nissedal	7	2	57	61
Fyresdal	5	2	40	56
Tokke	12	3	100	110
Vinje	21	7	168	192
Aust-Agder	541	3 694	2 409	4 056
Risør	27	20	162	304
Grimstad	52	19	363	673
Arendal	222	2 368	671	1 263
Gjerstad	12	4	90	112
Vegårshei	6	2	48	72
Tvedestrand	23	8	175	308
Froland	15	6	127	159
Lillesand	113	1 243	273	454
Birkenes	25	6	131	180
Åmli	10	3	80	108
Iveland	3	1	23	39
Evje og Hornnes	13	6	100	133
Bygland	9	3	70	94
Valle	8	2	61	103
Bykle	5	2	36	55
Vest-Agder	961	1 904	3 979	5 658
Kristiansand	344	1 256	1 714	2 320
Mandal	39	14	278	473
Farsund	146	253	323	378
Flekkefjord	30	10	208	349
Vennesla	98	317	346	303
Songdalen	17	5	122	175
Søgne	24	7	170	331
Marnardal	8	3	67	76
Åseral	5	2	45	37
Audnedal	5	2	44	61
Lindesnes	21	7	139	389
Lyngdal	28	15	188	289
Hægebostad	6	2	49	76
Kvinesdal	180	8	209	311
Sirdal	10	3	77	90

Table C8 (cont.). **Emissions to air by municipality. 1995. Tonnes, CO_2 in 1 000 tonnes**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Rogaland	2 652	1 355	9 001	16 525
Eigersund	94	130	523	425
Sandnes	129	41	902	1 424
Stavanger	235	247	1 881	2 838
Haugesund	61	21	404	712
Sokndal	38	52	235	139
Lund	17	5	141	150
Bjerkreim	17	5	127	144
Hå	49	14	318	438
Klepp	48	17	300	406
Time	39	11	226	350
Gjesdal	26	8	200	266
Sola	280	372	790	4 083
Randaberg	15	5	107	175
Forsand	8	3	89	52
Strand	24	11	170	232
Hjelmeland	16	6	159	126
Suldal	18	7	171	161
Sauda	291	13	62	261
Finnøy	16	7	110	114
Rennesøy	19	7	170	141
Kvitsøy	1	1	12	29
Bokn	7	3	75	74
Tysvær	678	11	618	2 604
Karmøy	501	352	1 020	955
Utsira	1	0	6	21
Vindafjord	24	7	185	205
Hordaland	2 990	2 464	9 330	50 691
Bergen	461	200	2 870	6 544
Etne	16	6	135	134
Ølen	10	3	68	109
Sveio	15	5	131	170
Bømlo	18	8	146	265
Stord	26	14	221	319
Fitjar	11	4	90	140
Tysnes	8	4	77	135
Kvinnherad	208	278	357	415
Jondal	2	1	26	41
Odda	377	145	415	240
Ullensvang	14	6	131	135
Eidfjord	8	3	77	59
Ulvik	5	2	46	45
Granvin	8	3	81	58
Voss	43	15	318	412
Kvam	205	868	550	408
Fusa	10	4	88	132
Samnanger	10	3	75	91
Os	28	11	217	339
Austevoll	11	5	106	187

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Sund	10	4	76	135
Fjell	35	11	245	431
Askøy	60	105	316	387
Vaksdal	18	6	134	153
Modalen	1	1	12	10
Osterøy	17	7	135	178
Meland	10	3	69	138
Øygarden	69	2	52	20 646
Radøy	11	4	75	225
Lindås	1 249	726	1 839	17 810
Austrheim	7	3	62	85
Fedje	2	1	12	26
Masfjorden	8	3	82	91
Sogn og Fjordane	1 076	1 418	4 138	3 530
Flora	38	36	335	355
Gulen	13	6	128	88
Solund	3	2	44	39
Hyllestad	5	2	47	68
Høyanger	106	136	169	131
Vik	9	4	86	78
Balestrand	11	5	96	74
Leikanger	8	4	77	70
Sogndal	25	8	186	235
Aurland	10	3	84	78
Lærdal	13	5	114	96
Årdal	377	314	321	124
Luster	13	5	104	134
Askvoll	8	4	77	94
Fjaler	7	3	67	69
Gaular	12	4	100	93
Jølster	15	5	122	121
Førde	30	11	187	372
Naustdal	8	3	60	73
Bremanger	238	775	812	234
Vågsøy	49	56	317	179
Selje	8	3	68	98
Eid	18	7	153	162
Hornindal	4	1	31	38
Gloppen	19	7	148	184
Stryn	27	9	202	242
Møre og Romsdal	979	663	5 581	7 111
Molde	48	18	348	566
Kristiansund	30	12	195	526
Ålesund	112	65	769	1 227
Vanylven	20	22	164	116
Sande	8	3	84	87
Herøy	39	82	207	215
Ulstein	13	4	98	189

Table C8 (cont.). **Emissions to air by municipality. 1995. 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			
Hareid	10	4	88	112	Holtålen	9	3	78	79
Volda	18	8	160	173	Midtre Gauldal	28	9	247	233
Ørsta	29	13	256	299	Melhus	49	15	404	430
Ørskog	9	3	75	75	Skaun	20	8	162	176
Norddal	9	4	92	70	Klæbu	7	2	50	82
Stranda	15	6	120	131	Malvik	36	10	290	405
Stordal	4	1	27	56	Selbu	12	4	91	131
Sykkylven	16	6	132	197	Tydal	3	1	28	34
Skodje	16	4	116	140					
Sula	19	13	157	162	**Nord-Trøndelag**	538	744	3 926	4 240
Giske	12	4	84	132	Steinkjer	71	25	550	638
Haram	20	8	178	240	Namsos	30	14	189	324
Vestnes	23	8	177	233	Meråker	46	475	253	123
Rauma	33	11	289	266	Stjørdal	88	60	555	647
Nesset	12	4	100	110	Frosta	6	3	47	63
Midsund	6	3	58	66	Leksvik	9	3	77	115
Sandøy	3	2	30	43	Levanger	69	47	506	538
Aukra	7	3	66	76	Verdal	48	16	335	429
Fræna	29	9	205	239	Mosvik	3	1	22	33
Eide	11	4	97	108	Verran	10	4	64	74
Averøy	15	6	124	141	Namdalseid	9	3	74	82
Frei	11	3	78	106	Inderøy	36	54	266	163
Gjemnes	10	3	85	93	Snåsa	15	5	141	103
Tingvoll	12	4	105	113	Lierne	7	2	61	64
Sunndal	306	304	348	228	Røyrvik	4	1	20	22
Surnadal	19	7	153	194	Namsskogan	11	4	117	69
Rindal	7	2	52	64	Grong	19	6	173	134
Aure	9	4	90	103	Høylandet	8	2	64	72
Halsa	7	3	73	68	Overhalla	14	4	100	116
Tustna	4	2	40	43	Fosnes	3	1	31	33
Smøla	7	2	61	107	Flatanger	4	1	31	43
					Vikna	10	4	78	117
Sør-Trøndelag	1 218	3 425	6 437	8 063	Nærøy	18	7	150	194
Trondheim	368	779	1 845	4 076	Leka	2	1	24	43
Hemne	213	1 040	706	233					
Snillfjord	8	3	78	66	**Nordland**	2 280	4 628	9 173	6 945
Hitra	12	4	108	126	Bodø	95	47	559	883
Frøya	12	5	97	129	Narvik	47	26	334	486
Ørland	14	5	89	120	Bindal	7	3	70	63
Agdenes	7	3	64	62	Sømna	7	3	58	56
Rissa	25	8	220	221	Brønnøy	21	8	156	191
Bjugn	18	18	133	127	Vega	4	2	32	55
Åfjord	12	4	103	111	Vevelstad	3	2	43	17
Roan	3	1	29	35	Herøy	5	2	37	46
Osen	4	1	34	34	Alstahaug	17	7	124	144
Oppdal	31	10	260	242	Leirfjord	8	3	67	67
Rennebu	23	7	193	154	Vefsn	262	297	432	367
Meldal	13	4	94	116	Grane	18	6	171	99
Orkdal	273	1 477	890	451	Hattfjelldal	6	5	50	68
Røros	19	6	141	189	Dønna	5	2	41	50

Table C8 (cont.). **Emissions to air by municipality. 1995. Tonnes, CO_2 in 1 000 tonnes**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Nesna	5	3	59	38
Hemnes	18	7	157	155
Rana	650	1 871	1 515	1 021
Lurøy	6	3	54	54
Træna	1	1	11	18
Rødøy	5	2	52	58
Meløy	20	16	440	146
Gildeskål	10	4	84	91
Beiarn	3	1	29	32
Saltdal	22	8	199	169
Fauske	31	11	235	321
Skjerstad	4	2	40	42
Sørfold	370	1 839	1 041	321
Steigen	9	4	72	93
Hamarøy	14	5	118	101
Tysfjord	413	363	1 427	78
Lødingen	10	4	85	73
Tjeldsund	7	2	56	65
Evenes	12	3	80	89
Ballangen	14	8	121	95
Røst	2	1	15	17
Værøy	2	1	14	19
Flakstad	4	1	33	33
Vestvågøy	28	10	195	253
Vågan	24	10	178	180
Hadsel	22	9	178	188
Bø	9	3	71	76
Øksnes	12	5	81	88
Sortland	27	10	198	249
Andøy	20	7	139	164
Moskenes	3	1	22	29
Troms	663	1 184	3 844	4 230
Harstad	51	22	336	491
Tromsø	128	65	844	1 228
Kvæfjord	11	5	94	87
Skånland	13	5	98	105
Bjarkøy	2	1	27	14
Ibestad	5	3	48	41
Gratangen	6	3	50	44
Lavangen	5	2	37	37
Bardu	20	7	132	179
Salangen	7	3	54	72
Målselv	38	15	233	341
Sørreisa	13	5	71	119
Dyrøy	4	2	36	35
Tranøy	6	3	49	54

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes			
Torsken	2	1	19	18
Berg	5	2	33	28
Lenvik	249	999	935	430
Balsfjord	31	11	228	251
Karlsøy	8	4	66	90
Lyngen	10	5	70	77
Storfjord	11	4	82	100
Kåfjord	10	4	79	96
Skjervøy	6	3	47	59
Nordreisa	17	7	126	171
Kvænangen	6	3	49	64
Finnmark	311	376	2 249	2 604
Vardø	7	7	52	59
Vadsø	19	11	162	173
Hammerfest	21	22	130	195
Guovdageaidnu-Kautokeino	18	7	168	171
Alta	66	28	480	651
Loppa	3	2	30	32
Hasvik	3	2	21	27
Kvalsund	11	4	82	78
Måsøy	4	2	29	43
Nordkapp	12	8	105	88
Porsanger	22	8	152	213
Karasjohka-Karasjok	13	5	104	118
Lebesby	5	2	38	53
Gamvik	4	2	29	43
Berlevåg	4	2	27	35
Deatnu - Tana	17	7	130	157
Unjarga - Nesseby	8	3	64	64
Båtsfjord	8	10	74	55
Sør-Varanger	67	244	374	352
Other regions	13 030	2959	104 162	181 076
Spitsbergen	99	482	218	103
Bjørnøya	0	0	0	0
Hopen	0	0	0	0
Jan Mayen	0	0	0	0
Continental shelf south of 62° N	9 263	1 071	57 668	171 232
Continental shelf north of 62° N	1 908	1 024	34 470	8 492
Air space above 100 m[2]	1 426	208	4 333	1 091
Fishing in distant waters[3]	333	174	7 474	158

[1] Includes emissions from international maritime transport in Norwegian ports and from foreign aircraft below 100 m.
[2] Includes emissions from Norwegian aircraft more than 100 m above Norwegian territory. [3] Includes emissions from Norwegian fishing vessels outside the Norwegian Economic Zone.
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	1995	Per unit GDP (kg/1000 USD)[2] 1995	Per capita (tonnes per capita) 1995
Whole world	14 640	18 362	19 060	21 023	21 085	21 713	..	3.8
OECD	8 848	10 975	10 664	11 244	11352	11 780	649	10.9
Norway	28	31	29	31	32	34	373	7.8
Denmark	64	63	63	53	57	61	623	11.7
Finland	41	59	52	54	50	54	668	10.6
Sweden	98	73	62	53	52	56	374	6.3
France	443	486	386	378	374	362	333	6.2
Italy	307	376	362	409	416	424	417	7.4
Netherlands	161	159	150	161	168	179	665	11.6
Portugal	16	26	27	42	47	51	486	5.1
United Kingdom	662	594	568	584	584	565	578	9.6
Switzerland	39	42	42	44	45	42	284	5.9
Germany	1 018	1 084	1 033	982	911	884	614	10.8
Canada	342	435	405	431	438	471	822	15.9
USA	4 267	4 778	4 633	4 908	4 961	5 229	797	19.9
Japan	781	917	910	1 065	1 097	1 151	471	9.2

[1] The figures for Norway according to these data from the OECD differ somewhat from more recent Norwegian calculations of emissions. [2] GDP 1995 expressed in 1991 prices.
Source: OECD (1997).

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

	1980	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996*	Percentage change 1980-1996
Emissions from													
Norway	16.7	14.2	14.2	14.2	14.8	14.6	15.0	15.8	14.2	14.5	11.3	11.9	-29
Sweden	1.5	1.4	1.6	1.5	0.9	1.1	1.1	1.0	1.3	1.4	1.3	1.4	-7
Finland	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	-67
Denmark	3.0	2.3	2.5	2.7	2.2	2.7	2.1	2.4	2.1	2.8	2.6	1.8	-40
Netherlands	1.7	2.2	1.2	2.3	1.7	2.4	1.9	1.5	1.0	1.3	0.9	0.9	-47
United Kingdom	3.4	3.1	2.6	3.3	4.5	4.4	3.3	3.3	2.0	2.4	2.7	1.6	-53
Germany	4.8	5.0	3.7	6.1	4.8	3.3	4.0	3.7	2.8	5.0	3.7	2.8	-42
France	1.0	1.9	0.8	1.6	1.7	2.3	1.2	1.2	1.0	1.2	1.8	0.9	-10
Belgium	0.4	0.6	0.3	0.7	0.6	0.8	0.5	0.5	0.4	0.4	0.4	0.3	-25
CIS	0.9	2.2	1.9	2.0	0.9	1.2	1.4	0.6	1.9	1.6	1.3	1.4	56
Poland	2.1	2.0	1.7	2.8	1.7	1.5	2.5	1.0	1.2	1.9	1.6	1.2	-43
Czech Republic, Slovakia	0.4	0.4	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.5	0.4	0.3	-25
Other countries	1.3	1.9	1.5	1.1	1.9	3.1	1.5	1.5	1.1	1.0	1.4	0.8	-38
Unspecified	11.5	10.5	9.3	9.2	12.9	13.5	10.7	11.3	8.1	8.6	12.1	11.5	0
TOTAL	48.9	48.0	42.0	48.1	49.1	51.4	45.7	44.3	37.6	42.8	41.7	36.9	-25

Source: Berge (1997).

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

	1980	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996*	Percentage change 1980-1996
Emissions from													
Norway	5.3	6.9	8.1	7.6	6.8	6.3	7.3	6.9	6.9	6.5	7.5	9.1	72
Sweden	4.3	4.9	5.7	5.0	3.3	3.6	3.6	3.2	4.3	4.0	3.4	4.1	-5
Finland	1.0	1.4	1.4	1.0	0.9	1.1	0.9	0.8	1.2	1.0	0.9	0.8	-20
Denmark	2.8	2.4	3.6	3.3	2.8	2.9	3.1	2.7	2.3	3.0	2.5	2.2	-21
Netherlands	3.1	2.5	2.4	4.4	3.2	4.3	3.4	3.2	2.2	2.4	2.1	2.0	-35
United Kingdom	15.3	13.7	14.1	18.5	24.6	24.8	19.9	19.6	11.7	13.0	13.3	9.3	-39
Germany	11.9	9.6	8.8	13.3	10.4	9.5	9.4	7.6	6.4	8.1	6.7	5.6	-53
France	2.7	2.1	1.9	3.0	3.4	4.5	2.1	2.4	1.6	2.0	3.2	1.7	-37
Belgium	1.6	1.2	0.8	1.8	1.6	1.9	1.4	1.3	0.9	0.9	0.9	0.8	-50
CIS	1.5	2.6	2.4	2.5	1.1	1.8	1.5	0.8	1.8	1.4	1.1	2.0	33
Poland	2.9	2.7	2.9	3.7	2.0	2.0	3.2	1.7	2.1	2.5	2.4	2.3	-21
Czech Republic, Slovakia	1.8	1.4	1.4	1.7	1.2	1.4	1.9	1.5	1.2	1.1	0.9	0.8	-56
Ocean	2.4	7.2	6.4	8.5	8.8	10.2	7.6	8.2	5.6	6.6	7.4	5.1	113
Other countries	1.4	1.3	2.1	1.0	2.0	2.6	1.8	1.9	1.3	1.6	2.3	1.1	-21
Unspecified	14.9	16.6	15.4	14.8	18.8	20.1	16.2	15.9	13.0	13.7	15.6	12.4	-17
TOTAL	72.7	76.5	77.4	90.1	90.9	97.0	83.3	77.7	62.5	67.8	70.2	59.3	-18

Source: Berge (1997).

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

	1980	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996*	Percentage change 1980-1996
Emissions from													
Norway	13.2	9.0	7.2	6.6	5.8	5.1	4.5	3.7	3.0	3.0	3.4	3.2	-76
Sweden	8.3	5.2	5.1	4.2	2.2	1.9	1.7	1.4	1.9	1.7	1.5	1.8	-78
Finland	2.5	2.3	1.9	1.2	0.8	1.0	0.7	0.5	0.6	0.5	0.4	0.3	-88
Denmark	5.9	3.3	3.9	3.5	2.6	2.6	3.1	2.3	1.8	2.4	2.0	1.5	-75
Netherlands	2.4	1.2	0.9	1.7	1.0	1.3	1.0	0.8	0.5	0.6	0.5	0.4	-83
United Kingdom	33.4	23.8	22.5	28.3	35.4	36.2	25.6	23.7	14.4	13.7	14.3	8.1	-76
Germany	27.0	25.1	21.7	28.6	19.6	16.9	15.7	9.9	9.6	14.4	9.5	8.3	-69
France	5.4	2.4	1.6	2.4	2.7	3.3	1.8	1.9	1.3	1.5	2.0	1.2	-78
Belgium	3.1	1.7	0.9	1.9	1.4	1.6	1.2	1.1	0.7	0.8	0.8	0.6	-81
CIS	16.5	20.6	18.8	14.5	10.3	10.7	11.2	7.5	8.5	6.2	7.3	7.0	-58
Poland	8.4	7.9	8.2	11.2	6.7	5.5	7.3	4.1	5.4	6.6	5.6	3.5	-58
Czech Republic, Slovakia	5.6	4.5	4.8	5.5	3.3	4.2	4.3	3.3	2.9	4.0	2.7	2.2	-61
Ocean	2.6	6.3	5.7	6.9	7.1	7.7	5.9	6.4	4.7	5.6	6.1	3.3	27
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	1.8	-44
Other countries	4.4	3.6	3.5	1.7	3.5	4.3	2.5	2.8	2.3	2.8	3.0	2.2	-50
Unspecified	35.8	36.6	33.4	34.0	42.9	44.2	37.2	39.0	29.7	30.4	36.0	35.4	-1
TOTAL	177.6	156.7	142.9	155.0	149.1	150.2	126.8	111.6	89.5	96.7	98.2	80.8	-55

[1] Emissions from natural sources in oceans.
Source: Berge (1997).

Appendix D

Waste

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	2 222 781	2 722 158	22	1 088 379	1 261 982	16	1 134 403	1 460 176	29
Østfold	142 671	157 118	10	72 232	70 679	-2	70 439	86 439	23
Akershus	174 886	204 447	17	101 733	129 772	28	73 154	74 675	2
Oslo	293 509	429 862	46	110 844	130 778	18	182 665	299 084	64
Hedmark	80 911	103 173	28	48 371	57 873	20	32 541	45 300	39
Oppland	97 428	100 988	4	48 944	48 625	-1	48 485	52 363	8
Buskerud	118 670	141 094	19	55 767	67 566	21	62 904	73 529	17
Vestfold	114 408	137 844	20	54 684	64 363	18	59 724	73 481	23
Telemark	76 230	96 584	27	43 464	51 839	19	32 766	44 745	37
Aust-Agder	45 549	55 437	22	23 306	33 022	42	22 243	22 415	1
Vest-Agder	94 290	99 390	5	40 779	45 289	11	53 512	54 101	1
Rogaland	194 859	221 107	13	93 000	111 259	20	101 859	109 849	8
Hordaland	237 517	334 160	41	108 732	130 432	20	128 786	203 729	58
Sogn og Fjordane	54 956	54 769	0	25 379	30 766	21	29 577	24 003	-19
Møre og Romsdal	107 437	123 830	15	58 824	64 513	10	48 613	59 317	22
Sør-Trøndelag	122 684	150 728	23	59 798	71 654	20	62 886	79 074	26
Nord-Trøndelag	47 400	61 465	30	25 948	32 386	25	21 452	29 080	36
Nordland	114 234	127 886	12	61 400	61 695	0	52 835	66 191	25
Troms	70 090	83 281	19	37 960	37 866	0	32 131	45 416	41
Finnmark	35 052	38 994	11	17 218	21 605	25	17 835	17 389	-3

Source: Statistics Norway.

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

	Total			Household waste			Industrial waste		
	1992	1995	Change (%)	1992	1995	Change (%)	1992	1995	Change (%)
Whole country	185 542	372 512	101	92 864	228 698	146	92 678	143 814	55
Østfold	8 302	31 988	285	6 061	14 206	134	2 241	17 782	693
Akershus	17 100	36 070	111	15 102	33 282	120	1 998	2 788	40
Oslo	17 726	52 223	195	12 207	26 278	115	5 519	25 945	370
Hedmark	4 753	15 701	230	1 974	9 611	387	2 779	6 091	119
Oppland	9 118	22 206	144	4 136	14 511	251	4 982	7 695	54
Buskerud	11 233	15 724	40	7 446	13 480	81	3 787	2 244	- 41
Vestfold	25 129	29 771	18	12 495	15 317	23	12 634	14 454	14
Telemark	4 170	16 207	289	3 595	10 759	199	575	5 448	847
Aust-Agder	5 174	6 462	25	3 753	4 832	29	1 421	1 629	15
Vest-Agder	17 821	18 258	2	4 500	12 156	170	13 321	6 102	- 54
Rogaland	12 375	26 190	112	9 344	19 187	105	3 031	7 004	131
Hordaland	25 719	41 423	61	3 998	19 093	378	21 721	22 330	3
Sogn og Fjordane	1 603	4 255	165	890	3 277	268	714	978	37
Møre og Romsdal	13 530	14 876	10	3 120	10 542	238	10 410	4 335	- 58
Sør-Trøndelag	3 265	12 158	272	1 960	8 933	356	1 306	3 224	147
Nord-Trøndelag	5 868	10 333	76	1 585	5 728	262	4 283	4 605	8
Nordland	1 199	7 928	561	614	3 567	481	585	4 361	645
Troms	1 439	9 390	553	67	3 459	5 102	1 372	5 930	332
Finnmark	18	1 348	7 389	18	478	2 556	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	1 776 615	1 033 514	58.2	20 777	1.2
Østfold	98 712	66 045	66.9	829	0.8
Akershus	159 764	127 321	79.7	453	0.3
Oslo	244 000	210 000	86.1	0	0.0
Hedmark	70 930	22 223	31.3	82	0.1
Oppland	77 219	54 945	71.2	1 135	1.5
Buskerud	94 479	70 328	74.4	335	0.4
Vestfold	85 492	72 200	84.5	85	0.1
Telemark	70 538	42 643	60.5	267	0.4
Aust-Agder	39 117	31 311	80.0	426	1.1
Vest-Agder	57 938	35 274	60.9	2 296	4.0
Rogaland	135 636	87 633	64.6	1 055	0.8
Hordaland	174 166	57 741	33.2	6 532	3.8
Sogn og Fjordane	40 175	20 375	50.7	1 953	4.9
Møre og Romsdal	86 665	69 082	79.7	2 529	2.9
Sør-Trøndelag	108 419	15 071	13.9	940	0.9
Nord-Trøndelag	49 898	21 360	42.8	603	1.2
Nordland	96 272	8 877	9.2	767	0.8
Troms	58 362	17 092	29.3	420	0.7
Finnmark	28 833	3 993	13.8	70	0.2

Source: Statistics Norway.

Table D4. **Municipal waste delivered for material recovery, by material. Tonnes**

Material	1992 Total	1992 Household waste	1992 Industrial waste	1995 Total	1995 Household waste	1995 Industrial waste	1996 Total	1996 Household waste	1996 Industrial waste
Total	185 542	92 864	92 678	372 513	228 699	143 814	548 800	279 800	269 000
Paper and cardboard, total	90 703	60 860	29 843	169 608	131 356	38 252	194 900	139 400	55 600
Paper	75 340	58 902	16 439	71 717	61 801	9 916	97 500	97 200	300
Cardboard	15 363	1 959	13 404	24 720	5 548	19 172	52 100	14 000	38 100
Drinking cartons	..	..	..	816	816	0	2 300	2 300	-
Paper and cardboard, mixed	..	..	..	72 355	63 191	9 164	43 000	25 800	17 200
Glass	14 613	11 682	2 931	17 968	16 035	1 933	19 900	18 600	1 300
Plastic	1 055	154	901	1 786	969	817	1 800	900	900
Iron and other metal	36 711	7 143	29 568	47 292	19 470	27 822	63 800	23 600	40 200
Food and biol. waste, total	9 280	1 170	8 110	34 399	18 120	16 728	46 900	29 200	17 700
Food, slaughterhouse waste and fish waste to animal feed	..	..	..	17 014	3 353	13 661	19 800	7 000	12 900
Food and biol. waste to central composting facilities	..	..	..	17 834	14 767	3 067	27 100	22 300	4 800
Wood waste (incl. park and garden waste)	5 374	603	4 771	77 970	36 377	41 573	94 800	53 800	41 000
Textiles	1 214	1 206	8	4 101	3 996	105	7 300	7 300	-
Other	26 592	10 045	16 547	18 934	2 374	16 560	92 400	7 000	85 400

Source: Statistics Norway.

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

Material	Sorting at source			Sorting at waste treatment and disposal plants/ recycling centres
	Total	Sorting and collection at source	Sorting on delivery	
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 metal (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]. Whole country. 1978/79, 1985/86, 1992 og 1995**

	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	22.0
1992	9.1	2.6	11.2	27.6
1995	12.1	3.4	6.0	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, by county. 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. 1990-1997*. Tonnes**

Category of hazardous waste	1990	1991	1992	1993	1994	1995	1996	1997*
Total	59 643	65 629	87 542	98 369	92 211	101 756	118 810	128 360
Waste oil	31 203	29 921	32 896	34 261	39 115	41 637	41 162	42 750
Other oil-contaminated waste	17 512	8 259	9 625	10 967	12 808	16 676	16 235	18 232
Stable oil emulsions	4 003	2 095	1 747	2 051	2 813	2 002	2 480	6 358
Waste solvent	1 530	2 379	2 485	3 022	4 884	4 319	3 989	3 893
Paints, glue, varnish and printing ink	2 047	2 308	2 849	2 820	2 782	3 580	4 060	3 996
Distillation residues	141	259	287	389	668	207	69	15
Tars	1	31	0	17	220	253	673	362
Waste containing mercury (Hg) or cadmium (Cd)	881	1 099	950	1 244	1 371	346	93	205
High priority metals or metal compounds that constitute a health or environmental hazard	-	-	-	-	19	1 883	3 262	3 637
Waste containing cyanide	6	19	8	33	22	13	14	18
Pesticides	16	16	12	45	52	72	87	44
Isocyanates and other very reactive substances	8	4	14	22	37	55	63	52
Corrosive substances and products	1 439	1 343	1 264	2 473	1 896	2 554	4 084	4 308
Waste brought ashore from oil-drilling/production	-	16 590	33 592	36 673	19 867	21 296	35 244	38 237
Other very toxic or environmentally hazardous substances	808	948	1 240	2 739	1 978	2 865	2 464	2 267
Waste containing PCBs	16	16	13	27	911	123	287	87
Photographic chemicals	8	312	527	1 554	2 682	3 838	4 488	3 510
Halons	-	-	-	-	-	3	2	130
CFCs	-	-	-	-	-	0	46	14
Asbestos	..	..	..	..	..	..	..	181
Other unspecified waste	24	30	33	32	86	34	7	64

Source: Norsas.

Table D9. **Hazardous waste delivered to the system for hazardous waste management, by county. 1991-1997*. Tonnes**

	1991[1]	1992[1]	1993[1]	1994[1]	1995	1996	1997*
Total	49 091	53 890	61 707	72 091	101 766	118 740	128 360
Østfold	1 990	2 226	3 100	5 993	5 998	6 133	5 955
Akershus	3 361	4 080	4 623	4 957	4 845	4 810	5 039
Oslo	3 261	2 987	3 744	5 597	5 532	6 938	8 806
Hedmark	1 010	1 155	1 230	1 534	1 401	2 101	1 836
Oppland	1 478	1 149	1 740	2 145	2 221	2 673	2 758
Buskerud	2 906	2 534	2 787	3 581	3 890	3 681	4 276
Vestfold	2 318	3 238	3 754	4 419	4 890	4 820	4 611
Telemark	2 563	2 393	2 200	2 191	3 428	3 743	3 462
Aust-Agder	647	700	655	859	960	1 001	1 317
Vest-Agder	2 019	1 799	2 689	2 544	1 959	2 445	3 278
Rogaland	5 816	8 290	9 060	10 258	14 095	17 201	18 245
Hordaland	10 518	10 251	10 681	12 693	26 571	27 824	20 813
Sogn og Fjordane	1 383	1 822	2 901	1 989	11 639	13 086	14 560
Møre og Romsdal	2 785	3 430	4 131	4 206	4 534	11 628	22 298
Sør-Trøndelag	1 761	2 125	1 985	2 248	2 616	2 738	2 818
Nord-Trøndelag	976	1 015	1 157	1 443	1 370	1 333	1 331
Nordland	2 395	2 539	2 994	3 133	3 366	3 362	3 507
Troms	1 086	1 398	1 560	1 517	1 756	2 250	2 114
Finnmark	789	718	674	747	656	874	1 288
Svalbard and Jan Mayen	29	41	42	37	40	48	50

[1] Waste brought ashore from oil drilling/production not included.
Source: Norsas.

Table D10. **Quantities of manufacturing waste[1] generated, for selected materials and methods of treatment. 1993 and 1996**

Material	1993 Total	1993 Re-cycling and/or re-use	1993 Incinera-tion with energy recovery	1993 Other treat-ment	1996 Total	1996 Re-cycling and/or re-use	1996 Incinera-tion with energy recovery	1996 Other treat-ment
	tonnes	percentage			tonnes	percentage		
Total	2 967 435	27	30	43	2 479 290	43	19	39
Of which:								
Paper and cardboard	206 756	75	2	22	173 258	69	4	27
Plastic	34 132	15	3	83	53 798	39	6	54
Glass	55 093	80	0	20	19 223	75	0	25
Tyres	400	53	0	47	3 909	62	0	38
Rubber (except tyres)	1 228	0	0	100	1 557	0	0	100
Iron and other metal	180 123	88	0	12	253 592	93	-	7
Food, slaughterhouse waste and fish waste	446 629	81	0	19	378 686	89	4	7
Processed wood	878 676	7	81	12	790 794	33	53	14
Textiles	16 320	5	2	94	9 203	7	0	93
Slag	272 431	0	0	100	201 302	0	-	100
Sewage sludge (as tonnes dry weight)	250 177	0	9	90	154 198	0	0	100

[1] Does not include hazardous waste.
Source: Statistics Norway.

Table D11. **Quantities of manufacturing waste[1] generated, by method of treatment 1993 and by method of treatment and sector 1996. Tonnes**

Sector	Total	Material recovery and/or re-use	Incineration with energy recovery	Incineration without energy recovery	Landfilled	Sent for sorting	Biological treatment	Used for landscaping	Emptied into sewer system	Other treatment
Total 1993	2 967 435	795 005	886 986	4 398	829 247	46 028	65 659	324 704	1334	14 072
Total 1996	2 479 290	1 086 137	479 091	7 212	576 560	35 275	9 162	242 261	6771	36 820
Manufacture of:										
Food products, beverages and tobacco	525 634	413 380	21 495	2 320	64 005	6 227	5 400	987	6259	5 562
Textiles and textile products	7 877	2 197	318	1	5 073	265	13	10	0	0
Leather and leather products	2 941	178	1 938	0	764	28	33	0	0	0
Wood and wood products	623 984	238 742	342 879	593	34 696	191	257	6 427	0	200
Pulp, paper and paper products, publishing and printing	426 748	123 194	94 057	289	156 358	9 624	39	43 008	7	172
Refined petroleum products	8 263	1 380	0	0	1 847	374	0	4 663	0	0
Chemicals and chemical products	87 372	13 371	2 121	1 893	36 346	2 501	2 646	5 215	1	23 277
Rubber and plastic products	26 207	11 760	1 846	93	10 976	1 476	15	39	0	2
Mineral products	99 808	14 332	344	224	53 545	2 662	306	28 194	1	201
Metals and metal products	424 938	156 072	1 383	345	114 985	2 569	80	148 798	501	204
Machinery and equipment	51 102	38 726	814	550	8 807	1 980	150	5	1	70
Electrical and optical equipment	26 008	13 859	301	136	8 353	3 201	0	158	0	0
Transport equipment, incl. oil rigs	86 810	45 578	522	188	31 164	4 059	86	4 718	1	495
Furniture and other manufacturing	81 598	13 368	11 074	582	49 640	118	138	39	0	6 637

[1] Does not include hazardous waste.
Source: Statistics Norway.

Table D12. **Quantities of hazardous waste generated, by method of treatment 1993 and by method of treatment and category 1996. Tonnes**

Category of hazardous waste	Total	Delivered to approved facility	Treated on-site
Total 1993	320 282	235 552	84 730
Total 1996	395 434	272 533	122 901
Waste oil, lubricating oil, etc	37 931	36 304	1 627
Other oil-contaminated waste	5 354	2 824	:
Oil emulsions	4 256	4 052	:
Organic solvents containing halogens	866	854	:
Organic solvents not containing halogens	9 828	5 450	4 378
Paints, glue, varnish and printing ink	4 721	4 111	610
Distillation residues and tarry waste	2 603	1 707	:
Waste containing heavy metals	94 434	5 122	89 311
Lead accumulators	1 163	1 149	:
Waste containing cyanide	:	:	:
Pesticides	:	:	:
Isocyanates, etc	3	:	:
Other organic waste	4 201	1 682	:
Strong acids	192 744	192 384	:
Strong alkalis	2 870	736	:
Other inorganic waste	14 301	11 363	:
Waste containing PCBs	:	:	:
Photographic chemicals	1 598	1 587	11
Radioactive waste	:	:	-
Asbestos	137	137	:
Infectious waste	:	:	:
Other	18 376	3 028	15 348

Source: Statistics Norway.

Table D13. **Quantities of hazardous waste generated, by sector and treatment, 1996. Tonnes**

Sector	Total	Delivered to approved facility	Treated on-site
Total	395 434	272 533	122 901
Manufacture of:			
Food products, beverages and tobacco	4 487	2 853	1 634
Textiles and textile products	84	65	:
Leather and leather products	1 443	:	:
Wood and wood products	1 012	968	44
Pulp, paper and paper products, publishing and printing	2 892	2 814	78
Refined petroleum products	4 199	1 321	:
Chemicals and chemical products	222 351	211 048	11 303
Rubber and plastic products	1 158	669	:
Mineral products	345	191	:
Metals and metal products	145 071	40 768	104 303
Machinery and equipment	3 315	3 127	188
Electrical and optical equipment	1 941	1 746	195
Transport equipment, incl. oil rigs	6 523	6 402	121
Furniture and other manufacturing	614	558	:

Source: Statistics Norway.

Appendix E

Waste water treatment

Table E1. **Municipal waste water treatment. Hydraulic capacity (PU) and number of plants by size categories and treatment methods. 1996**

Treatment method	Total	Size by hydraulic capacity (PU)					
		50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total PU	5 388 436	28 602	220 022	388 697	882 895	1 364 720	2 503 500
Mechanical	1 366 588	12 974	127 793	172 386	379 095	450 340	224 000
Chemical	3 409 109	1 340	7 415	60 694	329 160	806 000	2 204 500
Biological	96 450	1 275	14 230	33 945	6 500	40 500	-
Chemical/biological	412 371	1 571	34 330	111 530	137 140	52 800	75 000
Unconventional	75 688	11 024	34 794	6 370	23 500	-	-
Other/unknown	28 230	418	1 460	3 772	7 500	15 080	-
Number of plants, total	2 210	435	1 047	422	217	72	17
Mechanical	1 124	201	611	187	97	26	2
Chemical	241	19	32	62	75	39	14
Biological	125	19	65	36	3	2	-
Chemical/biological	320	25	131	124	35	4	1
Unconventional	380	165	201	9	5	-	-
Other/unknown	20	6	7	4	2	1	-

Source: Statistics Norway.

Table E2. **Municipal waste water treatment plants. Hydraulic capacity (PU) by treatment method. County[1]. 1996**

County	Total	Treatment method					
		Mechanical	Chemical	Biological	Chemical/ Biological	Uncon- ventional	Other/ unknown
Whole country	5 388 436	1 366 588	3 409 109	96 450	412 371	75 688	28 230
Counties 01-10	3 496 877	171 128	2 914 788	36 810	321 846	50 571	1 734
Counties 11-20	1 891 559	1 195 460	494 321	59 640	90 525	25 117	26 496
01 Østfold	346 450	2 250	323 400	530	20 095	50	125
02 Akershus	1 132 750	-	1 120 060	250	12 005	60	375
03 Oslo	351 105	-	350 000	75	80	950	-
04 Hedmark	219 515	2 085	83 170	2 555	109 640	20 915	1 150
05 Oppland	285 092	1 485	163 444	390	101 381	18 308	84
06 Buskerud	318 981	1 643	274 294	2 060	33 380	7 604	-
07 Vestfold	253 196	42 580	195 530	-	14 880	206	-
08 Telemark	246 705	700	218 750	13 500	13 155	600	-
09 Aust-Agder	145 438	86 580	33 050	15 850	9 150	808	-
10 Vest-Agder	197 645	33 805	153 090	1 600	8 080	1 070	-
11 Rogaland	452 997	173 102	251 660	26 800	1 250	185	-
12 Hordaland	335 317	237 658	66 350	3 930	25 550	1 829	-
14 Sogn og Fjordane	78 143	68 123	181	4 250	1 750	3 769	70
15 Møre og Romsdal	184 976	155 131	20 000	800	2 840	1 055	5 150
16 Sør-Trøndelag	373 483	208 168	138 335	4 215	19 755	2 940	70
17 Nord-Trøndelag	179 765	143 720	10 120	11 530	10 595	3 800	-
18 Nordland	136 791	103 527	1 950	7 135	2 340	633	21 206
19 Troms	104 335	75 185	3 650	855	14 995	9 650	-
20 Finnmark	45 752	30 846	2 075	125	11 450	1 256	-

Source: Statistics Norway.

Table E3. **Municipal waste water treatment. Number of people connected to separate waste water treatment plants, by type of treatment. County[1]. 1996**

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	819 864	61 644	346 997	3 387	7 770	270 998	83 586	33 664	11 818
Counties 01-10	378 115	13 255	116 750	2 195	5 791	172 940	30 033	28 108	9 043
Counties 11-20	441 749	48 389	230 247	1 192	1 979	98 058	53 553	5 556	2 775
01 Østfold	29 832	1 262	17 654	156	891	1 037	2 290	6 460	82
02 Akershus	51 389	5 234	24 356	1 400	1 826	9 123	5 950	1 503	1 997
03 Oslo	1 383	-	15	-	120	30	1 218	-	-
04 Hedmark	72 938	941	13 468	-	515	45 874	5 278	6 456	406
05 Oppland	69 748	451	3 939	-	63	58 134	919	6 237	5
06 Buskerud	42 331	934	11 294	90	638	23 123	1 953	2 047	2 252
07 Vestfold	34 926	2 625	22 229	392	846	2 785	2 404	951	2 694
08 Telemark	30 172	327	9 890	74	124	12 800	5 724	671	562
09 Aust-Agder	23 856	937	7 280	29	495	11 299	2 753	510	553
10 Vest-Agder	21 540	544	6 625	54	273	8 735	1 544	3 273	492
11 Rogaland	40 351	2 142	25 905	215	376	7 487	3 441	48	737
12 Hordaland	94 105	8 393	43 238	231	1 065	22 910	16 354	1 520	394
14 Sogn og Fjordane	37 811	3 243	12 594	56	3	15 089	6 814	-	12
15 Møre og Romsdal	69 110	10 455	42 489	34	51	7 872	6 800	972	437
16 Sør-Trøndelag	49 836	3 060	23 831	199	269	12 896	7 317	2 010	254
17 Nord-Trøndelag	34 293	2 730	14 455	438	30	4 850	10 525	520	745
18 Nordland	50 963	8 186	30 182	19	180	9 602	2 152	466	176
19 Troms	49 967	7 538	33 672	-	5	8 664	48	20	20
20 Finnmark	15 313	2 642	3 881	-	-	8 688	102	-	-

[1] Permanent residents.
Source: Statistics Norway.

Table E4. **Phosphorus (P) from water waste treatment plants and scattered settlements[1]. Whole country. 1994-1996**

	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
					Percentage	
Whole country						
1994	578	388	1 415	166	71	30
1995	601	364	1 338	157	69	30
1996	563	342	1 435	141	72	29
North Sea counties						
1994	144	151	1 056	105	88	41
1995	128	133	1 036	114	89	46
1996	116	121	1 172	100	91	45
Rest of country						
1994	433	237	327	63	43	21
1995	472	231	243	43	34	16
1996	447	221	263	41	37	16

[1] Differences in calculated discharge figures for 1994-1996 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 E5. **Total sludge production and quantities used for different purposes. Whole country, 1996**

	Tonnes sludge	Percentage
Total	95 288	100
Parks etc.	8 642	9.1
Agriculture	46 508	48.8
Landfills	11 681	12.3
Temporary storage	16 719	17.5
Separate landfills	2 678	2.8
Other	9 060	9.5

Source: Statistics Norway.

Table E6. **Nutrients and organic matter in sewage sludge as percentage of dry weight. 1996**

Substance	Percentage of dry weight: Mean value per plant	Min. value	Max value	Standard deviation
Organic material	62.1	19.9	97.0	15.7
Nitrogen (Kjeldahl)	2.8	0.2	5.0	0.9
Nitrogen (NH_3-N)	0.3	0.01	1.3	0.3
Total phosphorus	1.6	0.01	10.2	1.2
Potassium	0.2	0.01	1.3	0.2
Calcium	3.4	0.01	23.3	6.1

Source: Statistics Norway.

Table E7. **Total annual costs per subscriber in current NOK. Ratio between fees and annual costs in the municipalities (income-to-cost ratio) as percentage. 1993-1996**

	Annual costs per subscriber				Income-to-cost ratio			
	1993	1994	1995	1996	1993	1994	1995	1996
Whole country	2 159	2 188	2 228	2 037	80	88	92	95
North Sea counties	2 624	2 630	2 638	2 549	76	84	91	93
Rest of country	1 553	1 650	1 706	1 469	88	96	94	99
Østfold	2 907	2 737	2 851	2 841	90	88	95	97
Akershus/Oslo	2 333	2 381	2 186	2 039	74	90	103	101
Hedmark	3 252	2 787	2 831	2 715	70	79	83	87
Oppland	3 561	3 621	3 717	3 755	66	67	68	69
Buskerud	3 125	3 245	3 432	3 240	70	76	82	85
Vestfold	1 871	2 146	2 291	2 291	92	112	98	106
Telemark	2 165	2 512	2 675	2 892	83	64	86	99
Aust-Agder	2 849	3 391	3 680	3 456	79	80	81	87
Vest-Agder	3 314	3 094	3 150	3 035	76	76	80	81
Rogaland	1 693	1 996	2 050	1 959	74	84	84	89
Hordaland	1 500	1 791	2 061	1 562	106	116	111	114
Sogn og Fjordane	1 769	1 690	1 825	1 916	83	88	82	90
Møre og Romsdal	1 643	1 654	1 617	1 564	77	84	87	95
Sør-Trøndelag	1 300	1 211	1 352	1 337	92	96	94	99
Nord-Trøndelag	2 526	2 076	2 268	2 153	82	102	91	95
Nordland	1 355	1 184	1 233	783	84	95	92	93
Troms	1 521	1 172	1 459	1 335	87	113	104	121
Finnmark	786	1 091	1 190	1 137	80	82	89	91

Source: Statistics Norway.

Table E8. **Average fees per subscriber, 1994 - 1997. NOK**

County	Connection fee				Annual fee per m³ water			
	1994	1995	1996	1997	1994	1995	1996	1997
Whole country	8 739	10 465	11 125	11 320	5.42	5.87	6.50	7.02
North Sea counties	9 726	13 195	14 158	14 260	7.61	8.43	8.96	9.71
Rest of country	8 069	8 663	9 107	9 370	3.68	4.10	4.56	5.08
Østfold	5 837	7 450	8 015	7 916	9.89	11.03	11.95	13.37
Akershus/Oslo	12 788	16 600	15 486	15 522	8.76	9.44	9.75	10.24
Hedmark	10 450	13 315	17 522	17 931	8.87	9.96	11.84	12.60
Oppland	8 557	18 151	22 274	22 891	8.07	8.48	8.99	9.45
Buskerud	8 737	11 780	10 731	11 544	7.44	8.43	8.41	9.34
Vestfold	16 216	16 618	19 379	17 942	6.06	6.83	6.81	7.66
Telemark	5 374	8 058	7 539	6 286	5.83	7.99	8.15	8.85
Aust-Agder	9 789	12 372	11 148	11 889	5.51	6.39	6.57	7.16
Vest-Agder	9 882	11 455	11 017	11 658	5.50	5.60	6.14	6.72
Rogaland	9 557	10 530	10 401	11 257	3.19	2.88	3.69	4.60
Hordaland	8 930	8 495	10 140	10 742	3.15	3.29	3.85	4.52
Sogn og Fjordane	8 124	11 556	11 735	11 841	3.50	4.08	3.99	4.86
Møre og Romsdal	8 642	8 926	9 427	9 227	3.77	3.93	4.37	4.66
Sør-Trøndelag	9 980	11 810	12 313	12 116	4.89	4.91	5.72	6.10
Nord-Trøndelag	7 340	7 588	8 230	8 917	4.87	5.52	6.05	6.67
Nordland	5 280	5 767	7 124	7 698	3.67	6.03	5.68	6.05
Troms	3 339	4 198	4 349	4 431	2.94	2.95	3.49	3.77
Finnmark	10 349	12 588	8 995	8 574	2.70	2.86	2.60	3.26

Source: Statistics Norway.

Table E9. **Gross investments in municipal waste water treatment and average investment per subscriber in 1995 and 1996**

County	1995			1996		
	Investments in NOK 1000	No. of subscribers	Investments per subscriber (NOK)	Investments in NOK 1000	No. of subscribers	Investments per subscriber (NOK)
Whole country	1 431 636	1 441 024	993	1 344 379	1 561 702	861
North Sea counties	787 383	806 621	976	697 252	821 629	849
Rest of country	644 253	634 403	1 016	647 127	740 073	874
Østfold	112 958	82 030	1 377	122 037	85 646	1 425
Akershus/Oslo	211 169	362 719	582	174 013	373 679	466
Hedmark	70 514	57 640	1 223	61 692	56 289	1 096
Oppland	67 761	52 443	1 292	54 045	52 572	1 028
Buskerud	96 330	65 340	1 474	56 309	67 340	836
Vestfold	79 831	65 670	1 216	83 203	66 269	1 256
Telemark	60 561	52 207	1 160	66 603	47 123	1 413
Aust-Agder	56 053	26 531	2 113	34 731	28 926	1 201
Vest-Agder	32 206	42 040	766	44 619	43 785	1 019
Rogaland	107 702	131 760	817	86 226	132 738	650
Hordaland	157 849	110 018	1 435	252 756	152 052	1 662
Sogn og Fjordane	22 174	24 626	900	15 582	24 056	648
Møre og Romsdal	54 652	69 527	786	56 806	72 497	784
Sør-Trøndelag	125 957	107 513	1 172	66 346	107 730	616
Nord-Trøndelag	42 349	36 045	1 175	36 645	37 316	982
Nordland	65 399	78 124	837	71 733	133 398	538
Troms	52 686	49 487	1 065	48 964	50 408	971
Finnmark	15 485	27 363	566	12 069	29 878	404

Source: Statistics Norway.

Appendix F

Agriculture

Table F1. **Agricultural area in use. km²**

	Agricultural area in use, total	Cereals and oil seeds	Other agricultural areas	Cultivated meadow	Surface-cultivated meadow
1949	10 456	1 520	1 560	5 422	1 954
1959	10 107	2 182	1 347	4 828	1 750
1969	9 553	2 525	859	4 584	1 585
1979	9 535	3 252	856	4 195	1 232
1989	9 911	3 530	850	4 438	1 093
1997*	10 386	3 401	741	4 881	1 363

Source: Statistics Norway.

Table F2. **Nutrient balance for agricultural areas. 1 000 tonnes as nitrogen and phosphorus**

	Nitrogen (N)					Phosphorus (P)			
	Commercial fertilizer	Manure	NH_3 losses	Removed in crops	Surplus	Commercial fertilizer	Manure	Removed in crops	Surplus
1985	110.8	72.1	15.6	85.9	81.5	24.8	11.8	17.9	18.8
1986	106.0	71.8	15.6	80.5	81.7	22.8	11.8	16.7	17.9
1987	109.8	70.2	15.6	84.0	80.5	22.0	11.6	17.4	16.1
1988	111.2	68.4	15.6	81.9	82.1	19.7	11.3	16.7	14.3
1989	110.1	68.1	15.3	80.7	82.2	17.4	11.2	16.5	12.0
1990	110.4	68.5	15.4	96.8	66.7	16.0	11.2	19.9	7.4
1991	110.8	69.5	16.0	95.0	69.3	15.2	11.4	19.4	7.2
1992	110.9	70.0	16.4	79.6	84.8	14.8	11.5	16.0	10.3
1993	109.3	69.2	16.2	92.5	69.8	13.7	11.4	18.7	6.4
1994	108.3	70.2	16.4	83.4	78.6	13.7	11.5	16.7	8.5
1995	110.9	71.2	18.9	87.1	76.1	13.3	11.7	17.6	7.4
1996	111.9	73.5	17.0	91.6	76.7	14.3	12.1	18.5	7.8

Sources: Statistics Norway, Norwegian National Grain Administration and Norwegian Agricultural Inspection Service.

Table F3. **Sales of commercial fertilizer expressed as content of nitrogen and phosphorus. Whole country**

	Total, tonnes		Mean quantity (kg) applied per decare agricultural land in use	
	Nitrogen (N)	Phosphorus (P)	Nitrogen (N)	Phosphorus (P)
1980/81	102 513	26 980	10.9	2.9
1981/82	107 546	28 291	11.4	3.0
1982/83	109 120	27 638	11.5	2.9
1983/84	110 648	27 382	11.6	2.9
1984/85	110 803	24 828	11.6	2.6
1985/86	106 011	22 752	11.1	2.4
1986/87	109 807	21 935	11.5	2.3
1987/88	111 208	19 699	11.6	2.0
1988/89	110 138	17 376	11.1	1.8
1989/90	110 418	16 002	11.1	1.6
1990/91	110 790	15 190	11.0	1.5
1991/92	110 123	14 818	11.0	1.5
1992/93	109 299	13 722	10.8	1.4
1993/94	108 287	13 688	10.6	1.3
1994/95	110 851	13 291	10.8	1.3
1995/96	111 976	13 836	10.8	1.3
1996/97	112 879	13 522	10.9	1.3

Sources: Statistics Norway and Norwegian Agricultural Inspection Service.

Table F4. **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]
	Decares	Percentage					
Whole country							
1989/90	3 649 601	3.0	81.6	..	..	0.3	18.2
1995/96	3 437 554	7.7	57.9	3.1	38.1	0.9	..
1996/97*	3 412 675	6.8	56.6	3.1	39.1	1.1	..
Counties 01-10							
1989/90	3 071 938	3.5	83.4	..	..	0.3	16.3
1995/96	2 943 570	8.9	58.7	3.5	36.8	1.0	..
1996/97*	2 935 812	7.8	56.7	3.6	38.4	1.3	..
01 Østfold							
1989/90	660 337	5.3	91.6	..	..	0.5	7.9
1995/96	660 797	17.9	64.6	2.9	31.4	1.1	..
1996/97*	653 288	13.5	61.8	2.7	34.2	1.3	..
02/03 Akershus/Oslo							
1989/90	699 503	3.6	89.5	..	..	0.2	10.3
1995/96	643 954	11.5	64.6	2.8	31.0	1.6	..
1996/97*	661 415	9.0	64.2	2.7	31.4	1.7	..
04 Hedmark							
1989/90	657 356	1.1	75.5	..	..	0.1	24.4
1995/96	629 842	2.2	57.1	6.3	35.9	0.6	..
1996/97*	639 371	2.0	53.0	5.5	40.7	0.9	..
05 Oppland							
1989/90	287 309	2.6	74.6	..	..	0.4	25.0
1995/96	262 043	1.5	56.8	3.7	38.4	1.1	..
1996/97*	255 710	1.2	56.4	4.8	37.7	1.2	..
06 Buskerud							
1989/90	306 307	3.6	81.7	..	..	0.1	18.1
1995/96	296 737	5.4	51.2	2.4	45.4	1.0	..
1996/97*	292 245	7.6	47.5	5.2	46.1	1.3	..
07 Vestfold							
1989/90	327 163	5.2	84.1	..	..	0.7	15.2
1995/96	329 740	9.1	53.3	1.8	44.3	0.7	..
1996/97*	317 873	11.8	53.0	1.5	43.8	1.8	..
08 Telemark							
1989/90	107 438	4.1	74.0	..	..	0.0	26.0
1995/96	98 855	4.1	40.6	2.4	56.3	0.7	..
1996/97*	96 013	4.2	42.0	2.5	55.5	0.0	..
11 Rogaland							
1989/90	50 788	0.1	9.6	..	..	0.7	89.7
1995/96	37 390	0.3	3.5	0.1	94.2	2.1	..
1996/97*	34 648	0.2	2.7	0.3	95.8	1.1	..
16 Sør-Trøndelag							
1989/90	165 710	0.1	74.5	..	..	0.1	25.5
1995/96	149 866	0.7	55.0	0.5	44.3	0.2	..
1996/97*	144 446	1.3	58.9	0.2	40.6	0.3	..
17 Nord-Trøndelag							
1989/90	327 353	0.4	82.0	..	..	0.0	17.9
1995/96	285 666	0.4	60.4	0.6	38.9	0.0	..
1996/97*	280 428	0.4	61.9	0.5	37.4	0.0	..

[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: Bye and Mork (1998).

Table F5. **Sales of pesticides expressed as tonnes active substances. Environmental taxes on pesticides**

	Sales of pesticides Tonnes active substanes					Taxes as per cent of purchase price		Taxes, million NOK		
	Total	Fungi-cides	Insecti-cides	Herbi-cides	Other sub-stances, including additives	Environ-mental tax	Control fee	Total	Environ-mental tax	Control fee
1985	1 529.3	138.4	38.7	1 236.2	116.1	-	-	-	-	-
1988	1 193.6	107.8	37.9	919.2	128.7	2.0	5.5	..	1.5	..
1989	1 033.8	119.5	27.3	856.9	30.1	8.0	6.0	30.3	17.3	..
1990	1 183.5	153.0	19.0	965.1	46.4	11.0	6.0	28.5	20.2	8.3
1991	760.0	133.1	18.5	563.7	44.7	13.0	6.0	26.7	18.8	7.9
1992	781.1	148.6	26.9	561.3	44.3	13.0	6.0	31.6	22.5	9.1
1993	764.6	179.7	16.9	510.1	57.9	13.0	6.0	32.0	21.9	10.1
1994	861.5	156.7	20.5	626.0	58.3	13.0	6.0	30.7	21.0	9.7
1995	930.7	167.3	19.2	689.0	55.2	13.0	6.0	27.6	18.9	8.7
1996	706.4	139.7	14.5	503.4	48.8	15.5	7.0	32.3	21.8	10.5
1997	755.4	175.4	17.9	505.0	57.1	15.5	7.0	30.4	21.0	9.5

Sources: Norwegian Agricultural Inspection Service and Norwegian Agricultural Economics Research Institute.

Table F6. **Number of holdings managed ecologically, areas and grants disbursed. Whole country**

	Number of holdings managed ecologically	Area of agricultural land managed ecologically	Agricultural area under conversion to ecological farming	Total grants to ecological farming	Conversion and acreage support
		Decares		Million NOK	
1986	19	..	..	-	-
1987	41	..	..	-	-
1988	52	..	..	-	-
1989	89	..	..	5.1	-
1990	263	..	..	12.5	4.0
1991	410	18 145	6 288	20.4	6.6
1992	473	26 430	582	23.4	7.9
1993	501	32 343	5 444	22.2	5.8
1994	542	38 278	6 916	22.3	5.8
1995	670	44 596	13 082	23.4	5.9
1996	911	46 573	32 401	35.1	13.7
1997*	1 278	73 921	43 143		

Sources: Debio and Ministry of Agriculture.

Appendix G

Forest

Table G1. **Forest balance 1996. Whole country. 1 000 m³ without bark**

	Total	Spruce	Pine	Broad-leaved trees
Growing stock on 1.1[1]	650 845	295 148	217 431	138 267
Total losses	10 753	6 983	2 173	1 597
Of which total roundwood cut	8 654	5 940	1 711	1 004
Sales, excl. fuelwood	7 413	5 590	1 603	220
Fuelwood, sales and private	1 039	199	62	777
Own use	202	151	45	7
Other losses	2 099	1 044	462	593
Logging waste	559	356	103	100
Natural losses	1 540	687	359	493
Total increment	22 376	11 454	5 991	4 931
Growing stock on 31.12	662 468	299 618	221 249	141 600

[1] Volume and average annual increment for 1994-1997 for all land types in counties inventoried.
Source: Norwegian Institute for Land Inventory. (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 m³ without bark**

	Growing stock				Annual increment			
	Total	Spruce	Pine	Broad-leaved trees	Total	Spruce	Pine	Broad-leaved trees
Whole country								
1933	322 635	170 960	90 002	61 673	10 447	5 835	2 535	2 077
1967	435 121	226 168	133 972	74 981	13 200	7 131	3 364	2 706
1990	578 317	270 543	188 279	119 495	20 058	10 528	5 200	4 330
1994/97[1]	650 845	295 148	217 431	138 267	21 987	11 283	5 889	4 814
Region, 1994/97								
Østfold, Akershus/Oslo, Hedmark	182 395	97 865	65 243	19 287	6 720	3 842	2 072	807
Oppland, Buskerud, Vestfold	142 417	82 500	39 259	20 657	4 632	2 839	974	818
Telemark, Aust-Agder, Vest-Agder	116 414	38 512	52 995	24 907	3 457	1 351	1 304	802
Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal	77 465	16 759	33 551	27 155	3 037	1 242	895	901
Sør-Trøndelag, Nord-Trøndelag	83 998	49 397	18 902	15 698	2 565	1 554	434	576
Nordland, Troms	45 247	10 112	5 306	29 829	1 499	456	148	895
Finnmark	2 910	1	2 175	734	78	0	62	16

[1] Volume and average annual increment for all types of land use classes for 1994-1997 in counties inventoried.
Source: Norwegian Institute for Land Inventory. (Figures from inventories supplemented by calculations by Statistics Norway for Finnmark, where no inventory has been carried out.)

Appendix H

Fishing, fish farming

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]	Greenland halibut[1]	Barents Sea capelin[3,5]	Norwegian spring-spawning herring[4]	North Sea herring[4]	North Sea cod[3]
1977	2 130	240	480	120	4 800	280	50	820
1978	1 800	260	470	100	4 250	360	70	810
1979	1 490	320	480	130	4 160	390	120	810
1980	1 210	250	550	100	6 720	470	140	1 010
1981	1 200	190	530	110	3 900	510	210	850
1982	1 010	110	480	110	3 780	510	290	840
1983	750	70	480	120	4 230	580	450	650
1984	870	50	410	110	2 960	610	730	720
1985	1 010	140	370	110	860	510	760	500
1986	1 250	270	350	120	120	450	780	680
1987	1 060	240	370	110	100	1 200	890	570
1988	820	160	360	110	430	3 870	1 140	430
1989	920	120	330	110	860	4 710	1 270	420
1990	960	120	400	90	5 830	4 650	1 150	330
1991	1 510	150	510	90	7 290	4 810	950	300
1992	1 940	250	650	50	5 150	4 590	690	410
1993	2 510	540	690	60	800	4 390	470	350
1994	2 340	600	580	50	200	5 090	550	480
1995	2 100	600	610	50	190	5 520	560	490
1996	2 040	550	570	40	500	5 560	540	440
1997	1 940	540	520	30	910	9 130	690	710

Table H1 (cont.). **Stock trends for some important fish species. 1 000 tonnes**

Year	North Sea haddock[3]	North Sea saithe[3]	North Sea whiting[3]	North Sea plaice[3]	North Sea sole[3]	Blue whiting (northern and southern stock)[4]	Mackerel (North Sea, western and southern)[4]
1977	570	540	1 110	480	60	..	
1978	670	460	780	480	60	..	
1979	670	500	950	480	50	..	
1980	1 250	450	840	490	40	..	
1981	670	550	640	490	50	4 620	
1982	840	590	490	570	60	3 340	
1983	760	690	510	560	70	2 270	
1984	1 490	640	490	570	70	1 870	2 750
1985	860	580	440	560	60	2 120	2 710
1986	720	550	660	660	50	2 420	2 740
1987	1 070	400	540	650	60	2 040	2 730
1988	430	370	420	640	70	1 730	2 830
1989	400	390	560	600	100	1 650	2 880
1990	340	360	480	570	120	1 530	2 770
1991	750	400	460	480	110	1 870	3 140
1992	610	440	410	450	110	2 440	3 160
1993	890	450	400	410	100	2 360	2 850
1994	530	450	410	340	90	2 320	2 560
1995	1 020	530	440	340	80	2 260	2 600
1996	670	450	370	340	60	2 200	2 460
1997	640	480	420	390	60	2 430	2 570

[1] Fish aged 3 years and older.
[2] Fish aged 2 years and older.
[3] Fish aged 1 year and older.
[4] Spawning stock.
[5] 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*	1997*
Total	1 804	1 686	1 725	1 519	1 949	2 372	2 353	2 292	2 466	2 597	2 801
Cod	305	252	186	125	164	219	275	374	364	359	401
Haddock	75	63	39	23	25	40	44	74	80	97	106
Saithe	152	148	145	112	140	168	188	189	219	222	184
Tusk	30	23	32	28	27	26	27	20	19	20	14
Ling/blue ling	25	24	29	24	23	22	20	19	19	20	16
Greenland halibut	7	9	11	24	33	11	15	13	14	17	12
Redfish	18	25	27	41	56	38	33	29	22	29	22
Others and unspecified	34	29	29	30	44	43	57	31	27	25	32
Capelin	142	73	108	92	576	811	530	113	28	208	156
Mackerel	159	162	143	150	179	207	224	260	202	137	137
Herring	347	339	275	208	201	227	352	539	687	763	917
Sprat	10	12	5	6	34	33	47	44	41	59	7
Other industrial fisheries[1]	500	526	696	655	447	527	541	587	746	642	798

[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**

	Total	Oxytetra-cycline chloride	Nifura-zolidone	Oxolinic acid	Trimetoprim + sulfadiazine (Tribrissen)	Sulfa-merazine	Flume-quin	Flor-fenikol
1981	3 640	3 000	-	-	540	100	-	-
1982	6 650	4 390	1 600	-	590	70	-	-
1983	10 130	6 060	3 060	-	910	100	-	-
1984	17 770	8 260	5 500	-	4 000	10	-	-
1985	18 700	12 020	4 000	-	2 600	80	-	-
1986	18 030	15 410	1 610	-	1 000	10	-	-
1987	48 570	27 130	15 840	3 700	1 900	-	-	-
1988	32 470	18 220	4 190	9 390	670	-	-	-
1989	19 350	5 014	1 345	12 630	32	-	329	-
1990	37 432	6 257	118	27 659	1 439	-	1 959	-
1991	26 798	5 751	131	11 400	5 679	-	3 837	-
1992	27 485	4 113	-	7 687	5 852	-	9 833	-
1993	6 144	583	78	2 554	696	-	2 177	56
1994	1 396	341	-	811	3	-	227	14
1995	3 116	70	-	2 800	-	-	182	64
1996	1 037	27	-	841	-	-	105	64
1997	746	42	-	507	-	-	74	123

Source: Norwegian Medicinal Depot.

Table H4. **Exports of some main groups of fish products. 1 000 tonnes**

	Fresh	Frozen whole	Fillets	Salted or smoked	Dried	Canned	Meal	Oil
1981	24.6	58.7	74.0	13.6	86.2	15.0	266.5	107.3
1982	46.2	100.2	76.3	14.9	68.8	11.2	228.6	101.1
1983	91.5	62.6	91.6	24.9	59.4	22.4	283.9	128.0
1984	72.9	78.7	98.5	24.6	69.5	22.7	248.9	76.9
1985	74.5	79.5	95.9	20.3	64.6	23.4	173.9	114.3
1986	139.4	98.8	95.2	22.7	62.9	24.4	92.6	38.8
1987	189.6	114.2	105.0	38.0	40.6	24.3	88.3	71.3
1988	212.5	126.7	105.1	36.9	47.0	22.9	68.9	45.6
1989	215.1	159.8	95.2	46.2	48.0	23.2	45.4	39.1
1990	238.8	263.4	71.0	34.6	50.6	23.9	45.3	42.7
1991	249.6	366.9	68.7	48.6	50.3	23.0	110.8	58.5
1992	258.8	351.6	103.2	48.0	57.4	23.9	140.1	53.7
1993	309.1	412.4	141.3	66.4	62.6	23.9	139.6	62.0
1994	307.4	518.2	195.2	100.1	66.5	26.4	72.0	63.5
1995	341.1	579.7	210.8	94.4	70.5	20.6	66.1	85.6
1996	369.5	682.7	234.3	91.5	76.1	19.3	87.1	68.1
1997*	427.4	802.2	241.6	82.3	75.8	18.1	64.0	55.1

Source: Statistics Norway.

Table H5. **Export of fish and fish products by important recipient country. Million NOK**

			Of this					Of this	
	Total	EU countries total	France	Denmark	United Kingdom	Germany	Other countries total	Japan	USA
1982	5 931.4	2 494.0	419.9	211.4	880.9	338.3	3 437.5	229.5	421.2
1983	7 367.7	3 186.2	568.8	337.2	1 022.1	515.0	4 181.3	334.5	747.6
1984	7 675.2	3 233.3	530.3	350.3	1 026.7	545.8	4 442.1	408.2	920.1
1985	8 172.3	3 605.0	605.1	377.1	1 202.0	632.8	4 567.8	463.8	1 129.2
1986	8 749.4	4 293.9	781.0	626.9	1 014.2	705.5	4 455.5	408.8	1 194.7
1987	9 992.3	5 597.0	1 114.1	926.7	1 059.1	754.2	4 395.3	501.0	1 397.9
1988	10 693.1	6 107.2	1 318.6	1 115.1	987.2	932.3	4 585.9	808.0	1 059.6
1989	10 999.2	6 416.1	1 305.5	1 196.0	1 019.5	892.9	4 583.1	755.7	996.1
1990	13 002.4	8 119.2	1 617.1	2 046.3	868.8	1 046.5	4 883.3	1 067.5	754.7
1991	14 940.4	9 114.8	1 534.8	2 021.9	991.0	1 196.1	5 825.6	1 797.7	436.4
1992	15 385.2	10 180.2	1 850.7	1 794.1	1 388.9	1 309.3	5 205.0	1 366.3	400.0
1993	16 619.1	10 365.3	1 835.9	1 690.1	1 542.3	1 369.2	6 253.8	1 810.3	565.7
1994	19 540.2	11 709.4	2 250.3	1 767.8	1 484.5	1 698.3	7 830.8	1 999.2	723.1
1995	20 088.6	13 171.6	2 137.9	2 192.1	1 590.6	1 605.0	6 917.0	1 987.5	799.3
1996	22 434.6	13 832.4	2 167.2	2 430.9	1 764.2	1 527.9	8 602.2	2 503.8	760.9
1997*	24 652.9	14 542.9	2 278.2	2 642.5	2 026.6	1 532.5	10 110.0	2 751.2	960.4

Source: Statistics Norway.

Table H6. **Export of fresh and frozen farmed salmon. 1000 tonnes and million NOK**

	Total		Fresh or chilled		Frozen		Fresh and frozen fillets and smoked	
	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	1 359.7	21.4	1 160.6	2.6	147.8	0.5	51.4
1986	39.8	1 756.9	34.4	1 458.6	4.5	205.1	0.9	93.2
1987	44.2	2 281.4	39.2	1 967.3	4.0	207.1	1.0	107.0
1988	66.7	3 155.9	56.0	2 594.9	10.0	484.8	0.7	76.2
1989	96.8	3 621.4	81.1	2 954.6	14.4	531.5	1.3	135.3
1990	132.6	5 019.0	92.8	3 423.8	37.9	1 411.1	1.9	184.1
1991	134.3	4 968.0	91.3	3 149.3	35.4	1 300.3	7.7	518.4
1992	130.9	4 991.9	107.1	3 881.8	15.0	518.1	8.8	592.0
1993	141.0	5 236.1	117.9	4 087.4	13.1	466.0	10.0	682.9
1994	168.8	6 383.5	140.7	4 942.2	13.1	483.1	15.0	958.2
1995	206.3	6 714.6	169.4	5 007.1	19.7	653.7	17.2	1 053.8
1996	237.2	6 923.7	191.1	5 041.2	23.0	651.7	23.0	1 230.9
1997*	260.5	7 579.7	205.3	5 390.6	27.9	803.4	27.3	1 385.6

Source: Statistics Norway.

Table H7. **Catch quantities[1] and export value of fish and fish products. Selected countries**

	1993		1994		1995	
Country[2]	Catch quantity 1000 tonnes	Export-value Million USD	Catch quantity 1000 tonnes	Export-value Million USD	Catch quantity 1000 tonnes	Export-value Million USD
China	17 568	1 542	20 719	2 320	24 433	2 854
Peru	9 010	685	11 997	980	8 943	870
Chile	6 035	1 125	7 839	1 304	7 591	1 704
Japan	8 081	767	7 396	743	6 758	713
USA	5 934	3 179	5 922	3 230	5 634	3 384
India	4 546	836	4 738	1 125	4 904	1 241
Russia	4 461	1 471	3 781	1 720	4 374	1 628
Indonesia	3 685	1 419	3 917	1 583	4 118	1 667
Thailand	3 395	3 404	3 537	4 190	3 502	4 449
Norway	2 562	2 302	2 551	2 718	2 807	3 123
South Korea	2 649	1 335	2 700	1 411	2 688	1 565
Philippines	2 264	478	2 276	533	2 269	502
Denmark	1 656	2 151	1 916	2 359	2 041	2 460
North Korea	1 782	..	1 802	..	1 850	..
Iceland	1 718	1 138	1 560	1 265	1 616	1 343

[1] Catch quantities include sea-water and fresh-water fisheries and aquaculture production. Whales, seals and other marine mammals and marine plants are not included.
[2] Countries are ranked according to catch quantities in 1995.
Source: FAO (1997b and c).

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