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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 trends in the extraction and use of natural resources and changes in the state of the environment, focusing particularly on relationships between these factors and other economic developments. The annual publication Natural Resources and the Environment gives an overview of this work.

Natural Resources and the Environment 1999 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, fisheries, and land use in urban settlements.

The book also describes results from Statistics Norway›s research into resource and environmental economics. The 1999 edition includes articles on possible consequences of the Kyoto Protocol, energy use by households and industry and the relationship between status and growth. 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 1999.

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 other members of the editorial committee were Karin Ibenholt and Knut Einar Rosendahl. This edition is being translated into English by Alison Coulthard and Veronica Harrington Hansen.

Introduction and summary

What environmental trends were apparent in 1998?
This year's edition of *Natural Resources and the Environment* presents a mixed picture of general environmental developments. Some factors are showing negative trends; for example, emissions of greenhouse gases are still increasing, and the quantity of waste generated by households is rising sharply, at about the same rate as GDP (gross domestic product) (figure 1). Energy use, some of which has negative environmental consequences, rose more quickly than GDP in 1998, after a slower rise in the preceding years. However, there are also positive signs: treatment of waste water is gradually improving, waste management is being improved to make better use of resources, and emissions of some air pollutants are being reduced (figure 2).

Investments in oil and gas extraction in the North Sea are now dropping. If the low level of investments continues, this will eventually result in a lower level of activity, and thus reduce environmental pressure from this sector.

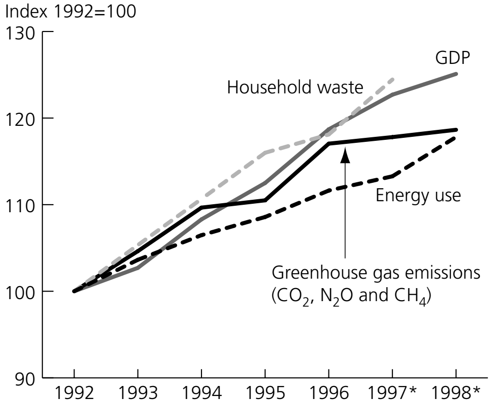
In general, it seems that at least one of the following applies to environmental problems where there has been a positive trend:

1. There has been clear legislation and a set of instruments available to the authorities, who have been in a position to enforce and use them.
2. Environmental measures have not been a threat to general economic activity or to powerful economic interests.
3. Technological developments have made it possible for example to reduce emissions or restrict the use of environmentally-harmful products at an acceptable cost.

Which areas are covered by this publication?
A simplified, but now generally recognized way of analysing environmental problems is to distinguish between

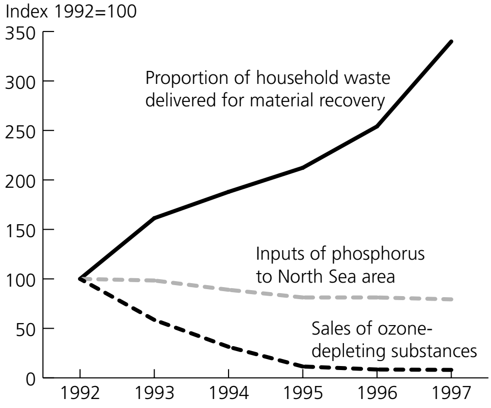
- driving forces (population, economic activity), which cause
- environmental pressures (emissions to air and water, waste generation, extraction of natural resources) resulting in changes in
- the state of the environment (water quality, air quality, biological diversity), and
- environmental impacts (fish mortality, reduction in crop yields, species extinction). This will at some point lead to a
- societal response to problems (e.g. imposition of a CO_2 tax, protection of areas, treatment of emissions). The response in turn results in changes in economic driving forces, environmental pressures and the state of the environment.

Figure 1. **Relative changes in GDP and important environmental indicators that are showing negative trends**



Source: Statistics Norway.

Figure 2. **Relative changes in important environmental indicators that are showing positive trends**



Sources: Statistics Norway, Norwegian Pollution Control Authority and Norwegian Institute of Water Research.

Environmental statistics and analyses from Statistics Norway focus on how people *exert pressure* on the environment in the form of pollution and use of natural resources, and not so much on the state of the environment. This publication therefore contains relatively little information on the state of the environment and environmental impacts. However, in some chapters the response to environmental problems is discussed to illustrate the measures being implemented by the *public authorities*.

The information in the book is based mainly on Statistics Norway's own material, although some data from other sources have also been used. Thus, the book does not attempt to cover all environmental problems. For example, one of the most serious problems at present, the threat to biological diversity, is not dealt with directly here.

Summary

Chapter 1 deals with *economic driving forces* and presents macro-economic trends that are of importance for environmental pressures and the state of the environment. In recent years, Norway has been experiencing a period of economic expansion, involving greater oil and gas activity in the North Sea, a high rate of investment and higher consumption in the public and private sectors. However, in 1998 this upturn seems to have been interrupted. Investments in the North Sea reached a record level in 1998, but will drop sharply in 1999. In the medium term, general economic growth is expected to level off. This will probably have an effect on environmental pressures that are closely related to economic activity, especially emissions to air and waste generation. However, lower economic growth may cause employment problems and reduce revenues in the public sector, thus making it more difficult for the authorities to give environmental considerations priority in their policies. We have already witnessed one example of this when the government considered whether to reduce or remove CO_2 taxes in the oil sector to maintain the level of activity in the sector. Another question is what shifts will take place in demand as the economy develops. It is expected that the demand for services will continue to rise more rapidly than that for goods. Since the production of services, except in the transport sector, generally has less environmental impact than the production of goods, this shift by itself will contribute towards a positive environmental trend. However, the effect will not be sufficient to prevent several environmental problems from worsening unless the authorities alter the operating parameters to promote environmentally-friendly activities.

Chapter 2 on *energy* provides updated statistics on resources and the extraction and use of crude oil, natural gas and hydropower. In 1998, the two most important trends in the energy sector were (1) a drop in overall *production* of petroleum on the Norwegian continental shelf after continuous strong growth for the past 18 years, and (2) continued growth in domestic *energy use*, which again reached record levels. The drop in production was partly a result of restrictions on extraction imposed by the authorities in response to lower prices on the world market, and partly to delays in starting production, maintenance and technical problems on some fields. Measured in constant prices, the oil price in 1998 was the lowest since 1973. The rise in *energy use* was related to the sharp rise in real wages and relatively low prices for electricity and fuel oils. Both electricity consumption and sales of transport oils rose sharply. Demand for both these energy sources is dependent on household consumption and general economic activity in production sectors. Norway was a net importer of electricity for the third year running, despite the fact that electricity production was markedly higher than in a normal year as a result of high precipitation. In the period 1960-1995, Norway was a net importer of electricity only in 1960, 1977 and 1986. An analysis by Statistics Norway indicates that electricity consumption will rise substantially until 2020 unless strong measures are introduced.

Worldwide, extraction and use of fossil energy commodities are the most important cause of air pollution, which may have local, regional or global effects. These are discussed in Chapter 4 on *emissions to air*. Preliminary calculations of Norwegian emissions of the greenhouse gas carbon dioxide (CO_2) show little change from 1997 to 1998 (from 41.4 to 41.6 million tonnes). Given the drop in oil and gas production in 1998, a reduction in CO_2 emissions might have been expected. The main reason that there was in fact little change was a rise in emissions from metal manufacturing and road traffic. Emissions of methane dropped by 1 per cent from 1997, whereas N_2O emissions rose by 6 per cent. In the period 1990-1997, total greenhouse gas emissions rose by more than 7 per cent. A substantial drop in NO_x emissions from road traffic would be expected as the proportion of cars fitted with catalytic converters rises, but the effect of this is partly masked by the growth in traffic and greater use of diesel vehicles, which generate high NO_x emissions. NO_x emissions from road traffic were reduced by a total of 3 per cent from 1997 to 1998.

Global emissions of greenhouse gases, mainly carbon dioxide, methane and nitrous oxide, are so high that there are signs that they are beginning to have an impact on the global climate. One indicator of this is that the global mean temperature has been substantially higher in the last ten years than the average since 1856, when measurements started (the highest temperature in the entire period was recorded in 1998). The world community is now attempting to coordinate measures to limit emissions of these gases, primarily through the Kyoto Protocol. To increase the efficiency of these measures, several countries, including Norway, would like to see a system of emissions trading. However, this requires coordination and a radical improvement of methods of calculating countries' emissions. Analyses by Statistics Norway show that if CO_2 taxes are introduced internationally to limit emissions, this will have relatively little impact on activities in the North Sea. Neither oil wealth nor the level of exploration activities will be greatly reduced.

According to the *surveys of living conditions* carried out by Statistics Norway, road traffic is the most important cause of exposure to noise and pollution. Both road and air traffic are growing rapidly. For example, in 1997 each Norwegian travelled an average of 37 km every day, as compared with 18 km in 1970. Analyses by Statistics Norway show that the net social benefits are greater if noise is reduced by direct noise protection measures rather than by reducing traffic by means of general taxes on fuel, provided that the authorities use tax revenues to increase public consumption. Chapter 3 quantifies the actual growth in *passenger and goods transport* in Norway during the past 50 years, and discusses the underlying causes and the effects of this increase.

Chapter 5 on *waste* shows that the quantity of household waste generated is still rising sharply. Statistics Norway's waste accounts for paper, metal, glass and wet organic waste show that the quantities of all these fractions of waste have been tending to rise in recent years. Although the public authorities consider measures to *minimize waste generation* to be the most important way of limiting waste problems, most measures implemented are intended to ensure environmentally sounder *waste treatment*. Analyses by Statistics Norway show that measures designed to avoid waste generation, for instance taxation of materials used in production, provide greater social benefits than waste treatment measures. As regards waste treatment, some of the most important measures are sorting of household waste at source and collection schemes based on agreements between the authorities and industry and on return schemes for certain products. In recent years, there has been a marked increase in the number of municipalities where waste is sorted and in the number of fractions that can be sorted. For example, the per capita quantity of household waste delivered for material recovery rose from 64 kg in 1996 to 90 kg in 1997. The authorities have entered into agreements with a number of branches of industry concerning the return of discarded products, and other fractions are recycled on the basis of regulations and deposit and return schemes. Schemes exist for hazardous waste, packaging waste, batteries, car tyres, scrapped cars, waste oil, fridges and freezers containing CFCs, household appliances, and electrical and electronic products. Schemes like these ensure that waste management has less negative impact on the environment and that better use is made of the resources in waste, but they have little effect on waste generation.

According to the North Sea agreements, Norway undertook to reduce discharges of nitrogen and phosphorus to the North Sea by about half, using 1985 as the base year. As Chapter 6 shows, these requirements have still not quite been achieved, but a number of measures, many in the fields of *waste water treatment* and *agriculture*, have been implemented to reduce inputs. Inputs of phosphorus to the North Sea from the waste water sector were reduced by 60 per cent from 1985 to 1997, whereas nitrogen inputs were reduced by only 11 per cent. This is because the measures introduced to improve waste water treatment have mainly focused on phosphorus removal, and the municipalities, which are responsible for waste water treatment, have been able to finance these measures in full through fees. Statistics Norway's figures show that the fees covered 102 per cent of the costs in 1997, as compared with 95 per cent in 1996. In order to improve water quality further in sensitive areas (the inner Oslofjord and around the Hvaler archipelago in the outer Oslofjord), priority is now being given to the construction of nitrogen removal facilities at certain large treatment plants in the inner Oslofjord and in the catchment area of the river Glomma. Nevertheless, only 3 per cent of the planned investments in nitrogen removal facilities had been carried out by 1997. Statistics Norway's agricultural statistics show that in recent years, there have been no significant changes in agricultural practices (fertilizer application, density of domestic animals, soil management) that would be expected to result in lower runoff of nutrients, see Chapter 7. Inputs of phosphorus and nitrogen from agriculture have been reduced by 26 and 19 per cent respectively between 1985 and 1997, but there have been only small changes in recent years.

Chapter 8 on *forest* shows that there has been a slight increase in the timber harvest from 1996 to 1997. Nevertheless, the harvest is still less than half the total annual increment, and the volume of the growing stock is rising by about 1.8 per cent per year. This means that the uptake of CO_2 from the atmosphere by forests corresponds to more than 40 per cent of Norway's anthropogenic CO_2 emissions. Accumulation of CO_2 in forests is not considered to be a means of meeting Norway's commitment under the Kyoto Protocol. The volume of the growing stock has more than doubled since 1925, when the National Forest Inventory was started. However, the forests are strongly influenced by forestry operations. The Directorate for Nature Management estimates that 900 of the 22 000 species associated with forests in Norway are rare or threatened by extinction. However, the results from the monitoring programme for forest damage show that the health of forests has improved for the first time in the 1990s.

In 1996, Norway's fisheries ranked as number 10 in the world, and the country was the world's second-largest fish exporter. Chapter 9 shows that the value of Norwegian fish catches rose by more than NOK 1 billion in 1998 to more than NOK 10 billion, despite a small drop in the quantity caught. Sound management of fish stocks is becoming increasingly important, both because of the economic importance of the fisheries industry and because prices may rise in future as a result of over-exploitation of many of the world's fisheries. Data from the Institute of Marine Research show that the

Norwegian spring-spawning herring stock is still high, but that the North-East Arctic cod stock has dropped sharply. Quotas have therefore been substantially reduced from 1998 to 1999. 1998 was another record year for the fish farming industry; salmon production reached 342 000 tonnes and salmon exports were worth almost NOK 9 billion.

Chapter 10 deals with *population* and *land use in urban settlements*. About 74 per cent of Norway's population today lives in urban settlements, but these cover only 0.7 per cent of the area of the country. There is thus considerable pressure on land in many urban settlements. Nevertheless, buildings cover less than 10 per cent of the area of urban settlements, and housing accounts for less than half of the built-up area. However, there are substantial differences between settlements. Statistics Norway is at an early stage in the development of statistics for urban settlements, but in future this will be a tool that can be used to provide systematic information on land-use developments in urban areas, and that will therefore be important in their management.

NOREEA (NORwegian Economic and Environmental Accounts) is a project designed to develop integrated accounts for economic and environmental data in Norway. An integrated system has now been made for emissions to air, and a valuation of three selected natural resources: *oil and gas*, *forest* and *fish* has been carried out. Chapter 11 indicates that the return (resource rent) on these resources in 1995 was NOK 29, 1 and -1 billion, respectively.

1. Economic driving forces

Economic activity is an important driving force behind the extraction of natural resources and changes in environmental quality. Information concerning the most important features of economic developments is therefore important for understanding trends in the extraction of natural resources and changes in the environmental situation. A cyclical upturn has been under way in Norway since 1993, with rising production and consumption. However, this trend seems to have been interrupted in 1998. A high and rising rate of production and consumption can contribute to a deterioration in environmental quality in some areas. At the same time, higher income can lead to a greater demand for a clean environment and make environment-related investments possible. More stringent emission standards and more clean-up measures may then result, which in turn can contribute to a positive trend for some environmental conditions.

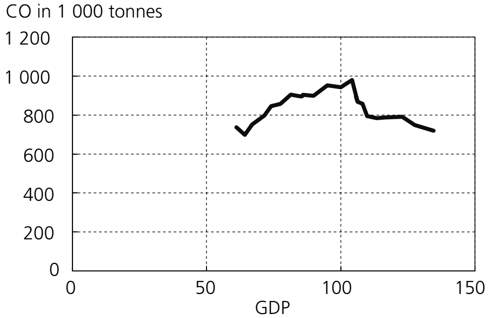
1.1. Introduction

There is a complex relationship between the extraction of natural resources, environmental quality and economic activity. Economic activity results in the use of natural resources and various types of environmental stresses. However, 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, most service sectors use fewer natural resources and have lower emissions per unit of production than manufacturing sectors. Price changes can also influence the use of resources and environmental stresses. A higher price for one 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 affects the economy in two ways, partly in the form of investment activity and partly because the income created results in higher demand. Both these mechanisms contribute to higher production in other sectors.

Consumption influences the environment indirectly in the form of higher demand for goods and services, and directly in the form of, for instance, emissions to air from passenger transport and waste generation. One example of the economy-environment feedback is air pollution that may damage health, which in turn can have a negative impact on labour productivity.

Figure 1.1. **Relationship between developments in GDP and emissions of CO in Norway 1973-1996. GDP indexed, CO in 1 000 tonnes**



Source: National accounts, Statistics Norway and emissions inventory from Statistics Norway and the Norwegian Pollution Control Authority.

Several studies have dealt with the relationship between economic trends and various environmental problems, such as emissions to air of harmful gases (see e.g. Shafik and Bandyopadhyay 1992, Selden and Song 1994 and Pearson 1994). For several environmental problems, these studies have found a correlation with per capita income in the form of an inverted U-shaped curve: environmental problems increase with economic growth, but when income reaches a certain level, the curve slopes downwards, and as economic growth continues, environmental problems are reduced, as shown in figure 1.1. Environmental problems that have been shown to reflect this relationship are primarily of a local nature, e.g. emissions of sulphur dioxide (Grossman and Krueger 1995) and lead (Hilton and Levinson 1998). However, several types of environmental problems do not seem to diminish with economic growth above a certain level. This applies to CO_2, for example, which is because this kind of emission cannot be removed by purification processes (Holtz-Eakin and Selden 1995).

One reason for the inverted U-curve might be that once basic needs such as food, shelter and heating have been met, the demand for a clean environment increases. The authorities can then be pressured into introducing more stringent environmental standards. At the same time, high income makes it possible to invest in more environmental technology and increase funding for research and development in the field of "clean" technology. It is also possible that after a certain number of years of pollution from production and consumption, there is greater awareness of the harmful effects and this leads to the introduction of measures to minimize the damage. The composition of consumption may also play a role, in that higher income does not necessarily lead to an increase in the quantity of goods, but to a higher proportion of luxury goods. It might therefore be expected that the rise in household waste would stagnate or slow when economic growth rose above a certain level. Studies of the relationship between per capita income and generation of household waste, however, do not confirm a U-curve connection in this context (see, for example, World Bank 1992).

1.2. Economic trends in Norway

The total economic activity in a country is usually measured by 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 3.7 per cent annually. 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. In 1998, however, economic growth began

Table 1.1. **Average annual growth in some key macroeconomic aggregates. Periods 1989-1992, 1993-1997 and 1998*. Per cent**

	1989-1992	1993-1997	1998*
Gross domestic product	2.3	4.5	2.0
- Mainland Norway	0.7	3.7	2.9
Private consumption	0.9	3.9	3.2
General government consumption	4.1	2.0	2.8
Gross fixed investment	-5.4	7.5	6.6
- Mainland Norway	-6.8	11.6	2.0
- Petroleum activities	10.2	-2.1	22.3
Exports	7.7	7.1	0.5
- Traditional goods	4.5	8.7	3.7
- Crude oil and natural gas	14.1	9.6	-3.2
Imports	2.9	7.7	6.9

Source: National accounts, Statistics Norway.

to slow, and preliminary figures show that mainland GDP expanded by just below 3 per cent. 1998 was a turbulent year for the Norwegian economy, with growing imbalances in the labour market and an accelerating rise in costs. There have been several indications that Norway has now passed a cyclical peak, and towards the end of 1998 there were signs of stagnation or decline in both investment and household demand, partly as a result of high interest rates.

Table 1.1 shows the average growth in some key macroeconomic aggregates since 1989. Most of these showed slower growth in 1998 than the average for the period 1993-1997, with the exception of general government consumption and investment in the oil sector. Growth in general government consumption was considerably slower than GDP growth at the beginning of the cyclical upturn, but gained momentum in 1996, 1997 and 1998. Total general government expenditure amounted to 46 per cent of GDP in 1998. The general government sector has low energy use and low emissions to air in relation to GDP, according to calculations in the NOREEA project (Statistics Norway 1998).

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 in mainland Norway and petroleum activities. In 1998 mainland Norway accounted for about 68 per cent of total investment and the petroleum sector for about 28 per cent, while the ocean transport sector accounted for the remainder. Investment in the petroleum sector is examined in more detail below.

In 1998, exports of crude oil and natural gas accounted for 29 per cent and traditional goods for 43 per cent of total exports, while ships and platforms (2 per cent) and services (26 per cent) accounted for the remainder.

1.3. Developments in the industries

Oil and gas extraction

Norway is very dependent on the use of fossil energy resources, and developments in international oil and gas markets have a considerable influence on the country's economy. In 1998, oil and gas extraction accounted for about 10 per cent of GDP, a decline of 4 percentage points since 1997. This decline is due to the fact that gross oil and gas production volumes fell by 3.3 per cent, while at the same time average oil and gas prices declined by 26 per cent. The value of oil and gas production thereby fell by 36 per cent. Measured in units of energy, the Petroleum Directorate's production statistics for the period January-November 1998 show a total reduction of 2.9 per cent compared with the same period the previous year, consisting of an increase in gas production of 2.1 per cent and a reduction in oil production of 4 per cent. Average oil production in 1998 came to 2.9 million barrels per day. Gas exports rose by 1.3 per cent, while exports of oil fell by 4.2 per cent. Investment in the petroleum sector showed a sharp growth from 1997 to 1998 (table 1.1), and according to provisional calculations 1998 will represent a new peak, with investment amounting to NOK 79.2 billion (current NOK). This is an increase of NOK 16.7 billion on the final figure for 1997. Investment in field development is estimated at NOK 45.1 billion for 1998, as much as NOK 9.9 billion more than in 1997. Investment in fields on stream rose by NOK 3.6 billion from 1997 and is estimated at a total NOK 12.9 billion in 1998. Other investment in the extraction of crude oil and natural gas and pipeline transport includes exploration activities (NOK 7.6 billion in 1998), onshore activities (NOK 5.7 billion) and pipeline transport (NOK 8.4 billion).

The downward trend in oil prices that started at the end of 1997 continued in 1998. The reasons for this downward trend were a combination of an increase in OPEC production quotas just before the decline in prices began and a drop in demand as a result of the economic crisis in Asia. A mild winter in many parts of the world and the extension of Iraq's agreement with the UN also resulted in a further increase in the surplus of oil. In 1997, the spot price of Brent Blend was on average about USD 19 p/b, whereas in 1998 it was USD 13 p/b. For Norway the fall in oil prices has been offset to a certain extent by an appreciation of the US dollar. The overall effect was a substantial reduction in the average crude oil price of NOK 40, to NOK 96 p/b in 1998. Measured in 1998 NOK, the price of crude oil has not been as low since the Norwegian oil age began in 1973. The decline in oil production in 1998 is partly a result of the low oil price, since production restrictions of 100 thousand barrels a day were introduced in 1998 in an effort to maintain prices. Other reasons for the sluggish trend in production are delays in the start-up of some of the new fields and technical problems at a number of others. In the longer term, however, prices - and expectations concerning price movements - will influence the level of investment, and thereby production. Investment involves an extensive planning process and changes in the oil price do not affect investment until at least 12 to 18 months later, with the exception of investment in exploration which can be adjusted at short notice[1]. This means that the low oil prices will be reflected in investment in the course of 1999.

Central government revenues from petroleum activities rose substantially up to 1997, but in 1998 the net cash flow from petroleum activities fell by NOK 35.5 billion to about NOK 49 billion. This sharp drop is due to a decline in tax revenues and operating revenues from the state's direct financial interest in petroleum activities, which in turn is a result of the low oil prices. About NOK 17 billion of petroleum revenues was used to cover the government budget deficit excluding petroleum activities, while just over NOK 29 billion was allocated to the Government Petroleum Fund.

[1] Investment in exploration is the only type of investment in this sector that was reduced from the 1997 figure of NOK 8.3 billion to NOK 7.6 billion in 1998.

The high level of activity in the petroleum sector in the last few years has resulted in a sharp rise in energy use in this sector. The use of natural gas increased from 34 PJ in 1976 to 153 PJ in 1997, but consumption dropped by 7.2 per cent to 148 PJ between 1997 and 1998, see also Chapter 2.3. 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 116.7 TWh in 1998, an increase of about 4.6 per cent from 1997. Electricity imports exceeded exports by 3.6 TWh in 1998 (imports of 8.0 TWh and exports of 4.4 TWh), see also Chapter 2.

Net domestic consumption[2] rose by 5 per cent to 110.4 TWh, which is the highest consumption ever recorded. The increase in the general supply was partly a result of colder weather compared with 1997. Adjusted for temperature fluctuations, consumption rose by 4 per cent. Consumption also rose by 5 per cent in power-intensive manufacturing due to increased production in these sectors.

According to preliminary calculations, electricity consumption in 1998 accounted for about 46 per cent of total energy consumption outside the energy sectors, which is the same as in 1997. In the period 1976 -1992 this share increased from 40 to 50 per cent. Electricity consumption then declined slightly up to 1997, partly as a result of a sharp rise in electricity prices in this period. However, in 1998 prices fell and the price of spot power was on average NOK 0.121/kWh (excluding VAT and network charges), which is about 11 per cent lower than in 1997. The price of electricity for households was also consistently lower in 1998 than in 1997.

Manufacturing and mining

Production in manufacturing and mining rose in volume by 2 per cent in 1998, according to preliminary figures. Production in the basic chemicals, basic metals, machinery, furniture and other manufacturing industries expanded at a faster pace than the average growth in manufacturing. Export deliveries expanded by 4 per cent in 1998, a decline of 5 percentage points in comparison with growth in 1997. Imports of manufacturing goods increased by 10 per cent in 1998, as was the case in 1997. Domestic deliveries rose by only 0.6 per cent.

Electricity consumption in power-intensive manufacturing sectors came to 30.5 TWh in 1998, a rise of just over 5 per cent from the previous year.

There have been relatively wide variations in energy use between the various manufacturing sectors in the periods 1989-1992 and 1993-1997 (table 1.2). In the mining sector, energy intensity (energy use per unit of production) fell sharply in the period 1989-1992 and continued to decline in the second period, although at a much slower pace. For manufacturing industry as a whole, energy intensity declined in the period 1989-1992, then increased slightly in the years 1993-1997. Trends within the various manufacturing sectors, however, show wider variations. In particular, the oil-refining sector re-

[2] Net domestic consumption is production plus import surplus minus the power used to produce and distribute electricity (pumped storage, consumption by power plants and losses).

Table 1.2. **Average annual growth in value added at constant prices and total energy use in manufacturing. Periods 1989-1992, 1993-1997 and 1998*. Per cent**

	1989-1992		1993-1997		1998*	
	Value added	Total energy use	Value added	Total energy use	Value added	Share of total GDP
Mining and quarrying	2.8	-8.4[1]	2.6	0.5	-1.7	0.2
Manufacturing	-1.3	-1.7	2.8	3.2	1.3	12.0
- Food products, beverages and tobacco	-2.0	3.5	2.0	0.1	-3.0	1.8
- Textiles, wearing apparel, leather	-1.5	-2.2	-0.7	6.1	-5.2	0.2
- Pulp, paper and paper products	-0.4	-0.4	4.3	5.3	-0.6	0.5
- Publishing, printing, reproduction	-1.6	1.5	2.8	1.0	0.3	1.3
- Refined petroleum products	-0.2	-4.3	-14.0	-37.3	-11.0	0.2
- Basic chemicals	-1.3	-3.2	3.4	7.5	3.3	0.6
- Chemical and mineral products	-1.7	0.9	3.7	-1.0	-1.2	0.9
- Basic metals	1.7	-2.3	0.5	1.1	4.0	0.8
- Machinery	-2.8	-0.2	4.7	9.9	4.6	3.3
- Ships and oil platforms	4.7	6.6	3.8	-2.3	2.9	1.3
- Other manufacturing industries	-6.1	1.5	1.8	5.5	5.7	0.9

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

corded a sharp reduction in total energy use in both periods. Total energy use in the machinery industry and other manufacturing industries, however, rose considerably more than gross production in both periods. In other sectors, energy intensity seems to have declined in the first period to increase in the second, and vice versa. The changes in energy intensity are ascribable to structural changes within the sectors as well as temperature and price changes that influence energy use in the sectors to a varying extent.

As a share of total energy use in the various manufacturing sectors, electricity consumption increased in the period 1989-1992, declining again in the period 1993 to 1997. Preliminary figures for 1998 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

Production in the construction sector rose in volume by 4.4 per cent from 1997 to 1998, according to preliminary figures. A relatively high rate of growth, 8.5 per cent, from 1996 to 1997 was followed by much slower growth throughout 1998. Value added in the industry accounted for 4.3 per cent of total GDP in 1998.

Construction investment contracted by 2 per cent from 1997 to 1998, with investment in housing and in public sector construction both declining by 0.7 per cent, while other construction investment in mainland Norway fell by 4.6 per cent. It thus appears that the sharp growth in the construction sector that began in 1994 is now slowing. Several major investment projects were completed in the course of 1998, for example Gardermoen airport and investment related to the

Table 1.3. **Average annual growth in value added, total energy use and electricity use in primary industries. Periods 1989-1992, 1993-1997 and 1998*. Per cent**

	1989-1992			1993-1997			1998*	
	Value added	Total energy use	Electricity use	Value added	Total energy use	Electricity use	Value added	Share of total GDP
Agriculture	0.8	-3.3	-10.9	1.7	0.2	9.5	4.2	1.1
Forestry	-2.8	-2.5	..	-2.6	-2.0	..	-4.0	0.2
Fishing and hunting, incl. fish farming	4.0	-3.5	..	14.8	4.4	..	-1.7	0.8

Source: National accounts and Energy Statistics, Statistics Norway.

lowering of the school entrance age to 6 years. Other reasons for the decline in investments include the increase in interest rates from the third quarter, which may have discouraged housing investment. Delays in the processing of construction applications by municipal authorities since 1 January due to the new Planning and Building Act may also have influenced investment trends.

Value added in the construction sector showed an average annual decline of 3.6 per cent in the period 1989 to 1992. In the period 1993 to 1997, however, growth was positive, showing an average annual rise of 5.1 per cent. Energy use in this sector fell by an average of just over 12 per cent a year in the period 1989-1992, but increased by an average 7 per cent a year in the period 1993-1997. It thus appears that the energy intensity in the industry declined sharply in the periods of economic slowdown, increasing during the current cyclical upturn.

Primary industries

Production in these industries (agriculture, forestry and fishing, including fish farming) rose by about 1 per cent in 1998, measured in constant prices. As a result of higher product prices, the value added in these industries increased by as much as 8 per cent in 1998. Although production grew at approximately equal rates in agriculture and the fishing industry, intermediate consumption sank in agriculture, resulting in value added growth in volume terms of 4.2 per cent. In the fisheries sector, on the other hand, intermediate consumption increased, and value added at constant prices declined by 1.7 per cent. Within the fisheries sector, only the fish farming industry has recorded growth, and the value of production was greater than in traditional fisheries in 1998. In 1998, as in 1997, 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 value added. There has been a decline in energy intensity in these industries throughout the period 1989 to 1997, with the exception of the forestry sector where there was a slight increase in the period 1993-1997. Electricity consumption was only recorded for the agricultural sector and in this sector electricity consumption as a share of total energy use declined in 1989-1992 and increased in 1993-1997, i.e. the opposite of the case in manufacturing.

Table 1.4. **Average annual growth in value added at constant prices, total energy use and electricity use in private services. Periods 1989-1992, 1993-1997 and 1998*. Per cent**

	1989-1992			1993-1997			1998*	
	Value added	Total energy use	Electricity use	Value added	Total energy use	Electricity use	Value added	Share of total GDP
Total	0.7	-0.5	2.7	3.6	4.3	4.2	4.2	39.0
Transport and communication	3.5	-1.3	-3.5	6.6	5.0	3.2	4.6	6.4
- Post and telecommunications	9.3	-8.5	-9.0	5.4	-0.3	1.0	8.1	1.8
- Inland water and coastal transport	-1.9	-1.0	-	3.8	4.3	-	4.4	0.2
- Other transport	0.0	-0.7	0.5	7.6	5.6	4.4	2.0	4.4
-- Railway transport	..	-5.5	-10.7	..	-1.9	0.2	..	..
-- Other land transport	..	1.9	-	..	6.2	-8.6	..	..
-- Air transport	..	-3.9	-	..	5.2	-	..	..
Other private services[1]	0.1	0.4	3.8	2.9	3.4	4.3	4.1	32.6

[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, Statistics Norway.

Private services

Production in private services as a whole rose by 3.9 per cent and value added by 3.7 per cent from 1997 to 1998. The highest growth was recorded for post and telecommunication services and business services (table 1.4). The most important service industry from an environmental perspective is the transport industry, which is discussed in a separate chapter (Chapter 3). The volume of production in domestic transport rose by 2.8 per cent from 1997 to 1998. The number of passengers who travelled from Norwegian airports in January-November 1998 was about 4.7 per cent above the level in the same period one year earlier. Domestic travel increased by 4.3 per cent, while the volume of charter traffic declined by the same margin. Total production in the air transport sector increased in volume by 2.4 per cent in 1998, but because of an increase in intermediate consumption, the value added for the industry fell by over 2 per cent measured at constant prices.

1.4. Households

Household consumption grew by 3.4 per cent in 1998, which is a slightly lower rate of growth than the average for the period 1993-1997. In these years, 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 1998, however, real disposable income increased by 3.8 per cent, i.e. the saving ratio increased by 0.5 percentage points, giving a saving ratio for 1998 of 6.8 per cent, almost as high as the level at the beginning of the cyclical upturn in 1993.

Table 1.5 shows changes in private consumption and household energy use in households for the years 1989 to 1998. In the period 1989-1992 energy use rose at a slower pace than consumption, as it did in the period 1993-1997 as a whole. In 1993-1996, both components showed approximately the same trend, but in 1997 energy use fell by just over 1 per cent due to high electricity prices and

Table 1.5. **Average annual growth in household consumption, energy use and waste. Periods 1989-1992, 1993-1997 and 1998*. Per cent**

	1989-1992	1993-1997	1998*
Household consumption	0.8	3.7	3.4
- Consumption of goods	0.6	4.0	3.9
- Services	1.9	3.1	2.6
- Direct purchases abroad by resident households	-4.1	5.1	2.8
Energy use in households, housing purposes	0.1	1.3	5.9
- Electricity	2.7	0.7	5.1
- Oil	-17.2	-2.1	8.1
- Other	-3.5	4.5	..
Petrol and diesel	1.4	-0.1	..
Household waste	3.8	4.5	..

Source: National accounts and Energy Statistics, Statistics Norway.

relatively warm weather. Shifts have taken place in the composition of the various energy carriers. The consumption of heating oil has declined substantially since 1989, from a 9 per cent share of total energy consumption in 1989 to only 4 per cent in 1997. 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, electricity as a share of total energy consumption in households increased in the period 1989-1992, while it declined slightly in the period 1993-1997. In 1989, electricity accounted for 72 per cent of total energy use in households. The use of other energy carriers in housing has remained relatively constant at just over 20 per cent throughout the period 1989-1997.

Energy consumption in households rose, according to preliminary figures, by about 6 per cent in 1998, partly due to lower mean temperatures and lower prices that year compared with 1997. The consumption of fuel and electricity in households rose by 8.1 and 5.1 per cent respectively. Electricity prices were reduced by 7.7 per cent, while fuel prices fell by 5.9 per cent.

The consumption of goods accounted for about 58 per cent of total household consumption in 1998, and showed a rise in volume of 3.9 per cent from 1997. The consumption of goods declined slightly in the first quarter of 1998, then increased in the two following quarters, and then declined sharply in the last quarter of the year. Household purchases of durables (furniture, electrical equipment, equipment for recreational activities and education) increased in volume by as much as 11.2 per cent in 1998. Factors underlying this vigorous growth are increased disposable income, relatively low interest rates in the first half of the year and the fact that prices for durables remained virtually unchanged. However, car purchases fell by 3.2 per cent in 1998. Purchases of both durables and private cars declined in the fourth quarter, and this is related to the rise in interest rates in the third quarter. It became more expensive to purchase these goods through borrowing, and the opportunity cost of these goods increased, i.e. saving in financial assets became more financially advantageous. At the same time, purchases of private cars and durables had risen sharply for some time, and it is possible that the need for these goods had reached a temporary peak.

The consumption of clothing and footwear showed a relatively high rate of growth in 1997, increasing by 8.4 per cent. Prices for clothing and footwear fell by just over 2 per cent, while the change in prices from 1997 to 1998 for total household consumption was 2.5 per cent. The higher consumption is an important factor underlying the increase in waste quantities from households, see also Chapter 5.

Household consumption of services accounted for about 42 per cent of total consumption in 1998, with a growth in volume of 2.6 per cent, a little less than in 1997. Growth was recorded in all categories of services, except railway and tram transport and clothing and shoe repairs. The sharpest growth was recorded in the use of post and telecommunication services, with a volume growth of 11 per cent. This growth may be attributable to lower prices for telecommunication services and increased access to modern computer and telecommunications equipment in the home. Consumption of services related to the operation of private means of transport rose by 5.9 per cent. These services include repair services and the growth in consumption of these services is related to the EEA roadworthiness test for cars, which was introduced on 1 January 1998.

1.5. Outlook for 1999 and 2000

The period of economic expansion in Norway that began in 1993 probably reached a turning point towards the end of 1998, and Statistics Norway expects a drop in domestic demand in 1999 due to a reduction in investment, a restrictive fiscal policy, high interest rates and a low rate of economic growth among our most important trading partners. A slower or declining growth in production will probably mean lower energy use and reduced emissions to air, depending on how the decline affects the various sectors of the economy. On the other hand, a period of economic contraction may prompt economic agents to place less emphasis on environmental considerations.

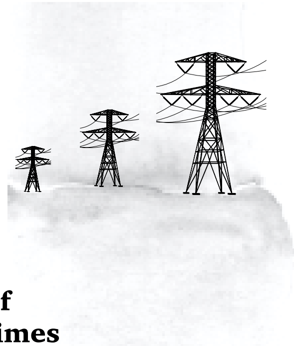
Real wage growth will remain high as we move into 1999 as a result of the wage carry-over, but in the long term a less tight labour market and lower profitability in manufacturing industry will give less room for wage increases. However, household real income will show a lower rate of growth in 1999 than in 1998, partly because of high rates of interest, and growth in consumption is expected to slow. This may result in a lower rate of growth in waste generated by households.

For petroleum activities, it is likely - based on the oil companies' own estimates - that petroleum investment will be substantially reduced in 1999 and in the years ahead. However, oil and gas production is expected to increase from 1998 to 1999 due to an increase in capacity.

Documentation: Statistics Norway (1999a).

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

2. Energy



Norway has large energy reserves, and extracts far larger quantities of energy commodities than are needed for domestic use. In 1998, extraction of energy commodities was between eight and 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 between 3 and 4 per cent of world production in 1998. This indicates that the rate of extraction is relatively high. Given the same rate of extraction and the estimated Norwegian petroleum resources, Norway's oil resources will be exhausted in 26 years and its gas resources in 127 years. Petroleum extraction accounted for 10 per cent of GDP and 29 per cent of export income in 1998, which was a marked reduction from the year before.

Norway has the largest hydropower resources in Europe, but the developed hydropower potential nevertheless only accounted for about 5 per cent of Norway's total energy extraction in 1998. Of the country's total hydropower potential, 63 per cent is developed and 20 per cent is protected. Net electricity consumption reached a record level in 1998, and for the past three years, Norway has been a net importer of electricity. Norway's per capita energy use is more than three times higher than the average for the world as a whole, and 15 per cent higher than the average for the OECD countries. The large proportion of energy-intensive manufacturing, the cold climate that necessitates the use of large amounts of energy for heating, and the scattered pattern of settlement are factors that contribute to this.

Energy use has a major environmental impact; for example, a large proportion of global air pollution is generated by petroleum combustion. Energy extraction and conversion also have major environmental effects.

2.1. Resource base and reserves

Crude oil and natural gas

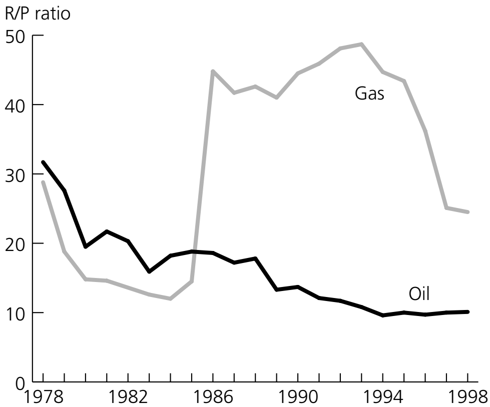
In the context of oil and gas activities, the Norwegian Petroleum Directorate distinguishes between *resources*, which include all more or less definitely proven deposits, and *reserves*, which are recoverable resources in fields that are already developed or where development has been approved. At the end of 1998, the remaining Norwegian reserves of crude oil totalled 1.81 billion standard cubic metres oil equivalents (Sm^3 o.e.), and corre-

Table 2.1. **World reserves[1] of oil and gas as of 1 January 1999**

	Oil		Gas	
	Billion Sm^3 o.e.	Per-centage	Billion Sm^3 o.e.	Per-centage
World	164.6	100.0	145.7	100.0
North America	4.4	2.7	6.5	4.5
Latin America	21.8	13.3	8.0	5.5
Western Europe (incl. Norway)	3.0	1.8	4.5	3.1
Eastern Europe	9.4	5.7	56.7	38.9
Middle East	107.1	65.1	49.5	34.0
Africa	12.0	7.3	10.2	7.0
Asia and Australasia	6.8	4.2	10.2	7.0
OPEC	127.3	77.3	62.5	42.9
Norway	1.8	1.1	1.2	0.8

[1] For Norway, proven reserves means resources in fields that are already developed or where development has been approved. Otherwise the definition may vary somewhat from country to country.
Sources: Oil & Gas Journal (1998) and Norwegian Petroleum Directorate (figures for Norway).

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



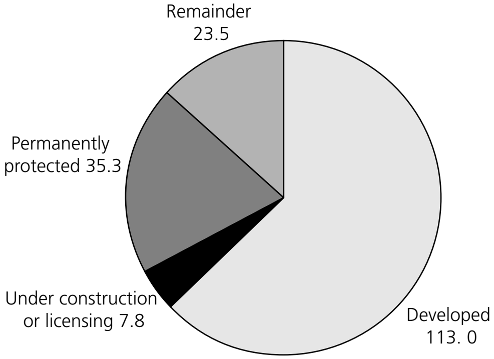
Sources: Energy Statistics, Statistics Norway and Norwegian Petroleum Directorate.

sponded 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. 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 total remaining Norwegian petroleum resources are 4.6 billion Sm^3 o.e. crude oil (including wet gas) and 6.1 billion Sm^3 o.e. natural gas. Of this, 39 and 19 per cent respectively are defined as reserves (see above), and 41 and 46 per cent respectively are uncertain 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, the total calculated crude oil resources on the Norwegian continental shelf will be exhausted after 26 years, and the natural gas resources after 127 years. If only reserves are included, i.e. the remaining resources in fields that are already developed or where development has been approved, the corresponding figures are 10 years for oil and 25 years for gas. The ratio between reserves and annual production (the R/P ratio) will change with time, depending on the rate of extraction, prices, the discovery of new fields and technological developments. Historical trends in 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.

Norway's proven oil reserves are larger than those of any other European country except Russia (as of 1 January 1999). Russia also has the world's largest gas reserves, a third of the total, and the Netherlands and Norway have the largest

Figure 2.2. **Hydropower potential as of 1 January 1999, in TWh per year**



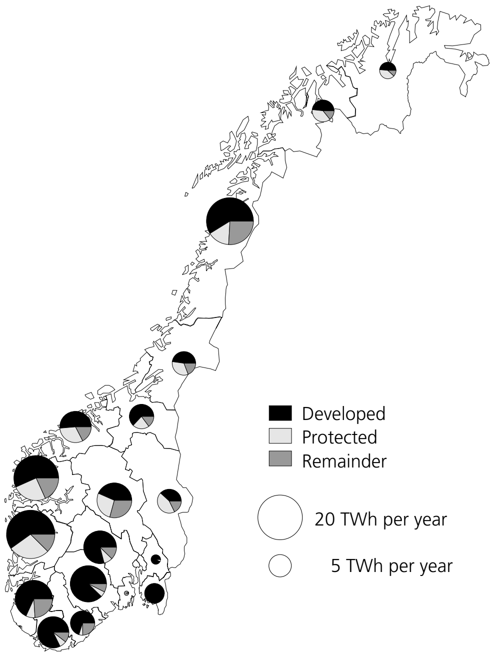
Source: Norwegian Water Resources and Energy Administration

reserves otherwise in Europe. In Western Europe, 58 per cent of the oil reserves and 26 per cent of the gas reserves are on the Norwegian continental shelf, according to figures from the Oil & Gas Journal. For the world as a whole, 77 per cent of the oil reserves and 43 per cent of the gas reserves are within the OPEC area, and 65 per cent of the oil reserves and 34 per cent of the gas reserves are in the Middle East. At the end of 1998, 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 1999, Norway's economically exploitable hydropower resources totalled 179.6 TWh (expressed as mean annual production capability, i.e. the production capacity of the power stations in a year with normal precipitation). 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 1999, 113.0 TWh was developed

Figure 2.3. **Norway's hydropower reserves by county as of 1 January 1999, in TWh per year**



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

and 35.3 TWh permanently protected, and this corresponds to 63 and 20 per cent respectively of Norway's total hydropower potential (figure 2.2). Developed hydropower potential accounted for about 5.4 per cent of total energy extraction in Norway in 1998. The counties Telemark, Hordaland, Sogn og Fjordane and Nordland account for 46 per cent of Norway's developed resources. Nordland has 19 per cent of the country's remaining production capacity that is neither developed nor protected, Oppland and Sogn og Fjordane have 12 per cent each, and 10 per cent is in Hordaland. In counties such as Østfold, Akershus and Oslo, the entire hydropower potential is either developed or protected (figure 2.3).

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/tonne	..	0.80	0.10	0.60
Coal coke	28.5 GJ/tonne	..	0.80	-	0.60
Petrol coke	35.0 GJ/tonne	..	0.80	-	-
Crude oil	42.3 GJ/tonne = 36.0 GJ/m^3	0.85 tonnes/m^3	..	..	..
Refinery gas	48.6 GJ/tonne	..	0.95	..	0.95
Natural gas (1998)[2]	40.5 GJ/1000 Sm^3	0.85 kg/Sm^3	0.95	..	0.95
Liquefied propane and butane (LPG)	46.1 GJ/tonne = 24.4 GJ/m^3	0.53 tonnes/m^3	0.95	..	0.95
Fuel gas	50.0 GJ/tonne	..	..	..	..
Petrol	43.9 GJ/tonne = 32.5 GJ/m^3	0.74 tonnes/m^3	0.20	0.20	0.20
Kerosene	43.1 GJ/tonne = 34.9 GJ/m^3	0.81 tonnes/m^3	0.80	0.30	0.75
Diesel, gas and light fuel oil	43.1 GJ/tonne = 36.2 GJ/m^3	0.84 tonnes/m^3	0.80	0.30	0.70
Heavy distillate	43.1 GJ/tonne = 36.2 GJ/m^3	0.88 tonnes/m^3	0.80	0.30	0.70
Heavy fuel oil	40.6 GJ/tonne = 39.8 GJ/m^3	0.98 tonnes/m^3	0.90	0.30	0.75
Methane	50.2 GJ/tonne	..	..	..	..
Wood	16.8 GJ/tonne = 8.4 GJ/solid m^3	0.5 tonnes/m^3	0.65	-	0.65
Wood waste (dry weight)	16.8 GJ/tonne	..	..	..	..
Black liquor (dry weight)	14.0 GJ/tonne	..	..	..	..
Waste	10.5 GJ/tonne	..	..	..	..
Electricity	3.6 GJ/MWh	..	1.00	1.00	1.00
Uranium	430-688 TJ/tonne	..	..	..	..

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

Energy units

	PJ	TWh	Mtoe	Mbarrels	MSm^3 o.e. oil	MSm^3 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	0.089	0.0034
1 Mtoe	42.3	11.75	1	7.49	1.18	1.044	0.040
1 Mbarrel	5.65	1.57	0.13	1	0.16	0.14	0.0054
1 MSm^3 o.e. oil	36.0	10.0	0.9	6.4	1	0.89	0.034
1 MSm^3 o.e. gas	40.5	11.3	1.0	7.2	1.13	1	0.038
1 quad	1053	292.5	24.9	186.4	29.29	26.00	1

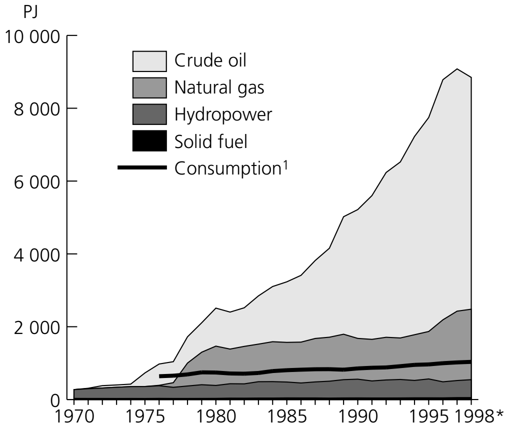
1 Mtoe = 1 mill. (crude) oil equivalents
1 Mbarrel = 1 mill. barrels crude oil (1 barrel = 0.159 m^3)
1 MSm^3 o.e. oil = 1 mill. Sm^3 oil
1 MSm^3 o.e. gas = 1 mrd. Sm^3 natural gas
1 quad = 10^{15} Btu (British thermal units)

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

Section 2.6, which deals with the economic objectives and results of the new Energy Act, states that investments in the power sector were reduced by 17 per cent from 1991 to 1997. One of the reasons for introducing the 1990 Energy Act was that the way the electricity market was organized led to large efficiency losses; for example, investments in electricity production were very high. An increase in the transmission capacity between Norway and other countries and the fact that the most profitable and least controversial projects have already been carried out have also contributed to the reduction in hydropower developments. A committee appointed by the Government has evaluated the energy and power balance towards the year 2020. Analyses by Statistics Norway in this connection have shown that implementation of the Kyoto Protocol or adaptation to even stricter emission targets will have consequences both for electricity consumption and for hydropower developments, and for whether gas-based power production will be profitable, see section 2.5.

Coal

At the end of 1998, Norway's coal resources on Svalbard were about 63 million tonnes, defined partly as certain and partly as probable deposits. At the end of 1998, 36 per cent of the resources were classified as proven. Store Norske Spitsbergen Kulkompani estimates the marketable quantity of coal, i.e. the quantity that is assumed to be marketable at some point in the future, to be 25.2 million tonnes at the end of 1998, in other words only 40 per cent of the coal resources. At the 1998 rate of extraction, the estimated quantity of coal for sale will last for 62 years. At the end of 1997, the world's exploitable coal resources were 1 032 billion tonnes (BP 1998). At the current rate of extraction, they will last for 219 years. The largest resources are found in the former Soviet Union, the USA and China.

2.2. Extraction and production

Total extraction of energy commodities in Norway dropped by 2.6 per cent from 1997 to 1998 as a result of a 4 per cent reduction in crude oil extraction. This is the first time since 1981 that there has been a drop in energy extraction between two consecutive years. Since 1976, however, energy extraction has risen by an average of 10.5 per cent per year as a result of the growth in oil and gas extraction in the North Sea (figure 2.4). Total consumption of energy commodities has only risen by 2.3 per cent per year in the same period. If we compare total extraction with total consumption, we can see that the net export potential (the part of the diagram above the consumption line)

Table 2.2. **World production of crude oil and natural gas in 1998***

	Oil		Gas	
	Million Sm^3 o.e.	Per cent	Million Sm^3 o.e.	Per cent
World	3 842.5	100.0	2 340.2	100.0
OPEC	1 611.7	41.9	285.8	12.2
North America	485.1	12.6	752.2	32.1
Latin America	549.4	14.3	130.4	5.6
Western Europe	362.5	9.4	266.7	11.4
Western Europe	424.3	11.0	732.6	31.3
Middle East	1 216.4	31.7	140.6	6.0
Africa	396.7	10.3	85.2	3.6
Asia and Australasia	408.2	10.6	232.5	9.9
Saudi-Arabia	480.8	12.5	35.5	1.5
Former Soviet Union	411.7	10.7	700.3	29.9
USA	368.2	9.6	564.0	24.1
Iran	209.4	5.4	33.9	1.4
China	185.7	4.8	21.7	0.9
Venezuela	181.2	4.7	27.3	1.2
Mexico	178.2	4.6	49.7	2.1
Norway[1]	175.0	4.6	43.5	1.9
United Kingdom	152.7	4.0	95.9	4.1
Canada	116.9	3.0	188.3	8.0
Indonesia	75.4	2.0	67.9	2.9
Algeria	47.8	1.2	58.5	2.5
Netherlands	3.2	0.1	73.9	3.2

[1] Figures for Norway differ from newer figures from the Norwegian Petroleum Directorate that are used elsewhere in this chapter.
Source: Oil & Gas Journal (1999).

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

Source: National Accounts, Statistics Norway.

has risen dramatically since 1976. In 1997, extraction of primary energy commodities was 8.9 times higher than consumption. In 1998, this ratio dropped to 8.6 as a result of the drop in extraction and a rise in consumption. About 90 per cent of the energy extracted in 1998 was exported.

Crude oil and natural gas

Even though the value of oil and gas extraction dropped by as much as 36 per cent from 1997 to 1998, this is still Norway's most important industry measured in terms of export revenue and value added (proportion of GDP). In 1998, exports of crude oil and natural gas dropped by NOK 43 billion from the year before, and totalled NOK 120 billion, or 29 per cent of the country's total exports (figure 2.5). The industry accounted for 9.7 per cent of GDP, but only about 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 on the Norwegian continental shelf totalled 222.5 million Sm^3 o.e. in 1998, a drop of 2.9 per cent from 1997. Net production of natural gas rose by 2.3 per cent to 43.6 million Sm^3 o.e. This was almost 2 per cent of total world gas production in 1998 (see table 2.2). Production of NGL[1] and condensate dropped by

[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).

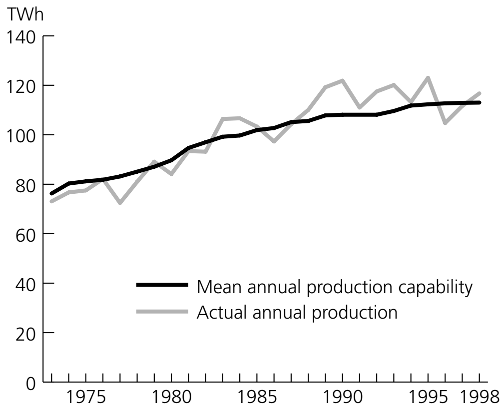
4.1 per cent. Oil production (excluding NGL and condensate) was 168.9 million Sm^3 o.e. in 1998, or 2.91 million barrels per day, as compared with 3.02 million barrels per day in 1997. Norway's crude oil production accounted for just over 4 per cent of world production in 1998 (table 2.2).

Oil production including NGL and condensate was 178.8 million Sm^3 o.e. in 1998, which is about 20 per cent below the figure used in the national budget for 1998. One reason is that in April 1998, production was reduced by 100 000 barrels per day, or about 5.8 million Sm^3 per year. In addition, the final date for production start on some fields was delayed, and several fields produced less as a result of technical problems and maintenance.

Production on most fields, especially the large ones, was lower in 1998 than in 1997. Overall production on the four largest fields (Oseberg, Gullfaks, Statfjord and Ekofisk), which accounted for almost half of total oil production on the continental shelf, was reduced by 12.1 per cent.

Gas production rose relatively less in 1998 than in the four preceding years. There were only five gas fields where production rose from 1997 to 1998, including the two largest gas-producing fields on the continental shelf, Troll East and Sleipner. Production on Troll East rose by 39.4 per cent, and it produced more than twice as much as Sleipner, the next largest gas producer, in 1998. These two fields together produced 25.2 million Sm^3 o.e., and accounted for 65.6 per cent of gas production on the Norwegian continental shelf.

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



Source: Norwegian Water Resources and Energy Administration.

Electricity

Electricity production in Norway in 1998 totalled 116.7 TWh, which was 4.6 per cent higher than the year before, see figure 2.6 and table A6 in the Appendix. This was partly a result of a high degree of filling of the reservoirs and a rise in demand. Production in 1998 was about 3 TWh more than the estimated mean annual production capability, which is the level of production expected in a year when inflow to the reservoirs is normal and reservoir capacity is fixed (figure 2.6). As a result of high inflow to the reservoirs from precipitation and melting snow in the mountains, the degree of filling was higher than normal for most of 1998. Despite this, there was a small import surplus in all months in 1998 except August-October. This was explained by low prices and net electricity consumption of more than 110 TWh, which was a record level (Appendix, table A6). The spot prices of electricity were very low in the summer months, which meant that some producers met their contractual obligations by means of imports, buying electricity on the power exchange instead of producing it themselves. The energy utilities expected spot prices to rise during the autumn and winter, and therefore stored up water reserves. Net imports of electricity totalled 3.6 TWh, about 5 per cent less than the year before. 1998 was the third year running that Norway was a net importer of electricity. In the whole period 1960-1995, Norway was only a net importer of electricity in 1960, 1977 and 1986.

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 1998 totalled somewhat more than 400 000 tonnes according to preliminary figures, which corresponds to about 11.5 PJ. Production in the past two years has been substantially higher than in preceding years as a result of the re-opening of the Svea mine. Of total sales in 1997, 25 per cent was used for energy purposes in Finland and on Svalbard, and a small amount (3 500 tonnes) for residential heating in North Norway. The remaining 75 per cent was used for industrial purposes (particularly cement manufacturing) in Norway, the UK and Germany. World coal production in 1997 was almost 4.7 billion tonnes (OECD 1998c), which converted to energy units is about 98 000 PJ (BP 1998). Total production consisted of 80 per cent hard coal and 20 per cent brown coal. Brown coal accounted for almost 80 per cent of production in Germany, which is the world's largest producer. World coal production has changed relatively little in the last few years, but was 25 per cent higher in 1997 than in 1980, and more than 60 per cent higher than in 1973. Most of the rise has taken place outside the OECD area, particularly in China, although production has also risen in the USA during this period. In Europe, production has generally dropped. The largest producers in 1997 were China and the USA, which accounted for 30 and 25 per cent of the total respectively, converted to energy units. 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

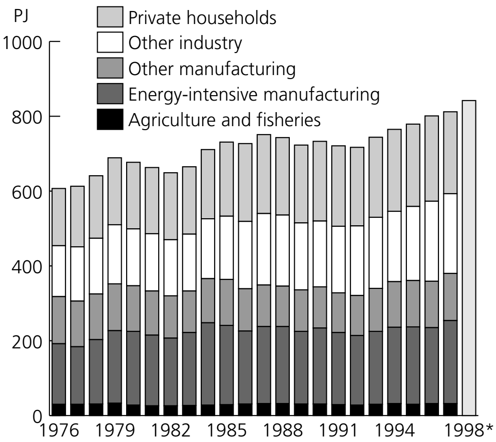
Wood, wood waste and black liquor (waste from chemical pulp production) are the most important biofuels in Norway. Production of these fuels, including production for own use, is more than 40 PJ per year. This is equivalent to about 10 per cent of energy production from hydropower. The figure is uncertain because the data are incomplete. In 1997, energy equivalent to about 4.7 PJ was generated for district heating by waste incineration, and about 90 per cent of this may be classified as bioenergy. Methane emissions from landfills totalled 189 000 tonnes (preliminary figures) in 1998, corresponding to an energy content of about 10 PJ. In recent years, more and more of this gas has been used for energy purposes or flared. In 1998, 22 800 tonnes (1.1 PJ) was extracted for these purposes, and an estimated 30 per cent was used for energy purposes.

2.3. Energy use

In 1998, Norway's total energy use (excluding international maritime transport), was 1 038 PJ. Energy use in the energy sectors accounted for 18 per cent of this.

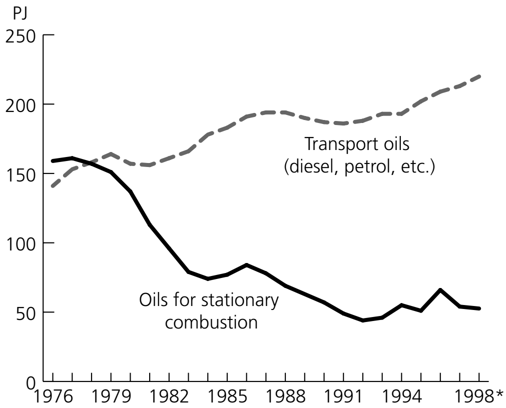
Consumption of energy commodities, excluding the energy sectors and interna-

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



Source: Energy Statistics, Statistics Norway.

Figure 2.8. **Consumption of oil products**



Source: Energy Statistics, Statistics Norway.

tional maritime transport, totalled 813 PJ in 1997 and 846 PJ in 1998 (preliminary figures), which gives a rise of 4 per cent (figure 2.7 and Appendix, table A4). Energy use rose by an average of 1.4 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

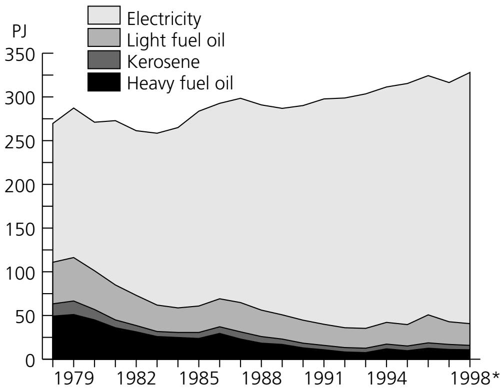
Net energy use in the energy sectors (hydropower production, oil and gas extraction, oil refineries, etc.) dropped from 207 PJ in 1997 to 192 PJ in 1998 (preliminary figures). The use of natural gas in the extraction of crude oil and natural gas, which accounts for a large proportion of this, dropped from 153 PJ in 1997 to 148 PJ in 1998 (see Appendix, table A5). This is a decrease of 7.2 per cent, after an average rise of almost 9 per cent per year from 1976 to 1997. Most of the gas is used for energy purposes, In 1998, 13 per cent was flared. Particularly large amounts of energy are needed to generate power on oil platforms, because the efficiency of this process is very low. The drop in energy use in 1998 is related to lower oil production and a smaller rise in gas production than in earlier years (see the section on crude oil and natural gas). Even though energy use in oil and gas extraction is now much higher than in the 1970s, the amount of energy used per unit of crude oil and natural gas produced has been reduced in the same period.

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 the energy sectors and international maritime transport, dropped by about 9 per cent from 1976 to 1998, despite the fact that oil consumption for transport rose by 56 per cent, or 2.0 per cent per year, in the same period (figure 2.8 and Appendix, table A4). Transport now accounts for 81

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



Sources: Statistics Norway (Energy Statistics) and Norwegian Petroleum Institute.

per cent of total oil consumption, as compared with 47 per cent in 1976. Goods and passenger transport have risen by an average of 1.2 and 2.3 per cent per year, respectively, since 1976. 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 2.7 per cent from 1997 to 1998 (preliminary figures). Sales of heating kerosene, light fuel oil and heavy fuel oil also fell by 8, 5 and 4 per cent respectively from 1997 (figure 2.9), even though 1998 was a rather colder year. This is probably explained by the fact that electricity prices dropped somewhat more than oil prices (see also section 2.4).

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

Electricity consumption

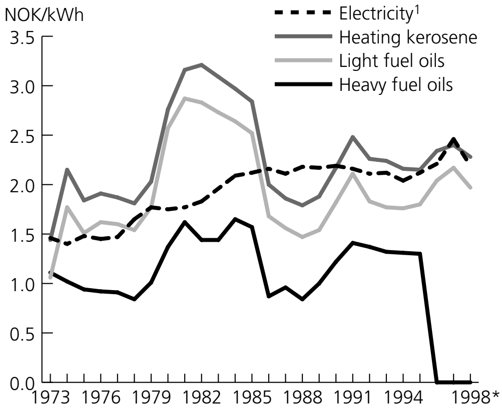
Net consumption of electricity was 110.4 TWh in 1998, which is the highest level ever recorded and more than 5 TWh more than the year before. Both general consumption and consumption in energy-intensive manufacturing rose by about 5 per cent, to 75 and 30.5 TWh respectively. The rise in consumption by energy-intensive manufacturing can be explained by growth in production. The rise in general consumption is explained partly by somewhat colder weather in 1998 than in 1997. Nevertheless, general consumption corrected for temperature rose by almost 4 per cent. This is linked to the rise in purchasing power, which resulted in a larger demand for goods and services, and thus a need for more electricity in manufacturing and service sectors. More use of electrical equipment and a steady rise in the average size of dwellings also contribute to the rise in electricity consumption. Moreover, electricity prices dropped from 1997 to 1998, partly because of stiffer competition in the power market and high precipitation. Analyses of energy use in households are described in section 2.7. Section 2.8 describes an analysis of electricity consumption in energy-intensive manufacturing, including projections of electricity consumption in the aluminium industry.

Since 1988, hydropower production in Norway has risen by an average of 0.1 per cent per year, and net domestic electricity consumption has risen by 1.0 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. They are advantageous to Norway as well, since the need for investments to ensure that the demand for power is met in dry years is reduced and export opportunities after periods when precipitation is high are improved.

World energy use

In 1996, Norway accounted for 0.24 per cent of total world energy use, defined as the total primary energy supply (production of primary energy carriers adjusted for imports, exports, changes in stocks and international maritime transport). The OECD countries together accounted for 53 per cent of this (Appendix, table A8). Per capita energy use in Norway was 15 per cent higher than the average for the OECD countries and more than three times the world average. This is explained by the high proportion of energy-intensive manufacturing industries, the cold climate which means that a great deal of energy is needed for heating, and the scattered pattern of settlement, which leads to a high volume of transport. Of the Nordic countries, only Denmark has lower per capita energy use than Norway. In the world as a whole, per capita energy use is highest in Iceland, followed by the USA and Canada. Per capita energy use in OECD member countries is almost five times higher than in the rest of the world. Energy intensity in Norway, measured as energy used per unit of GDP, is now somewhat more than 60 per cent of the average for the OECD countries. However, if these figures are adjusted for local purchasing power, the figure for Norway is about 85 per cent of the OECD average.

Figure 2.10. **Prices of fuel oils and electricity[1] for heating (as utilized energy), in fixed 1980 prices including all taxes and tariffs**



[1] Electricity prices for 1997 and 1998 are as of 1 January and 23 February respectively; for earlier years, the average price for the whole year is given.
Sources: Energy Statistics, Statistics Norway, Norwegian Water Resources and Energy Administration, Norwegian Competition Authority and Norwegian Petroleum Institute.

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

2.4. Energy prices

Electricity

As of 4 January 1999, the average electricity price for households including taxes (but excluding the charge for use of the grid) was NOK 0.282 per kWh, 8 per cent lower than at the same time the previous year, and 24 per cent lower than on 1 January 1997. Electricity prices to households fluctuated a good deal in 1998, and the price was generally lower than the year before. Prices were lowest during the summer and autumn, when the degree of filling of the reservoirs was high and spot prices were low. However, many large suppliers raised electricity prices on 1 January 1999. This may be because the degree of filling of the reservoirs was lower than normal and spot prices had risen. The consumer tax on electricity, excluding VAT, was also raised at the beginning of 1999. Early in 1999, it was NOK 0.0594 per kWh, whereas in 1998 it was NOK 0.0575 per kWh.

More and more households are now making use of the opportunity to change supplier. At the beginning of October 1998, 90 650 households were using a supplier other than the local electricity utility. This corresponds to about 4.5 per cent of all households in Norway. In October 1997, the corresponding figure was 1.4 per cent.

The use of spot power for electric boilers accounted for 4.9 TWh in 1998, about 5 per cent more than the year before. Many people probably changed from oil to electricity because both spot prices and contract prices for electricity were reduced from 1997, and because spot prices for electricity dropped slightly more than oil prices in relative terms. Weighted by quantity, the price of spot power, excluding VAT and the charge for use of the grid, was on average NOK 0.121 per kWh in 1998, about 11 per cent lower than the year before. The spot price was particularly low in July and August, when it averaged NOK 0.069 and 0.054 per kWh, respectively. In August the spot price dropped to its lowest level, NOK 0.02 per kWh.

Fuel oils

Measured as utilized energy (i.e. corrected for efficiency), the listed prices of light fuel oil and heating kerosene were NOK 0.49 and 0.567 per kWh (including VAT) in 1998, which is 7 and 3 per cent respectively lower than the year before. However, listed prices are not entirely representative, because discounts of 4 per cent or more are commonly offered, but they indicate price changes from one year to another. Figure 2.10 shows trends in the price of utilized energy in fixed 1980 prices from 1973 to 1998. Table A7 in the Appendix shows the prices of heating products measured as energy *supplied*.

2.5. Energy and power balance up to the year 2020

In April 1997, the Government appointed a committee to evaluate the energy and power balance up to the year 2020. The committee submitted its report in summer 1998 (NOU 1998:11). In connection with this, Statistics Norway was commissioned by the committee to use its economic models to describe scenarios for the energy and power balance up to the year 2020. Differing estimates of economic growth and the possible obligations resulting from the Kyoto Protocol (see Chapter 4) made it necessary to construct several scenarios. A general equilibrium model for the Norwegian economy, MSG-6, was used to calculate trends in electricity consumption. Electricity production, trade in electricity trade and electricity prices in the Nordic power market were calculated using the model NORMOD-T. The models were coordinated so that these parameters were consistent for the whole period.

Bye et al. (1998) discuss expected trends in Norwegian energy use, electricity production and trade, electricity prices and emissions of greenhouse gases up to the year 2020, given different forms of adaptation to the Kyoto Protocol. In a reference scenario in which the Kyoto

Protocol is not put into effect, energy use for stationary purposes rises sharply from 1996 to 2020 (38 TWh). This increase is met by gas-based electricity production (24 TWh) and an increase in hydropower production (18 TWh), so that in a year when inflow to the reservoirs is normal, net trade in electricity is approximately zero. The total costs of new gas-fired power plants, which are estimated to be just over NOK 0.20 per kWh measured in current monetary value, determine the producer price. Total Norwegian greenhouse gas emissions rise by 23 per cent compared with the 1990 level.

If the Kyoto Protocol is implemented, we assume that the international permit price will be about NOK 200 per tonne CO_2 (cf. Chapter 4.6). When permit prices are introduced in Norway, emissions of CO_2 will be lower than in the reference scenario. However, the reduction will not be sufficient to fulfil Norway's commitment under the Kyoto Protocol. It will be necessary to buy CO_2 permits totalling in the order of 6-7 million tonnes CO_2, depending on whether or not industry is exempted, costing about NOK 1.2 - 1.4 billion per year. The electricity price will be about NOK 0.26 per kWh. This means that gas-based electricity production will become unprofitable in Norway, given that gas-fired power plants are also required to pay the CO_2 tax and there are no "zero CO_2" gas-fired power plants. There will be greater expansion of hydropower capacity and a good deal of development of wind power and biofuel-based electricity generation.

The Kyoto Protocol is probably the first step towards stricter international restrictions on greenhouse gas emissions. We have therefore also calculated the effects of a CO_2 tax (or permit price) of NOK 400 per tonne CO_2. This is assumed to be sufficient to achieve a 15 per cent reduction in greenhouse gas emissions internationally in addition to what is required by the Kyoto Protocol. Norwegian emissions will be further reduced, but proportionally less than they are by a tax of NOK 200 per tonne CO_2. This means that Norway will have to buy permits for about 12 million tonnes CO_2, costing about NOK 5 billion per year. In this scenario, the price of electricity is about NOK 0.29 per kWh. Hydropower production rises somewhat, while electricity consumption drops. There is a rise in net electricity exports.

There is a good deal of uncertainty associated with technological advances in the years ahead. If they proceed more rapidly than assumed in the calculations described above, energy use per unit manufactured will decrease, while the level of socio-economic activity, and thus energy use, will rise. The analysis shows that more rapid technological developments will result in higher energy use, which is the opposite of what many people expect.

In some of the calculations, stationary energy use was held stable at the 1996 level. If we also assume that energy-intensive manufacturing industries are to be exempt from the policy instruments, this goal requires extensive use of instruments in other sectors of society. If the electricity tax is raised, the calculations suggest that a level of about NOK 0.65 per kWh is required to stabilize stationary energy use. This is eleven times the current tax level.

Holmøy et al. (1998) discuss how Norwegian electricity consumption would be affected by a rise in the reference price of electricity. The reference price is the price of electricity including the cost of transport to a central point in the grid, but excluding taxes and distribution costs. According to the model MSG-6, a one per cent rise in the reference price results in a decrease of 0.3 per cent in Norwegian electricity demand. A drop in use by private-sector mainland industries accounts for 87 per cent of this, and lower electricity consumption in households for the rest. There is no reduction in consumption in the public sector or in offshore industry. In private-sector mainland industries, 74 per cent of the drop in electricity consumption is explained by changes in the use of factor inputs, and 26 per cent by changes in industrial structure. Metal manufacturing accounts for more than half of the reduction in electricity consumption in mainland industries.

Aasness (1998) focuses on distributional effects of electricity taxes. The main conclusion is that the current system, with a proportional electricity tax and VAT on electricity, is most favourable for wealthy households, since poor households generally use a larger proportion of their income on electricity than wealthier households (cf. section 2.7 on residential energy use). A progressive electricity tax can alter these distributional effects to some extent. The analysis describes two alternatives for a progressive electricity tax: a higher tax rate per kWh when electricity consumption per household exceeds a certain level, and a higher tax when per capita consumption exceeds a certain level. The latter is most favourable for poor households. However, if a progressive tax is used, the highest tax rate applies to only small amounts of electricity. A progressive tax thus has little effect on total electricity consumption in households.

Project financed by: Ministry of Petroleum and Energy.

Project documentation: Bye, Johnsen, Aune and Hansen (1998), Holmøy, Olsen and Strøm (1998) and Aasness (1998).

2.6. The 1990 Energy Act: economic objectives and results

The Norwegian electricity sector has been regulated and dominated by the public sector for about 90 years, partly to safeguard Norwegian ownership rights to natural resources at the beginning of the century and partly due to uncertainty concerning investments in capital-intensive power development projects just after the Second World War. The new Energy Act (which came into force on 1 January 1991) altered the legislative and economic framework for the power sector, and parts of the sector were exposed to competition. There were two main reasons for this change:

1) Statutory provisions governing the power sector were not consolidated, but scattered in various Acts and regulations, making it difficult to have an overview. It was also difficult to use the existing legislation for future regulation of the energy sector.

2) Several studies had shown large efficiency losses as a result of the way the electricity market was organized. Firstly, investments in power production were too high, resulting in overcapacity and a lower rate of return in the sector than would have been the case given an optimal rate of development. Normally, the power sector should yield an economic rent, i.e. profits exceeding normal returns to capital. In fact, the rate of return in the sector was less than the normal rate of 7 per cent. In other words, the power sector

yielded no economic rent in the period 1978-1988 (Bye and Johnsen 1991). Secondly, the supply of network services, i.e. transmission and distribution services, was inefficient because the network tariffs, or the prices of these services, were too high. This was mainly caused by investments in the grid that were not cost-effective (Kittelsen 1994). Thirdly, the large differences in electricity prices to different groups of consumers resulted in a potential loss of efficiency in the market. This is because in the optimal case, all consumers should pay the same price (Bye and Johnsen 1991 and Bye and Strøm 1987). The total calculated loss of efficiency in the electricity market, electricity generation, transmission and distribution amounted to NOK 15-20 billion per year, or approximately 8-10 per cent of the total fixed assets in the electricity sector in 1991. This was an important underlying reason for the desire to deregulate the power market and introduce more competition.

Objectives of the Energy Act

An important objective of the Energy Act was to improve the efficiency of the energy market and thereby improve the utilization of the developed hydropower resources. One aim was therefore to allow the market to bring about a narrowing of price differentials between customer groups, even though energy-intensive manufacturing was still kept outside the market. A division was introduced between those parts of production that can function in a market (power generation) and those parts that are natural monopolies (network services), in addition to a licensing requirement for those engaged in monopoly activities. Another objective was to provide a framework for more cost-effective development of power plants. This is being done by ranking projects according to rising costs and by choosing solutions that reflect market demand for energy and capacity. A third objective was to reorganize the sector by merging both energy utilities and distribution utilities to make operations more cost-effective. Finally, Statkraft (the Norwegian Energy Corporation) was to be reorganized by separating network services and electricity production in order to promote deregulation and competition.

Results of the Energy Act

The introduction of the new Energy Act seems basically to have had the intended effects[2], even though this has taken somewhat longer than expected due to rigidities in the initial phase. Investments in the power sector have been reduced by 17 per cent from 1991 to 1997, and the rise in mean annual production capability (i.e. the production capacity in a year with normal temperature and precipitation) has almost stopped. The return in the power sector has also dropped because greater competition has resulted in lower prices, and this has also helped to restrain investments. However, it may take many years before it is possible to achieve the economic rent which this sector should yield, because of substantial over-expansion, not only in Norway, but also in other northern European countries. Some mergers of utilities have already taken place, and this trend will probably intensify. Network charges have also been reduced considerably, so that much of the efficiency potential that existed has probably been realized. However, technological advances, mergers,

[2] However, other factors may also have influenced developments: for example, the 1984 Master Plan for Water Resources, the protection plans for water resources and a reduction in the resources available. See Bye and Halvorsen (1998) for a more detailed discussion.

etc., will continue to take place, and may increase the efficiency the potential in the future. Furthermore, the variation in electricity prices between manufacturing sectors has been reduced somewhat, whereas the differences between manufacturing, services and household customers have widened. This is partly because the electricity utilities introduced relatively high fees for households who wished to change supplier, and because contracts with energy-intensive manufacturing industry were still excluded. New rules and regulations are still being introduced, such as the requirement for a separation of power supplies and network services, and appear to be resulting in considerable changes. It is therefore important to continue to follow developments in this sector.

Project financed by: Statistics Norway.

Project documentation: Bye and Halvorsen (1998).

2.7. Residential energy use

Energy use for stationary purposes in Norwegian households is rising steadily, partly because of economic growth and developments in household consumption that lead to a rise in the demand for energy. For example, the proportion of households that have electrical appliances such as dishwashers and tumble dryers has risen considerably in the last twenty years. Political signals have been sent indicating that the rise in energy use should be moderated, and that it may be appropriate to raise taxes on energy use. The question is what effect higher taxes would have on energy use.

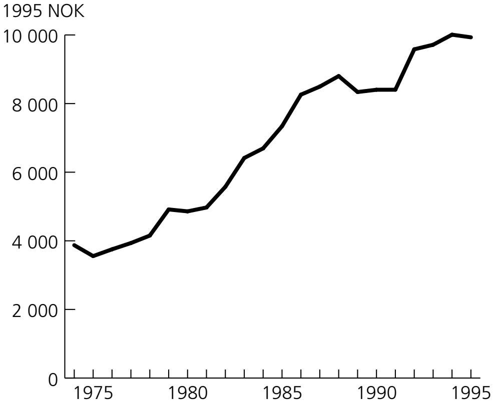
The demand for various forms of energy for stationary purposes in Norwegian households is being studied in the project "Flexible residential energy use". Using data from a sample of households, we are trying to find out more about the mechanisms that are important for long- and short-term energy demand by households. We are focusing particularly on the flexibility of energy demand, i.e. the extent to which consumption can be adapted to factors such as price changes, and how far one form of energy can be replaced by another. In studies of flexibility, it is important to take into account the fact that households are not a homogeneous group, but have widely varying physical and socio-economic characteristics. It is therefore reasonable to assume that households will exhibit variations in behaviour as regards energy demand. Furthermore, energy is used as a means of obtaining services such as heat, cooling, freezing and lighting. It is important to take these factors into account in studies of the adaptation of households to energy markets over time.

The work done so far in the project includes processing and quality control of data and two econometric analyses. One of these focuses on electricity consumption over time, taking into account purchases of electrical appliances. The other deals with choice of heating equipment by households and what determines total energy use once heating equipment has been purchased. Data collection and processing and the two analyses are described below.

Data for econometric analyses from the surveys of consumer expenditure 1974-1995

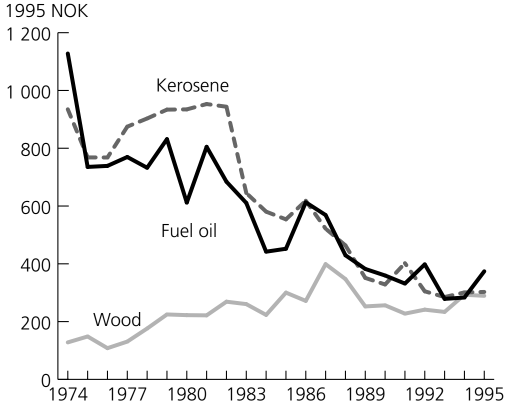
Databases have been established, based largely on data from the surveys of consumer expenditure, which contain information on 1 200 households per year for a period of 22 years starting in 1974. This

Figure 2.11. **Average expenditure on electricity per household in surveys of consumer expenditure 1974-1995**



Sources: Surveys of consumer expenditure and consumer price index, Statistics Norway.

Figure 2.12. **Average expenditure on fuel oil, kerosene and wood per household in surveys of consumer expenditure 1974-1995**



Sources: Surveys of consumer expenditure and consumer price index, Statistics Norway.

means that for a large number of variables, we have data for about 25 000 households. The purpose of the databases is to enable us to carry out econometric analyses of household energy demand based on choices by individual households. The material is comprehensive, and provides a sound basis for an insight into energy use in households. Below, we present annual averages for the households in the sample, most of which are replaced each year. The results have not been corrected for non-response and other biases, as they are in Official Statistics of Norway (see e.g. Statistics Norway 1996). Halvorsen et al. (1999) describe the data in more detail.

Figures 2.11 and 2.12 show changes in household expenditure (measured in 1995 NOK) on electricity, oil and wood in the samples of households used in the surveys of consumer expenditure. Average expenditure on electricity has risen from about NOK 4 000 per household in 1974 to about NOK 10 000 in 1995.

Expenditure on electricity as a proportion of gross household income has also risen, from 1.8 per cent in 1974 to 2.7 per cent in 1995. Average expenditure on fuel oil, kerosene and wood per household in the sample, measured in fixed prices, has fluctuated quite widely in the past 20 years, but has shown a downward trend. Expenditure on fuel oil, kerosene and wood accounted for about 1 per cent of average gross household income in the sample in 1974, and 0.3 per cent in 1995. Figure 2.12 also shows that expenditure on wood has risen in the period 1975-1995, while expenditure on fuel oil and kerosene has decreased substantially.

What determines residential electricity consumption?

In this analysis, we take into consideration the fact that the demand for electricity is influenced by the stock of electrical household appliances. If households purchase new appliances, both the proportions of old and new appliances and the number of appliances change with time. To reflect the decision process underlying purchases of electrical equipment, the econometric model is divided into two stages. In the first stage, purchases of electrical equipment are determined as a function of variables including the prices of electrical appliances and electricity. Electricity consumption is determined in the second stage as a function of the estimated values found in the first stage and a number of variables that take into account characteristics of the household.

The results show that purchases of kitchen stoves and fridges result in a drop in electricity consumption, whereas purchases of other appliances result in a rise in consumption. Electrical appliances may be purchased either to replace old equipment or to increase the stock of appliances. Technical advances have made various kinds of equipment more energy-efficient with time. Purchases of new equipment thus have an influence on electricity consumption both because the stock of equipment changes and because more energy-efficient equipment is purchased. It has not been possible to separate these effects in our data. However, the results show that electricity consumption rises as the stock of electrical appliances increases.

Electricity consumption rises with household income, with the number of members in the household, and with the size of the dwelling, but drops with electricity price and the age of the dwelling. The latter result may be related to the fact that the wiring capacity is higher in newer houses. The variations in electricity consumption between different types of households can be illustrated by the fact that if all other factors are equal, consumption is 2 700 kWh lower in a household in a block of flats than in other types.

How do energy prices influence residential energy use for space heating?

Energy use for space heating is closely related to the type of heating equipment used. The degree to which the output of the equipment can be regulated, for example by means of thermostats, is important for total energy use for heating purposes. The type of heating equipment also determines which energy sources are used, for example electricity, wood or kerosene. We have analysed which factors determine the choice of heating equipment in households, and what determines energy use once the type of equipment has been chosen.

In addition to the price of the heating system and expected energy costs, the analysis shows that characteristics of the dwelling and household are of importance for the type of heating system chosen. These include the type of dwelling and the number of persons in the household. Income and energy prices are of importance in most energy analyses, and have a clear effect on energy use in this analysis as well. In contrast to the analysis of electricity consumption and electrical appliances described above, the results show that outdoor temperatures influence energy use. When temperatures drop, total energy use by the household rises. The results give no information on how use of each energy type changes. In cold periods, electricity consumption may even fall if the low temperature means that the household supplements electric heating with wood-firing or starts up an oil-fired central heating system.

Energy price elasticity is a measure of how energy demand changes as the price of energy rises. For the period 1993-1995 as a whole, we find that energy price elasticity was -0.5. This means that if the price of energy rises by one per cent, energy use drops by 0.5 per cent. Compared with the demand for other goods and services, energy demand shows moderate sensitivity to a rise in the price of goods or services. For example, consumption of a basic necessity like food is influenced less and consumption of a "luxury" like air transport is influenced more than energy consumption by changes in their respective prices[3].

In addition to average energy price elasticity, we have investigated the energy price elasticities of different groups of households. Households are divided into two groups, one with above-average and one with below-average income. The results show that high-income households reduce energy use more in response to a rise in energy prices than do low-income households. The reason may be that energy use is already relatively low in low-income households, so that there is in practice little possibility of any further reduction, whereas high-income households can more easily reduce energy use without a noticeable effect on household welfare.

Project financed by: Statistics Norway and Research Council of Norway.

Project documentation: Halvorsen et al. (1999), Halvorsen and Larsen (1998), Nesbakken (1998a) and (1998b).

2.8. Energy use in manufacturing industries

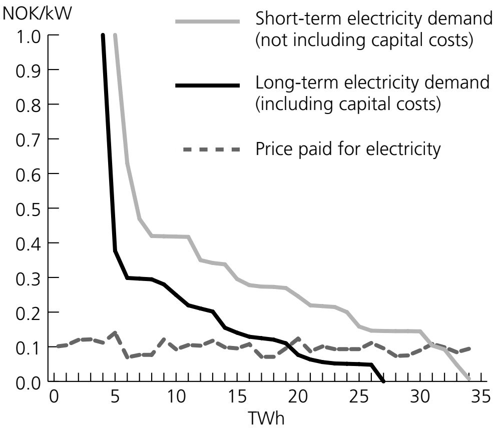
Energy-intensive manufacturing is an important export industry in Norway. It includes the pulp and paper industry, the manufacture of basic chemicals and metal manufacturing. These industries account for about one quarter of total Norwegian electricity consumption, and have developed largely in response to supplies of cheap electrical power. However, the competitiveness of this sector may be affected as it faces rising electricity prices as a result of deregulation of the electricity market and higher taxes. According to the industry itself, it is dependent on cheap energy to be able to compete on international markets.

The demand for energy is influenced not only by changes in energy prices but also by the processing techniques used in the individual firm. When a firm invests in machinery and buildings, it also determines to a large degree how high its energy demand will be in the future. Two studies that are part of the project «Flexible energy use in manufacturing industries» have dealt with short- and long-term energy demand by energy-intensive manufacturing.

In the first of these, we constructed hypothetical energy demand curves showing the price each firm could pay in the short and the long term without making a loss. This price, their potential willingness to pay, is calculated as the firm's gross and net profit (before electricity costs), respectively, per kWh used. In the short term, all variable costs must be covered, and in the long term capital costs must also be included. The data used are based

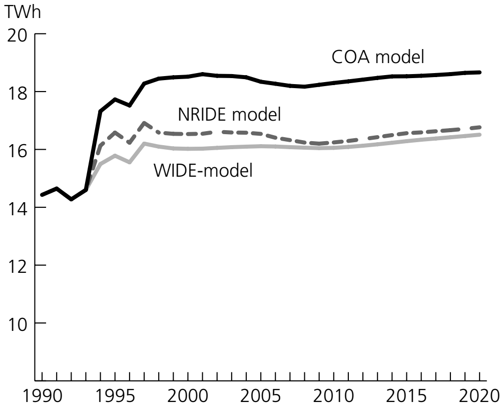
[3] The price elasticity of food is estimated to be -0.2 and that of air transport -1.5, see Aasness and Holtsmark (1993).

Figure 2.13. **Aggregate hypothetical electricity demand by energy-intensive manufacturing, 1993**



Source: Larsson (1999a).

Figure 2.14. **Projections of electricity consumption in the aluminium industry from 1994 to 2020**



Source: Larsson (1999b).

on Statistics Norway's industrial statistics for 1993, when product prices were unusually low. We have therefore used 1990 product prices to estimate potential income. Figure 2.13 shows the aggregated hypothetical demand curve. Actual electricity consumption by the firms in question in 1993 was 35.7 TWh. The demand curves rank firms engaged in energy-intensive manufacturing according to their potential willingness to pay in the method described above. The demand curves show that energy-intensive manufacturing is sensitive to a rise in the price of electricity. The least profitable parts of the industry, which accounted for more than one third of electricity consumption in this sector, cannot cover their long-term costs if the electricity price is as high as in 1993.

The aim of the second study was to find the econometric model that best explains energy demand for the aluminium industry in Norway in the period 1972-1993. The models used distinguish between long-term and short-term demand. The first, the COA model (Berndt et al. 1980) estimates short-term demand, which is not necessarily optimal in the long term. It is costly to adjust capital to changes in prices of the variable factor inputs. The other two models, NRIDE (Nadiri and Rosen 1969) and WIDE (Walfridson 1987) estimate long-term demand. In the short term, each factor input is constrained by an adjustment cost. The WIDE model also takes capacity utilization into account. The models are described in more detail in Larsson (1999b).

In addition to estimating values for the parameters in these models, we have drawn up a projection of electricity consumption up to 2020. The scenario is based on the same assumptions as the reference scenario in the report from the committee appointed to evaluate the energy and power balance up to the year 2020 (NOU 1998:11), see section 2.5.

It is not possible to determine statistically which of the three models best predicts energy demand. The choice of model must therefore be based on other criteria and personal judgement. However, the models give very different results for projections of electricity consumption (figure 2.14). The COA model indicates a rise in energy consumption for the period 1993-2020 that is about twice that given by the NRIDE and WIDE models (4.1 TWh as compared with 2.2 TWh and 1.9 TWh respectively). The reason for this is that the COA model shows electricity and capital to be complementary factor inputs. Complementarity means that a rise in the price of a factor input results in lower demand for the complementary factor input. This is in contrast to substitutable factor inputs. Two commodities are substitutes if a rise in the price of one of them results in greater demand for the other. Estimates made using the NRIDE and WIDE models indicate that electricity and capital are substitutes.

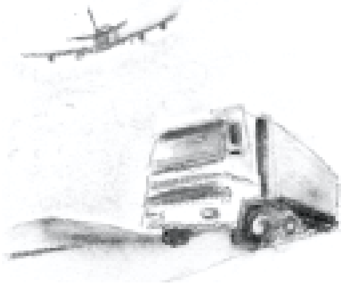
Project financed by: Nordic Council of Ministers, Research Council of Norway.

Project documentation: Larsson (1999a) and (1999b).

Documentation, energy in general: Statistics Norway (1998b).

More information on energy in general may be obtained from: Lisbet Høgset, Trond Sandmo, Bente Tornsjø, Finn Roar Aune and Runa Nesbakken.

3. Transport



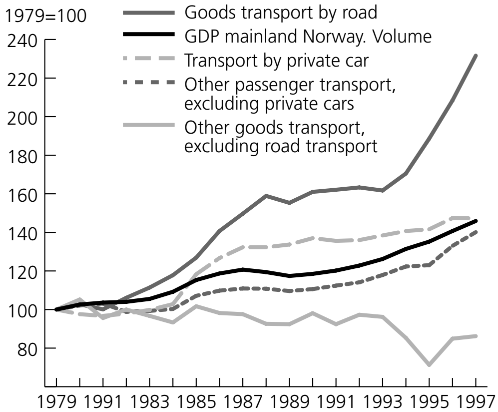
Economic growth and growth in transport activities are closely connected. Efficient transportation and a growth in transport capacity are needed to make use of a consistently increasing production capacity, and rising incomes in themselves result in a growing demand for transport services. Since 1946, passenger transport in Norway has risen thirteen-fold and goods transport five-fold. Over the same period, Norway's GDP increased seven times and private consumption five times measured in constant prices. In 1997, Norwegians travelled an average distance of 37 km a day each. This large volume of traffic has a major impact on the environment. A substantial portion of all air pollution is generated by combustion emissions from various modes of transport, and the Survey of Living Conditions shows that 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

There has been a steep increase in domestic transport[1] work in recent decades. Since 1946, passenger transport has risen thirteen-fold, goods transport in tonne-kilometres is five times greater in volume, and if oil and gas transport from the North Sea is included, no less than ten times greater. Passenger transport by private car, transport from the North Sea to the Norwegian mainland and goods transport by road have contributed most to this development. Since 1980, the transport industries[2] have accounted for a total of about 7-10 per cent of gross domestic product (GDP) and employment. Among the transport industries, transport by sea accounts for the largest proportion of GDP, but most of this activity takes place outside Norway's borders. If both international sea traffic 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 important modes of transport since 1979. The figure shows that goods transport by road has increased considerably more than GDP, passenger transport has grown consistently over the period as a whole at a rate close to the growth in GDP. Goods transport other than by road has decreased

1 Does not include transport to and from other countries.
2 Excluding transport on own account.

Figure 3.1. **Growth in the volume of GDP for mainland Norway and development in domestic goods and passenger transport. Index. 1979=100**



Sources: National accounts and Transport and Communication Statistics from Statistics Norway.

slightly in this period. The Ministry of Transport and Communications expects passenger transport to grow more slowly than GDP for mainland Norway in the period 1995-2010. Goods transport by road and GDP are expected to grow at about the same rate during this period (Report to the Storting No. 36 (1996-97)).

3.2. Transport networks and vehicles

At the end of 1997, the total length of public roads in Norway was 91 254 km, or 282 metres of road per km² of land area in Norway (excluding Svalbard and Jan Mayen). There are substantial variations between counties; in Oslo, for example, total road length per km² is 2 863 metres, whereas in Finnmark it is only 82 metres. National roads 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

Table 3.1. **Length of public roads**

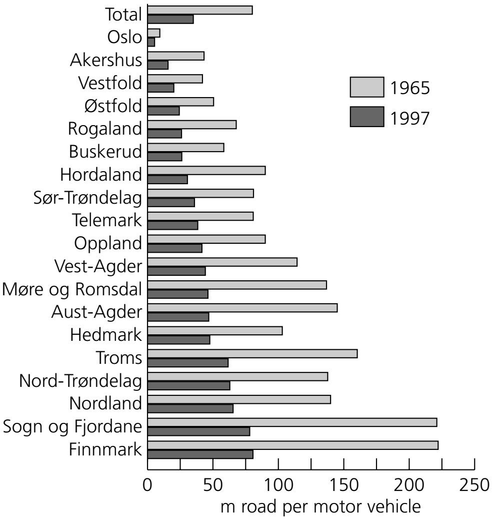
Year	Kilometres in all	Metres per motor vehicle	Metres per km² land area
1930	37 443	716	116
1935	39 237	551	121
1940	42 598	416	132
1945	43 980	452	136
1950	44 673	309	138
1952	45 809	249	141
1955	47 388	170	146
1960	51 233	97	158
1965	65 737	80	203
1970	72 262	65	223
1975	77 101	58	238
1980	81 717	48	252
1985	85 882	40	265
1990	88 922	38	275
1995	90 262	36	279
1996	91 346	37	282
1997	91 254	35	282

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

480 km², or a little more than the area of the municipality of Oslo. The figures include the hard shoulder, but not embankments, ditches, noise zones, etc.

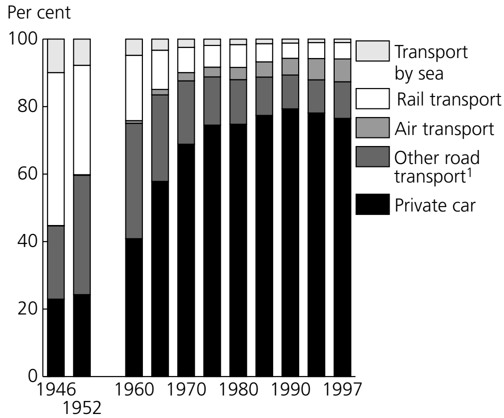
The number of metres of public road per vehicle dropped steeply from 1930 and up to the mid-1980s (table 3.1), so that car density today is far higher than it was 70 years ago. Particularly in the decades before and after the Second World War, the number of motor vehicles rose much faster than the length of public roads. However, a substantial proportion of road investments has been used to expand the existing road network. There has been little change in car density over the last ten years. By the end of 1997, there was an average of 35 metres of public road available per motor vehicle. Car density is highest in Oslo, where only 5.4 metres public road is available per car registered

Figure 3.2. **Metres of road per motor vehicle by county**



Source: Directorate of Public Roads.

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



[1] Other road transport includes motorcycles, mopeds, taxis, hirecars and buses.
Sources: Transport and Communication Statistics from Statistics Norway and the Institute of Transport Economics.

in Oslo, while in Finnmark the figure is over 80 metres (figure 3.2).

In 1997, the total length of cycleways and footways along national roads was 2 733 km, an increase of about 1 000 km since 1990. In addition, Norway has an estimated 51 500 km forestry roads in use all year round (see also Chapter 8.2).

The total length of the public railway network has remained fairly constant since the end of the Second World War at just over 4 000 km. Today, about 60 per cent of the lines are electrified, as against barely 17 per cent in 1945/46.

3.3. Passenger transport

Passenger transport has grown substantially over the last decades and there have been wide variations between the different modes of transport in terms of growth. Import restrictions for private cars were lifted in October 1960, and from 1960 to 1975 the proportion of total passenger transport work carried out by private cars rose from 40 to 75 per cent (figure 3.3 and Appendix, Table B1). This proportion has changed very little since 1975 (76.5 per cent in 1997). Other important trends over the last few years are the considerable increase in air transport, while other modes of transport have lost market shares in the passenger transport market. Transport by rail, however, has increased its percentage again in the last few years so that by 1997 it had regained its 1987 position at 4.9 per cent.

The transport work of scheduled motor bus transport has remained almost unchanged since 1970, with just over 3.4 billion passenger-kilometres in 1997. The share of the total transport work declined from 16 to 6.8 per cent in the same period.

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

Year	Total	Private car	Other passenger transport by road	Air	Rail[1]	Sea
1946	4.05	0.93	0.88	0.00	1.83	0.40
1952	5.40	1.31	2.04	0.01	1.86	0.45
1960	8.94	3.65	3.51	0.08	1.99	0.49
1965	12.84	7.43	3.93	0.25	1.78	0.50
1970	18.31	12.61	3.44	0.45	1.37	0.45
1975	24.14	17.99	3.45	0.70	1.55	0.45
1980	27.30	20.41	3.61	0.99	1.84	0.44
1985	31.44	24.34	3.57	1.42	1.69	0.42
1990	34.77	27.58	3.49	1.72	1.57	0.41
1995	35.51	27.74	3.49	2.24	1.68	0.36
1997	37.33	28.56	4.05	2.53	1.81	0.38

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

Railways, including suburban railways and urban tramways, accounted for 2.9 billion passenger-kilometres in 1997, and, of this, 0.4 million passenger-kilometres was on suburban railways and urban tramways. These figures have changed relatively little since 1980 although the share of the total transport work carried out by railways dropped by two percentage points to 4.9 per cent in 1997.

Although passenger transport by sea may be common in some regions, the total volume is relatively limited. In 1997, 45 million passengers were carried on domestic routes, with 82 per cent accounted for by car ferry services.

While in 1970 air transport accounted for only 2 per cent of domestic transport work measured in passenger-kilometres, this figure had risen to 6.8 per cent in 1997, equalling the percentage for transport by scheduled bus. The figure for rail transport was bypassed in 1988. Although air transport is now the second most important mode of transport, accounting for 4.1 billion passenger-kilometres in 1997, this is only 8.8 per cent of the figure for cars. Since the average plane journey is a good 400 km, air transport work, measured by the number of passengers transported, is moderate. In 1997 10 million passenger journeys were made by air.

Private cars are far and away the dominant mode of transport today, especially for short and medium-length journeys. The domestic transport work accounted for by private cars in 1997 was calculated at 46 billion passenger-kilometres, about the same as the year before.

From the end of 1996 to the end of 1997, the stock of private cars rose by as much as 5.8 per cent (almost 100 000 cars). This is mainly because only 42 152 cars were scrapped in 1997. In 1998, the number of private cars increased more moderately, by 28 000, and by the end of 1998 there were a total of 1.79 million. The average age of the stock of Norwegian private cars is rising, and was 10.0 years at the end of 1997. The average age was lowest in Oslo, 8.4 years, and highest in the county of Oppland, 11.3 years. In 1970, the average age of private cars was 6.3 years. The rise in the average age of cars is mainly due to the fact that the stock of cars has grown only slightly since 1987, with sales of new cars remaining low until 1994.

In 1997, Norwegians travelled an average of 37 kilometres every day, over nine times as far as in 1946 (Table 3.2). However, people travelled the same distance by boat and train in 1946 as they did in 1997.

Several factors influence the volume of transport and its distribution among the various modes. 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 particularly influenced the use of private cars. Families with children in particular give priority to car use. In 1995, 87 per cent of all married couples with children owned private cars, as compared with 75 per cent for married couples without children. More than one in three of all couples with children owned more than one car. Long distances to schools, day care facilities and 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 wider choice of both place of residence and occupation. Cars also provide far more mobility and flexibility than 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 in 1995 showed that car journeys to and from outdoor recreation areas, sports and other activities and visits to family and friends accounted for 31 per cent of the transport work. Statistics Norway's holiday survey showed that cars were the most important mode of transport in half of all the holiday trips taken in 1997, while planes were used in 34 per cent. The remaining 15 per cent of the total number of holiday trips were divided fairly equally between rail, bus and boat/ferry (Statistics Norway 1998c). However, the percentage of holiday trips by car has declined in recent years, from 58 per cent in 1994 and 61 per cent in 1993. On the other hand, there has been a sharp rise in the same period in the share of holiday trips by plane. In 1993, 21 per cent of holiday trips were by plane, and this figure rose to 25 per cent in 1994 and 34 per cent in 1997. These changes in transport patterns must be viewed in the light of the rise in the number of international journeys in the same period. If the figures are limited to domestic travel only, private cars accounted for 69 per cent of holiday trips in 1997.

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 (Report to the Storting No. 4 (1996-97)). While the average rate of growth in transport work by private car and public transport in the period 1980-1995 was 2.2 and 1.3 per cent respectively, average annual growth is expected to drop to 1.3 for private cars and 1.0 per cent for public transport in the period 1995-2010. It is estimated that the growth in total transport work will be substantially lower than the general growth in consumption for the whole period. The lower rate of growth in transport work over the next few years is expected in particular because of structural trends related to the size and composition of the population. 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 increased by 5 per cent. The figures showed little change from 1996 to 1997.

3.4. Goods transport

In 1946, domestic goods transport work totalled 4.1 billion tonne-kilometres. By 1997, this figure had risen to 21.3 billion tonne-kilometres, excluding oil and gas transport from the North Sea (figure 3.4 and Appendix, Table B2). Growth was steepest up to the end of 1973. Since then, it has been relatively moderate. Other important trends since 1960, measured in absolute figures, have been the stagnation in transport by rail and sea and the rise in road transport. In recent years, transport from the North Sea to mainland Norway has shown a steep upward trend (cf. figure 3.5).

At the end of the 1950s, goods transport by rail and by road totalled about 1 billion tonne-kilometres each. In 1997, transport by rail had increased to 1.9 billion tonne-kilometres and transport by road to 11.8 billion tonne-kilometres. The railways have lost market shares in short-distance transport in particular.

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 1997, this figure had dropped to 35 per cent. Whereas transport by rail has merely shown a lack of growth, there has been a clear reduction in transport by sea, even in absolute terms.

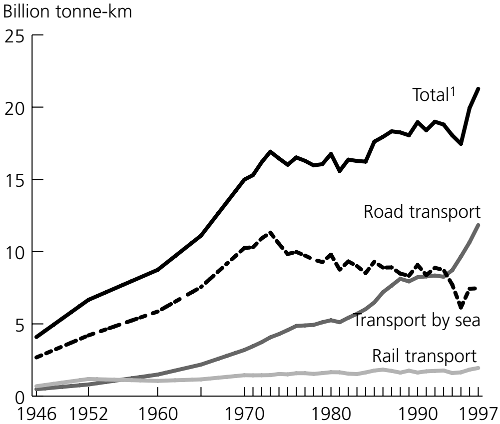
Goods transport by air is moderate and has not increased over the last few years. Total transport work was the same in 1997 as in 1985, about 0.02 billion tonne-kilometres.

Goods transport by road has shown steady growth since 1960. In 1994, road transport outstripped sea transport (excluding oil transport by ship from the North Sea) for the first time, and in 1996, goods transport by road accounted for 56 per cent of total domestic transport work. In 1960, the corresponding figure was 17 per cent. In 1997, a total of 261 million tonnes of goods were transported by road. This was over 81 per cent of total domestic tonnage transported in mainland Norway.

Oil transport from the North Sea to mainland Norway has grown dramatically, see figure 3.5, and by 1997 it had equalled the transport work of all the other modes of transport together. In 1997, oil and gas transport totalled 20.3 billion tonne-kilometres and of this 11.4 billion was by ship, more than twice as much as in 1995. The remaining oil and gas transport is by pipeline, and has shown little change over the last few years.

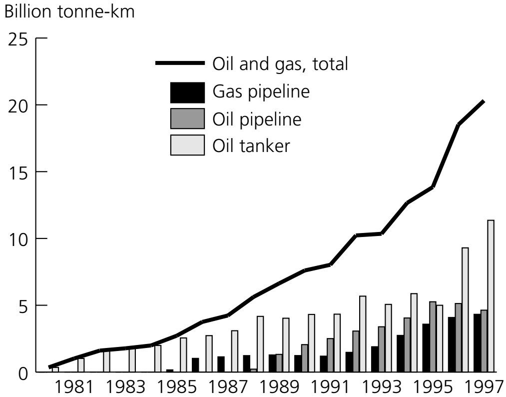
A society's transport service needs will change with economic growth and development. The lorry appears to be best adapted to today's requirements and needs. Physical accessibility is important. Only lorries can transport goods from door to door without the need for expensive reloading. Time is also becoming an increasingly more important consideration, partly because with the increase in production by order, companies are keeping their own stocks to a minimum. As a result, consignments are smaller and more frequent. 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 the lorry is by far the dominant mode of transport for distances of 30 to 150 kilometres, despite the fact that for half the goods in the study there were parallel rail or shipping routes. There is only any real

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



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

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



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

competition in long-distance transport (over 400 km), but even here lorries have a 50 per cent share of the transport of general cargo. Transport by sea comes into its own in cases where a low price per transport kilometre is important and the transport time less important, for example for bulk transport.

Efficient transport is dependent on modern infrastructure. And road transport has undoubtedly pulled ahead of transport by sea and rail as a result of road construction and improvement (to withstand higher axle loads), and the construction of bridges and tunnels. Even though the promotion of intermodal transport, i.e. combinations of various modes of transport, e.g. road/rail/road, is an express goal, both nationally and internationally, all the statistics both in Norway and in the rest of Europe show that transport by road is on the increase. The fact that rail has not captured a larger share of goods transport, particularly over the longer distances, is to a great extent due to the lack of capacity on railway networks.

Even though the share of domestic transport by ship is on the decline, shipping is the dominant mode in international goods traffic. In 1997, 72 per cent of all imports and exports, including oil transport from the North Sea to other countries, were transported by ship. In terms of tonnage, 182 million tonnes were transported, of which 90.4 million were carried by Norwegian ships. Goods transport by lorry (Norwegian and foreign) accounted for barely 3 per cent, or 7.2 million tonnes.

In the Government's Long-term Programme for 1998-2001 (Report to the Storting No. 4 (1996-1997)), it is assumed that the rate of growth in goods transport in mainland Norway will be considerably lower in the period 1995-2010 than in the previous 15-year period. The average annual growth rates in transport work for road and sea/rail from 1980 to 1995 were 4.3 per cent and 1.5

per cent respectively. From 1995 to 2010 inclusive, the average annual rate of growth for road transport is expected to be 1.9 per cent, lower than the rate for sea/rail at 2.0 per cent. One of the reasons for this is the introduction of a CO_2 tax in addition to existing taxes. (The Long-term Programme is based on the assumption that agreement will be reached on an international climate treaty to stabilize global emissions of CO_2 at the 1990 level.) Road transport is expected to grow at a rate close to the growth in GDP. From 1995 to 1996, the general increase in goods transport work was between 2 and 3 per cent, slightly below the growth in GDP. However, goods transport by road rose by over 10 per cent and preliminary calculations show approximately the same increase from 1996 to 1997.

3.5. Emissions from road traffic

The Norwegian motor vehicle stock, including a number of different kinds of motor vehicles and types of engines, is responsible for a large proportion of emissions to air in Norway. This is the reason why in 1992-93 Statistics Norway developed a model for the calculation of emissions from road traffic. The model was updated and further developed in 1997-98 to incorporate new data on driving patterns for passenger vehicles and include emissions from alternative fuels (LPG, hydrogen, etc.) The model now calculates combustion and evaporation emissions for all the most important pollutants[3]. The classes of motor vehicle included in the model are the private car, van, lorry, bus, moped and motorcycle, all of which are divided into classes by type of fuel.

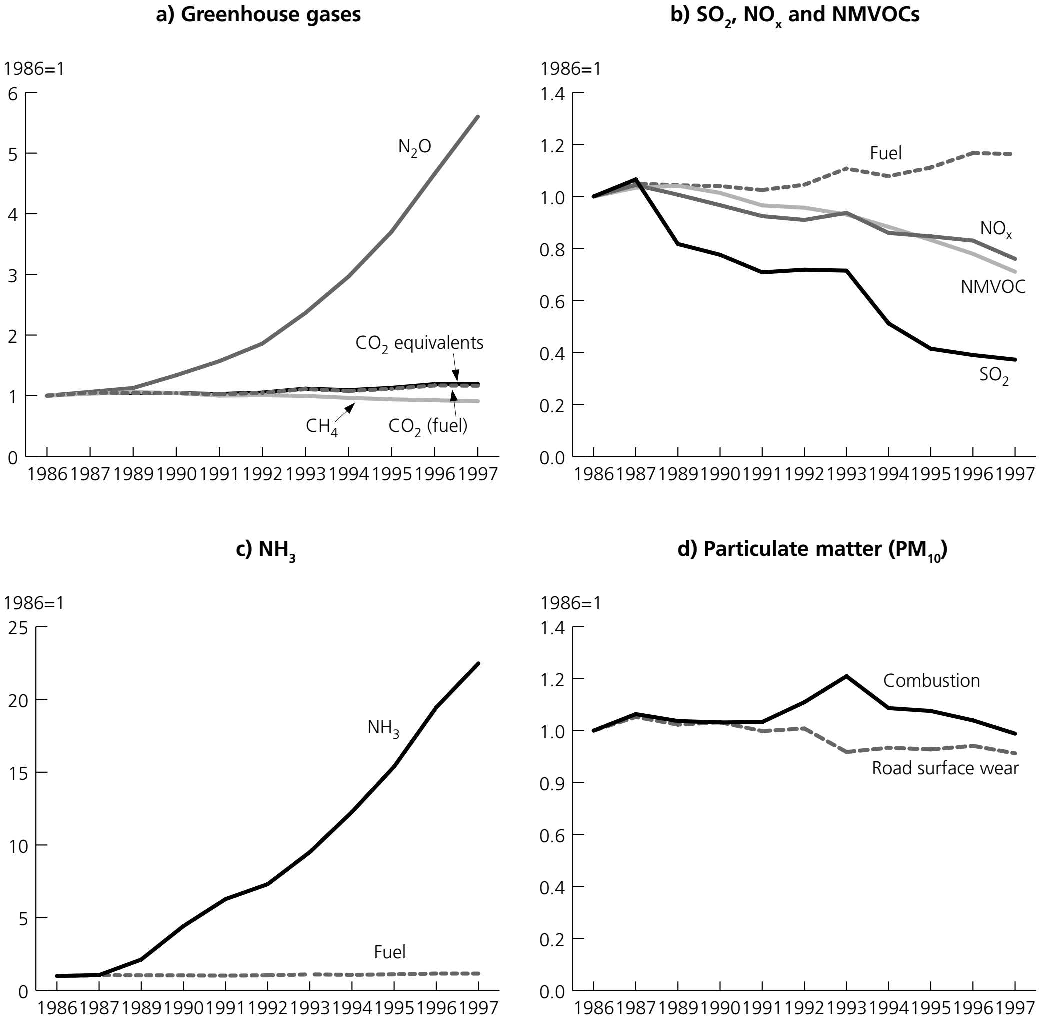
The development in total emissions from road traffic for the period 1986-1997 is shown in figure 3.6 and Appendix, Table B3.

There has been a marked reduction in emissions of SO_2 and lead (63 and 99 per cent respectively) from 1986 to 1997 (figure 3.6). Emissions of lead are now negligible, although they were relatively high until the beginning of the 1990s. This reduction is due to the transition to unleaded petrol. Emissions of NO_x, CO and NMVOCs have decreased somewhat (by 24, 37 and 29 per cent), while exhaust emissions of particulates (PM_{10}) have only decreased by 1 per cent. Emissions of particulate matter as a result of wear and tear on road surfaces have been reduced by 9 per cent since 1986 (figure 3.7). CO_2 emissions have increased by 16 per cent, while emissions of ammonia (NH_3) and nitrous oxide (N_20) have shown a marked increase. Emissions of PAHs (polycyclic aromatic hydrocarbons) and benzene have been reduced by 9 and 42 per cent respectively since 1986.

Emissions of PM_{10} as a result of wear and tear on road surfaces have been calculated for the first time in Norway. These calculations are uncertain, but an initial estimate is shown in figure 3.7. The emissions seem to have decreased somewhat over the last ten years. This is due to more hardwearing road surfaces and the introduction of studded tyres with lighter studs and non-studded tyres. Calculations show that in the winter months when studded tyres are in use, emissions of PM_{10} from exhaust and from wear and tear on road surfaces are about equal. Nevertheless, local emissions due to road

[3] The model includes CO_2, CH_4, N_2O, SO_2, NO_x, NH_3, NMVOCs, CO, lead, PM_{10}, $PM_{2,5}$, PAHs and benzene, and emissions of PM_{10} and $PM_{2,5}$ from wear and tear on road surfaces (see box 4.1, for more details on the various pollutants).

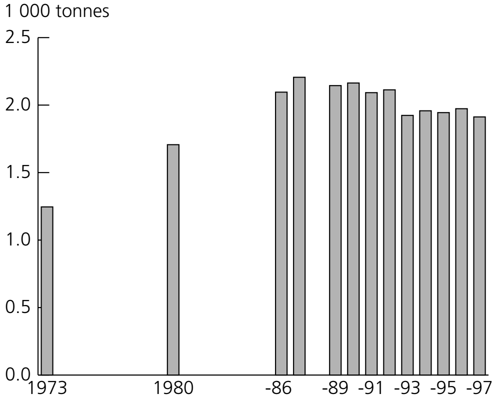
Figure 3.6. **Trends in emissions from road traffic and in fuel consumption. 1986-1997. Index. 1986=1 (see box 4.1 for explanation of components)**



Source: Bang et al. (1999).

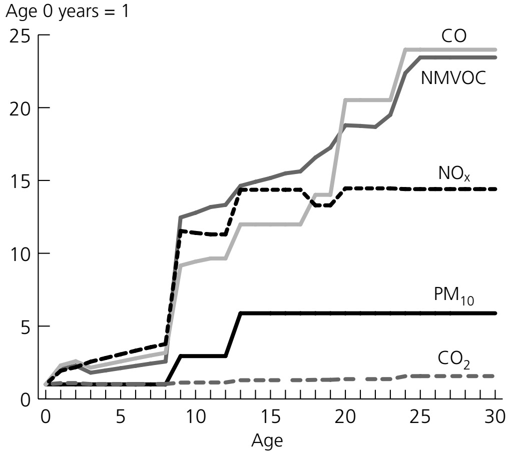
surface wear and tear may sometimes be of greater significance for the concentration of particulate matter in the air than exhaust emissions. This is because emissions of particulate matter from wear of road surfaces will be particularly high on days when the roads are dry, there is dust at the road's edge and/or a high proportion of vehicles have studded tyres because when roads are damp, road dust is not swept up into the air to any significant degree. To a large extent, road dust is not disturbed until the road surface dries. Future emissions of particulate matter from wear and tear of road surfaces will depend on these two factors. If no

Figure 3.7. **Emissions of PM_{10} due to road surface wear**



Source: Bang et al. (1999).

Figure 3.8. **Average emissions[1] per km from petrol-driven private cars by age of car. 1997**



[1] PM_{10} does not include wear and tear on road surfaces.
Source: Bang et al. (1999).

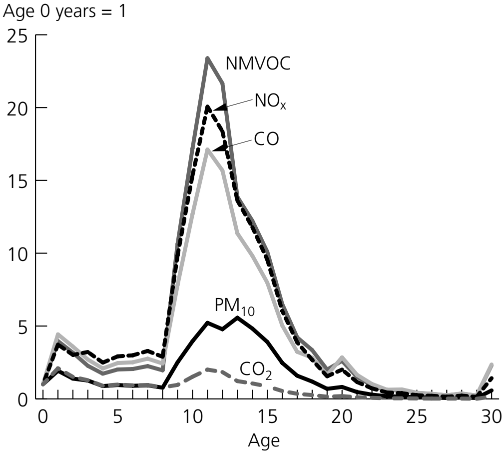
changes are made in road surfaces, the use of studded tyres, speed limits or other factors, emissions will increase in proportion to the increase in the total number of kilometres driven.

In the model, account has been taken of the extra emissions generated by starting a cold engine (20 °C or lower) and the use of engine heaters. Information about the use of engine heaters has been taken from the 1997 Survey of Living Conditions, and it is assumed that engine heaters are only used on days when the temperature is below 0 °C. Our calculations show that the use of an engine heater reduces the average additional emission contribution due to starting a cold engine of NMVOCs, CH_4 and CO, evened out over a year, by 10-20 per cent. Additional fuel consumption because of cold starts is reduced by 3-6 per cent, while additional emissions of NO_x can increase or decrease, depending on the year of manufacture of the vehicle and type of fuel used. How long the engine must run to achieve normal running temperature will depend on both the external temperature and the engine's temperature when it is started; usually this will take 2-3 minutes.

Factors affecting changes in emissions over time

Fuel consumption: There has been a considerable increase in the consumption of both petrol and autodiesel from 1973 up to the present. However, petrol consumption has decreased slightly since 1990. Diesel consumption has increased by over 50 per cent in the same period. One explanation for this is that the number of diesel vehicles has doubled in this period, while the number of petrol cars has only increased very slightly. A special return on old vehicles brought in for scrap that was offered in 1996 helped to bring down the number of petrol-driven cars in the same year. The decrease in petrol consumption can also partly be explained by the fact

Figure 3.9. **Total emissions[1] from petrol-driven private cars by age of car. 1997**



[1] PM_{10} does not include wear and tear on road surfaces.
Source: Bang et al. (1999).

that new car models use less and less fuel per kilometre.

Changes in specific emissions (emissions per kilometre driven): Changes in specific emissions are due to the introduction of new technology when the vehicle stock is renewed and ageing of the individual vehicle. For petrol-driven vehicles, emissions of most pollutants are lower the more recent the car's year of registration (figure 3.8). The change is particularly marked for private cars registered after 1989 (cars with catalytic converters). However, use of a converter increases emissions of NH_3 and N_2O. Stricter emission requirements were adopted in 1995 and 1997. For diesel vehicles, emission standards have been introduced (as for passenger vehicles in 1991, 1995 and 1997 and for heavy vehicles in 1993 and 1996), and specific emissions of NO_x, CO, NMVOCs and especially particulate matter have decreased. Specific emissions will change as the vehicle becomes older. This effect is particularly marked for cars with a catalytic converter because the converter considerably reduces emissions, but becomes less effective over time. For other vehicles too, irrespective of type of fuel, emissions of most components will increase as the vehicle becomes older. In general, fuel consumption (l/km) increases with the age of the vehicle.

Age profile for the vehicle stock: Emissions per kilometre from cars are determined on the basis of factors such as the car's age. It is therefore important to have information on the age profile of the vehicle stock so as to be able to calculate emissions. Sales of new cars in the last few years, and in particular in 1996 and 1997, have been higher than they were in the early 1990s. Nevertheless, most of the cars bought in the mid-1980s are still in use. This means that private cars without a catalytic converter accounted for about half the number of kilometres driven in 1997. Therefore older vehicles account for a relatively large share of the emissions of NO_x, CO and NMVOCs in particular. This is illustrated in figure 3.9. Sales of diesel vehicles have also been high over the last few years. About half of the kilometres driven by heavy vehicles in 1997 involved vehicles that satisfied the 1993 emission requirements.

Sulphur and lead content in fuel: Emissions of SO_2 and lead are determined by the levels of sulphur and lead in fuel. Both the sulphur content of petrol and diesel, and the lead content of petrol are much lower today than in 1973. This is the reason for the decrease in emissions of SO_2 and lead.

Studded tyres and road surfaces: Emissions of road dust nearly doubled in the period from 1973 to 1987. After 1987, more hard-wearing road surfaces, lighter studs and the introduction of non-studded tyres has led to a decrease in emissions despite an increase in the total number of kilometres driven.

Future emissions and alternative fuels

Emissions in the future will depend on the increase in the total kilometres driven per year, the rate of renewal of the vehicle stock, the introduction of new technology and new types of fuel. Projections about emissions will therefore depend on assumptions made in relation to these factors. In our basic projections, we have assumed that the increase in traffic will be as assumed in the Government's Long-term Programme for 1998-2001 (Report to the Storting No. 4 (1996-97)), and if emission standards proposed for implementation in the EU from the years 2001 and 2005 are introduced. With this scenario, by the year 2020 emissions of CO_2 from road traffic will have increased by 1 million tonnes (11 per cent) from the 1997 level. Emissions of particulate matter, NO_x, CO and NMVOCs will decrease by 6, 3, 5 and 6 per cent respectively per year up to 2020. Emissions of SO_2 will drop by 80 per cent in the same period as a result of new fuel quality requirements.

Future (and historical) emissions of nitrous oxide (N_2O) are uncertain. These emissions will probably increase up to the year 2010. If nitrous oxide emissions from new private cars are reduced in the course of the next ten years as a result of measures to reduce emissions of this greenhouse gas, the effect will be gradual due to the gradual replacement of old vehicles with cars with low N_2O emissions.

Future emissions of particulate matter as a result of wear and tear on road surfaces will depend on the extent to which non-studded tyres replace studded tyres, what kinds of road surface are used and changes in driving speeds. If these factors are not changed, the emissions will increase in proportion with the expected increase in volume of traffic.

Any new types of fuel or engine technologies that are introduced are expected to have relatively little effect on emissions. This is partly because requirements with regard to emissions from "old" petrol and diesel engines will be strict and emissions will remain relatively low, and partly because the introduction of new types of engine is expected to be slow. Different engine technologies may have different effects on emissions. The replacement of petrol-driven private cars by electric cars or cars with fuel cells (hydrogen) and the introduction of heavy vehicles running on DME (dimethyl ether) are generally speaking the best alternatives as far as emissions are concerned, based on the assumptions that have been made as to how far these engine technologies will be used. The use of biodiesel (or biogas) will reduce CO_2 emissions in particular.

Emissions to air from the most common modes of transport

Holtskog and Rypdal (1997) discussed energy use and emissions to air from the most common modes of transport. Calculations show that emissions of greenhouse gases per passenger-kilometre are highest for high-speed passenger boats and coastal services, while emissions in goods transport (per tonne-kilometre) are highest for aircraft. These figures take into account actual utilization of capacity. See also Chapter 4 and Appendix, Tables C5 and C6.

Project finance: Emissions to air from road traffic: Norwegian Pollution Control Authority.

Documentation: Bang et al. (1999).

3.6. Emissions to air from foreign ships in Norway

Emissions to air from foreign ships in Norway were first calculated in 1997-98. Total emissions from these ships are so high that they can have an adverse effect on local air quality, acidification and climate change. Emissions from ships, including foreign ships, that sail between Norwegian ports (national sea traffic) are Norway's responsibility under the definitions used in climate agreements. Ships, whether Norwegian or foreign, that sail between a Norwegian port and a foreign port, i.e. international sea traffic, are *not* included in the climate agreements.

In domestic shipping, the energy consumption of foreign vessels was less than a quarter of that of Norwegian ships (Flugsrud and Rypdal 1996). In spite of this, emissions of SO_2 were over twice as high (about 5 800 tonnes against 2 280 tonnes). It is thought that SO_2 emissions are so high in relation to the level of fuel consumption because foreign ships use more heavy fuel oil with a high sulphur content[4]. However, this assumption is uncertain.

If foreign ships in Norwegian domestic and international sea traffic are considered together, their emissions of SO_2, NO_x, particulate matter and CO_2 account for 35, 8, 7 and 2 per cent of total Norwegian emissions. In 1997, these ships used more than 278 000 tonnes of fuel within the baseline[5], against approximately 263 000 tonnes in 1996. In 1996, 85 per cent of the fuel was used at sea, with the remaining 15 per cent in the harbour area, and ships sailing between Norwegian ports (national sea traffic) accounted for half of the fuel used at sea. Figure 3.10 shows fuel consumption by foreign ships within the baseline in 1996 on a 50 x 50 km grid. Consumption is highest around the Oslofjord and along the coast from Rogaland to Møre og Romsdal.

Box 3.1. Definitions

In the context of climate agreements, *national sea traffic* is defined as *all ships moving between two ports in the same country*, irrespective of the ship's nationality (EMEP/Corinair 1996 and 1999). Voyages to oil installations or fishing grounds are included.

All ships moving between a port in the country in question and a foreign port are defined as *international sea traffic*. This means that in Norway a foreign ship sailing from, for example, Rotterdam to Oslo will be included in the group international sea traffic. When the same ship continues to Fredrikstad, another Norwegian port, it will be included in the group national sea traffic since it would then be sailing between two ports in the same country. International sea traffic is not included in the agreements on emissions reduction and is therefore not included in national emission figures.

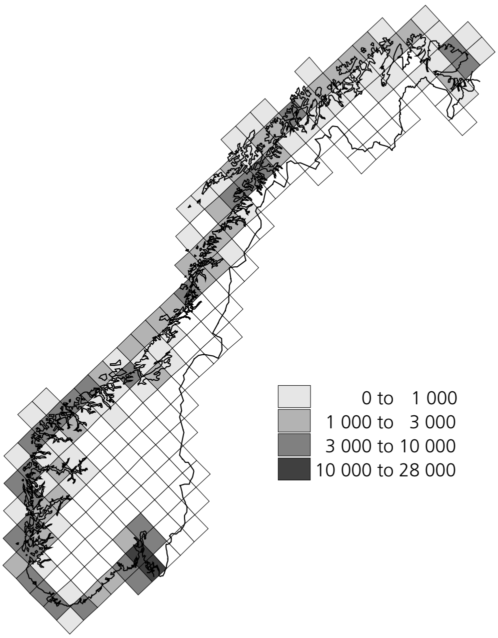
Foreign ships are ships that are not registered in Norway.

Along the coast is defined as in Norwegian territorial waters, within the four-mile limit.

[4] The calculations are based on the assumption that engines with an output of less than 2 000 kW use gas oil with a sulphur content of 0.5 per cent, while engines with an output of more than 2 000 kW use heavy fuel oil with a sulphur content of 2.7 per cent (Lloyd's Register 1995).

[5] Line drawn between the outermost skerries not submerged at high tide.

Figure 3.10. **Fuel consumption by foreign ships within baseline shown on a 50 x 50 km grid. 1996. Tonnes per square**



Source: Flugsrud and Haakonsen (1998).

Emissions were calculated by multiplying operating times for the ships with the specific emission factors (in kg/hour) for the various classes and sizes of ship. Operating times were estimated based on ship movements as registered in the COSS register[6] and normal speeds taken from EMEP/CORINAIR (1996 and 1999). Levels of fuel consumption and emissions of NO_x, CO, NMVOCs and CH_4 will depend on engine characteristics. For these, emission factors specific to the various classes and size of ship were calculated from equations published by Lloyd's Register (1995).

Project documentation: Flugsrud and Haakonsen (1998).

Project finance: Ministry of the Environment.

3.7. Road traffic noise in Oslo: what developments can we expect and what are the best countermeasures?

Noise is one of the greatest environmental problems associated with road traffic in Norway today and it is expected to increase in the future as a result of a growing volume of traffic. In addition to the fact that many people are annoyed by noise, noise can in some cases result in adverse effects on health, in the form of stress and psychological problems. Noise from road traffic therefore results in a social welfare loss.

Noise is measured in decibels (dB), which is a logarithmic scale of measurement. In order to represent how the human ear perceives noise, a graph, called the *A-weighting curve,* has been constructed to illustrate the ear's perception of noise. Noise is then given in dB(A). The Ministry of the Environment has stipulated limit values for average noise levels indoors in housing over a 24-hour period at 30-35 dB(A). For comparison, the sound of normal speech at a range of one metre corresponds to a noise level of about 58 dB(A) and the rustle of leaves in calm weather a level of about 20 dB(A). In order to estimate the health risks associated with a specific level of noise in a population or an area, an often-used indicator is the *number of people who are highly annoyed by noise.*

[6] The Norwegian armed forces COSS register (Coastal Operations and Surveillance System) contains information on the movements of non-military foreign ships.

In 1997 about 95 000 persons in Oslo were exposed to noise levels indoors which exceeded the limit value of 30 dB(A) stipulated by the Ministry of the Environment. Of these, about 28 000 persons were highly annoyed by noise (source: calculations produced for Statistics Norway by the Oslo municipal health authorities). How noise pollution will develop in the future as a result of a growing volume of road traffic has been calculated, measured by the number of persons exposed to and highly annoyed by noise.

Our calculations indicate that by the year 2010 about 110 000 people living in Oslo will be exposed to noise indoors in housing which exceeds 30 dB(A). Of these an estimated 33 000 persons will be highly annoyed by noise. This corresponds to an increase in the number of persons exposed to noise levels above the limit value and persons highly annoyed by noise from 1997 to 2010 of 15 and 18 per cent respectively. These calculations are based on an estimated increase in the volume of traffic in Oslo in this period of 29 per cent.

We have also looked at the costs involved in preventing an increase in the number of persons that are highly annoyed by noise in relation to the 1997 level. The use of screening (insulation of outer walls and noise screens) to prevent an increase in the number of persons in Oslo who are exposed to noise exceeding 30 dB(A) indoors will result in a yearly cost of between 8 and 116 million 1995 NOK (calculated as a fixed yearly cost). If a fuel tax is imposed instead so that the volume of road traffic is maintained at a constant 1997 level, and public expenditure is increased in parallel with the increased tax income, it is estimated that Oslo's share of the yearly costs of this measure, measured in terms of a reduction in added value (GDP), will reach 1.9 billion 1995 NOK.

In other words, the calculations show that in order to restrict noise from road traffic, direct methods such as noise screens and insulation of outer walls will be considerably more accurate, and therefore more cost-effective, than an indirect method such as a general fuel tax.

Project finance: The Research Council of Norway.

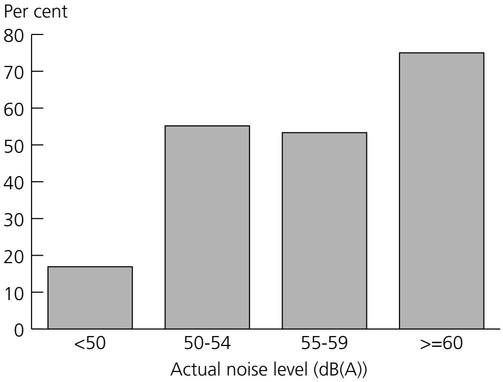
Project documentation: Hansen (1999).

3.8. Reasons for perceived levels of noise and pollution

In the Surveys of Living Conditions carried out by Statistics Norway, people have been asked whether they felt annoyed by noise and pollution. However, it is also interesting to known whether subjective perceptions are closely linked to objective criteria such as level of exposure to noise, which can be estimated from other statistics. In this analysis, we have compared perceived levels of noise and pollution with actual levels of noise and pollution near people's homes by means of a logistic regression analysis. We have also looked for a possible connection between the various types of noise and pollution and for possible connections between these and socio-economic factors such as age, income, etc.

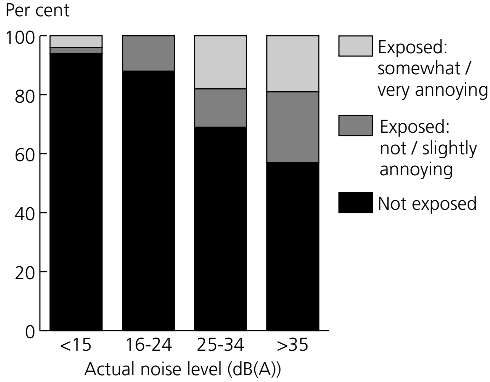
Our analysis showed significant connections between subjective perceptions of annoying noise or pollution and calculated levels of noise and pollution. Figures 3.11 and 3.12 show how subjective perceptions of annoying noise levels increase with the levels of noise from aircraft and

Figure 3.11. **Proportion of Oslo population who regard aircraft noise (outside home) as somewhat/very annoying as a function of actual noise level[1]. 1997**



[1] It should be noted that this survey was carried out before the location of Oslo's main airport was moved to Gardermoen. Noise levels in Oslo have declined since.
Source: Flugsrud, Haakonsen and Zhang (1998).

Figure 3.12. **Proportion of sample exposed or not exposed to road traffic noise (inside their homes). Those exposed are subsequently categorized according to how annoying they found the noise. Oslo. 1997**



Source: Flugsrud, Haakonsen and Zhang (1998).

road traffic. In the same way, perceptions of annoying levels of dust or smells caused by pollution rise when concentrations of particulate matter and nitrogen oxides increase.

The analysis also shows that there is a connection *between* the various forms of noise and pollution in terms of annoyance, in other words that one form of annoyance has a tendency to reinforce another. The results show that the more annoying *road traffic noise* is felt to be, the more annoying *air traffic noise* is perceived to be, given the same calculated level of aircraft noise.

Furthermore, the figures show that annoyance caused by dust associated with road traffic depends on the perception of an unpleasant smell, irrespective of the source of pollution. There is also a connection between annoyance caused by dust from industry, construction work and the like, and the concentration of particulate matter and nitrogen dioxide (gas) emitted from these sources. However, it is often difficult for people to know where dust comes from. Many people may believe that the dust they can see comes from industry, while in fact the real culprit might be the wood burned in stoves and fireplaces. And annoyance because of unpleasant smells from industry will also reinforce the perception of annoying levels of dust.

When the levels of annoyance due to aircraft noise and to road traffic pollution are analysed in combination, the figures show that annoyance because of noise also reinforces the annoyance felt because of pollution. This is in spite of the fact that the actual noise from aircraft has no direct impact on pollution. One interpretation of these figures might be that people who already feel annoyed by one source of pollution perceive an additional source as more annoying than people who are only exposed to one (in other

Box 3.2. About the statistics

The analysis is based on the responses given by the 350 individuals who were interviewed in Oslo in connection with the 1997 Survey of Living Conditions. We have compared levels of road traffic noise, aircraft noise and pollution concentrations with these responses. The Norwegian Institute for Air Research has provided data on air pollution, the Oslo municipal health authorities have provided data on road traffic noise and the Civil Aviation Administration has provided data on aircraft noise related to air traffic at Fornebu (Oslo's main international airport until October 1998).

words, they develop a lower tolerance for additional sources of pollution).

While measuring perceptions of pollution and noise levels, we have also examined whether there are variations between people according to their age, gender, level of education, household income, type of housing, floor (in a block of flats), living space, and term of residence (number of years living in the same house). The analysis has shown that the only factor that is significant in the perception of noise is the floor people live on in a block of flats - and then only in connection with noise from aircraft and not from road traffic. The reason for this may be that people who live on the highest floors may be exposed to more aircraft noise than those who live lower down. Another reason might be that people who live on the top floors see aircraft and are therefore able to connect their annoyance to the correct source. Finally, it may be the case that people who live lower down in a block of flats are exposed to a higher overall level of noise, so that aircraft noise to a certain extent “drowns” in other noise.

Uncertainties

Not all of the environmental issues in the Survey of Living Conditions can be linked directly to the calculated levels of noise or pollution. One of the most important sources of particulate matter in Oslo is wood-burning stoves. However, wood burning is not mentioned in the Survey.

In addition, the pollution concentrations used in the analysis are only shown on a 1 x 1 km grid. Of course, there may be sizeable variations in the actual concentration within each square, but we have had to use the same concentrations for all the dwellings within one square.

There are of course uncertainties in connection with the sample of people interviewed in the Survey of Living Conditions. Most importantly, the number of people interviewed was small in areas with the highest levels of noise or pollution, and this means that there is a particularly high degree of uncertainty with regard to this group.

Project finance: Statistics Norway and the Ministry of the Environment.

Project documentation: Flugsrud, Haakonsen and Zhang (1998).

3.9. Actions to reduce environmental problems in the transport sector

A substantial proportion of environmental problems can be attributed to the transport sector, and in particular to major towns and cities where traffic density is high. The clearest examples of this are traffic noise and emissions of harmful gases and particles via exhaust from cars and wear and tear on road surfaces due to studded tyres. Evidence of environmental damage, for example in ground water, as a result of the salting of icy roads has also been documented (Public Roads Administration 1996). Disturbances of the landscape as a result of new transport structures (e.g. road construction or siting of an airport) also have an impact on the natural environment.

The following is a list of measures implemented to reduce the negative environmental effects of the transport sector.

Legislative measures

The regulations of 30 May 1997 relating to limit values for local air pollution and noise: Pollution from the transport sector is covered under the Pollution Control Act, which provides a legal basis for absolute limit values for air pollution and noise tolerance levels. Owners of roads and terminals are responsible for implementing measures if calculations show that the limit values *may* be exceeded in the future. These regulations will be reviewed on the basis of a future EU directive dealing with this area.

Tighter restrictions on exhaust emissions: In 1985, maximum levels of lead and benzene in petrol were regulated. Catalytic converters were made compulsory for all petrol-driven cars from the 1989 model and onwards, and as a result of this measure emissions of several gases were substantially reduced. Restrictions on emissions from petrol-driven cars were tightened further in 1995 and 1997. Restrictions on emissions were also introduced for diesel-driven vehicles; for private cars in 1991, 1995 and 1997, and for heavy-duty vehicles in 1993 and 1996. The restrictions include a maximum limit on sulphur. Apart from this, the new EEA roadworthiness tests for cars that are more than four years old will ensure that exhaust emissions remain within specified limit values and that many of the most polluting cars are scrapped.

Land-use and transport planning: Important basic requirements as regards planning are contained in the National Policy Guidelines for coordinated land use and transport planning. According to these guidelines, land use and transport systems are to be developed to provide for transport that is as efficient, safe and environmentally sound as possible, and to ensure that the need for transport is kept to a minimum. The guidelines recommend, for example, that when road networks become overloaded, alternatives such as traffic regulation and improvements to the public transport system should be considered on a par with the construction of new roads. The regulations concerning impact analyses were adopted to ensure that environmental problems in the transport and communications sector are analysed at an early stage as part of the planning process.

Speed reductions: In Oslo, speed limits may be lowered at times when pollution levels are particularly high. This would reduce the amount of particulate matter that is swept up into the air.

Noise restrictions for aircraft: The UN International Civil Aviation Organization has defined noise restrictions for aircraft. On the basis of international legislation, the aircraft with the highest levels of noise are to be phased out by April 2002.

Economic measures

Taxes on car ownership and use: In total, there is a high level of taxes on car ownership and use in Norway. It is the view of the Ministry of Transport and Communications that the introduction of fuel taxes has resulted in a considerably lower volume of transport and improved energy efficiency in the transport sector. These taxes are both general and specific to various emissions (lead and CO_2). A purchase tax (paid once) helps to control the numbers and thereby the use of cars, and is formulated in such a way as to give an incentive to buy energy-efficient and environmentally sound vehicles.

Periodically higher refund payment for scrapped cars: In 1996 the refund payable for scrapped cars was temporarily increased in order to reduce the stock of older cars and thereby reduce emissions. Over 211 000 private cars were delivered to the scrapyards in 1996, as against 50 000-70 000 in a normal year. The effect of this measure is short-lived.

Subsidies for public transport: Transport by bus and rail is subsidized in order to increase the number of people who choose to travel by public transport. If people choose this option rather than, for example, travelling by private car, this can help to make the use of transport more environmentally friendly.

Other methods

Alternative fuels: In the 1999 budget, funds have been allocated by the Ministry of Transport and Communications for pilot projects on the use of alternative fuels. These projects focus mainly on the use of natural gas, but other alternative fuels such as DME (dimethyl ether), LPG (propane), biodiesel and biogas are also mentioned.

Reduction in the use of studded tyres: There have been public information campaigns in the largest towns on the disadvantages of using studded tyres. A reduction in the use of these tyres will reduce emissions of particulate matter. Other methods are also being considered (taxes, compulsory measures) if the use of studded tyres does not decrease enough (80 per cent non-studded tyres by the year 2002).

Noise screens: On stretches of road where noise levels are particularly high, screens have been erected to deflect noise. Since 1980, over 200 kilometres of noise screens have been constructed at a cost of NOK 0.5-1 billion (as of 1996).

Documentation, transport in general: Statistics Norway (1998d).

More information, transport in general: Jan Monsrud and Asbjørn Wethal.

4. Emissions to 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 radiative forcing (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 an average of 5.2 per cent from 1990 levels during the period 2008-2012. However, Norway's emissions may rise by 1 per cent. Norwegian greenhouse gas emissions rose by slightly more than 7 per cent from 1990 to 1997 as a result of large increases in emissions of CO_2 and methane. From 1997 to 1998, emissions of CO_2 have been stable, despite lower oil production. A rise in metal production and road traffic meant that there was no overall drop in emissions. Methane emissions dropped slightly from 1997, while nitrous oxide emissions rose.

As regards emissions of pollutants that can cause injury to health, emissions of particulate matter remained stable from 1997 to 1998, whereas emissions of nitrogen oxides (NO_x) rose by 1 per cent.

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 certain 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, volatile organic compounds 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, and carbon dioxide, methane and nitrous oxide are the most important greenhouse gases. Boxes 4.1 and 4.2 summarize the adverse effects of various air pollutants.

The next three sections describe Norwegian emissions to air and changes in emission levels. This is followed by a section on the effects of air pollution on health and a description of climate prob-

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, NO_x and NMVOCs (in sunlight)	Increases the risk of respiratory complaints and vegetation damage. Recommended air quality guideline from Norwegian Pollution Control Authority: 80 $\mu g/m^3$ (8-hour mean).
Benzen (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 air quality guideline from Norwegian Pollution Control Authority: 10 mg/m^3 (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)	Increase the risk of respiratory disease (particularly NO_2). Maximum concentrations recommended in Norwegian air quality guidelines are 75 $\mu g/m^3$ (24 hour-mean) and 50 $\mu g/m^3$ (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}: diameter less than 10 μm, $PM_{2.5}$: diameter less than 2.5 μm. Increase the risk of respiratory complaints. Maximum concentrations recommended in Norwegian air quality guidelines are 24-hour means of 35 $\mu g/m^3$ (PM^{10}) and 20 $\mu g/m^3$ ($PM_{2.5}$). These PM limit values are 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 air quality guidelines from Norwegian Pollution Control Authority: 90 $\mu g/m^3$ (24-hour mean) and 40 $\mu g/m^3$ (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 (1996b and 1996c), 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[1]

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, 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. forests , 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 1997).
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 1966). Variations in global mean temperature are shown in figure 4.11. Recently, articles have been published claiming that the effect of greenhouse gases is negligible, and that sunspot activity is of decisive importance for climate trends (e.g. Brekke and Engvold 1998). In Seip and Fuglestvedt's (1998) view, there is not sufficient scientific evidence for this. They say that there is agreement that changes in both sunspot activity and concentrations of greenhouse gases influence the climate, but that the relative importance of the two factors has not been clarified.
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 4.3.)
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 1997 there were about the same number of pollution episodes[2] (21 days) as the average for the 10-year period 1987-1996 (20.5 days). The highest hourly mean concentration in 1997 was 162 $\mu g/m^3$ (Norwegian Pollution Control Authority 1998). No measuring station recorded above 180 $\mu g/m^3$, which is the EU population warning threshold (recommended limit 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] Health problems caused by air pollution are discussed in section 4.5.
[2] 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 (1997), Norwegian Pollution Control Authority (1998a).

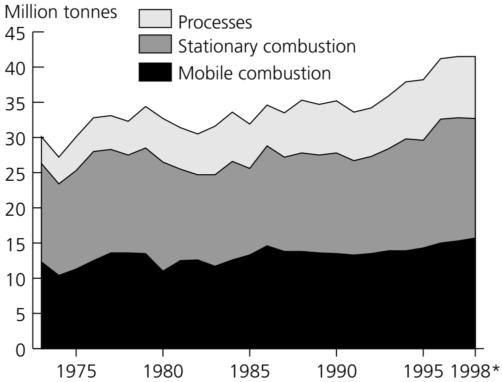
Box 4.3. Sources of emissions

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 in the calculations, but dust from industrial processes is not.

Figure 4.1. **Emissions of CO_2 by source**



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

lems and analyses related to the Kyoto Protocol. Finally, there is a brief overview of measures introduced by the authorities to reduce Norwegian emissions to air.

4.2. Trends in national emissions

Carbon dioxide (CO_2)

Norwegian emissions of the greenhouse gas carbon dioxide (CO_2) were almost unchanged from 1997 to 1998, and according to preliminary figures, totalled 41.6 million tonnes in 1998, as compared with 41.4 million tonnes the year before. However, this is a rise of more than 18 per cent from 1990 (figure 4.1 and Appendix, table C1), which is the base year for the Kyoto Protocol. There have been wide variations in how much CO_2 emissions from different uses of fossil fuels have risen since 1990. For example, CO_2 emissions from stationary combustion in manufacturing have risen by 25 per cent, whereas emissions from residential heating have dropped by 38 per cent in the same period and now only account for 2 per cent of Norwegian CO_2 emissions. The most important sources of CO_2 emissions in Norway are oil and gas production (22 per cent) and road traffic (22 per cent).

In 1998, electricity prices were lower than in 1996 and 1997 and the winter was mild, although not as mild as in 1997. Fuel oil consumption dropped by almost 3 per cent from 1997 to 1998. Nevertheless, consumption was higher in 1998 than in 1995. CO_2 emissions from stationary combustion dropped by more than 2 per cent from 1997 to 1998.

Emissions from petroleum activities dropped by 2 per cent from 1997, mainly as a result of a drop in oil extraction. Emissions from mobile sources rose by

1 per cent from 1997 to 1998, including a rise of 4 per cent in emissions from road traffic. Emissions from shipping rose by 3 per cent. Otherwise, emissions from metal production rose particularly steeply. Process emissions from this sector have risen by 9 per cent as a result of higher production, whereas CO_2 emissions from certain types of chemical and mineral industry have dropped as a result of lower production.

Projections indicate that Norwegian CO_2 emissions will rise by between 31 and 42 per cent from 1990 to 2010 (see NOU 1998:11 and Report No. 29 (1997-1998) to the Storting). The most important reason for this substantial rise is that emissions from the petroleum sector, manufacturing and domestic transport are expected to rise steeply. The level of activity in the oil and gas sector is expected to reach a peak early in the next century (Ministry of the Environment 1997). The two gas-fired power plants Naturkraft is planning to build are included in both sets of calculations.

Methane (CH_4)

Methane emissions in Norway were reduced by about 1 per cent from 1997 to 1998. However, emissions have risen by about 9 per cent from 1990 to 1998, largely because of an increase in the amount of waste landfilled (see Chapter 5). Biological degradation of waste generates methane. Emissions are reduced by flaring and energy recovery of methane from landfills, and these processes have therefore limited the overall rise in emissions. The drop in emissions last year was also brought about in this way. In 1998, potential methane emissions from landfills were reduced by almost 11 per cent by extracting and using the gas. Methane emissions from landfills accounted for almost 54 per cent of total methane emissions in Norway, and the agricultural sector (domestic animals and manure) for 32 per cent. Agricultural emissions have also risen since 1990.

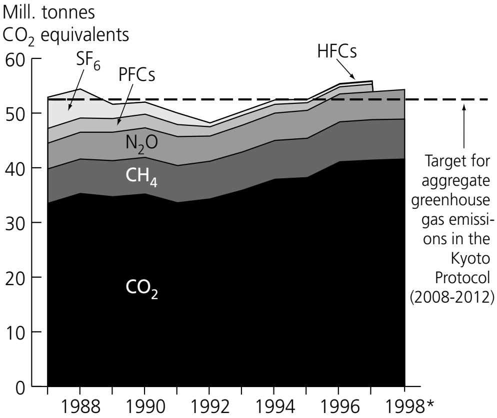
Gas extraction facilities have now been installed at more than 30 landfills, which account for 40-50 per cent of the quantity of waste landfilled annually (Report No. 29 (1997-1998) to the Storting). The Ministry of the Environment expects that such facilities will be installed at most large landfills in 1999, and that as a result, landfills with gas extraction facilities will receive about 70 per cent of the waste landfilled each year. In 1997, 8 per cent of the methane generated was flared or extracted for energy recovery (Norwegian Pollution Control Authority 1999). Waste can continue to generate methane for several decades after it has been landfilled.

The emission figures for methane from landfills have recently been thoroughly revised, see Norwegian Pollution Control Authority (1999). The emission figures have been reduced to about half the value previously calculated, so that the relative importance of methane for total greenhouse gas emissions is less than previously assumed.

Nitrous oxide (N_2O)

Agriculture and the manufacture of commercial fertilizer are important sources of nitrous oxide emissions. These emissions were reduced by 1 per cent from 1990 to 1998 as a result of technical improvements in fertilizer manufacture. However, emissions rose by almost 6 per cent from 1997 to 1998. There is a large degree of uncertainty associated with the level of nitrous oxide emissions. This is partly because information on the sources is

Figure 4.2. **Norwegian emissions of greenhouse gases. CH_4, N_2O and CO_2 up to 1998, the others up to 1997**



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

poor and partly because emissions can vary extremely widely. Sources of emissions from the agricultural sector include fertilizer use and indirect atmospheric deposition.

Other greenhouse gases

Emissions of perfluorocarbons (PFCs: CF_2 and C_2F_6) and SF_6 were reduced by 43 and 77 per cent respectively from 1990 to 1997, mainly as a result of wide-ranging measures to reduce emissions from the process industry (magnesium and aluminium production) The figures for 1998 were not available at the time of printing.

Emissions of hydrofluorocarbons (HFCs) rose from 0.1 to 44 tonnes from 1990 to 1997. These gases only constitute a very small proportion of total greenhouse gas emissions in Norway at present (0.2 per cent in 1997). However, HFC emissions are expected to rise in the next few years, mainly because they will replace chlorofluorocarbons (CFCs) and hydrofluorocarbons (HCFCs) in cooling equipment. In 1997, only 8 per cent of HFC emissions were generated by production of equipment containing the gases. The rest was released during use or after equipment was discarded. (The emission figures were calculated by the Norwegian Pollution Control Authority).

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.

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 (Global Warming Potential, see box 4.4). In 1997, emissions of greenhouse gases in Norway totalled 56 million tonnes CO_2 equivalents (see figure 4.2 and Appendix, tables C1 and C3). This corresponds to a rise of more than 7 per cent since 1990. Emissions rose by 1 per cent from 1996 to 1997. Figures for total emissions of greenhouse gases in 1998 cannot be drawn up yet since not all the underlying data are available. Several projections of greenhouse gas emissions in 2010 have been drawn up. These indicate that emissions will total 63-68 million tonnes CO_2 equivalents (NOU 1998:11 and Report No. 29 (1997-98) to the Storting). Since these projections were made, the method of calculating methane emissions from landfills, an important source of greenhouse gas emis-

Box 4.5. Norwegian commitments under international environmental agreements

Protocols are the most binding type of agreement. They generally set out specific emission targets to be met by individual countries. Section 4.7 describes some of the measures being used by the Norwegian authorities to reduce emissions to air.

National targets	Status
In the period 2008-2012, emissions shall not be more than 1 per cent higher than in 1990 (Kyoto Protocol).	In 1997, emissions were 7.5 per cent higher than in 1990
Eliminate all consumption of ozone-depleting substances (Montreal Protocol).	Achieved for halons and CFCs. HCFCs and methyl bromide are to be phased out by 2015 and 2005 respectively.
Sulphur emissions to be reduced by 76 per cent using 1980 as the base year (Oslo Protocol).[1]	Change 1990-1998: -78 per cent.
NOx emissions not to exceed 1987 level, then to be further reduced by the order of 30 per cent compared with the 1986 level by 2010.[1]	Emission reduction 1986-1998: <0.5 per cent. Emission reduction 1987-1998: <0.5 per cent.
VOC emissions from the entire mainland and the Norwegian Economic Zone south of 62° N to be reduced by 30 per cent by 1999 compared with the 1989 level. Emissions for the whole country including the economic zone not to exceed the 1988 level in 1999.[1]	*Rise* in emissions 1989-1998: 20 per cent.

[1] Negotiations on a new agreement to include NO_x, NMVOCs, SO_2 and NH_3 are in progress. Negotiations on emission targets have not yet been completed. The base year for the agreement will be 1990.
Sources: Proposition No. 1 (1998-99) to the Storting, emission inventories compiled by Statistics Norway and Norwegian Pollution Control Authority.

sions, has been reviewed, and the calculated emission figures have been substantially reduced. However, this change applies to all years, so that it has less impact on the calculated trend in emissions, to which international commitments are linked, than on the level of emissions. Total emissions are thus expected to rise by 8-13 million tonnes CO_2 equivalents from the 1990 level. This corresponds roughly to the estimated growth in CO_2 emissions, so that overall emissions of the other five greenhouse gases are expected to be more or less unchanged. However, emissions of some (e.g. methane) are expected to drop, while others (e.g. nitrous oxide) are expected to rise.

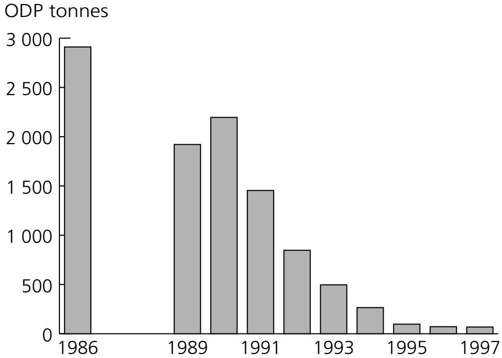
According to the December 1997 Kyoto Protocol, the industrial countries are on average to reduce their aggregate emissions of greenhouse gases by 5.2 per cent between 2008 and 2012 compared with the 1990 level. Norway is one of the few countries where a rise in total greenhouse gas emissions is permitted, 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, because afforestation on former agricultural land is a marginal activity. 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. See also section 4.6 on climate problems and the Kyoto Protocol.

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 4.3). Most of these substances are used in products (e.g. fridges) which eventually result in emissions to air. Emissions take place largely during use of equipment containing these gases, not during production, and 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 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). These gases have been replaced by HFCs, which are also greenhouse gases.

Measurements of the thickness of the ozone layer have been made in Norway since the mid-1930s. In the period 1979-1997, the ozone layer was depleted by an average of 0.4 per cent per year (Braathen 1999). 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 (Braathen 1999 and Norwegian Institute for Air Research 1996a). The thickness of the ozone layer is measured daily from Oslo, Tromsø and Ny-Ålesund (Svalbard) by the Norwegian Institute for Air Research and the Universities of Oslo and Tromsø.

Figure 4.3. **Imports of ozone-depleting substances to Norway**

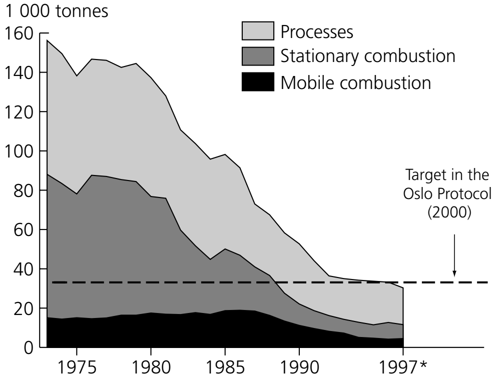


Source: Norwegian Pollution Control Authority.

Sulphur dioxide (SO_2)

Norwegian emissions of sulphur dioxide (SO_2) have been reduced by 78 per cent from 1980 to 1997 (figure 4.4). This is more than was needed to achieve 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) (box 4.5). 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. It appears that this goal will also be achieved. The reduction in SO_2 emissions from combustion can be explained by a changeover to the use of

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



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

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. Since 1975, Norway has used taxes on the sulphur content of oil products as an instrument for the reduction of sulphur dioxide emissions (Statistics Norway 1997a). The tax rates have been increased gradually.

About 62 per cent of Norway's SO_2 emissions in 1997 were generated by industrial processes, particularly the manufacture of metals and chemicals. 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.

Flugsrud and Haakonsen (1998) have shown that foreign ships in Norwegian waters emit large amounts of SO_2. Some of these ships ply between Norwegian ports and are therefore Norway's responsibility according to international environmental agreements. However, these emissions are not included in the inventory because of uncertainty related to the sulphur content of their fuel and because of the difficulty of following trends from year to year. If foreign ships in Norwegian domestic and international maritime transport are considered together, their emissions of SO_2, NO_x, particulate matter and CO_2 account for roughly 35, 8, 7 and 2 per cent of total Norwegian emissions. For more details about these emissions, see section 3.5 of the transport chapter. Norwegian ships engaged in international maritime transport are also excluded from the figures.

Sulphur deposition over Norway was calculated to be about 75 500 tonnes in 1997 (Berge 1998). This figure has been halved since 1990, mainly as a result of reductions in emissions in Europe (Appendix, table C12). About 3 800 tonnes of the total originates from Norwegian emissions, and 6 900 tonnes from sea water and other natural sources. Other large sources in 1997 were the United Kingdom (8 700 tonnes), Germany (2 600 tonnes) and Eastern Europe, Russia and the Baltic states (10 800 tonnes). About half of the total (37 000 tonnes) originates from unidentified sources. Of Norway's own sulphur emissions, a large proportion (about 43 per cent) was deposited over the North Sea and North Atlantic, and about 41 per cent in Sweden and over Norwegian territory.

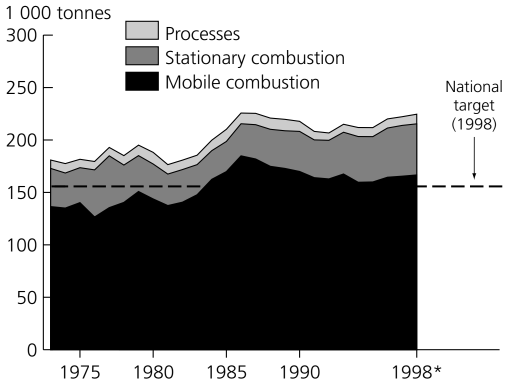
Nitrogen oxides (NO_x)

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 1998 show that overall emissions rose by 1 per cent from 1997 (Appendix, table C2). However, emissions from road traffic dropped by 4 per cent from 1997 to 1998, while emissions from shipping rose correspondingly. 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 and 1998, have brought down the average age of private cars. This may explain the reduction in emissions from road traffic in 1998. However, the effect of scrapping large numbers of older cars is short-lived. The new EEA roadworthiness tests for cars that are more than four years old will ensure that exhaust emissions remain within specified limit values and that many of the most polluting cars are scrapped. In 1998, 48 per cent of private cars (petrol-driven) were fitted with three-way catalytic converters, as compared with 24 per cent in 1995. Cars with catalytic converters accounted for 58 per cent of the volume of traffic generated by petrol-driven cars in 1998. A steep drop in NO_x emissions would be expected as the proportion of cars fitted with catalytic converters increases, but the effect of technological improvements is to some extent cancelled out by the increase in the volume of traffic.

Norway has achieved the goal of the Sofia Protocol, which was to stabilize NO_x emissions at the 1987 level by 1994. In 1988, Norway and 11 other countries signed a declaration of intent to reduce NO_x emissions by 30 per cent by 1998 compared with the 1986 level. However, the reduction actually achieved was less than 1 per cent. A new NO_x protocol is now being negotiated within the framework of the ECE Convention on Long-

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



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

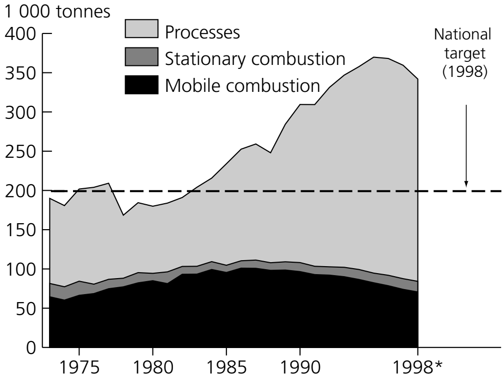
range Transboundary Air Pollution (ECE: UN Economic Commission for Europe). This will probably set out individual emission targets based on critical loads for acid rain and tropospheric ozone.

Total deposition of reduced nitrogen (e.g. ammonia) and oxidized nitrogen (e.g. nitrogen oxides) over Norway in 1997 was 87 600 tonnes (see Appendix, tables C10 and C11). This is a reduction of 6 700 tonnes since 1996. Of this, 20 700 tonnes originated from Norwegian emissions, and emissions from the United Kingdom and Germany together accounted for a further 15 900 tonnes (Berge 1998).

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 (47 per cent) and emissions from petrol engines (13 per cent). The rise in emissions during this period is a result of the growth in the volume of crude oil

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



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

transported and also, in the period 1973-1987, an increase in petrol consumption. Emissions of NMVOCs dropped by almost 5 per cent from 1997 to 1998. 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 20 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 1997 to 1998 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 current trend suggests that it will be difficult to achieve the target of reducing emissions by 30 per cent within the time limit. However, it will be possible to achieve this at a later date when measures such as recovery of oil vapour during loading and unloading from all crude oil ships on the Norwegian continental shelf and at the terminals and refineries are implemented. Measures at larger petrol stations and an increase in the proportion of cars fitted with three-way catalytic converters will also help to reduce emissions.

Particulate matter (PM_{10})

Emissions of particulate matter remained stable from 1997 to 1998. Emissions from stationary combustion were considerably reduced from 1973 to 1983. This can be explained by a drop in the use of heavy fuel oil for heating. From 1990 to 1998, overall emissions rose by 4 per cent. However, from 1990 to 1998 emissions from stationary combustion rose by 11 per cent. Emissions from heating in private households (mainly wood-firing) rose by 10 per cent in this period, and accounted for 58 per cent of total emissions in 1998.

Emissions of road dust (asphalt dust from the use of studded tyres) accounted for 8 per cent of the total. Emissions from processes (manufacturing, etc.) are not included in the calculations of total emissions.

Ammonia (NH_3)

Emissions of ammonia (NH_3) rose by 17 per cent from 1990 to 1998. Ammonia emissions are generated mainly by commercial fertilizer and manure and by treatment of straw with ammonia.

Carbon monoxide (CO)

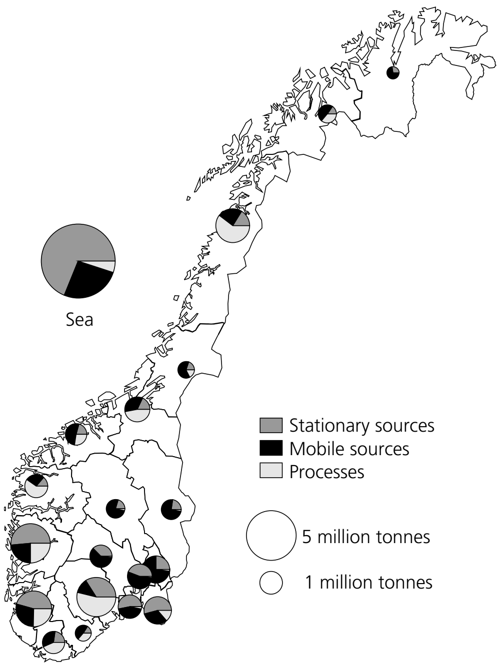
Carbon monoxide (CO) emissions rose from 1973 to the mid-1980s, since when there has been a marked reduction. From 1990 to 1998, total emissions were reduced by 26 per cent, with a reduction of almost 4 per cent from 1997 to 1998. The reduction since 1990 has been largely in emissions from mobile sources, and is mainly a result of improvements in combustion technology and lower petrol consumption. In 1997, emissions from petrol engines and heating of housing accounted for 55 and 22 per cent, respectively, of total CO emissions.

Lead (Pb)
Emissions of lead have been reduced by 99 per cent from 1973 to 1997. In 1998, no leaded petrol was sold in Norway. Lead pollution in air is now well below the level believed to cause injury to human health. About 48 per cent of total lead emissions can be traced back to mobile combustion sources, and 29 per cent to stationary combustion sources. Norway has undertaken to reduce total emissions of lead and cadmium in comparison with the reference year 1990.

Cadmium (Cd)
Emissions of cadmium dropped by 48 per cent from 1991 to 1997. In 1997, metal manufacturing accounted for 44 per cent of total emissions. The reduction in emissions in this period was also largest in this sector (67 per cent). Heating of housing (mainly wood-firing) accounted for almost 23 per cent of cadmium emissions in 1997.

Emissions in other countries
In the OECD countries, there has been a slight rise in CO_2 emissions in the period 1980-1995. CO_2 emissions per unit GDP and per capita CO_2 emissions are lower in Norway 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 are only half the Norwegian level. Worldwide, the production of electricity makes the largest overall contribution to CO_2 emissions. 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.

Figure 4.7. **CO_2 emissions in 1996 by source and county**

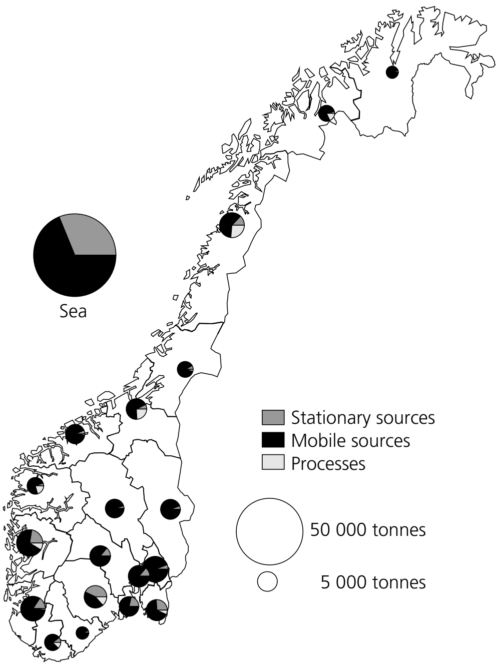


Digital map data: Norwegian Mapping Authority.
Source: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

This is because a high proportion of combustion in Norway takes place in gas turbines for electricity production on the continental shelf, and the country has a large amount of coastal shipping. Both these sources generate high NO_x emissions per unit of energy commodity consumed.

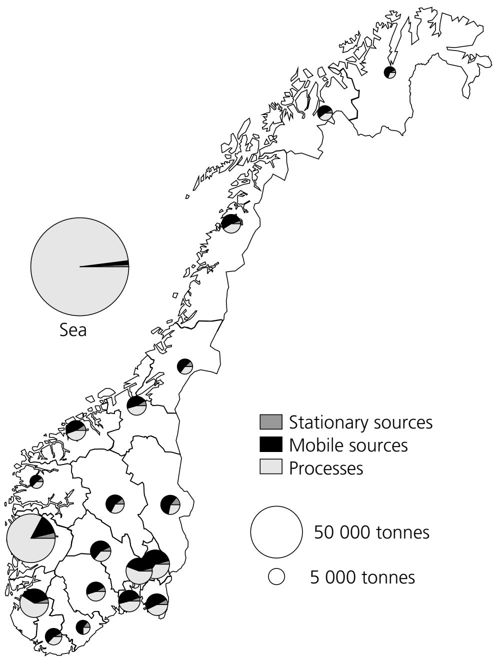
4.3. Emissions by county
In 1996, Hordaland and Telemark were the counties with the highest CO_2 emissions (figure 4.7). CO_2 emissions are also high in Rogaland and Nordland. In all four counties, metal production accounts for a relatively high proportion of emissions. In addition, fertilizer and cement

Figure 4.8. **NO_x emissions in 1996 by source and county**



Digital map data: Norwegian Mapping Authority.
Source: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

Figure 4.9. **NMVOC emissions in 1996 by source and county**



Digital map data: Norwegian Mapping Authority.
Source: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

production and the petrochemical industry are major sources in Telemark. Emissions from oil refineries are highest in Hordaland.

CO_2 emissions are high off the Norwegian coast (petroleum activities and shipping), where almost one third of Norway's total emissions are generated (figure 4.7 and Appendix, table C7). Emissions at sea also make large contributions 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.

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 source of CH_4 emissions. Process emissions from the manufacture of fertilizer in Telemark and Nordland account for 32 per cent of the country's total emissions of N_2O.

Østfold, Nordland, Sør-Trøndelag and Aust-Agder account for the largest SO_2 emissions from the mainland (Appendix, table C7). The manufacture of ferroalloys and chemical manufacturing are the main sources.

In all counties, NO_x emissions are dominated by mobile sources (figure 4.8). This means that there are large emissions in densely-populated areas. In Hordaland, where NO_x emissions are highest, 69 per cent of the total is generated by mobile sources, and 23 per cent by stationary combustion in manufacturing. In the county with the next-largest NO_x emissions, Akershus, mobile sources account for 94 per cent of the total.

Hordaland alone accounts for 25 per cent of total mainland emissions of NMVOCs (figure 4.9). The main sources are process emissions from loading of crude oil and oil refining.

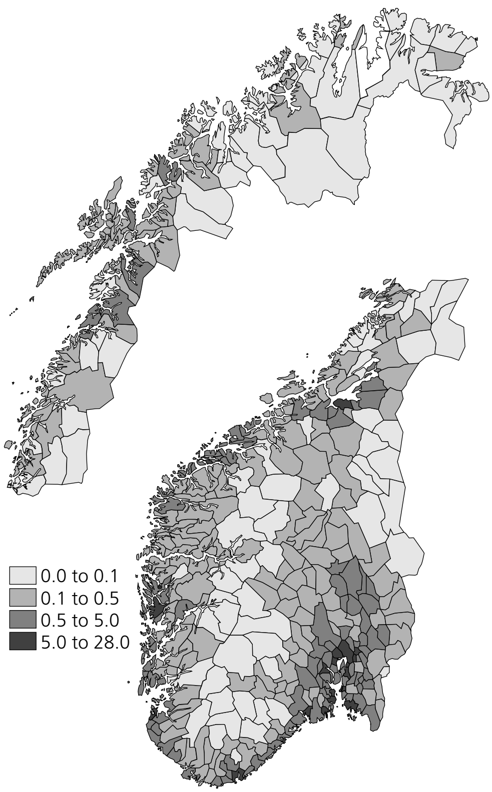
Emissions of particulate matter are highest in Hordaland, which is followed by Hedmark, Akershus and Østfold. The main sources are wood-firing and road traffic. CO emissions are highest in Akershus, largely as a result of road traffic.

4.4. Emissions by municipality

Emissions are calculated for the same number of components at municipal and national level. For some of the larger towns, air pollution is also calculated per basic unit (see box 4.7). Table C8 in the Appendix shows emissions to air by municipality. Box 4.6 gives references for the calculation method. There are uncertainties associated with the calculations. As an example of these emission figures, NO_x emissions are briefly discussed below.

In 1996, NO_x emissions were highest in the municipalities of Oslo, Porsgrunn and Bergen. Emissions totalled almost 6 800 tonnes in Oslo and almost 4 000 tonnes in Porsgrunn. The largest sources in these municipalities were road traffic and industry, respectively. If emissions per km² are compared, we find the highest values

Figure 4.10. **NO_x emissions by municipality in 1996. Tonnes per km²**



Digital map data: Norwegian Mapping Authority.
Source: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

in Stavanger, Porsgrunn, Moss and Oslo (figure 4.10). 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 Sørfold, followed by Tysfjord, Bremanger and Lindås; the main sources of emissions in these municipalities were cement manufacturing, metal production or oil refining. Per capita NO_x emissions are also high in certain municipalities with few

Box 4.6. 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 Bang et al. (1999). Emission figures may be found on Statistics Norway's website (www.ssb.no).

inhabitants where there are national highways.

4.5. Benefits to health of reduced air pollution

Levels of air pollution in several Norwegian towns are so high that the concentrations of pollutants specified in the authorities' recommended air quality guidelines are frequently exceeded, particularly in winter. High levels of air pollution increase the risk of injury to health. Children, old people and people suffering from chronic respiratory diseases are most vulnerable. In this section, we look more closely at the causes of poor air quality in towns, and then present a case study of the social benefits in the form of reduced injury to health derived from building a tunnel to enclose a stretch of main road.

Box 4.7. Calculation of air pollution per basic unit

Statistics Norway calculated emissions to air per basic unit in 11 Norwegian municipalities (Flugsrud et al. 1996 and Haakonsen et al. 1998a and 1998b) for the Norwegian Pollution Control Authority in 1998. Basic units are the smallest geographical unit Statistics Norway uses for statistical purposes, and an urban district consists of several basic units. Emissions in the following municipalities were calculated for 1994 and 1995: 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.

Causes of poor air quality in towns

The most important pollutants in a description of air quality are particulate matter (the term is used here to mean PM_{10}, i.e. particles with a diameter of less than 10 µm), NO_x, SO_2 and ozone (O_3) (see box 4.1). SO_2 is not regarded as a major problem with respect to air quality in Norwegian towns because coal and coke are no longer used for heating and because the sulphur content of most energy commodities has been reduced in recent decades. Ozone is primarily a problem in the summer months, and ozone concentrations in Norway are mainly caused by emissions originating from other countries that are transported by winds. Ozone concentrations are often lower in town centres than elsewhere. Because of this, studies of air quality in Norwegian towns generally focus most on particulate matter and NO_x. Since international studies of the connection between air pollution and injury to health suggest that particulate matter is particularly dangerous (see for example WHO 1997), particular attention has been focused on this pollutant.

The volume of local emissions usually has 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 and particulate matter. One reason for this is that emissions take place at ground level, where people are directly exposed, whereas emissions from sources such as heating are released some metres above ground. Emissions of particulate matter from road traffic include both exhaust emissions and emissions from wear of asphalt (road dust). Emissions from wear of asphalt 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. Wood firing in private households, which accounts for the largest proportion of emissions of particulate matter in the towns, also makes 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 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.

The social benefits of reducing air pollution – a study of a road-building project

As mentioned above, emissions from road traffic are the most important source of local pollution by particulate matter and NO_x. The design of road systems in built-up areas can therefore have a considerable effect on pollution levels. If new roads result in more traffic, air quality may deteriorate, whereas building tunnels may help to improve air quality. This study is based on a specific project in which part of an existing main road out of a large town is replaced by an extensive system of tunnels. We have calculated the social benefits in terms of reduced injury to health as a result of lower pollution levels. This is done using the damage function approach, based on scientific studies of the relationship between air pollution and the risk of injury to health. The reason for the study was that the Directorate of Public Roads wishes to compare this method with that currently used to calculate the benefits of reduced air pollution. The latter is based on people's willingness to pay for reductions in pollution levels.

Several scientific studies have shown a significantly higher risk of death on days (or in periods) when concentrations of particulate matter are high. A review of such studies may be found in WHO (1997). The elevated risk is run mainly by old and chronically ill people. The risk of hospital admission as a result of respiratory disease also rises, and several studies have found a significant relationship between the concentration of particulate matter and absence due to illness, for instance a study from Oslo by Hansen and Selte (1997). Health effects are 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 moderate concentrations of particulate matter in air can result in an increase in the number of cases of bronchitis and a reduction in life expectancy of 1-2 years, see WHO (1997). The latter effect is particularly serious, but there is some uncertainty as to how marked it is in Norway. Pollution by NO_2 can also contribute to serious health effects such as a higher risk of death in periods when concentrations are high, but so far international studies suggest that particulate matter is much more dangerous.

In this study, the relationships between various types of injury to health and concentrations of particulate matter and NO_2 have been linked to data on how pollution changes as a result of the road project. The data are based on the model V-luft as described by the Directorate of Public Roads (1998). About 30 000 people live in the area involved. The concentrations of particulate matter and NO_2 will be reduced by 14 and 4 per cent respectively after much of the road is replaced by tunnels. As a result of this, we calculate an expected drop in mortality of about 4 deaths per year, and that about 40 fewer people will develop chronic bronchitis. We also find an annual increase in labour of more than two man-years as a result of lower sick-leave figures. These figures are very uncertain, but nevertheless give a picture of what kind of benefits may be expected.

Calculations of the social value of these improvements in health are based partly on observable prices (e.g. hourly wage costs) and partly on studies of people's willingness to pay to avoid any increase in the risk of dying or developing a disease.

The social benefits of the reduction in injury to health brought by the road project are calculated to be about NOK 0.5 billion (present value through the 25-year life of the project at a discount rate of 7 per cent.) This is equivalent to about NOK 18 000 per person in the area. Almost 90 per cent of the benefits are related to lower mortality as a result of air pollution. Other benefits and costs of the road project were not calculated in this study.

The results are based on a number of assumptions that may be questioned. We have already mentioned the connection between pollution and the risk of dying or developing a chronic disease. Another important factor that influences the result is the value of a statistical life. This means the value that should be assigned to the benefits of a project (e.g. a road safety measure) that is expected to reduce the number of fatalities by one. If this value is higher than the cost of the project, the project should be carried out, but not otherwise. The higher the value assigned to a statistical life, the more profitable reductions in air pollution will be, since they reduce the number of fatalities. It is quite clear that the value of a statistical life is very difficult to estimate, and in this project we have followed the recommendations of a committee appointed by the Ministry of Finance (NOU 1997:27). The choice of discount rate, i.e. the rate at which future income and expenses are discounted, is also important. A lower discount rate would increase the value of the health benefits of lower pollution levels (but also raise the cost of the project). The discount rate used here (7 per cent) has been used as the standard in publicly-funded projects for many years.

Project financed by: Directorate of Public Roads and Norwegian Pollution Control Authority.

Project documentation: Rosendahl (1999).

4.6 Climate problems and the Kyoto Protocol

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 widely used 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 4.11). This is generally consistent with the trends predicted by climate models on the basis of rising concentrations of greenhouse gases in the atmosphere. Nevertheless, the temperature rise is still within the limits that could be explained by natural variations. In 1998, the global mean temperature was 0.58 °C higher than the average for 1961-1990. This was the warmest year since registration of the global mean temperature began in 1856, and 0.14 °C warmer than 1997, which was the second-warmest year (Norwegian Meteorological Institute 1999). 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.

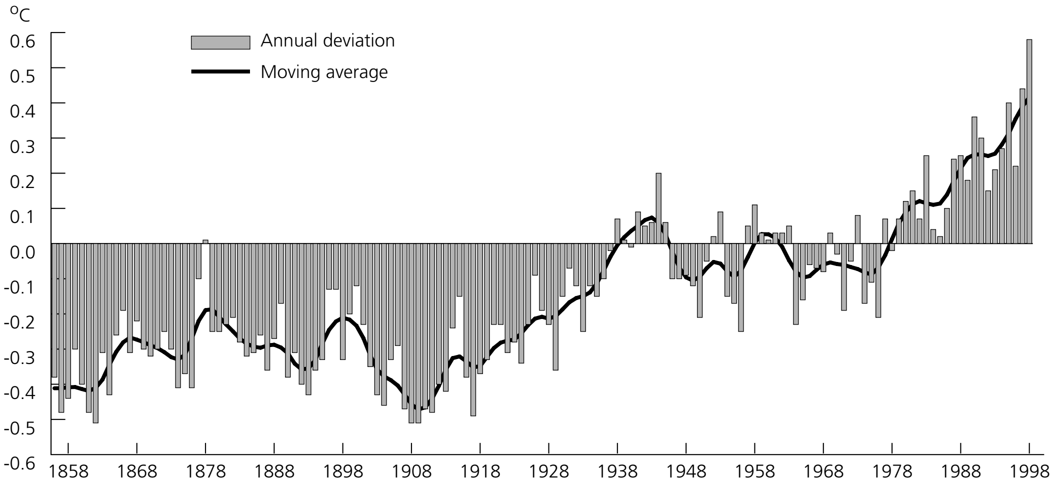
There is great uncertainty associated with the effects of a further temperature rise, but probable effects are changes in precipitation patterns, more frequent occurrence of extreme weather conditions, displacement of climate zones and a rise in sea level of 15-95 cm. This could have serious consequences for world agricultural production and for low-lying areas.

Recent decades have seen growing recognition in Norway and internationally of the importance of the global environment for both economic and social development. More and more environmental problems are regarded as global in nature, and the need for international cooperation to resolve them has been acknowledged. The UN General Assembly played an important role in this work by appointing the World Commission on Environment and Development (Brundtland Commission), which published the report *Our Common Future* in 1987. A number of important international conferences dealing with these issues have been held more recently.

- The UN Conference on Environment and Development in Rio de Janeiro in June 1992 resulted in the Framework Convention on Climate Change (FCCC), the Convention on Biological Diversity and principles for sustainable use of forests. The conference adopted Agenda 21, an international action plan for environment and development efforts into the next century.
- The first Conference of the Parties to the FCCC (COP1), or meeting of Annex I countries[1], was held in Berlin in March-April 1995 and resulted in a mandate for further negotiations to

[1] These correspond roughly to the member states of the OECD and countries with economies in transition (Eastern Europe and Russia).

Figure 4.11. **Changes in global mean temperature compared with the normal value for 1961-1990**



Sources: University of East Anglia and Norwegian Meteorological Institute.

draw up quantified emission commitments for these countries with specified time limits, focusing on the period after 2000.

- The second Conference of the Parties (COP2), held in July 1996 in Geneva, gave impetus to the preparation of the text of an agreement in which it was hoped that the Annex I countries would agree on binding emission reductions.
- The third Conference of the Parties (COP3), held in Kyoto in Japan from 1 to 12 December 1997, resulted in quantified commitments to reduce emissions and opportunities for joint implementation of emission reductions. This agreement is known as the Kyoto Protocol[2].

In Kyoto, the Annex B countries[3] agreed to reduce their aggregate emissions of the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) by 5.2 per cent between 2008 and 2012. The quantitative commitments in the agreement are differentiated - some countries must reduce their emissions to below the 1990 level (or the 1995 level for the last three gases), while others may allow a certain increase in emissions. Norway's overall greenhouse gas emissions may rise by one per cent compared with the 1990 level, while the EU as a whole must reduce emissions by 8 per cent. Flexibility mechanisms including trade in emissions credits mean that the actual emission reductions in individual countries may differ from these figures, but the commitment must then be met by buying and selling credits or by joint implementation projects in other countries.

[2] See the Kyoto Protocol to the United Nations Framework Convention on Climate Change, United Nations, FCCC/CP/1997/Add.1 10 December 1997.

[3] Annex B countries correspond more or less to Annex I countries under the Convention.

Box 4.8. The Kyoto mechanisms

Emissions trading
Countries that have undertaken commitments to reduce emissions may trade emissions credits among themselves. A country where the cost of reducing emissions by more than the target set out in the protocol is relatively low may sell credits to countries where the cost of achieving the target relatively high. Countries that sell credits must reduce their emissions *more* than the protocol requires, and purchasing countries can reduce them *less*.

Joint implementation
Two countries that have undertaken commitments to reduce emissions may agree that reductions financed by one country and carried out in the other are to be credited to the investor's emission inventory. Since the cost of reducing emissions varies widely between countries, this is a more cost-effective solution than requiring all countries to carry out emission reductions within their own borders.

Green development mechanism (CDM)
Similar to joint implementation, but CDM is applicable in cases where one party has undertaken a commitment to reduce emissions and the other has not.

Sources: UNFCCC (1997), ECON (1988 and no date) and Alfsen (1999).

The Protocol will enter into force when it has been ratified by at least 55 parties that account for at least 55 per cent of total CO_2 emissions from the industrial countries. In 1998, a new Conference of the Parties (COP4) was held in an attempt to deal with some unresolved matters in connection with the agreement. The meeting gave few answers, but the parties agreed on a schedule for further work. The earliest opportunity for adopting rules for the three Kyoto mechanisms, i.e. emissions trading, joint implementation and the green development mechanism (see Box 4.8) will be the Conference of the Parties in the year 2000 (COP6).

Norway has entered into an agreement with China to provide NOK 35 million towards the improvement and modernization of a large coal-fired power plant, which will reduce CO_2 emissions by improving energy efficiency (Cutter 1998). Like several other industrial countries, Norway has made such agreements in the hope that the emission reductions will be credited as the Kyoto Protocol becomes operational.

In 1998, the Storting also decided that a domestic quota-based emissions trading system for the most important greenhouse gases should be reviewed.

The measures that must be implemented if Norway is to meet its commitments under the Kyoto Protocol are discussed in Report No. 29 (1997-98) to the Storting on Norwegian implementation of the Kyoto Protocol. Some of them are also described in section 4.7.

Several international studies have provided estimates of the price of CO_2 emission permits in a system using tradable permits, given that total emissions of the gas are to be stabilized at the 1990 level, see Bye (1998). The estimates vary widely depending on expected trends without any restrictions on emissions and on which countries undertake binding goals for emission reductions. The studies also show that there is much to be gained from introducing a system of tradable permits rather than requiring each country to achieve its own emission restrictions separately.

Both implementation of the Protocol and a system of tradable emission permits are dependent on reasonably reliable calculations. At present, there is considerable uncertainty as regards figures for greenhouse gas emissions. The first analysis presented in this section describes the problems this poses for implementation of the protocol and emissions trading. After this, we present four analyses of possible consequences of the Kyoto Protocol for Norway. The first of these describes the importance of methane for overall greenhouse gas emissions and analyses how its inclusion may affect the permit price for greenhouse gases. The second reviews some possible consequences of the requirements of the Kyoto Protocol for the international permit price and for Norwegian petroleum wealth. The third analysis considers the interrelationship between the climate agreement, energy markets and exploration activity for oil, and the fourth deals with the consequences of the Kyoto Protocol for the Nordic electricity market. Finally, there is an analysis of the most cost-effective ways of including developing countries in a binding climate agreement.

Uncertainty in emission figures and consequences for the Kyoto Protocol

According to the Kyoto Protocol, Norway may allow its greenhouse gas emissions to rise by not more than one per cent from the 1990 level up to the period 2008-2012. However, figures for emissions of some greenhouse gases are very uncertain. A new analysis (Rypdal 1999) shows that, given our current knowledge, it is probably not possible to calculate trends in greenhouse gas emissions from 1990 to 2008-2012 to an accuracy of ±1 percentage point. This is mainly because of uncertainties relating to emissions of methane (CH_4) from landfills, nitrous oxide (N_2O) from agriculture and road traffic, and PFC (perfluorocarbons) from industrial processes.

Uncertainties in current greenhouse gas emissions

The Kyoto Protocol applies to emissions of all the most important greenhouse gases, weighted according to their global warming potentials (GWP) (see box 4.4). Emissions of CO_2 can be estimated with a fairly high degree of certainty (uncertainty probably less than 5 per cent), but uncertainty is higher for emissions of the other gases. For emissions of methane, PFCs and HFCs (hydrofluorocarbons) the uncertainty is probably 30-50 per cent. The estimate of SF_6 is relatively accurate. The uncertainty for emissions of nitrous oxide is greater than 50 per cent, and for certain sources of emissions even the order of magnitude is unknown. The uncertainty for total greenhouse gas emissions in Norway is estimated to be 10-15 per cent.

Uncertainty in trends in emissions

Emission data are largely derived from model-based calculations. This means that the emission figures for 1990 and for 2008-2012 are generally based on the same emission factors, emission models and assumptions. The uncertainty of the percentage change in emissions during a period (the trend) will therefore be much lower than for emission levels for each gas. The fact that the Kyoto Protocol is based on aggregate figures for all gases weighted according to their global warming potentials means that the trend estimate is relatively robust with respect to errors in the figures for individual gases.

We have used a sensitivity analysis to explore how errors in emission levels and trends for each greenhouse gas and certain emission sources will affect estimates of the overall trend in greenhouse gas emissions from 1990 to 2008-2012. Our interpretation of the Kyoto Protocol is that the maximum acceptable level of uncertainty is ± 1 percentage point. The analysis shows that the uncertainty for methane, nitrous oxide and PFCs is so high that changes in the figures may alter the trend estimate. It is thus not certain that it will be possible to calculate the increase in emissions from 1990 to 2008-2012 to an accuracy of ± 1 percentage point. This conclusion depends on trends in emissions of individual gases or in emissions from particular sources. In the short term, it will be difficult to reduce the level of uncertainty for certain sources of emissions. This applies particularly to nitrous oxide from agriculture, but also to methane from landfills and nitrous oxide from road traffic.

Uncertainty and tradable permits
Emissions trading involves the transfer of emission permits measured in tonnes even though emission levels are uncertain. The degree of uncertainty will depend on the quality of the emission inventory in the selling country, the mix of sources, and the sources from which emissions are reduced. It has not yet been decided how this uncertainty should be dealt with in emissions trading. For example, who bears the responsibility if new research shows that a bought and sold reduction of 5 million tonnes CO_2 equivalents proves to be only 4 million tonnes? The uncertainty of the emission levels in both the selling and the buying countries is also important in emissions trading. If these levels are adjusted upwards or downwards, the trend in emissions in both countries will also change, given that a fixed number of tonnes is being traded.

How should we respond to uncertainty?
In the short term, it will be difficult to reduce the level of uncertainty for the sources where uncertainty is highest. It is important to ensure that countries cannot meet their commitments by adjusting emission figures within the uncertainty range. International efforts are therefore being made to find satisfactory routines for reporting greenhouse gas emissions. This work includes:

- The development of detailed guidelines for reporting emission data. Have all sources been included? Are the best available methods being used? Are the data used consistent with current knowledge? Are the methods and data well-documented?
- Proposals for guidelines for reporting uncertainty in emission data.
- Proposals for standard routines for quality control and auditing.
- External evaluation and peer reviews, and comparison of the data reported by different countries.

Even if it is not possible to reduce the uncertainty of the data in the short term, it is thus possible to improve their quality by means of stringent requirements for what is reported and how the data are obtained.

In 1999, Statistics Norway will continue the development of statistical methods for quantifying and reporting uncertainties in the levels and trends of greenhouse gas emissions. Statistics Norway and the Norwegian Pollution Control Authority are making continuous efforts to improve calculation methods and the quality of the data used in emission inventories and reported to the Convention on Climate Change.

Project financed by: Norwegian Pollution Control Authority.

Project documentation: Rypdal (1999).

Methane emissions and permit prices for greenhouse gases

Studies that have attempted to provide estimates of permit prices for greenhouse gases indicate that if more gases are included in the climate protocol, prices will be substantially lower than if only CO_2 emissions are to be reduced. The Kyoto Protocol includes CO_2 and five other greenhouse gases. The permit price for greenhouse gases will depend on the costs of reducing emissions of all these gases. For reductions to be cost-effective both nationally and internationally, the marginal cost of further reductions must be the same for all measures and all gases.

Methane, a large proportion of which is generated by landfills and agriculture, is the most important greenhouse gas apart from CO_2. This means that the cost of reducing methane emissions can have an important influence on the overall permit prices for greenhouse gases. Methane accounts for about the same proportion of total greenhouse gas emissions in Norway as in the rest of the world, and the importance of methane emissions for the permit price in Norway can thus give an indication of their importance in other countries. To ensure cost-effective reduction of greenhouse gas emissions, the costs of reduction for all greenhouse gases, including methane, must be evaluated, and the cheapest measures must be implemented first.

The analysis includes new projections of quantities of municipal waste, which show faster growth than previously assumed. On the other hand, new research shows that methane emissions from landfills have been overestimated, and that methane is a less important greenhouse gas in Norway than previously suggested. Recent research also suggests that methane emissions can be reduced at fairly low cost. This means that permit prices may be low in the short term. In the longer term, stricter emission requirements may be introduced, making it necessary to eliminate a larger proportion of CO_2 emissions. The importance of CO_2 for permit prices will then rise relative to that of other greenhouse gases, and the permit price will rise. Thus, the relationship between trends in CO_2 emissions and emissions of other gases, of which methane is the most important, will play a key role when permit prices for greenhouse gases are determined.

Calculations for two scenarios, one with considerable and one with little possibility of substitution on the supply side for electricity, suggest that the opportunities for substitution have a strong influence on the permit price necessary to stabilize greenhouse gas emissions. Norway is not necessarily an expensive country in which to reduce greenhouse gas emissions. On the contrary, there are elements on both supply and demand side in the power market that suggest that it may be relatively inexpensive to reduce emissions in Norway. Given ample opportunities for substitution in energy production and use, a permit price of about NOK 200 per tonne CO_2 should be close to what is needed to ensure that the emission goals set out in the Kyoto Protocol are met internationally.

Many studies show rising marginal costs associated with the reduction of greenhouse gas emissions. In other words, the unit cost of reducing emissions rises as more stringent requirements are introduced. Steeper growth in emissions will mean that a higher permit price is needed. More recent analyses of global emissions indicate higher emissions than were projected prior to the Kyoto negotiations. This suggests that earlier analyses may have been overoptimistic as regards how low emissions would be without the introduction of restrictions.

Project financed by: Statistics Norway.

Project documentation: Bruvoll and Bye (1998).

The Kyoto Protocol, permit prices for CO_2 and consequences for the Norwegian petroleum sector

The Kyoto Protocol sets limits on greenhouse gas emissions from Annex B countries. The most important greenhouse gas is CO_2, and the main source of anthropogenic CO_2 emissions is combustion of fossil fuels such as oil, gas and coal. The starting point for this study is that CO_2 emissions are to be reduced by 5.2 per cent in the Annex B area, which is the same as the overall reduction required in emissions of all six greenhouse gases.

Reductions in CO_2 emissions can be achieved by various means, including taxes or a system of emission permits. An effective international market for tradable permits will result in a permit price corresponding to the tax required to give the same reduction in emissions. Under certain conditions, taxes and tradable permits will thus give the same result.

This study looks at the tax rate or permit price necessary to meet the requirements of the Kyoto Protocol, given various assumptions concerning OPEC's behaviour. At any given time, a CO_2 tax (or a system of tradable permits) will result in both a lower producer price and a higher oil price for consumers. A drop in demand and a lower producer price for oil and gas will have an impact on Norway's revenues from its petroleum resources.

We have used a dynamic model with a long time horizon (the PETRO model) to describe the oil, gas and coal markets. This takes into account the fact that an increase in extraction today will reduce the availability of the resource in the future. The model focuses on the optimal extraction rate for the resources over time. In the model, the cost per unit produced rises as the resource is depleted, and the considerable technological advances in extraction techniques are also taken into account. On the demand side, we assume that there are certain opportunities for substitution between the various fossil fuels. Changes in one of the markets thus also affect the other markets. We also assume that there is an unlimited supply of a carbon-free alternative energy source that can completely replace all fossil fuels. This energy source is initially assumed to be considerably more expensive than fossil fuels, but its price falls with time as a result of technological developments. This means that in time, the production of fossil fuels becomes unprofitable.

In the oil market, a distinction is made between OPEC and other countries (called the fringe). The fringe consists of many small producers, each of which considers the oil price as given. OPEC, on the other hand, has market power in the sense that the cartel can influence the price by changing the rate of production. Two scenarios have been studied, one in which OPEC acts as a cartel and the other in which the entire oil market is a competitive market. The market for natural gas is divided into three regions: OECD-Europe, rest of OECD and non-OECD. Because gas is expensive to transport, there is no trade between the regions, and each of the regions is modelled as a competitive market. The coal market is modelled as a global competitive market.

No quantitative emission commitments for developing countries were included in the Kyoto Protocol or at the subsequent meeting in Buenos Aires. Nevertheless, these countries may have to accept emission commitments at a later date. A scenario including global emission targets was therefore also modelled. In addition, a scenario involving additional emission reduction targets was modelled, in which it is assumed that the entire world is required to fulfil the Kyoto target by reducing emissions by 5.2 per cent by 2010. In addition, we assume that global emissions are required to be 20 per cent below the 1990 level in 2020. In both alternatives it is assumed that emissions remain stable once the targets have been met.

The results for the oil market show that in the first two to three decades, most of the burden of introducing CO_2 taxes is borne by consumers if OPEC functions as a cartel. The reason is that OPEC reduces production to maintain oil prices, so that the reduction in producer prices is not very large in this period. Given an effective international tradable permit market, the results indicate a CO_2 permit price that rises from NOK 100 per tonne in 2010 to just under NOK 300 per tonne in

Table 4.1. **Percentage reduction in Norwegian oil wealth**

	No Kyoto targets	Kyoto targets	Adittional emission targets
OPEC as cartel	Initial wealth	15	42
Free competition	70	80	90

Source: Lindholt (1998a)

2030. If the oil market becomes competitive, oil production will be higher in the first thirty years, and a higher permit price will be required to achieve a given emission target. In addition, the drop in producer prices will be greater if there is perfect competition, because all the oil producers consider the oil price as given. The results indicate that in this case, the permit price will rise from about NOK 200 per tonne CO_2 in 2010 to almost NOK 400 in 2030. Irrespective of the emission reductions required, the permit price can be considerably reduced once global oil production begins to fall because an alternative carbon-free energy source replaces oil.

If OPEC acts as a cartel, simulations show that the Kyoto commitments will lead to a reduction in Norway's oil wealth of about 15 per cent (table 4.1). However, at the same time revenues from hydropower will rise; see the section on the impact of the Kyoto Protocol on the electricity market. As an oil producer, Norway would lose much more if OPEC were to be dissolved than it will through implementation of the Kyoto Protocol. If OPEC were to be dissolved, or if individual member countries began to disregard their production quotas, Norway could lose about 70 per cent of its oil wealth in the scenario *without* emission targets. If the oil market becomes a competitive market, achievement of the Kyoto targets could reduce Norway's oil wealth by a further third. The reason is that in a market of this kind, the producer price for oil would fall by a greater margin, resulting in a relatively larger reduction of the oil wealth. Even though the relative loss as a result of the Kyoto targets is larger than in the cartel scenario, the loss in nominal terms is smaller, because the initial wealth of the fringe is substantially lower in the competitive market scenario. The combination of perfect competition and the Kyoto commitments may reduce the oil wealth by almost 80 per cent. The results indicate that Norway will lose about 20 per cent of its gas wealth through implementation of the Kyoto Protocol, irrespective of OPEC's behaviour.

If the requirements for emission reduction targets in the Kyoto Protocol are made globally applicable and additional commitments are introduced, these trends will be reinforced. This will result in higher CO_2 permit prices and a greater reduction in Norway's oil and gas wealth.

Project financed by: Statistics Norway.

Project documentation: Lindholt (1998a).

How will a climate agreement influence exploration for oil?

The restrictions on CO_2 emissions set out in the Kyoto Protocol will have a major impact on the markets for fossil fuels. One of a number of interesting questions is what influence this will have on oil exploration activities.

Exploration for oil must be considered in a long-term perspective for several reasons. Firstly, there is a long delay between the beginning of the exploration process and the time when it is possible to begin oil production from a field that has been discovered. Secondly, oil is a non-renewable resource, i.e. oil can only be produced from a particular field once. It is therefore important for the owner of an oil field to assess when it is most profitable to extract the oil. This depends among other things on expected future trends in the price of oil. If it seems likely that the oil price will remain low for the foreseeable future, it may be most profitable to extract the oil as soon as possible and place the revenues in such a way as to earn interest. On the other hand, if it seems likely that oil prices will rise rapidly as global supplies become scarcer, it may be more profitable to leave the oil in the reservoirs for the time being. Such considerations distinguish the oil market from most other markets, and may sometimes result in effects that are the reverse of what one would expect at first sight, as we shall see below.

To try to find an answer to the question in the title, we have expanded the PETRO model (see the previous section), which describes the oil, gas and coal markets. An important feature of the model is that it has a long time horizon and takes into account the owners' evaluation of when oil should be extracted. Another important feature is that it defines two groups of oil producers. One of these is OPEC, which acts as a cartel and can therefore influence oil prices. The second group includes all other producers, each of which acts independently. OPEC has an abundant supply of reserves available at low cost, whereas the other producers have fewer, more costly reserves. The latter group therefore produce oil and explore for new fields simultaneously. Both production and exploration activities depend on expected trends in oil prices.

Implementation of a climate agreement will mean that the parties to the agreement must introduce measures to limit CO_2 emissions. This can for example be done by introducing or raising CO_2 taxes. In this project, we have studied the possible effects of a rising CO_2 tax in the OECD countries (and later in the rest of the world). It is natural to assume that the producer price of oil will drop when a CO_2 tax is introduced. This is confirmed by the model, but the price reduction turns out to be small initially. However, the price drops more and more at a later stage. As a result, the non-OPEC countries find that oil production becomes less and less profitable. They will therefore accelerate some of their production plans, since profitability drops less initially than later in the period modelled. Production by this group therefore actually rises somewhat during the first forty years after the introduction of the CO_2 tax.

The model also shows that the level of exploration activity will rise somewhat as a result of a climate agreement, because of the rise in production. This is because it is profitable to delay exploration activity until just before the oil is to be extracted. Since production rises initially, so will the level of exploration activity. Although the rise is small, this finding is probably very different from the expected result of an agreement designed to reduce the use of fossil fuels.

Project financed by: Ministry of the Environment.

Project documentation: Berg, Kverndokk and Rosendahl (1999).

The impact of the Kyoto Protocol on the electricity market

In this article, we analyse some consequences of the implementation of the Kyoto Protocol for the Norwegian and Nordic electricity markets. The main focus is on possible effects in the year 2010. It is assumed that internationally cost-effective implementation of the emission targets of the Kyoto Protocol will entail an international (and Nordic) tax rate or permit price of NOK 200 (1995 NOK) per tonne CO_2 equivalent for greenhouse gases. We have used a model of the Nordic electricity market (NORMOD-T) in conjunction with a national long-term macroeconomic model, MSG-6, in this study.

A regime involving international trading of emission permits has been compared with a reference scenario in which it is assumed that the Kyoto Protocol is not ratified. We have also simulated alternatives in which energy-intensive manufacturing industries are either sheltered from higher electricity prices or fully integrated into the electricity market, but are otherwise subject to the same tax on or permit price for CO_2 emissions as the rest of the economy.

According to the calculations, implementation of the Kyoto Protocol may have a number of consequences for the electricity market in the Nordic countries. The use of fuels such as coal, gas and oil will be more expensive for power producers, thus increasing the marginal production costs for thermal power plants (coal-, gas- or oil-fired). The costs of hydropower, wind power, nuclear power and biofuel-based electricity production will not be directly affected by a stricter climate policy. Electricity demand will drop as a result of lower activity in sectors where production generates emissions of greenhouse gases. Changes in production costs and the demand for power will affect electricity prices, and patterns of trade in electricity will be altered. The calculations indicate that producer prices for electricity in the Nordic countries may rise by 10-30 per cent compared with the levels expected if the current tax regime and tax rates are continued. The rise in power prices will also result in lower electricity consumption and thus lower overall electricity production.

Implementation of the Kyoto Protocol may increase trade in electricity despite the overall drop in production and consumption. This is because access to production resources that generate no or only small emissions varies widely from country to country. Further reductions in emissions can be achieved if power-intensive manufacturing industries and the pulp and paper industry have to pay the market price for electricity. Lower consumption in these sectors will replace polluting electricity production in other countries. The importance of power-intensive manufacturing varies greatly in the Nordic countries, and the volume of electricity made available for the market if these industries have to pay market-based power prices will therefore also vary. The inclusion of power-intensive manufacturing in the electricity market will therefore increase the volume of trade.

As regards emissions, the impact of the Kyoto Protocol in 2010 varies depending on which country we consider. In Norway, hydropower production generates no greenhouse gas emissions, while gas-based electricity production and emissions from this will be reduced (there are no political restrictions on gas-fired power plants in the reference scenario). In the reference scenario, electricity production in Sweden consists mainly of hydropower and nuclear power, supplemented with some production based on oil, gas and biofuels. Depending on how the Kyoto Protocol is implemented in the Nordic countries, CO_2 emissions from the power sector in Sweden can be greatly reduced. In Denmark and Finland, where power production is dominated by thermal power plants fuelled by coal and gas in the reference scenario in 2010, emissions will be more than halved by the drop in domestic production, a certain changeover to gas for electricity production and some import of electricity replacing domestic production. The overall effect of the Kyoto Protocol is to reduce CO_2 emissions from power production in the Nordic countries in 2010 to less than half the level expected without CO_2 taxes or permit prices. Power plants with high CO_2 emissions will be replaced by new hydropower production, biofuel-based power production and new efficient gas-fired power plants.

Project financed by: Ministry of Petroleum and Energy and Research Council of Norway.

Project documentation: Aune, Bye and Johnsen (1998).

How can developing countries be included in binding international environmental agreements?

Irrespective of the impact of the Kyoto Protocol, it is likely that global emissions of greenhouse gases will continue to rise well into the next century, mainly because emissions in countries such as India and China are rising rapidly. Future international climate agreements will therefore have to include binding emission targets for developing countries if we are to succeed in reducing global greenhouse gas emissions.

During the process leading up to the Kyoto Protocol, the most important developing countries were unwilling to become parties to a climate agreement involving binding emission targets. An important reason for this was the argument that climate problems have largely been created by emissions from the industrial countries, which therefore have a particular moral responsibility for emission reductions. A related argument is that continued economic development in the developing countries will in practice involve further rises in their greenhouse gas emissions. A climate agreement that includes stringent emission goals for these countries could therefore involve substantial costs and hinder economic development.

On the other hand, many developing countries can reduce their emissions at relatively lower cost than a number of the industrial economies. A climate agreement that permits emissions trading and includes the developing countries may make it profitable for developing countries to sell emissions credits to industrial countries. The total costs of taking part in an agreement of this kind thus consist of the costs of emission reductions minus the income from sales or exports of emissions credits. The volume of exports or trade will depend largely on the emissions target or the quota for the developing country in question in the climate agreement.

In this study, we looked more closely at a simplified negotiation process including both industrial and developing countries in which the aim is to agree on a cost-effective international climate agreement. In this context, cost-effective means that specified emission targets are achieved at the lowest possible overall cost, which can theoretically be brought about through emissions trading. The industrial countries consider themselves to be committed to reducing emissions to a certain extent, whereas the developing countries are naturally reluctant to become parties to an agreement that will entail positive net costs for them. Nor can it be assumed that the developing countries will necessarily accept emission permits that are expected to entail zero net costs. This is because the marginal costs of emission reductions in the countries that are parties to the agreement, and thus the international price for emissions credits, will in practice be uncertain. Such uncertainty acts as a disincentive for the risk-averse developing countries to accept the climate agreement.

Since the industrial countries in the model have undertaken to reach an agreement, they will consider transferring resources to the risk-averse developing countries to compensate for variable prices and the uncertain marginal costs of emission reductions. The alternatives that have been analysed are an initial emission quota larger than that needed to give zero net costs and financial transfers.

The main conclusion is that financial transfers are a more effective means of encouraging the developing countries to become parties to the international climate agreement than larger initial emission quotas. The costs incurred by the industrial countries in persuading the developing countries to join the agreement are lower in this case lower than in the scenario using compensation by means of emission permits. Moreover, financial transfers can be used to persuade developing countries that exhibit a higher degree of risk aversion to join the agreement.

Project financed by: Research Council of Norway.

Project documentation: Søberg (1998).

4.7. Measures introduced by the authorities to reduce emissions to air

Every year, large amounts of pollutants are released to air in Norway. They may cause environmental damage at global, regional or local level, i.e. climate problems (enhanced greenhouse effect), acidification, or deterioration of local air quality (which in turn causes health problems). To reduce such emissions, various measures have been introduced. These included technological solutions, for instance improvements in combustion efficiency in engines that will reduce fuel consumption and emissions, and measures designed to reduce consumption of goods by consumers or industry (taxes or other restrictions on use).

In the following section, measures that have been introduced primarily to reduce emissions to air are described, and some other measures are also mentioned briefly. The measures are not evaluated, nor is this intended to be an exhaustive list at present, but a review of some selected measures. A number of other measures that for instance reduce fuel consumption in engines or the amount of waste landfilled will also result in lower emissions to air. If this is not their primary purpose, the measures are discussed in the appropriate chapters (car engines in Chapter 3 and waste reduction in Chapter 5). Box 4.5 gives an overview of Norway's commitments under international environmental agreements.

Legislative measures

Acts and regulations
The Pollution Control Act states as a general rule that pollution is prohibited without a permit from the pollution control authorities. Emissions to air from industry are therefore regulated by means of discharge permits, and the authorities can use clearly-defined sanctions to ensure compliance with permits. Discharge permits are used mainly for major point sources of emissions, while other smaller sources are generally governed by regulations.

The regulations of 30 May 1997 relating to limit values for local air pollution and noise require improvements to be made in the areas where pollution levels are highest. The EU is in the process of adopting even stricter limit values that will later apply in Norway as well as a result of the EEA Agreement. To improve local air quality in Oslo, it was decided in autumn 1988 to reduce speed limits on the main roads on days when pollution levels are particularly high. This has not yet been put into practice.

Regulations relating to the sulphur content of fuel oil pursuant to the Pollution Control Act and provisions on taxes on products containing sulphur also influence local air pollution caused by industrial activities and heating of housing.

Licences for landfills issued by the county governors include requirements for gas extraction to reduce methane emissions.

Agreements
The use of agreements between the authorities and business and industry on quantified emission reductions can be appropriate if it is assumed that this will be a more cost-effective solution than the use of other instruments. Such agreements will be sued instead of requirements laid down in discharge permits or in the Pollution Control Act.

The first agreement of this type in Norway dates from 1997, when the Ministry of the Environment and the aluminium industry agreed to limit emissions of greenhouse gases that at the time were not taxed or regulated in any other way.

Economic measures

A CO_2 tax was first introduced in 1991, and according to Report No. 29 (1997-98) to the Storting applied to about 60 per cent of all CO_2 emissions. The tax system is such that some sectors pay the full CO_2 tax, others pay tax at a reduced rate and some are exempt. Civilian aviation and domestic sea freight were exempt from the tax until recently, but in connection with the 1999 state budget it was decided to introduce a CO_2 tax for these sectors as well. As mentioned above, the tax rate varies from one sector to another: it is NOK 0.89 per litre for oil for combustion on the continental shelf, and about NOK 0.22 per litre for the pulp and paper industry, while coal and coke for process purposes in the ferro-alloy industry are exempt from the tax. Because of the low oil prices on the world market in 1998-1999, temporary exemption of the oil sector from the CO_2 tax is being evaluated. Norway is the only country that has introduced a CO_2 tax on oil extraction.

The SO_2 tax varies with the sulphur content of the mineral oil, and is currently NOK 17 per kg SO_2. Mineral oil with a sulphur content of less than 0.05 per cent by weight is exempt from the tax (Proposition No. 54 (1997-1998) to the Storting).

In autumn 1998, a scheme to encourage delivery of old, polluting wood-fired stoves was introduced locally in certain parts of Oslo. The municipality offered NOK 4000 to the first thousand people who replaced old stoves with new, cleaner types. However, far fewer than 1000 people took up the offer.

Information measures

The Government will intensify information measures connected with climate issues (Report No. 29 (1997-98) to the Storting). The aim is to reduce energy use and emissions by providing information on energy efficiency measures, measures to reduce car use, etc., and taking steps to encourage their use.

The authorities and private organizations (Norwegian Automobile Association) are running information campaigns to encourage people to buy non-studded winter tyres. The aim is for 80 per cent of cars to be fitted with these by the year 2002. The public is also being informed that if the goal is not achieved in the larger towns, other measures will be implemented (e.g. a tax on the use of studded tyres).

Other measures

To fulfil Norway's commitment to reduce NMVOC emissions by 30 per cent from 1989 to 1999, additional measures must be implemented. New technology is therefore being tested for the recovery of NMVOCs during loading of crude oil on tankers offshore. The authorities are also implementing an EU directive on the reduction of VOC emissions during storage of petrol and distribution of petrol from terminals to petrol stations. Negotiations between the authorities and the petroleum industry are also in progress with a view to an agreement of limited duration on the reduction of VOC emissions from this sector.

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

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

Further information may be obtained from: Gisle Haakonsen, Ketil Flugsrud, Kristin Rypdal and Knut Einar Rosendahl.

5. Waste

Economic growth and rising consumption have resulted in a steady increase in waste generation. Per capita generation of household waste reached 308 kg in 1997, 15 kg more than in 1996 and almost twice as much as 30 years ago. Of this, 90 kg was delivered for material recovery, which is a higher proportion than the year before. The increase in material recovery thus contributes to a reduction in the quantity of residual household waste that is incinerated or landfilled. In addition to household waste, waste is generated by business and industry and by the public sector. The most important environmental problems associated with waste include emissions of the greenhouse gas methane from landfills and emissions to air from incineration plants and waste transport. Projections drawn up by Statistics Norway indicate that the quantities of waste generated will continue to rise substantially.

5.1. Introduction

Main objectives of waste management policy

According to the environmental authorities, waste is to be managed in such a way as to minimize injury and nuisance for people and the natural environment (Proposition No. 1 (1998-1999) to the Storting). At the same time, the resources required by waste and its management must be minimized. The strategy set out by the authorities to solve problems related to waste generation and management is first and foremost to minimize both waste generation and the quantities of substances that are environmentally hazardous or a health hazard in the waste generated. Secondly, re-use, the recovery of useful materials and the extraction of energy from any waste generated are to be promoted. Thirdly, sound management of the residual waste is to be ensured. Hazardous waste is either to be recycled or receive final treatment in approved facilities. Finally, steps are to be taken to avoid serious pollution problems as a result of earlier inappropriate waste disposal. This is to be done by investigating areas where a possible danger is known to exist and polluted areas where there are plans to make changes in land use, and taking any measures considered necessary.

Policy instruments for waste management

The 1981 Pollution Control Act and appurtenant regulations include a number of provisions relating to waste management. The Act sets out a general prohibition on littering, a duty for municipalities

Table 5.1. **Important waste policy measures and instruments**

Measure	Objective	Results
Municipal waste management plans	Planning tool to improve waste treatment.	
Requirement for 100 per cent cost absorption	Ensure that the polluter-pays-principle is followed.	1995: average cost absorption absorption by the municipalities was 95 per cent.
Grading of waste management fees	Economic incentive for households to reduce residual waste quantities and increase the share sorted at source.	1997: 61 per cent of municipalities had some form of grading.
Tax on final waste treatment	Economic incentive to reduce quantities landfilled and increase recycling, material recovery and energy recovery. Payment for the environmental costs of waste.	
Agreements between industry and the authorities, return schemes	Agreements between the authorities and the business community to reduce quantities of packaging waste and reach given recycling levels.	Several agreements concluded between the environmental authorities and industry on collection and recycling of waste fractions. Other fractions are recycled on the basis of regulations and deposit and return schemes. Schemes exist for hazardous waste, packaging, batteries, car tyres, scrapped cars, waste oil, fridges and freezers containing CFCs, household appliances, and electrical and electronic products.
Grants for demonstrating collection and recycling schemes and establishing recycling facilities	Reduce waste quantities landfilled and make use of the resources in waste.	1997: 20 per cent of municipal waste used for material recovery. see Chapter 5.3 for results of recycling schemes.
Restrictions on landfilling of wet organic waste	Reduce methane emissions from landfills and make use of the resources in wet organic waste.	Quantities of waste biologically treated have risen in recent years. 5 per cent of all municipal waste received biological treatment in 1997.
Strict conditions for licences for landfills and incineration plants	Include collection of seepage and draining it away from vulnerable recipients, collection and flaring of methane, sorting recyclable materials at landfills, restrictions on quantities and types of waste landfilled, control and registration of waste, control of emissions after closure of landfills, measures to protect the local environment, limit values for emissions of dust, toxic substances, acid emissions, etc.	1995: 55 facilities purified seepage and 15 extracted gas: treated 52 and 26 per cent, respectively, of landfilled municipal waste. 1998: About 22 800 tonnes of methane flared or used for energy purposes.

Sources: Statistics Norway and Norwegian Pollution Control Authority.

to collect household waste, and a requirement that municipal waste collection fees must cover all costs of waste management, and encourages municipalities to grade their fees to promote waste reduction and recycling. In addition, there are various regulations governing the management of different waste fractions.

The Pollution Control Act also requires waste treatment and disposal plants to have permits from the pollution control authorities. These may set environmental standards for the plants.

Management of hazardous waste is governed by separate regulations. These lay down that hazardous waste shall not be mixed with other waste, but treated separately. They also lay down a duty to deliver hazardous waste to approved facilities and requirements for the enterprises involved in managing hazardous waste.

The most recent measure introduced to reduce the quantities of waste landfilled and to promote more recycling is a fee for waste delivered for final treatment, which became effective from 1 January 1999. Table 5.1 describes some of the most important measures and instruments implemented by the authorities.

Environmental problems associated with waste

Waste management results in a number of environmental problems. One of the most serious is generation of the greenhouse gas methane (CH_4) by rotting waste in landfills. In 1997, methane emissions from landfills accounted for more than 7 per cent of all greenhouse gas emissions in Norway (table 5.2). To limit these emissions, a growing proportion of the methane generated is flared or burnt for energy recovery. In 1998, about 23 000 tonnes of methane was flared or used for energy recovery, as compared with 800 tonnes in 1990. Despite this, methane emissions from landfills rose from 182 000 tonnes in 1990 to 189 000 tonnes in 1998. However, emissions dropped by 1 per cent from 1997 to 1998 (see also Chapter 4.2).

Table 5.2. **Emissions to air from waste treatment[1], in tonnes. Percentage of total emissions in Norway. 1997*, methane 1998***

	Emissions	Percentage of total emissions in Norway
Methane (CH_4) from landfills	189 000	54 (7.5[2])
Nitrogen oxides (NO_x)	1 000	0.4
Carbon dioxide (CO_2)	157 000	0.4
Particulate matter	46	0.2
Lead (Pb)	1.3	20.0
NMVOCs	322	0.1
Sulphur dioxide (SO_2)	184	0.6

[1] Methane from landfills, otherwise from incineration. Ranked in order of importance by estimated contribution to environmental damage.
[2] Calculated as the proportion of total greenhouse gas emissions.
Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

Incineration of waste results in emissions of harmful gases. However, the stricter standards that have been introduced for emissions from incineration plants have reduced such emissions in recent years. With the exception of lead, emissions from waste incineration account for only a very small proportion of total emissions of pollutants. Incineration of waste instead of landfilling reduces methane emissions because incinerated waste does not generate methane emissions when landfilled, unlike waste that is landfilled directly.

Polluted seepage from landfills can have toxic effects and cause nutrient enrich-

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 meanings.

In the Pollution Control Act, waste is divided into three categories: consumer waste, production waste and special waste (including hazardous waste). This classification is now being revised. 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.

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.

ment. Such problems are mainly associated with older landfills, since there are very strict requirements for newer sites to avoid such emissions. Waste management can also result in problems related to unpleasant smells, littering and vermin.

Waste also contains materials and energy that can be recovered and used. Ninety per cent of the energy that can be recovered from waste is considered to be bioenergy, and this can be used to replace fossil fuels. Material recovery can replace production based on virgin raw materials.

However, compared with direct landfilling and incineration, a greater degree of material recovery may result in higher costs in the form of more transport and emissions during further treatment of the waste. Some analyses suggest that both the environmental and the economic costs associated with certain types of material recovery have been underestimated.

Table 5.3. **Available statistics for quantities of waste generated in Norway[1], million tonnes per year**

Sectors	Waste quantity
Private households (Source: Statistics Norway 1998e)	1,4
Manufacturing (Source: Statistics Norway 1997b)	2,9
Construction[2] (Source: Hjellnes Cowi 1997)	14,2[3]
Mining and quarrying except energy-producing materials (Source: Norwegian Pollution Control Authority 1998b)	2,5
Parts of public sector [4] (Source: Kaurin, Vinju and Solheim 1996)	0,4
Fisheries[5] (Source: Foundation RUBIN 1996)	0,6

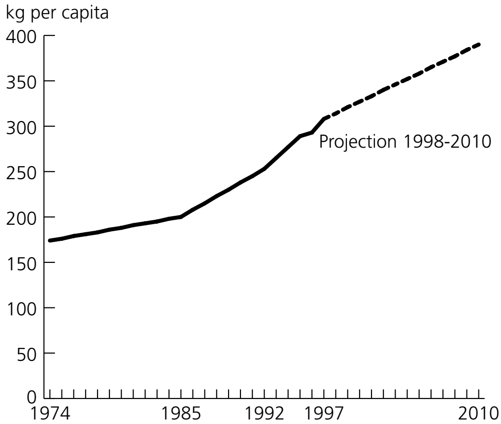
[1] Data lacking for several sectors.
[2] Average for 1983-1996.
[3] An estimated 13 million tonnes of this is stone waste from blasting and excavated soil and gravel.
[4] Technical services in the municipalities, the health and social affairs sector of central government administration, educational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

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 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. Table 5.3 shows annual figures for waste generation in Norway for those sectors for which statistics and calculations from various sources are available.

Figure 5.1. **Per capita generation of household waste and projections to 2010**

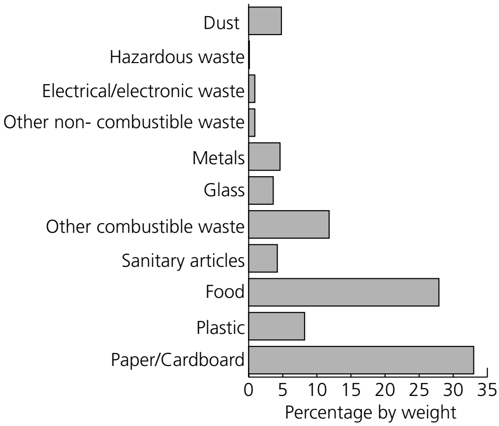


Sources: Waste Statistics from Statistics Norway and Halmø (1984).

Household waste

Household waste totalled 1.35 million tonnes in 1997 (Statistics Norway 1998e). The amount of household waste generated has been rising ever since the first surveys were made in the early 1970s. In 1974, each person generated an average of 174 kg household waste. In 1997, this had risen to 308 kg, see figure 5.1 (Statistics Norway 1998e, Halmø 1984). 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 increased to 3.4 per cent per year, and between 1992 and 1996 to 3.7 per cent per year, corresponding to an average annual rise of 10 kg per capita. From 1996 to 1997, the quantity of waste rose by 5.1 per cent or 15 kg per capita. Some of the rise may be explained by better registration methods and the fact that a larger proportion of waste is delivered to

Figur 5.2. **Composition of household waste in 1997**



Source: Heie (1998).

approved facilities. Nevertheless, it is clear that per capita generation of household waste is still rising. 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 Statistics Norway's earlier projections (Bruvoll and Ibenholt 1995). Per capita waste generation had already reached the level calculated for 2010 in 1996. Updated projections based on the same economic assumptions as the report on the energy and power balance up to the year 2020 (NOU 1998:11) indicate that per capita waste generation will rise by an average of 2.0 per cent annually up to 2010 if current waste management policy is continued. According to these calculations, per capita generation of household waste will rise to 390 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 1995). However, the effect appears to be less clear for high-income countries. Bruvoll (1999) analyses the effects of waste policy and other factors on waste quantities on the basis of American data, see section 5.7.

Sorting surveys 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). Other fractions account for less than 8 per cent of the total each, except for other combustible waste, which makes up 11.8 per cent (Heie 1998).

Production and consumer waste from manufacturing industries

In 1996, Norwegian manufacturing industries generated 2.5 million tonnes production and consumer waste (Statistics Norway 1997b, 1998f). 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 costs for industrial enterprises, and many of them have found that it pays 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, while 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.

See *Natural Resources and the Environment 1998* for a more detailed discussion of waste from manufacturing industries.

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. The regulations concerning hazardous waste, which were last revised in 1996, define the types of waste that are classified as hazardous and set out the rules that apply to treatment of such waste. Anyone who is in possession of hazardous waste is responsible for ensuring that it is kept, stored and managed properly. Any company that manages hazardous waste shall have a permit from the pollution control authorities. A nationwide system for reception, collection and treatment of hazardous waste has been developed and is administered by Norsas[1]. Norsas has calculated that in 1997, 655 900 tonnes of hazardous waste was generated in Norway, see table 5.4.

The quantities of hazardous waste generated by manufacturing industries rose from 320 000 tonnes in 1993 to 400 000 tonnes in 1996 (Statistics Norway 1997b, 1998f). The rise from 1993 to 1996 can be partly explained by an improvement in the quality of the data used in the calculations and partly by amendments to the hazardous waste regulations that altered the categories defined as hazardous waste. Most hazardous waste originates from two branches of industry: in 1996,

Table 5.4. **Quantities of hazardous waste generated in Norway in 1997**

Type	Quantity (tonnes)
Total	655 900
Norwegian hazardous waste delivered to the hazardous waste management system and treated in Norway	156 000
Corrosive waste from Kronos Titan, treated by NOAH	194 300
On-site treatment by companies	240 000
Export	45 600
Unknown	20 000

Source: Norsas (1999a).

56 per cent was generated by the manufacture of chemicals and chemical products and 37 per cent by metal manufacturing.

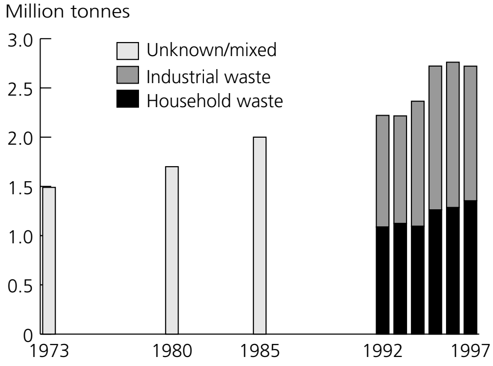
5.3. Waste management: more recycling

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 treating waste 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.

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, and most conclude that there is no straightforward answer to the question of which type of

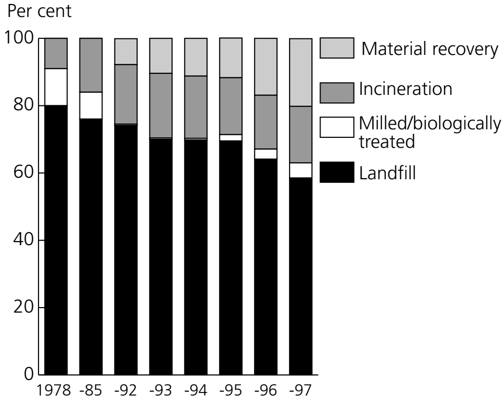
[1] Norwegian Resource Centre for Waste Management and Recycling

Figure 5.3. **Total quantities of municipal waste**



[1]Figures for 1993, 1994, 1996 and 1997 calculated on the basis of sample surveys.
Source: Waste Statistics from Statistics Norway.

Figure 5.4. **Municipal waste according to method of treatment, 1978-1997**



Source: Waste Statistics from Statistics Norway.

treatment is best that applies to all types of waste.

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, while in 1993, 1994, 1996 and 1997 only a sample of the municipalities reported. Data from the municipalities in the sample were used as a basis for calculating figures for the whole country.

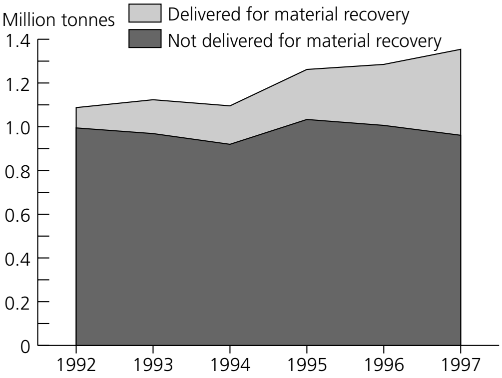
In 1997, municipal waste collection systems dealt with 2.72 million tonnes of waste (figure 5.5). This is a decrease of 40 000 tonnes from 1996, but an increase of about 500 000 tonnes since 1992.

Most municipal waste is still disposed of in landfills, but the quantity landfilled dropped by about 180 000 tonnes from 1996 to 1997 (figure 5.4). Figures for recent years show a sharp rise in the quantity of waste recycled. The proportion delivered for material recovery rose to 20 per cent in 1997, and a total of slightly more than 550 000 tonnes is now recycled (figure 5.5). The proportion of waste incinerated has remained more or less the same from 1992 to 1996 (16-18 per cent), but the quantity disposed of in this way has risen because of the rise in overall quantities of waste. The proportion treated biologically has risen from under 0.5 per cent to about 5 per cent in the same period.

The proportion of household waste delivered for material recovery has risen from 9 per cent in 1992 to 29 per cent in 1997.

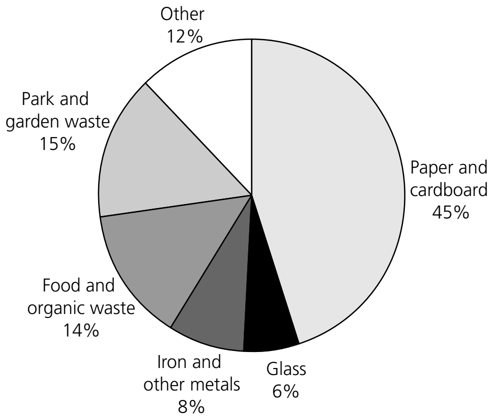
Almost half of the household waste delivered for material recovery is paper and cardboard (45 per cent) (figure 5.6). Other important fractions are waste from parks and gardens (15 per cent), food and organic waste (14 per cent), iron and

Figure 5.5. **Total quantities of household waste, by method of treatment. 1992-1997**



Source: Waste Statistics from Statistics Norway.

Figure 5.6. **Household waste delivered for material recovery[1], by material, 1997**



[1] Park and garden waste is composted: this is not strictly speaking material recovery, but is classified as biological treatment. See also figure 5.5.
Source: Waste Statistics from Statistics Norway.

other metals (8 per cent) and glass (6 per cent).

Almost half (49 per cent) 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 or waste treatment and disposal plants. In 1997, 300 of the country's 435 municipalities had introduced schemes for sorting and collection of waste at source. This is 66 more than in 1995, and such schemes applied to 77 per cent of the population, as compared with 52 per cent in 1995.

Municipal collection schemes are most widespread for paper and cardboard. In 1997, 73 per cent of the population in 283 municipalities was served by collection schemes for this fraction. Collection schemes for beverage cartons have been expanded, and in 1997, applied to 58 per cent of the population. Households delivered a total of 178 000 tonnes of paper and cardboard for material recovery, which is almost three times as much as in 1992.

Schemes for collection of glass waste covered 4.2 per cent of the population in 1995, and 5.8 per cent in 1997, whereas the proportion of the population who could have metal waste collected dropped from 2.9 per cent in 1995 to 2.4 per cent in 1997.

In 1995, 25 municipalities collected food and organic waste for composting at central facilities. By 1997, this had risen to 105 municipalities. These schemes covered 16 per cent of the population in 1997, as compared with 4 per cent in 1995. Municipal collection schemes for food waste to be used as animal fodder have also expanded somewhat. In 1997, 4.1 per cent of the population was served by such schemes, as compared with 2.3 per cent in 1995. In 1997, 173 municipalities had introduced municipal schemes for composting at home, but in most cases only a small proportion of households was included in the schemes. In all, 2.7

per cent of the population was covered by municipal schemes for composting at home.

A proportion of industrial waste is also processed through municipal waste collection schemes. In 1997, this totalled 1.37 million tonnes, a drop of 109 000 tonnes from 1996, but a rise of 233 000 tonnes since 1992. Twenty per cent of the industrial waste dealt with in municipal schemes was used for material recovery. This is a rise of 2 percentage points from 1996.

The number of municipal waste treatment and disposal plants is dropping steadily, and there is a strong tendency to retain a few large remaining plants that take waste from a number of municipalities. In 1997, more than half of the intermunicipal plants took waste from four or more municipalities, and 308 of the country's 435 municipalities were affiliated with intermunicipal waste management companies. In addition, 48 municipalities had definite plans to enter into such cooperation. If these plans are implemented, a total of 82 per cent of the country's municipalities, or 63 per cent of the population, will be served by intermunicipal companies. The proportion of municipalities involved in intermunicipal companies is lowest in central parts of Southern and Eastern Norway and the Trøndelag counties, whereas 92 per cent of the municipalities in North Norway and Hedmark and Oppland counties have intermunicipal waste management companies (Statistics Norway 1998g).

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. 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.

See *Natural Resources and the Environment 1998* for a more detailed discussion of the management of waste from manufacturing industries.

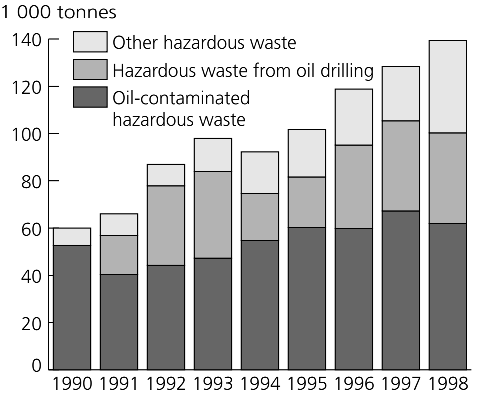
Hazardous waste management

Waste that is classified as hazardous waste 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.

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 1998 it had risen to almost 140 000 tonnes, see figure 5.7. In 1998, various categories of oily waste made up 44 per cent of the total and waste from oil drilling 28 per cent. The rise in the quantity of hazardous waste from 1997 to 1998 is mainly explained by a rise in the category slag, dust, ash, catalysts, blasting agents, etc.

The hazardous waste management system originally included all companies that were licensed to deal with hazardous waste. An EU list of hazardous waste categories has since been taken into use

Figure 5.7. **Quantities of hazardous waste delivered to the hazardous waste management system, main fractions**



Source: Norsas (1999a).

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

Year	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
1997	45 582	36 433

Source: Norsas.

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 is not registered in the hazardous waste management system. This is true, for instance, of waste dealt with by 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.

See *Natural Resources and the Environment 1998* for a more detailed discussion of the management of hazardous waste.

Exports and imports of waste

Most of the waste generated in Norway is treated within the country’s borders, but a larger proportion of waste for recycling is exported. This includes large amounts of waste paper of de-inking quality, for example newspapers and other printed matter. In 1998, almost 219 000 tonnes of waste paper was exported (Prosessindustriens landsforening 1999). This is almost 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. Substantial amounts of waste paper, mainly packaging waste, are also imported. In 1998, just under 53 000 tonnes of waste paper was imported (Prosessindustriens landsforening 1999).

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 year (table 5.5). 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 after 1995 is explained by the import of about 20 000 tonnes of fly ash[2] from waste incineration in Denmark. This is delivered

[2] Ash from waste incineration that is removed by means of filters.

to a landfill run by Norwegian Waste Management. Exported hazardous waste is sent for recycling or destruction in approved facilities, mainly in OECD countries. The largest proportion is recycled in Northern Europe (Norsas 1999b).

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. The latter is the case for packaging waste, where business and industry are required to achieve a certain percentage of recycling. There are now a number of companies involved in various recycling and collection schemes.

5.4. Waste accounts

Introduction

Both the scope and the degree of detail in the waste statistics have been expanded during the 1990s. Nevertheless there are problems because the statistics do not provide a complete picture of waste streams in Norway. This is partly because they are not well enough coordinated, so that we have a badly-fitting jigsaw puzzle with some pieces missing. Differences in the ways in which terminology is used and understood and in waste classification add to the difficulties of comparing data. The waste accounts are intended to solve these problems. They can be used:

- to provide a better overview of waste quantities and streams,
- as a practical tool, for example in following trends in the quantities of important waste fractions and in verifying whether political goals are achieved,
- in socio-economic analyses, for example to investigate the connections between economic driving forces and waste generation,
- to improve coordination by providing a clearer framework for data collection and through the use of data available in already existing statistics,
- to develop more systematic terminology.

Methods

The waste accounts are being developed on the basis of traditional principles for natural resource accounting, as a material balance between annual waste generation and the waste treatment/disposal each year. In practice, the accounts may be regarded as a multidimensional matrix, where the dimensions are represented by a few selected characteristics of the waste. These are:

- material type
- product type
- origin
- form of treatment/disposal.

As a general principle, existing data sources such as statistics on external trade, production and waste have been used wherever possible, and new costly investigations have thus been avoided so far. By the end of 1998, accounts had been developed and published for *paper, glass, wet organic waste* and *metals*.

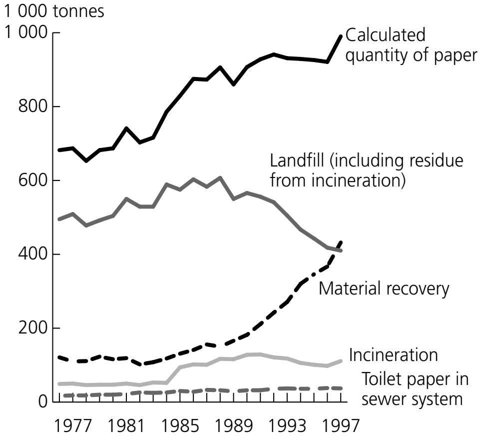
Calculation methods will be further developed in the next few years, and time series and previously published figures will be revised as a result.

Two different methods have been used to estimate waste quantities. One might be called the "supply of goods method", and is a theoretical method of calculating waste quantities. It assumes that waste quantities are equal to the supply of goods, which is estimated from statistics on import, export and production of goods. The second method might be called the "waste statistics method" and uses existing waste statistics where these are adequate. The calculations for the waste accounts are based on a number of different data sources of varying quality. In cases where the basic data are too poor or completely lacking, various estimation techniques have been used to fill the gaps.

Paper and cardboard

The annual quantities of waste paper have been calculated using both methods. The waste statistics method gave a somewhat lower figure for total quantities of waste paper than the supply of goods method for the period 1985-1993, but a somewhat higher figure for 1994-1996. The two methods gave almost identical results for 1997. The supply of goods method would be expected to give rather higher figures, since some paper is never registered as waste. The higher figures given by the waste statistics method in 1994-1996 can be explained by changes in stocks of paper, such that more paper was removed from than entered the stocks. Some of the difference may also be explained by uncertainties in the data.

Figure 5.8. **Waste paper by method of treatment/disposal**



Kilde: Statistisk sentralbyrå (1999b).

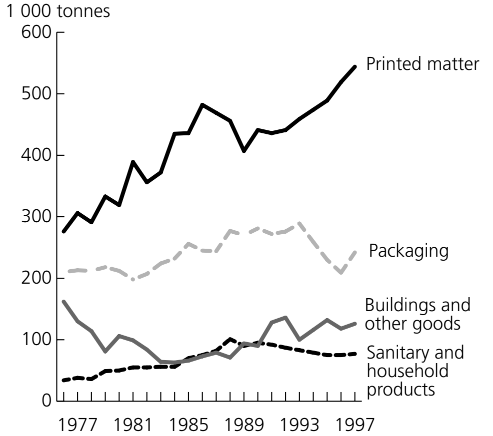
The results presented below are based on figures from the supply of goods method.

Total quantities of waste paper rose from 1983 to 1998. During the first half of the 1990s, the quantities remained fairly stable, but rose again from 1996 to 1997. From 1976 to 1997, the total quantity of waste paper has risen by more than 300 000 tonnes (figure 5.8).

There have been changes in the treatment and disposal of waste paper during this period. Calculations show that in 1988, 600 000 tonnes (67 per cent) was landfilled and 150 000 tonnes (17 per cent) was used for material recovery. In 1997, 410 000 tonnes (41 per cent) of the waste paper was landfilled and 430 000 tonnes (44 per cent) used for material recovery. 1997 was the first year when more paper was used for material recovery than was landfilled.

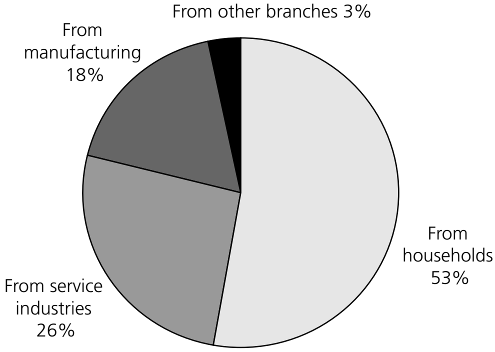
Throughout the period 1976-1997, the largest fraction of waste paper has been

Figure 5.9. **Waste paper by product category**



Source: Statistics Norway (1999b).

Figure 5.10. **Waste paper by origin**



Source: Statistics Norway (1999b).

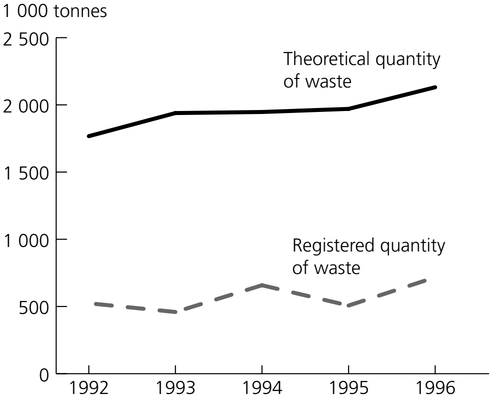
printed matter, which makes up about 50 per cent of the total. In 1997, 544 000 tonnes of waste printed matter was generated, which is 55 per cent of the total. The quantity of waste packaging dropped from about 289 000 tonnes in 1993 to 209 000 tonnes in 1996. In 1997, the quantity of this fraction rose again to 242 000 tonnes, and it made up 25 per cent of all waste paper. These two product categories have accounted for 70-85 per cent of all waste paper for the past 20 years (figure 5.9).

Private households generate the largest proportion of waste paper in Norway. In 1997, 53 per cent of all waste paper was generated by households, while service industries accounted for 26 per cent (figure 5.10). In these figures, toilet paper and paper used to light firewood are included in household waste, even though some is clearly used by business and industry. There have only been small changes in the proportions of waste paper generated by different sectors since 1985.

The amount of packaging that enters the country through imports of packaged goods is a very uncertain component of the calculations of annual waste paper quantities. The data used by Statistics Norway on waste packaging suggest that the figure may be as high as 120 000 tonnes per year. An investigation by the Norwegian Food Research Institute shows that in 1991, packaging with contents generated about 50 000 tonnes of waste paper (Norwegian Food Research Institute 1994). Both these figures are uncertain, but we have chosen to use the figures from the Norwegian Food Research Institute in these calculations.

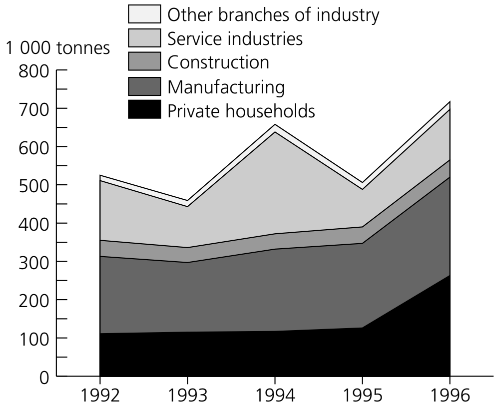
Figures for incineration are obtained from municipal waste incineration facilities. In addition, some paper is incinerated in smaller facilities. This is not registered in the accounts. About half the quantity registered as “delivered for material recovery” is exported. Some of this may be used for incineration and energy recovery, but at present it is unclear how much of the exported waste paper is incinerated.

Figure 5.11. **Theoretical and registered quantities of metal waste**



Source: Statistics Norway (1998h).

Figure 5.12. **Registered metal waste by origin**



Source: Statistics Norway (1998h).

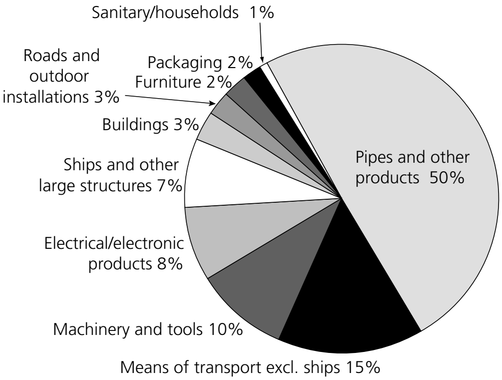
Metals

The metal accounts deal with all types of metal waste, and for the present focus on total quantities. Iron accounts for the largest quantities of metal waste. In 1996, the waste statistics available show that slightly more than 700 000 tonnes of metal waste was registered in Norway. This is a rise of almost 200 000 tonnes from 1992 (figure 5.11). However, calculations using the supply of goods method suggest that the quantity of metal waste actually generated is three to four times higher than this. This estimated quantity is called the theoretical quantity of waste in the following paragraphs.

There may be several reasons for the difference between the registered and theoretical quantity of waste. Firstly, several branches of industry are poorly covered by the waste statistics. Secondly, there is reason to believe that some of the waste generated never reaches the waste management system. Thirdly, product lifetimes may be underestimated in the calculation of the theoretical quantity of waste. Furthermore, some metal disappears through corrosion. However, both calculation methods show a tendency for waste quantities to rise from 1992 to 1996. This can largely be explained by the rise in metal supplies in the 1960s, 1970s and 1980s.

The most important sources of metal waste in Norway are manufacturing industries, private households and service industries (figure 5.12). Most of the metal from service industries consists of scrapped vehicles and other means of transport. There are particularly noticeable variations in the quantities of metal waste from two sectors in the period studied. The relatively large fluctuations in the quantities from service industries are almost entirely due to variation in exports of ships that are to be broken up. The rise in metal waste from households from 1995 to 1996 is largely due to the rise in the number of cars scrapped when the refund payment was temporarily raised in 1996.

Figure 5.13. **Theoretical quantity of metal waste by product types, 1996**



Source: Statistics Norway (1998h).

About 70 per cent of the registered metal waste is delivered for material recovery. Some of this is exported before material recovery. Somewhat more than 20 per cent of the registered metal waste is landfilled: some of this may be landfilled temporarily before material recovery. The highest proportion of metal waste is used for material recovery by manufacturing industries (93 per cent in 1996).

The theoretical quantity of waste has been split between the product categories used in the waste accounts (figure 5.13). The largest product group is pipes and other products. This category includes products that are difficult to classify definitely in one of the other product categories. Excluding this category, most metal waste generated belongs to the categories means of transport, ships and other large structures, machinery and tools, and electrical and electronic products. All product categories generated rising quantities of waste in the period 1990-1996, except for packaging, which was calculated to generate 40 000 tonnes in 1996 as against 47 000 tonnes in 1990.

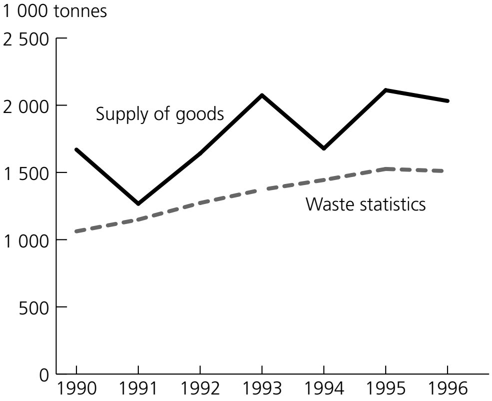
The figures are very uncertain. This is shown for example by the levels of statistical error, which vary from 10 to 25 per cent. Such errors arise because of discrepancies between the quantities reported by industry as delivered for material recovery and statistics for the quantities of scrap metal actually recycled. These in turn may be a result of the time lag between the delivery of waste and resmelting. It is also possible that imported scrap metal has been included in the figures, even though it is not supposed to be included in these statistics.

Wet organic waste

Wet organic waste is defined as readily degradable organic waste. An important environmental problem associated with this fraction is generation of the greenhouse gas methane if the waste breaks down in the absence of oxygen, for example in landfills. The accounts for wet organic waste include food, slaughterhouse waste and fish waste and park and garden waste. However, it was not possible to estimate the supply of goods for park and garden waste, which has therefore been omitted from comparisons of the two methods.

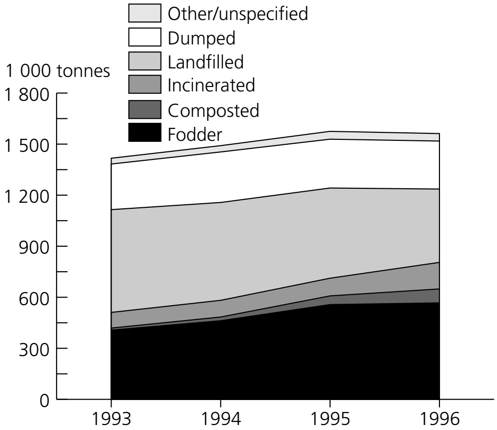
The quantity of wet organic waste generated in Norway has been estimated for the years 1990 to 1996. Fish waste dumped in Norwegian waters by foreign fishing vessels was not included. In 1996, rather more than 1.5 million tonnes of wet organic waste was generated in Norway. About 1.4 million tonnes of this was generated by the fisheries, private households and manufacturing industries. A large proportion of the waste was used for fodder production, landfilled or

Figure 5.14. **Wet organic waste calculated by the supply of goods and waste statistics methods**



Source: Statistics Norway (1998i).

Figure 5.15. **Wet organic waste by method of disposal**



Source: Statistics Norway (1998i).

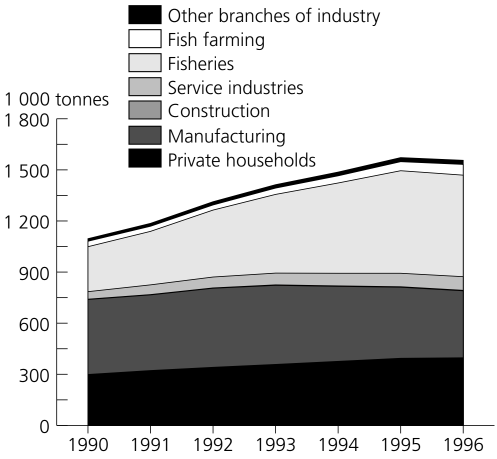
dumped at sea. The quantity of wet organic waste showed a tendency to rise until 1995, but no rise was registered from 1995 to 1996. This was mainly because the quantity of wet organic waste generated by manufacturing industries was reduced.

A number of different data sources have been used, and some of the figures are very uncertain. Using the supply of goods method, the quantity of wet organic waste in 1996 was estimated to be slightly more than 2.0 million tonnes (figure 5.14). This suggests that 1.5 million tonnes may be a minimum estimate and that the actual quantity is somewhat higher. The largest quantities of wet organic waste originate from fish catches, cereal production and imports of food and fodder. All these vary over time, which contributes to the relatively wide variation in quantities of wet organic waste estimated using the supply of goods method.

Material recovery in the form of fodder production, landfilling and dumping (fish waste dumped in the sea) are the most important forms of disposal of wet organic waste, and accounted for 567 000, 431 000 and 282 000 tonnes respectively in 1996 (figure 5.15). The quantity landfilled has dropped from about 600 000 tonnes in 1993, while the quantity used for fodder production rose from 407 000 to 567 000 tonnes, and the quantity composted from 12 000 to 82 000 tonnes in the period 1993 to 1996.

The most important sources of wet organic waste in 1996 were the fishing industry (596 000 tonnes), households (397 000 tonnes) and manufacturing industries (393 000 tonnes), see figure 5.16 and table D 16 in the appendix. During the 1990s, there has been a tendency for the fishing industry and households to generate more wet organic waste, whereas manufacturing has generated less. The rise in waste from the fisheries can be

Figure 5.16. **Wet organic waste by origin**

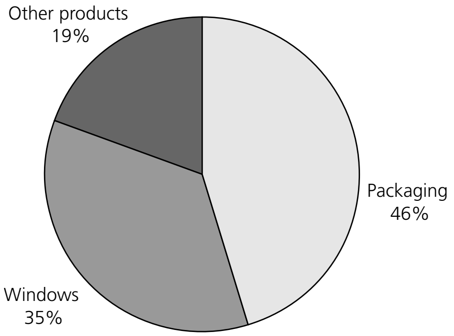


Source: Statistics Norway (1998i).

explained by the increase in catches during the 1990s, and the rise in waste from households reflects the general rise in household waste.

The fishing industry, manufacturing and fish farming used the largest amounts of waste for material recovery for fodder production: 293 000, 196 000 and 55 000 tonnes, respectively. Only about 2 per cent of household wet organic waste, or 8 300 tonnes, was used for fodder production. On the other hand, 64 000 tonnes of household waste was composted in 1996. This is 76 per cent of all wet organic waste that was composted in 1996. Most of the wet organic waste landfilled was generated by households and manufacturing industries. It is expected that the quantity of wet organic waste landfilled will decrease steadily, as fewer licences are granted for landfilling of this fraction.

Figure 5.17. **Glass waste by product types, 1996**



Source: Statistics Norway (1998i).

Glass

The two calculation methods have been combined in the glass waste accounts. The results show that in 1996, 121 420 tonnes of glass waste was generated in Norway. Most of this is packaging and windows. About 60 per cent of glass packaging waste is delivered for material recovery, whereas the corresponding figure for windows is only 2 per cent.

According to the calculations, packaging is the most important product group for glass waste, and accounts for 55 000 tonnes or 46 per cent of the total (figure 5.17). Windows are the other important product group, amounting to 43 000 tonnes or 35 per cent of all glass waste. Other product groups total 23 400 tonnes, or almost 20 per cent of the total.

Households and the construction industry are the sectors that generate most glass waste. They generate about 44 000 tonnes each, or 36 per cent of the total quantity of glass waste.

Household glass waste consists largely of packaging (75 per cent), whereas almost all the glass waste generated by the construction industry is windows and other building glass (97 per cent). It should be noted that all waste from windows has been assigned to the construction industry. Some should be assigned to households or other branches of industry, but no methods for splitting up the waste in this way have been developed as yet.

The calculations show that manufacturing industries generate more than 14 000 tonnes of glass waste. However, this figure is uncertain because the figures from different sources do not agree. Most manufacturing glass waste (90 per cent) consists of scrapped bottles from breweries and soft drink manufacturers. Service industries generate almost 17 000 tonnes glass waste, or 14 per cent of the total. This consists of several different product types, none of which is dominant.

Glass waste and its treatment only involve relatively minor environmental problems, since treatment generates hardly any emissions. The quantities involved are also much smaller than for other materials. Nevertheless, the emissions and costs associated with production and transport have been used as an argument for focusing on material recovery from glass waste. It has also been argued that transport emissions and costs are greater than the benefits gained from material recovery. In practice, there are only two ways of treating glass waste: material recovery and landfilling. Some glass waste is delivered to incineration facilities, but since glass is not combustible, it remains in the ash which is subsequently landfilled.

In all, about 28 per cent of the glass waste generated in Norway is used for material recovery. This corresponds to almost 34 000 tonnes, and consists almost entirely of glass packaging. Only insignificant amounts of other product types are used for material recovery. If the figures are split by sector, households and manufacturing industries are found to have the highest percentages recycled, about 65 per cent for glass packaging.

5.5. Economy of the municipal waste management system

Costs

In 1995, the costs incurred by the municipalities in connection with waste management totalled NOK 1 980 million. This is equivalent to 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 1 800 million.

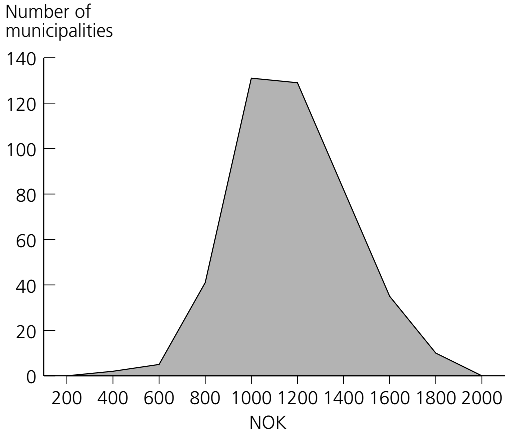
Fees for municipal waste collection systems

The average standard fee[3] has risen from NOK 959 in 1995 to NOK 1 081 in 1997. Although there was wide variation from one municipality to another, the standard fee in half the municipalities was between NOK 905 and NOK 1 244 (figure 5.18). Fees tend to be lowest in municipalities in Eastern and Southern Norway, and highest in North Norway. This tendency became more marked from 1995 to 1997.

The figures do not indicate any clear differences between the fees collected by large and small municipalities. In 1997, the municipalities collected a total of NOK 2 065 million in waste collection fees. This corresponds to a per capita fee of NOK 470.

[3] The annual waste collection fee paid by the largest number of subscribers in the municipality.

Figure 5.18. **Number of municipalities by the size of the standard waste management fee, 1997**



Source: Waste statistics from Statistics Norway.

Graded fees

In recent years, the environmental authorities have argued that waste collection fees should be graded, so that people who generate little waste or recycle their waste pay a lower fee. This is in accordance with the polluter-pays-principle. Statistics Norway's survey of municipal waste shows that 61 per cent of all municipalities graded their waste collection fees for households in some way in 1997. However, it should be noted that the figures give no information on the extent to which fees varied in each municipality, merely that such systems existed. The figures show that 35 per cent of all municipalities reduce the waste collection fee for households that compost their own waste. Fees are graded by the volume of the receptacle and by collection frequency in 27 and 13 per cent, respectively, of all municipalities. Fourteen per cent of the municipalities report that they have introduced schemes allowing households to choose between different receptacle sizes, collection frequencies and systems for sorting waste at source.

5.6. Economic and legislative framework and external costs of production based on recycled material

In this project, we have compared the economic and legislative framework for production based on recycled material with that for corresponding production based mainly on new (or virgin) materials. The two products we have studied are brown paper and energy. The project on brown paper considered two different production processes, one using only fibre from recycled paper, and the other using approximately 75 per cent new fibre and 25 per cent recycled paper. In the project on energy, we have compared production of energy based on waste plastic (i.e. waste incineration with energy recovery) with combustion of fuel oil.

The economic and legislative framework for production includes acts, regulations, etc. and taxes and subsidies that influence the way producers adjust to the market. The analysis also includes external costs, i.e. costs for society incurred by, but not borne by the producer. Differences in the legislative and economic framework and the external costs mean that the authorities favour one alternative rather than another, and this leads to distortions in competitive conditions between different production processes.

Production of brown paper

In this project, we studied the legislative and economic framework for two different producers of brown paper, and the external costs arising from the two processes. One producer uses approximately 75 per cent virgin (new) fibre and 25 per cent recycled pulp. The other uses only recycled pulp. The two products are not identical, since brown paper containing some virgin material is of somewhat higher quality. Nevertheless, we assume that the two products are so similar that the crucial factor in adaptation to the legislative and economic framework is relative changes in product prices.[4] We analysed three possible differences in the legislative and economic framework. The first is that the amount of direct support received per unit produced may differ between the two production processes. Secondly, the companies may pay different prices for a particular commodity that is used as a factor input in both processes. Alternatively, the price may be the same, but different from the market price. Thirdly, the production processes may involve different external costs, here used in the sense of environmental damage that the producer does not pay for.

Given the current policy framework, we find only small differences as regards the use and pricing of electricity. This is because both companies pay the CO_2 tax at only half the standard rate, and the price they pay for electricity is different from the average spot price[5]. We could not document any differences as regards the use of labour and other factor inputs.

We found a different picture as regards external costs. However, there were several of these that we were unable to quantify, for example the external costs of the forestry operations that deliver raw materials for the production process, the external costs of transporting timber or recycled paper, and the external costs of other treatment of waste paper. On the other hand, we were able to quantify the external costs associated with emissions to air and water during the actual production process. We found that the external costs for the producer using virgin raw materials were almost twice as high as for the producer using recycled pulp. This is explained by emissions of particulate matter during production using virgin pulp.

To summarize the results, we found that indirect support in the form of subsidies and external costs totalled NOK 250 per tonne for paper from virgin raw material and NOK 150 per tonne for paper from recycled pulp. This means that the legislative and economic framework we have been able to quantify favours production based on virgin raw material. However, the effect is small, since it only constitutes about 2.5 per cent of the price of the final product. Moreover, we lack estimates for important parameters, and the study was limited to only two producers. There is therefore a good deal of uncertainty associated with our conclusions. This study alone does not provide a basis for recommending measure to correct market conditions by changing the legislative and economic framework to alter the balance between material recovery and other final disposal of brown paper.

Energy production

Plastic makes up about 8 per cent of all household waste (figure 5.2). Increasing amounts of waste plastic are being sorted and used for energy recovery. The authorities' target is to ensure that 50 per cent of waste plastic packaging is recycled for energy purposes by 1999. In this project,

[4] Provided that differences in quality are reflected in the price of the end products, it is reasonable to ignore them in an evaluation of the legislative and economic framework.

[5] In 1996, these manufacturers paid about 55 per cent of the average spot price for electricity.

we compared the legislative and economic framework for energy production by incineration of waste plastic and by combustion of fuel oil. In this case, it is particularly relevant to consider the external costs associated with greenhouse gas emissions and how taxes can be set at an optimal level.

Plastic is produced from oil or gas and various additives. Oil is exempt from the CO_2 tax if it is used as a raw material in manufacturing and is retained in the finished product, as is the case in production of plastics. If the oil is used for combustion for energy purposes, a CO_2 tax (NOK 143 per tonne heavy fuel oil in 1998) is imposed. The alternative forms of final treatment of waste plastic are incineration or landfilling. Material recovery is only a way of prolonging the lifetime of the plastic; sooner or later, it must receive some form of final treatment. Landfilling and incineration of plastic generate emissions of the greenhouse gases methane and CO_2.

In calculations of external costs, the CO_2 tax on petrol has been used as the value the authorities put on reduced CO_2 emissions (NOK 384 per tonne CO_2 in 1998). The external costs associated with greenhouse gas emissions from landfills are NOK 37-59 per tonne plastic, as compared with almost NOK 800 per tonne if plastic is incinerated (table 5.6). The external cost of landfilling is so low because plastic only breaks down to a very limited extent in landfills, and therefore generates little gas[6]. However, landfilling generates larger emissions of methane than incineration. This is because the lack of oxygen results in incomplete degradation of the plastic in landfills, and methane is formed instead of CO_2. The external costs of methane emissions are considerably higher than for CO_2, because methane has a global warming potential 21 times that of CO_2. Even though there is no tax on methane emissions in Norway at present, it is appropriate to convert the quantity of methane into CO_2 equivalents, i.e. the number of tonnes of CO_2 that would have the same impact on global warming. Methane is one of the gases included in the Kyoto Protocol. In a landfill where 50 per cent of the gas is collected, i.e. 50 per cent of the methane generated is collected and burnt, the methane costs are therefore halved, but the costs of CO_2 emissions are doubled.

The external costs associated with greenhouse gas emissions from incineration of plastic are calculated to be NOK 768-777 per tonne. The costs of incineration are much higher than for landfilling because the total greenhouse gas emissions are much higher. Plastic is broken down more completely than in a landfill, and large amounts of CO_2 are formed, whereas methane emissions are very low. In addition to the large volume of gas, the costs rise because all the emissions are generated at one time.

As an alternative to taxing the actual emissions, it is possible to tax factor inputs (or products) that generate the pollution. This can be viewed as a prepaid emission tax. When plastic is produced, the carbon content of the oil or gas is transferred to the product, and is not released until the plastic is incinerated.

[6] We have used a half-life for plastic of 50 years, but this figure is uncertain. If the half-life is 70 years, the costs are 20 per cent lower, and if it is 30 years, the costs are about 25 per cent higher. In addition, there is uncertainty concerning the quantity of methane generated in a landfill. This depends on many factors, including the design and depth of the landfill and the local climate.

The environmental impact of a product tax will in this case largely correspond to the effect of an emission tax. As the alternative form of final treatment of the plastic, landfilling, results in lower environmental costs, a refund corresponding to the reduction in costs should be given if the plastic is landfilled. In this way, a refundable product tax can function as an emission tax. Table 5.6 shows that between 92.5 and 95 per cent of the tax should be refunded at a landfill without gas extraction. For landfills with gas extraction, even more should be refunded. A system of this type might be complicated to administer. On the other hand, the introduction of a tax on the factor input oil/gas in plastic production at a rate in accordance with the climate costs might cause plastic prices to rise, thus reducing material use and waste generation.

Because the emission costs of final treatment of waste plastic vary greatly, it may be more appropriate to introduce a tax on final treatment than a tax on the factor input, oil in plastic production. If reduced CO_2 emissions are valued on the basis of the tax on heavy fuel oil instead of petrol, the rate should be about NOK 285 per tonne for incineration and NOK 10-20 for landfilling. The calculated costs of landfilling plastic are much lower than the general tax on final waste treatment (NOK 300 per tonne waste) that has been introduced in 1999. For incineration of plastic, the final treatment tax will vary between NOK 150 and 300 per tonne depending on the degree of energy recovery. The calculated costs of greenhouse gas emissions from incineration are generally higher than the final treatment tax, especially as the tax rate is only NOK 150 per tonne when all the energy is used. The final treatment tax of NOK 300 per tonne waste is based on emissions of methane and CO_2 from landfilling and incineration of mixed waste, including only a small proportion of plastic. For administrative reasons, the tax does not vary according to the composition of the waste.

Table 5.6. **External costs of greenhouse gas emissions from landfilling and incineration of plastic. NOK per tonne**

	Methane	CO_2	Total
Landfilling of plastic (mixed or foil)	32-51	5-8	37-59
Landfilling of plastic and collection of 50 per cent of gas	16-26	8-12	24-38
Incineration of plastic (mixed or foil)	1(0.5)	767-776	768-777

Sources: Lindholt (1998b) and Norwegian Pollution Control Authority (1996).

Project financed by: Ministry of the Environment.

Project documentation: Lindholdt (1998b) and Ibenholt and Brekke (1999).

Factors that influence waste generation and treatment

This study analyses the effects of waste policies and identifies other factors that explain waste generation and the distribution of waste treatment between material recovery, incineration and landfill. The analysis is based on data from all states in the USA. Policy factors include price incentives, i.e. taxes on final treatment (incineration and landfilling) and subsidies on material recovery and systems for waste collection and sorting at source. In addition to political measures, we have also considered the effect of land prices (which we assume influence landfill costs), income and population density.

International comparisons show that total waste quantities rise with *income*. However, this only appears to apply to low- and middle-income countries, and the relationship is unclear for the countries with the highest per capita incomes. This study shows no significant relationship between disposable income and total waste quantities. On the other hand, the analysis shows that in states with a higher average income, the share of waste incinerated increases.

The literature offers different explanations of why total waste quantities rise with *population density*, since some waste fractions increase while others decrease. In this study, we found a negative relationship between population density and waste quantities.

The analysis also supports the general results found in the literature, which show that economic incentives such as *taxes on final waste treatment* are an effective means of influencing the choice of treatment method. Landfill taxes reduce the quantities landfilled and increase the quantities incinerated or recycled. However, we did not find that taxes on final treatment or grants for recycling reduce the total quantities of waste generated. Instead, we found that a rise in the price of final treatment resulted in substitution in the form of more material recovery. This indicates that all forms of treatment, including material recovery, must be taxed if the goal is to reduce total waste generation. An alternative to taxing all waste generation (i.e. all materials after they have been used in production and consumption processes) is to impose general taxes on the use of materials before they enter production processes.

Unlike other studies, this analysis shows no connection between income and waste generation. We found no indicator that can be used to measure scope of the authorities' recycling targets, and the analysis therefore gives no information on the effect of regulation in relation to such goals. However, the analysis does show that material recovery increases with the availability of *collection schemes* for waste to be recycled, and we assume that this improves as official recycling targets are made more ambitious. The increase in recycling entails a reduction in waste landfilled, but there is no effect on total waste quantities.

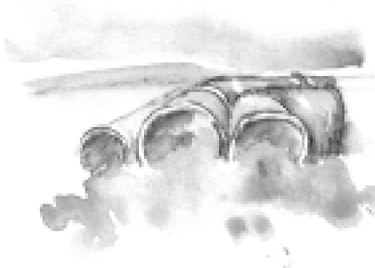
Project financed by: Research Council of Norway and Ministry of the Environment.

Project documentation: Bruvoll (1999).

Co-financing, waste statistics: Ministry of the Environment, Norwegian Pollution Control Authority and Research Council of Norway.

More information on waste statistics and waste analyses may be obtained from: Olav Rønningen, Øystein Skullerud, Anita Veie, Nina Arnesen, Annegrete Bruvoll and Olav Skogesal.

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 pressure on water resources 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. Sewage sludge, which contains nutrients and organic material removed from waste water, is a resource for agriculture, and in 1997, about 60 per cent of all sludge from waste water treatment plants was used in integrated plant nutrient management on agricultural areas, parks and other green spaces.

6.1. Introduction

Water resources are used in almost all forms of economic activity, and are therefore 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 substantial local problems.

Discharges of phosphorus and nitrogen in waste water have been a matter of concern for many years, because these nutrients play an important role in nutrient enrichment (eutrophication) of rivers, lakes and coastal areas. Nutrient enrichment leads among other things to excessive growth of algae and oxygen depletion. Waste water treatment plants are not the only source of large nutrient inputs; agriculture and industry are also important.

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. The main reason has been that the heavy pollution load in these waters has resulted in nutrient enrichment and periodical algal blooms. In addition, Norway has signed the North Sea Declarations, thus undertaking to halve inputs of phosphorus and nitrogen compared with the 1985 level.

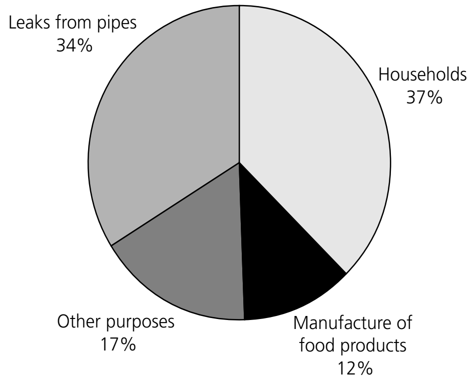
During the past 20 years, Norway has achieved a satisfactory level of treatment efficiency for phosphorus, mainly by building waste water treatment plants providing chemical or chemical/biological treatment. However, nitrogen is not as successfully removed from waste water. Despite the improvements in waste water treatment, there are still signs of poor water quality in parts of the Oslofjord. In the next few years, an attempt will be made to improve this situation by constructing nitrogen removal facilities at a few large treatment plants in Eastern Norway.

Norwegian discharges of phosphorus and nitrogen are relatively small compared with discharges from the other countries around the North Sea and the Baltic Sea. In order to reduce pollution of these seas, it is therefore important to cooperate across national borders.

6.2. Water supplies and water consumption

The National Institute of Public Health collects data from Norwegian water works. In 1996, 1 907 water works[1] were registered, of which 1 084 were municipal, 803 were private, 16 were intermunicipal and four were state-owned. These supplied 3.93 million people, or about 90 per cent of the Norwegian population (National Institute of Public Health

Figure 6.1. **Consumption of water from Norwegian water works. Whole country, 1994**



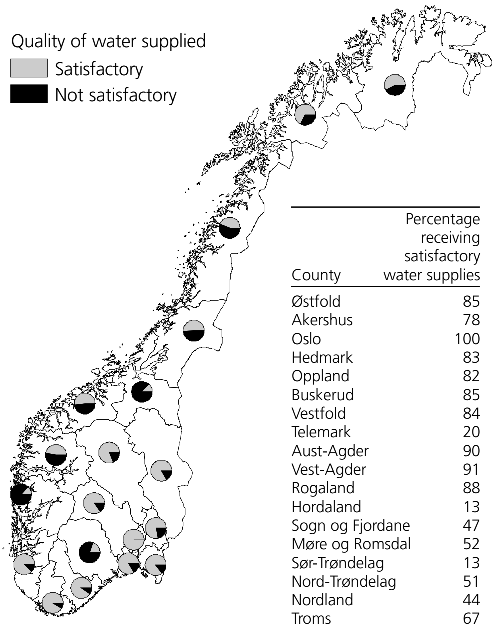
Source: National Institute of Public Health.

1998). The remaining 10 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. Surface water accounted for 88 per cent of this and ground water for only 12 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, the simple treatment needed, good protection against pollution, and the fact that only limited technical facilities are required, so that investment and operating costs are low. In many other European countries, ground water accounts for a large proportion of total water production.

1 Only facilities supplying at least 100 persons or 20 households or holiday homes are registered.

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



County	Percentage receiving satisfactory water supplies
Østfold	85
Akershus	78
Oslo	100
Hedmark	83
Oppland	82
Buskerud	85
Vestfold	84
Telemark	20
Aust-Agder	90
Vest-Agder	91
Rogaland	88
Hordaland	13
Sogn og Fjordane	47
Møre og Romsdal	52
Sør-Trøndelag	13
Nord-Trøndelag	51
Nordland	44
Troms	67
Finnmark	58

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

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. There is some uncertainty associated with these figures, and in particular the quantity of water lost through leakages may be somewhat higher than shown here.

An investigation of the quality of the water supplied by Norwegian water works (National Institute of Public Health 1998) 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 the criteria set out 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-Trøndelag 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.

Industry and agriculture are also large consumers of fresh water, but are largely self-sufficient, so that there are unfortunately no exact figures for water consumption in these sectors. Using investigations in Norway's neighbouring countries as a basis, it is reasonable to conclude that water consumption in industry is considerably higher than household consumption. In the agricultural sector, most water is used for livestock and irrigation of crops. The climate means that there is little need for irrigation in Norway, and water consumption in agriculture is therefore probably considerably lower than household consumption. The Norwegian Water Resources and Energy Administration has calculated Norway's total annual renewable water resources to be a little less than 400 billion m^3, so that water consumption in the country proba-

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

		Phosphorus		Nitrogen	
	Number of inhabitants	Total input, tonnes	Per capita input	Total input, tonnes	Per capita input
Whole country	4 393 000	2 200	0.50 kg	45 050	10.3 kg
- North Sea area[1]	2 220 000	583	0.26 kg	20 990	9.5 kg
- Area around the inner Oslofjord and catchment area of river Glomma[2]	1 400 000	285	0.20 kg	11 830	8.5 kg

[1] Sensitive area for phosphorus, see box 6.1.
[2] Sensitive area for nitrogen, see box 6.1.
Sources: Norwegian Institute for Water Research and Statistics Norway.

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. They remove only 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.

The number of i**nhabitant equivalents** (I.E.) in an area is given by the sum of the number of permanent residents and all waste water from industry, institutions, etc. converted to the number of people who would produce the same amount of waste water. One I.E. corresponds to 1.6 g phosphorus and 12.0 g nitrogen per day.

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.

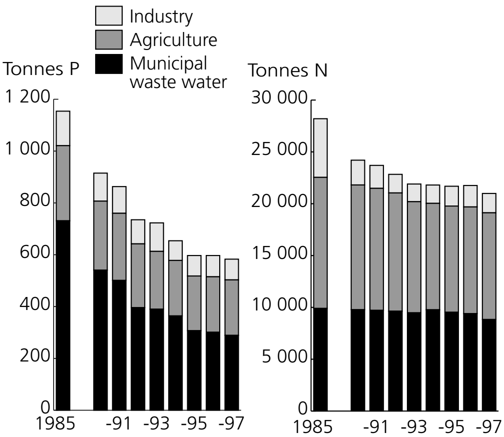
Separate waste water treatment plants are designed to treat amounts of waste water equivalent in amount or composition to that from up to seven permanent households or holiday homes (generally in scattered settlements).

The North Sea counties (or region) are the counties from Østfold to Vest-Agder, which drain almost entirely into the North Sea.

The sensitive area for phosphorus is the part of Norway to which the North Sea Agreements apply, and includes all land that drains to the coast from Østfold to Lindesnes at the southernmost tip of Norway. It consists of the counties Østfold, Akershus, Oslo, Hedmark (excluding areas that drain to Sweden), Oppland, Buskerud, Vestfold, Telemark, Aust-Agder and the eastern parts of Vest-Agder.

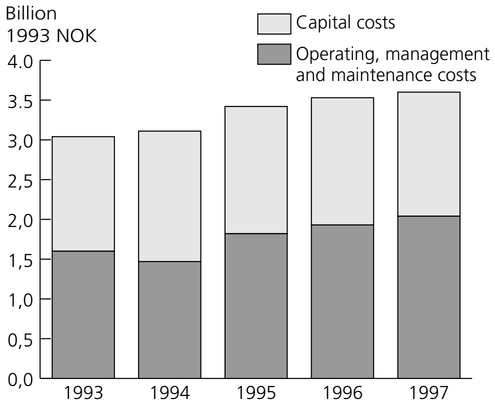
The sensitive area for nitrogen is the part of Norway to which the new nitrate directive applies (91/676/EEC), and includes all land that drains to the inner Oslofjord and the coastline from the border with Sweden to Strømtangen lighthouse (the catchment area of the river Glomma.)

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). 1985 and 1990-1997**



Source: Norwegian Institute for Water Research.

Figure 6.4. **Total costs in the municipal waste water treatment sector, whole country. Constant 1993 NOK**



Source: Waste water treatment statistics from Statistics Norway.

bly corresponds to well under 1 per cent of the water resources available.

6.3. Total inputs of nutrients to Norwegian coastal waters

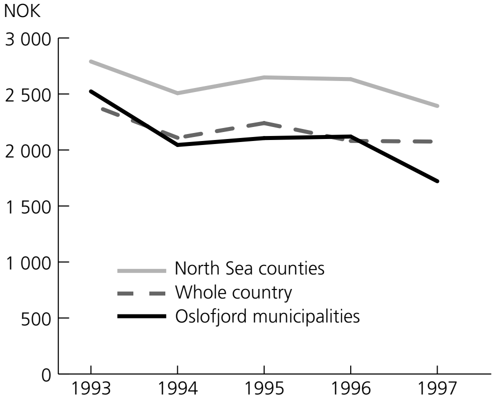
Total inputs of phosphorus and nitrogen to coastal waters around Norway are calculated annually. These figures are important in an evaluation of whether the measures implemented are appropriate, and whether the targets for reductions in nutrient inputs are being achieved. These calculations use discharge figures for waste water, agriculture and industry, and take into account retention in fjords and river systems.

In 1997, total Norwegian anthropogenic inputs of nutrients to coastal waters from agriculture, industry and waste water were calculated to be of the order of 2 200 tonnes of phosphorus and 45 000 tonnes of nitrogen (Bratli 1998). Discharges of waste water accounted for 58 and 41 per cent respectively of the total inputs of phosphorus and nitrogen in 1997. Table 6.1 shows discharges for the whole country and for the two regions to which international agreements on reductions apply.

Discharges of phosphorus vary so much between Eastern Norway and the rest of the country because conditions in recipients in the two areas are very different, and the pollution control authorities have therefore set different standards for waste water treatment. This has resulted in the investment of substantial resources in treatment of waste water and industrial discharges in areas draining to the North Sea (see sections 6.10 - 6.12) and measures to reduce runoff from agriculture in the same area (see Chapter 7).

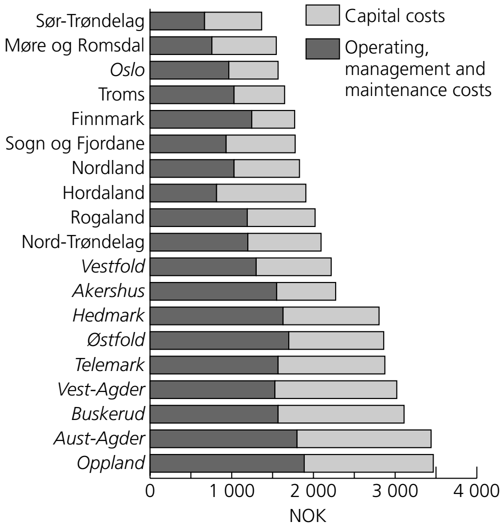
Figure 6.3 shows how the different sectors contributed to inputs of phosphorus and nitrogen to the North Sea from 1985 to 1997. Inputs of phosphorus and nitrogen from municipal waste water were

Figure 6.5. **Annual costs per subscriber. Constant 1993 NOK**



Source: Waste water treatment statistics from Statistics Norway.

Figure 6.6. **Annual costs per subscriber in 1997, by county (North Sea counties in italics)**



Source: Waste water treatment statistics from Statistics Norway.

reduced by 60 per cent and 11 per cent respectively from 1985 to 1997. The reductions in total discharges from all sectors were 49 and 26 per cent respectively.

6.4. Economy of the waste water treatment sector

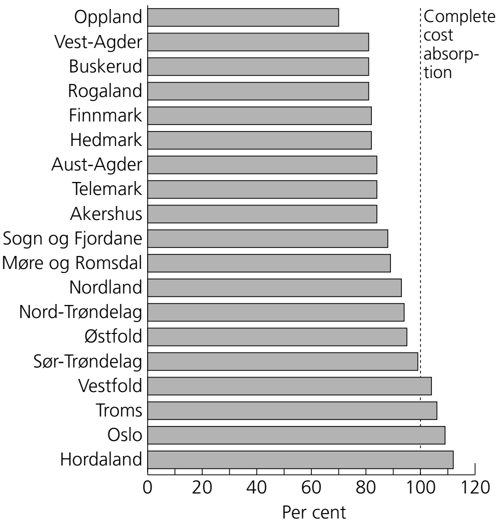
Costs

In 1997, total costs in the waste water treatment sector were about NOK 3.60 billion measured in constant 1993 NOK (figure 6.4). This is a rise of 2 per cent from the year before. Operating, management and maintenance costs accounted for NOK 2.04 billion of the total, and capital costs for NOK 1.56 billion. Operating, management and maintenance costs rose by 6 per cent from 1996, while capital costs dropped by 3 per cent. This indicates a drop in investments, which will be further discussed below.

In current prices, the total costs were NOK 3.25 billion in 1997. This is 0.42 per cent of GDP for mainland Norway.

The average annual cost per subscriber has dropped slightly since 1996 (figure 6.5). This is because the capital cost per subscriber dropped during the period. In 1997, the annual cost per subscriber in the Oslofjord municipalities was at its lowest level since 1993. The drop in 1997 may be partly explained by the fact that the subscriber figures for Oslo were revised last time they were reported. The annual cost per subscriber in the Oslofjord municipalities is also lower than in the whole country and in the North Sea counties. This is mainly because the capital cost per subscriber is lower in the municipalities around the inner Oslofjord than in the rest of the country. This in turn is explained by the fact that substantial resources have already been invested in this region. Investments per subscriber have dropped in the region since 1993, both in absolute terms and in relation to

Figure 6.7. **Ratio between income from fees and annual costs (income-to-cost ratio) in the counties. Average for the period 1993-1997**



Source: Waste water treatment statistics from Statistics Norway.

the average for the whole country, which has also dropped since 1993.

There are large variations between the counties in the annual cost per subscriber. Costs are higher in the North Sea counties than in other counties. This is because the proportion of high-grade waste water treatment plants is much higher in the North Sea counties. Oslo is the only North Sea county where costs are substantially lower than in most counties, which may be explained both by economies of scale and by the fact that investments have either been made earlier or postponed. Figure 6.6 shows annual costs split between capital costs and operating, management and maintenance costs.

Fees and income-to-cost ratios

Connection fees and annual fees are the municipalities' income from the waste water treatment sector. The connection fee is a one-off payment, whereas the annual fee is paid every year. In 1997, the municipalities collected a total of NOK 3.28 billion in waste water treatment fees. For the country as a whole, municipal fees rose by 3 per cent from 1996 to 1997, after adjustment for inflation. Income from fees dropped in only one county (Oslo).

The fees collected by a municipality are not supposed to exceed 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 102 per cent of total costs in 1997. The corresponding figure in 1996 was 95 per cent. However, the income-to-cost ratio varies widely from one municipality to another, from 15 to 244 per cent. Forty-two per cent of the 435 municipalities had an income-to-cost ratio of less than 90 per cent, 18 per cent had an income-to-cost ratio of 90 to 110 per cent, and 21 per cent had an income-to-cost ratio exceeding 110 per cent. Data needed to calculate the income-to-cost ratio are not available from the remaining 19 per cent of the municipalities. An income-to-cost ratio between 90 and 110 per cent means that the municipality has managed to budget its waste water treatment costs accurately. For the municipalities around the Oslofjord, the income-to-cost ratio is 111 per cent. Figure 6.7 and table E7 in the Appendix show income-to-cost ratios by county in the period 1993-1997. Four counties stand out because they repeatedly have an income-to-cost ratio exceeding 100 per cent. These are Oslo, Vestfold, Hordaland and Troms.

The municipalities fix annual fees on the basis of either the area of the subscriber's dwelling or measured water consump-

Box 6.2. Definitions

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

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

The **average cost per subscriber** for the whole country or by county can 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 because it takes into account variations in the number of subscribers in the various municipalities. In the second method, all municipalities are given the same weight, regardless of their population. The Norwegian Pollution Control Authority and the Ministry of the Environment use the second method for defining cut-off levels for grants.

The rate of the average annual fee (by municipality) is calculated using method 2, i.e. the sum of the rate per unit in each municipality divided by the number of municipalities, because the rate of the annual fee is reported per unit and not as a total sum. This means that method 1 cannot be used to calculate the average.

Gross investments less state grants gives the investments which form the basis for calculating municipal fees, and which subscribers are required to pay through fees. The difference between gross and net investments 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 interest rate 1 per cent higher than the annual average interest on a loan from the Local Government Bank of Norway with a term of 20 years. The extra 1 per cent is added to take risk into account. This is in accordance with the model used by the municipalities to calculate the basis for their fees.

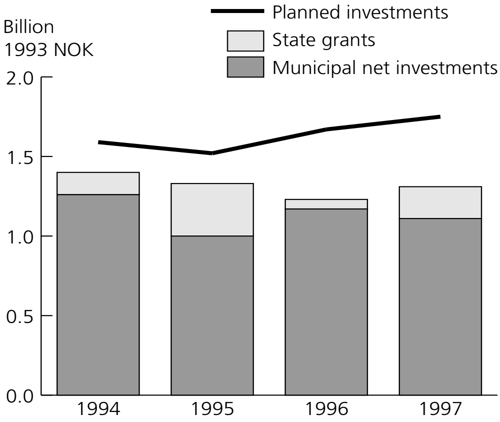
The municipalities around the inner Oslofjord (the Oslofjord municipalities) are defined as Oslo, Bærum, Asker, Røyken, Hurum, Lørenskog, Nesodden, Oppegård, Ski, Ås, Frogn og Vestby.

tion. There was a general rise in the level of fees in all counties from 1997 to 1998. The average rate of the annual fee (by municipality) for the country as a whole was NOK 1 770 for a dwelling of 140 m^2 in 1998, as compared with NOK 1 668 in 1997. This corresponds to a growth in real terms of 3 per cent from 1997 to 1998. In the North Sea counties, the rate of the annual fee was NOK 2 343 in 1998, as compared with NOK 2 247 in 1997. For the municipalities around the inner Oslofjord, the rates were NOK 2 070 in 1998 and NOK 1 860 in 1997. There were similar variations for fees based on measured water consumption.

Investments

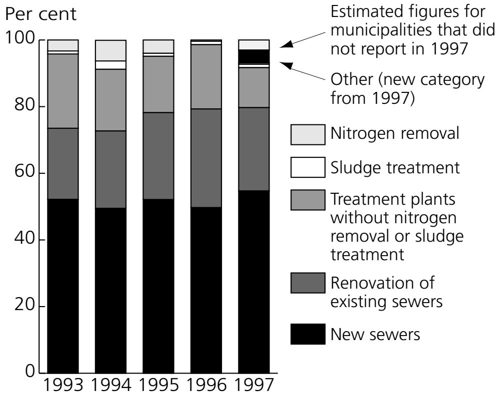
In 1997, gross investments in municipal waste water treatment totalled just over NOK 1.3 billion measured in fixed 1993 NOK, see figure 6.8. This is 7 per cent higher than in 1996 (adjusted for inflation). Investments in 1996 and 1997 were lower than in earlier years, and as a result, capital costs dropped in 1997. State grants increased substantially from 1996 to 1997, from NOK 68.6 million to NOK 225.6 million. The provision of state

Figure 6.8. **. Gross investments planned and carried out in 1994-1997. Constant 1993 NOK**



Source: Waste water treatment statistics from Statistics Norway.

Figure 6.9. **Gross investments by category, 1993-1997**



Source: Waste water treatment statistics from Statistics Norway.

grants is not a permanent arrangement. It is evaluated each year, and there will be a reduction in 1998 because funds were only transferred from the previous year for previously approved investment projects. The same will probably apply in 1999.

In 1997, 75 per cent of the planned investments were in fact carried out. The corresponding figures for 1994, 1995 and 1996 were 88, 88 and 71 per cent respectively. The planned level of investments has always been higher than the actual level.

In 1997, 80 per cent of gross investments were used for laying sewers and renovation of sewer systems (figure 6.9). Investments in plants without nitrogen removal facilities accounted for 12 per cent of the total, and construction of sludge treatment facilities for 1 per cent. Investments in plants with nitrogen removal accounted for only 0.4 per cent of total investments, and this is only 3 per cent of the planned investments for this category.

Investments in nitrogen removal facilities are necessary to meet the requirements of the North Sea Declarations for reductions in nitrogen inputs. There may be a number of reasons why such a small proportion of the planned investments in nitrogen removal facilities has been carried out. But the delays have arisen in the construction of two plants, and are due to a rise in construction costs, the need to evaluate different technical solutions and the fact that less funding than expected has been available in the form of state grants.

If gross investments per subscriber are considered, we find that the level is much lower in the municipalities around the inner Oslofjord than in the rest of the country, and that investments have dropped steadily in this area from 1993 to 1997. Substantial investments have already been made in this region, while others have been postponed and will be made in the future. In 1997, the municipalities around the inner Oslofjord invested NOK 419 per subscriber, while the corresponding figure for the whole country was NOK 931 and for the North Sea counties NOK 901.

6.5. Waste water treatment plants, discharges and waste water treatment

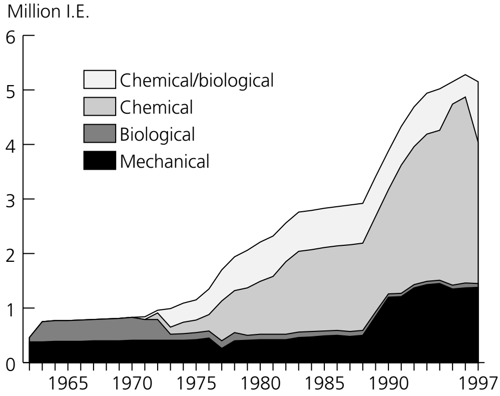
Waste water treatment plants and treatment capacity

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. In future, the emphasis will be on building separate nitrogen removal facilities at some of the larger plants in Eastern Norway.

Figure 6.10 shows a sharp increase in hydraulic capacity in 1988-1990, but only part of this is a real increase. An important reason for the apparently large increase in capacity is that during this period, plants that discharge untreated waste water were registered, and plants with strainers and sludge separators were registered as mechanical treatment plants.

In Norway, the most important means of preventing 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, which is necessary to remove phosphorus. This resulted in a large increase in chemical and chemical/biological treatment capacity during the 1990s. Other European countries have considered the removal of

Figure 6.10. **Hydraulic capacity by treatment method. 1962-1997**

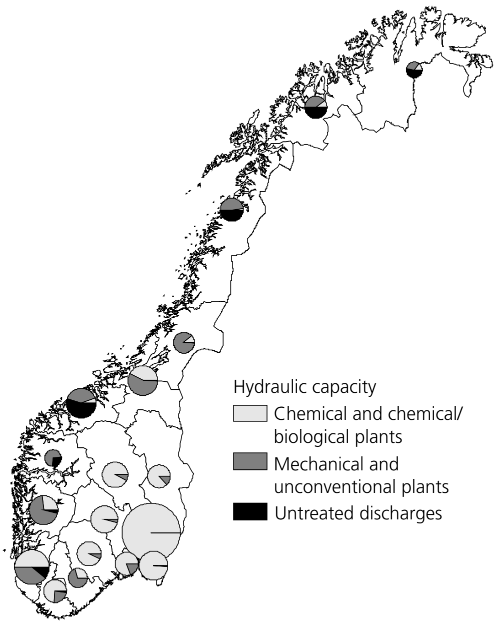


Source: Waste water treatment statistics from Statistics Norway.

organic matter to be more important, and make more use of biological treatment.

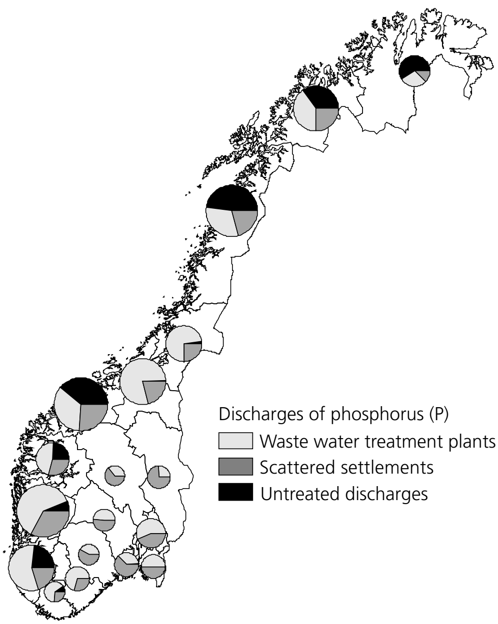
In 1997, 2 260 municipal and private waste water treatment plants with a treatment capacity of at least 50 inhabitant equivalents (I.E.) were registered in Norway. Their total treatment capacity was just under 5.3 million I.E. In addition, 551 waste water treatment plants that discharged untreated waste water were registered, and these had a total capacity of 575 000 I.E. In Eastern and Southern Norway, a large proportion of municipal waste water is treated in high-grade treatment plants (figure 6.11). Such plants account for 92 per cent of total treatment capacity in this area. Along the coast from Rogaland county and northwards, mechanical treatment and untreated discharges are more common, and high-grade treatment plants account for only 24 per cent of total hydraulic capacity. See also Appendix, tables E1 and E2.

Figure 6.11. **Hydraulic capacity by treatment method. 1997**



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

Figure 6.12. **Discharges of phosphorus and calculated treatment efficiency, by county. 1997**



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

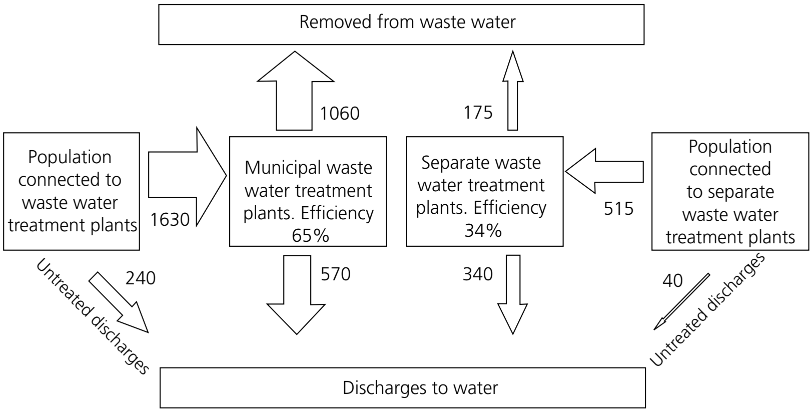
Sewer systems

In 1996, information on sewer systems was collected from 386 municipalities. The total length of sewer systems in these municipalities was reported to be 33 700 km, which gives an average of 8.2 m sewers per inhabitant. If figures for the remaining municipalities are calculated, the total length of sewer systems is found to be about 35 800 km. Waste water sewers account for 48 per cent of this, storm water sewers for 21 per cent and combined sewer systems for 31 per cent. As regards materials, 46 per cent of the sewers are of concrete, 41 per cent of PVC and 13 per cent of other materials.

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).

No information on sewer systems was collected in 1997, and since the data reported have been incomplete in earlier years, it is difficult to give quantitative information on the current situation and trends. However, almost 80 per cent of investments in 1997 were used on the sewer system (figure 6.9). There is reason to believe that individual municipalities have more information on their sewer systems (length, type and age) than Statistics Norway has received.

Figure 6.13. **Material flow diagram for phosphorus in waste water[1], tonnes. 1997**



[1] Leaks from sewers not included.
Source: Waste water treatment statistics from Statistics Norway.

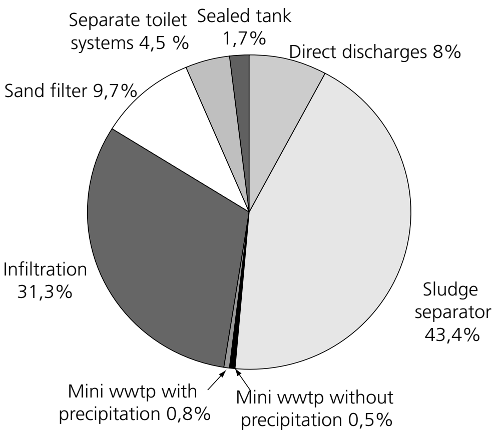
Discharges from waste water treatment plants

About 80 per cent of the population of Norway live 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 1997 were calculated to be about 570 tonnes, and the average treatment efficiency of these plants was 65 per cent. In the North Sea counties, the treatment efficiency was calculated to be 91 per cent. Treatment efficiency is relatively high in the North Sea counties because most of the treatment plants provide a chemical and/or biological treatment phase. In all, the North Sea counties, which account for 55 per cent of Norway's population, discharged 118 tonnes of phosphorus, or about 21 per cent of the country's total discharges from municipal waste water treatment plants.

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 452 tonnes of phosphorus was discharged from these plants in 1996. The average treatment efficiency in this area was calculated to be 30 per cent.

Thus, of a total quantity of about 1 630 tonnes phosphorus entering waste water treatment plants, about 1 060 tonnes was removed. This is retained as a component of sewage sludge, and is subsequently used e.g. in integrated plant nutrient management. Figure 6.13 summarizes material flows for phosphorus.

Figure 6.14. **Treatment methods for waste water from scattered settlements. Percentage of total number of persons (882 000) connected to separate plants, by type of treatment plant. 1997**



Source: Waste water treatment statistics from Statistics Norway.

Discharges from separate waste water treatment plants (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.

Slightly more than 20 per cent of the population is connected to separate waste water treatment plants, and most of these live in scattered settlements. For 1997, total discharges from these were calculated to be 341 tonnes of phosphorus (figure 6.13). The average treatment efficiency was about 34 per cent, which means that about 175 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 6.14).

Other sources of discharges

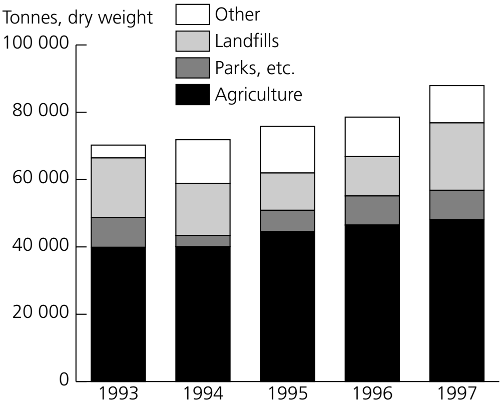
In addition to discharges from small separate waste water treatment plants in scattered settlements and treatment plants in built-up areas, there are also sewer systems that discharge untreated waste water in many areas. In 1997, 551 sewer systems of this type were registered, most of them in the counties Sogn og Fjordane, Møre og Romsdal, Nordland, Troms and Finnmark. It is calculated that such sewer systems discharged about 238 tonnes of phosphorus in 1997. Most of this 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 on average it is assumed that about 5 per cent of the waste water 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.

Disposal of sewage sludge and heavy metal content

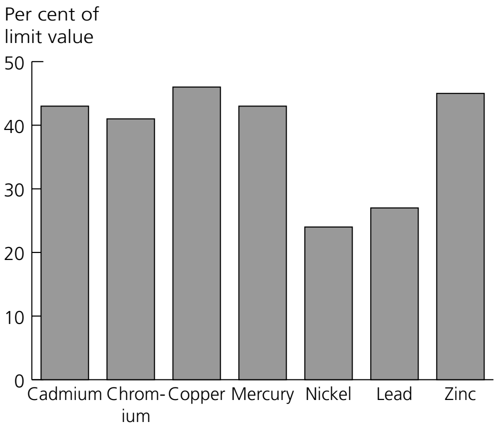
Sludge is a residual product of waste water treatment plants, and contains both organic matter and plant nutrients that can be used as fertilizer or in integrated plant nutrient management. In 1997, a total of 94 040 tonnes of sludge, expressed as dry weight, was used for various purposes. Of this, 51 per cent was used in integrated plant nutrient management on agricultural areas and 9 per cent on parks and other green spaces. The remainder of the sludge is used in land-

Figure 6.15. **Quantities of sewage sludge disposed of in different ways[1], whole country. 1993-1997**



[1] Some changes were made to the classification from 1996 to 1997, and the figures before and after this are not entirely comparable.
Source: Waste water treatment statistics from Statistics Norway.

Figure 6.16. **Average content of heavy metals in sewage sludge (average for all plants where measurements were made) in relation to the limit values for use on agricultural areas. Whole country. 1997**



Source: Waste water treatment statistics from Statistics Norway.

scaping landfills (21 per cent) and for other purposes (18 per cent), see figure 6.15 and Appendix, table E5.

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. The average content of all heavy metals in sludge from all plants is less than 50 per cent of the limit values for use on agricultural areas (figure 6.16). Even though the average figures are fairly low, there will be times when the content of certain heavy metals exceeds the limit values at many plants, so that the sewage sludge cannot be used on agricultural areas or parks and other green spaces.

6.6. Environmental effects of investments: costs in relation to the results achieved

When evaluating costs and fees in the waste water treatment sector, it is important to consider them in relation to the environmental effects achieved by the investments. The inhabitants of the North Sea counties have for many years been charged high waste water treatment fees to pay for the large investments that have been made in this region. As a result of these investments, 92 per cent of the treatment capacity in the North Sea counties is in high-grade plants, as compared with only 24 per cent in the rest of the country. More than 90 per cent of the phosphorus is removed from waste water in this region, and this has been necessary to safeguard the aquatic environment and the various user interests associated with water resources. The monitoring programme run by the Norwegian Pollution Control Authority and the Norwegian

Institute for Water Research has shown that the pollution situation has improved in the areas where most resources have been channelled into waste water treatment, such as the inner Oslofjord (Magnusson et al 1998). In other parts of the country, conditions in the recipients are better, allowing the municipalities to choose simpler and cheaper solutions, and charge the inhabitants lower fees.

In the municipalities around the inner Oslofjord, investments per subscriber have dropped in the period 1993-1997, and both the income from fees per subscriber and the costs per subscriber were below the national average in 1997, for the first time in this period. Although substantial investments have already been made in this region, further major investments are planned. It is therefore unlikely that the fees will be lowered.

In 1996 and 1997, almost 80 per cent of all investments were used for laying sewers and renovation of sewer systems. As a result of the continual expansion and renovation of the sewer systems, waste water from an increasing number of households is transported to waste water treatment plants and therefore satisfactorily treated. Leakages and overflow are also reduced. However, it is difficult to quantify the effects of such measures, and therefore also difficult to demonstrate an exact relationship between the input of resources and the environmental effect.

According to the current guidelines from the Ministry of the Environment, the municipalities may only cover their real costs through waste water treatment fees. In other words, the fees will be closely related to the municipalities' investments in sewer systems, waste water treatment plants and sludge treatment, and these investments play a crucial role in achieving the desired environmental effect. Thus in most cases, high fees will contribute to a reduction of the pollution load in the local aquatic environment.

Co-financed by: Norwegian Pollution Control Authority.

Documentation: Bersvendsen et al. (1999).

Further information may be obtained from: Kjetil Mork (sections 6.1 - 6.3 and 6.5 - 6.6), Julie Hass or Trude W. Bersvendsen (sections 6.4 and 6.6).

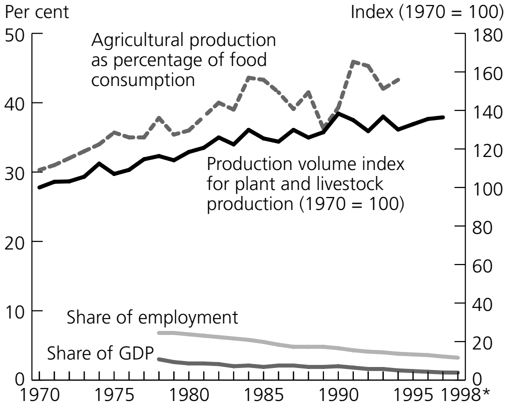
7. Agriculture

The agricultural sector has significant environmental impacts, both positive and negative. The open cultural landscape has largely been created by farming. But agricultural activities also contribute to 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 1998, the agricultural sector's share of total employment (measured as full-time equivalent persons) sank from 6.8 to 3.2 per cent (figure 7.1). In absolute figures, the drop was from 111 500 to 63 000 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 same period. 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

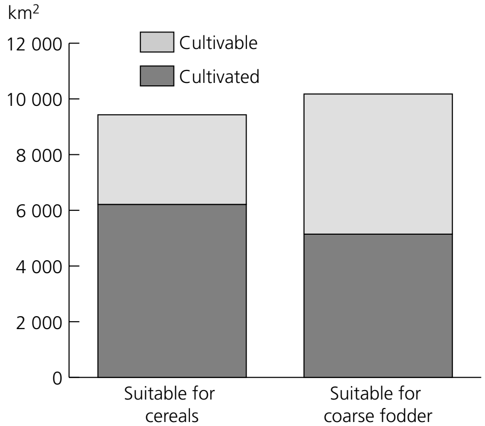
Figure 7.1. **Changes in the share of employment and GDP and percentage self-sufficiency in the agricultural sector, and changes in agricultural production**



Sources: National Nutrition Council, Budget Committee for Agriculture (1988) and National Accounts from Statistics Norway.

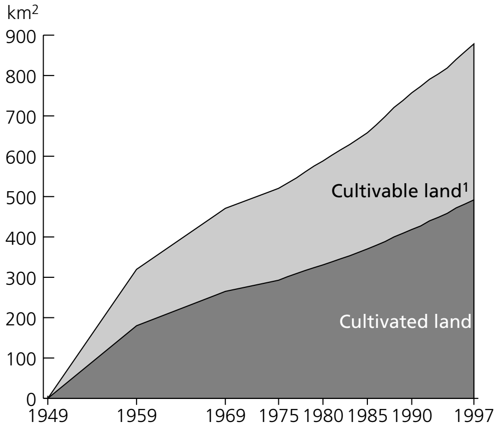
[1] This method of calculating the degree of self-sufficiency, i.e. corrected for imported feedstuffs, cannot be used after 1994 because the import monopoly for cereals was abolished.

Figure 7.2. **Agricultural land in Norway**



Source: Grønlund (1997).

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



[1] For 1949-1976, only data for cultivated areas are available. The area of cultivable land is estimated on the basis of the ratio between cultivable and cultivated land developed in the period 1976-1997

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

lowest for sugar, fruit and berries. Measured according to the production volume index used by the Budget Committee for Agriculture, agricultural production has risen by 20 per cent from 1979 to 1998 (Budget Committee for Agriculture 1998).

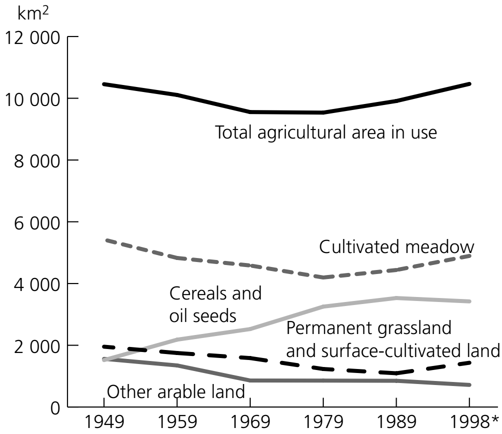
7.2. Land suitable for agriculture

The total area of land potentially suitable for agriculture in Norway has been calculated 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 in food is limited. At present, the self-sufficiency rate is between 40 and 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 agricultural land resources. One of the threats 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 880 000 decares, or about 4.5 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.

Figure 7.4. **Agricultural areas in use**



Source: Agricultural Censuses from Statistics Norway.

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 10 500 km² in 1998 (see Appendix, 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 1998, 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 about 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 (included in the area of permanent grassland), which has risen by 69 per cent since 1985. This is probably related to the introduction of acreage and cultural landscape support.

7.3. Environmental impacts

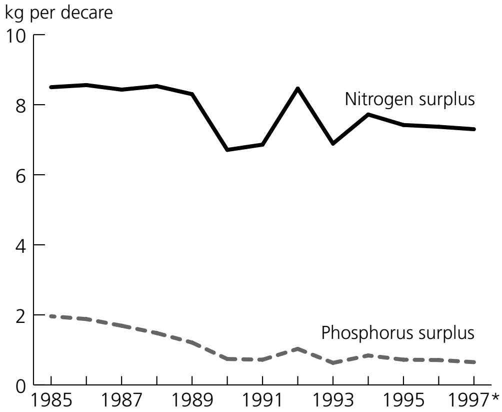
The negative environmental impacts of agriculture are pollution and alteration of biotopes (or landscape changes). Few systematic and nationwide figures are available for the latter. However, there are better statistics on pollution since this problem has been given priority in several contexts, for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

The most serious type of pollution from agriculture is considered to be runoff of nutrients (nitrogen and phosphorus). Agriculture accounts for just under 30 per cent of phosphorus inputs and about 50 per cent of nitrogen inputs to the coast (Bratli 1998) (see Chapter 6.3). Nutrient enrichment (eutrophication) is a particularly serious problem locally in water recipients where much of the surrounding land is agricultural.

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 (crops planted specifically to prevent erosion), etc.

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



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

- technical facilities (hydrotechnical facilities, improvement and expansion of manure storage facilities, etc.).

The agricultural sector is also responsible for significant emissions of ammonia (NH_3) and greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) (see paragraph below and Chapter 4, and Appendix, Tables C3-C5).

Surplus of nutrients

Good fertilizer management involves maximizing the uptake of the added nutrients 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 1997. 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).

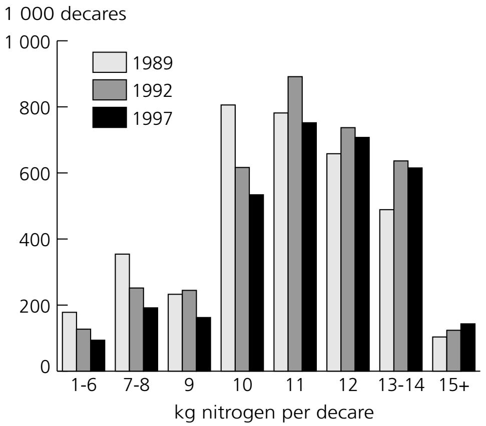
Using this method of calculation, we find that in 1985, the surplus per decare[2] of agricultural land was 8.5 kg nitrogen and 2.0 kg phosphorus. By 1997, these figures had dropped to 7.3 kg nitrogen and 0.65 kg phosphorus. The phosphorus surplus per decare dropped steeply from 1985 to 1990 because farmers reduced the amount of phosphorus applied in commercial fertilizer. Fluctuations in yields, especially at the beginning of the 1990s as a result of variable weather conditions, 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

[2] 1 decare = 0.1 hectare.

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



Source: Agricultural Censuses from Statistics Norway.

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 11.2 kg per decare from 1989 to 1997, while nitrogen fertilization of meadow has remained stable at 13.7 kg per 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 1997 this figure had risen to 56 per cent. The overall effect on pollution of more widespread use of fertilization plans is uncertain, since this results in heavier fertilization of some areas and lighter fertilization of others. Figure 7.6 shows the area under cereals and oil seeds by intensity of fertilizer application.

Application of animal manure

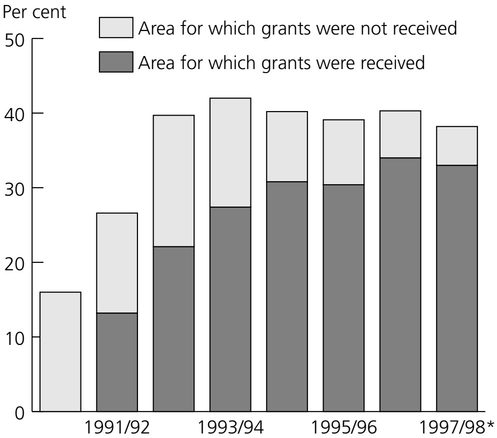
If livestock numbers are high in relation to the agricultural area in use, there may be an excess of manure and thus a risk of pollution. Total livestock numbers, and therefore the amount of manure produced, have changed little since 1985. The proportion of the manure applied during the growing season, 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.

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. The authorities therefore 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 because crop yields are expected to be lower in the following season without autumn tillage. In the long run, however, this measure will help to conserve soil and enable farmers to maintain levels of production without having to increase the input of other production factors. The

Figure 7.7. **Proportion of cereal acreage under stubble in autumn**



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

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 7.7 and Appendix, table F4). However, the proportion of the area under stubble for which support is granted has risen year by year and was 86 per cent in 1997-98. A growing proportion of the grants is being provided for areas that are particularly vulnerable to erosion.

Emissions from the agricultural sector

Emissions of *ammonia* (NH_3) from the agricultural sector account for 94 per cent of total ammonia emissions in Norway (table 7.1). The three most important sources are animal manure, the use of commercial fertilizer and treatment of straw with ammonia. Emissions from manure make up about 65 per cent of the total.

Livestock are the most important source of *methane* emissions (CH_4) in the agricultural sector. Methane is released directly in the form of intestinal gas and indirectly via manure. Livestock account for about 32 per cent of total methane emissions in Norway, of which 27 per cent is from intestinal gas and 5 per cent from manure.

Table 7.1. **Emissions to air from agriculture (showing pollutants for which the sector is an important source). 1998***

Pollutant	Tonnes	Percentage of total emissions in Norway
Nitrous oxide (N_2O)	9 400	55
Methane (CH_4)	109 400	32
All greenhouse gases (in CO_2 equivalents)[1]	5 400 000	10
Ammonia (NH_3)	25 400	94

[1] 1997*.
Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

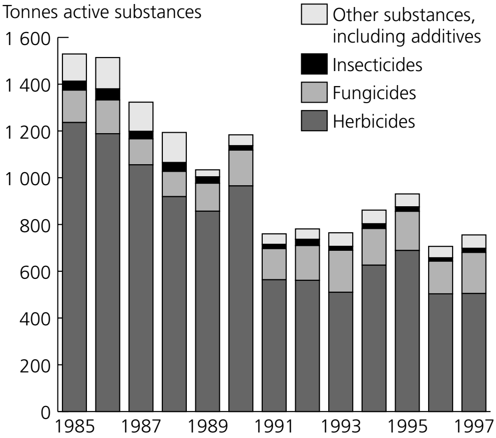
Sources of emissions of *nitrous oxide* (N_2O) from agriculture are the use of commercial fertilizer and manure, livestock, biological nitrogen fixation, decomposition of plant material, cultivation of mires, deposition of ammonia and runoff. Agriculture accounts for 50 per cent of total nitrous oxide emissions in Norway, and about half of this is emissions from runoff and the use of commercial fertilizer.

The agricultural sector generates about 10 per cent of total greenhouse gas emissions in Norway, measured as CO_2 equivalents. No measures have as yet been implemented to reduce emissions from the agricultural sector (see Chapter 4 and Appendix, tables C3-C5).

Use of pesticides

Residues of pesticides in soils, water and food products can cause injury to human health and environmental damage. Thus,

Figure 7.8. **Sales of pesticides expressed as tonnes active substances**



Source: Norwegian Agricultural Inspection Service.

there is always a certain risk associated with the use of these substances.

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 7.8 and Appendix, table F5). The degradation rates of different pesticides vary widely, as do their selectivity, mobility 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.

In the 1997 Sample Survey of Agriculture, Statistics Norway surveyed the areas of

Table 7.2. **Percentages of the area of some crops treated with chemical pesticides. 1996**

Type of crop	Herbicides	Fungicides	Insecticides
Potatoes	81.0	66.0	22.3
Grass	4.2	..	..
Cereals and oil seeds, total	82.9	28.1	14.7
Wheat	92.6	62.6	25.6
Barley	86.3	30.8	14.6

Source: Agricultural statistics from Statistics Norway.

agricultural land treated with chemical pesticides in 1996 (table 7.2).

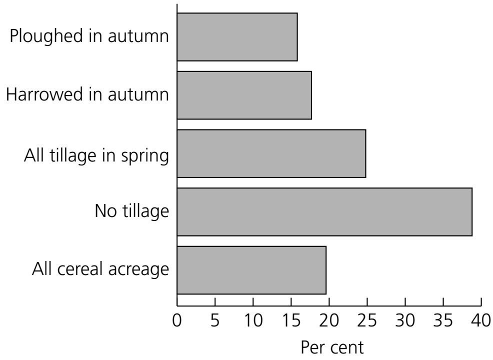
Measured in terms of the area treated, herbicides are the most widely-used pesticides. In 1996, 83 per cent of cereal and oil seed acreage was sprayed against weeds. Herbicides are used against both annual and perennial weeds (couch-grass etc.). Fungicides were sprayed on 28 per cent of cereal and oil seed acreage, while 15 per cent was sprayed with insecticides.

There are differences between cereal types in the use of pesticides. A larger proportion of wheat than barley is sprayed, and even less of the area under oats is sprayed. The extent of spraying depends on the resistance to disease of a cereal type, its potential yield and the grain price. Financially, the cereal farmer has most to gain by spraying areas where potential yield is high and where yields may be substantially reduced if pesticides are not used. This results in more intensive spraying in the best cereal areas than in more marginal areas.

Pesticides are used very little on meadow, and only 4.2 per cent of these areas were sprayed against weeds in 1996.

In 1996, 81 per cent of the potato acreage was sprayed with herbicides, 66 per cent with fungicides, and 22 per cent with

Figure 7.9. **Proportion of cereal acreage sprayed against perennial weeds according to soil management regime. Average for the period 1992-93 to 1997-98**



Source: Bye and Mork (1999).

insecticides. The fungicide was mainly used to combat potato dry rot.

Perennial weeds, especially couch-grass, are the most serious problem in cereal production. They are controlled either by tilling or by using herbicides. During the past six years, an average of 20 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, 39 per cent of the area under cereals that was not tilled at all (sown directly) was sprayed against perennial weeds, as compared with only 16 per cent of the autumn-ploughed area (figure 7.9). 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.

Crop damage caused by tropospheric ozone

Air pollution by tropospheric ozone has been shown to reduce yields of wheat, potatoes and cultivated meadow. This has been demonstrated by means of controlled greenhouse experiments. Together with the Norwegian Institute for Air Research and the Norwegian Meteorological Institute, Statistics Norway has calculated losses in yields in Norway in the period 1990-1995, and has estimated the social costs of these losses. Excess ozone concentrations in Norway are mainly caused by emissions of NO_x and VOCs (volatile organic compounds) in other countries, and we have therefore calculated the social benefits of implementing a new European protocol on reductions in NO_x and VOC emissions. The effects of reducing Norwegian emissions have also been calculated.

The Norwegian Institute for Air Research and the Norwegian Meteorological Institute have used measurements and models of the relationship between emissions and concentrations to calculate concentrations of tropospheric ozone for the years 1990-1995 and expected concentrations given future emissions reductions. Statistics Norway has figures for agricultural areas and yields in municipalities and counties, respectively. Using scientifically-based relationships between ozone exposure and crop damage, see for example Tørset et al (1997), losses in yields for wheat, potatoes and cultivated meadow have been calculated. The figures are shown in table 7.3. The losses correspond to between 4 and 7 per cent of expected yields.

Table 7.3. **Expected annual yields and losses in yields due to tropospheric ozone in Norway in the period 1990-1995. 1 000 tonnes**

	Expected annual yield	Average annual loss in yield
Wheat	274	18
Potatoes	426	18
Meadow, total	3 371	220

Source: Tørseth et al. (1997).

Table 7.4. **Annual social costs of losses in yields due to tropospheric ozone in the period 1990-1995. Million 1997 NOK**

	Fixed activity level	Fixed production level
Direct costs	159	277
Total social costs	243	385

Source: Tørseth et al. (1999).

The social costs of losses in yields depend on whether the response to lower yields is to increase imports or to step up the level of agricultural activity to maintain domestic production. This in turn depends on the authorities' objectives for agricultural production in Norway. There are at least two possibilities, as set out in Proposition No. 8 (1992-93) to the Storting on agricultural policy. The first objective is to retain the scattered pattern of settlement in Norway, and an important instrument to this end is to maintain the level of agricultural activity. If this is the main objective, losses in yields can be replaced by an increase in imports, since employment in agriculture will be unchanged. The second objective is the maintenance of food production in the long term. This means that to compensate for the loss in yields, inputs of resources to the agricultural sector must be increased. In this case, resources must be diverted from other sectors, so that a reallocation of resources in the economy takes place. Since either of these goals may be relevant here, we have calculated the costs of two alternatives, called *fixed activity level* and *fixed production level*.

The direct value of the losses in yields can be calculated by multiplying the losses in table 7.3 by a certain price, which however differs between the two alternatives. In the fixed activity level scenario, the import price is relevant, whereas in the case of fixed production level, the domestic producer price is most relevant. These may be very different, as shown in the first row of table 7.4. The direct costs of the losses in yields are NOK 159 and 277 million per year for fixed activity and fixed production level respectively.

In order to calculate the total social costs, we have used a model for the Norwegian economy (MSG-6). This can tell us something about the impact of reduced returns from agriculture on the rest of the economy in the two cases, and how gross domestic product (GDP) is changed. From table 7.4, we can see that changes in the macroeconomy add about NOK 100 million to the costs in both scenarios.

Implementation of the new protocol on reductions of NO_x and VOC emissions in Europe (see box 4.5, note 1) would reduce the costs shown in table 7.4 by one-third to one-quarter. If Norwegian NO_x emissions were reduced by a further 40 per cent, the costs would also be further reduced, by 10-20 per cent. Reductions in Norwegian VOC emissions, on the other hand, would have relatively little effect.

Project financed by: Norwegian Pollution Control Authority.

Project documentation: Tørseth et al. (1999) and Tørseth et al. (1997).

Table 7.5. **Agricultural policy instruments in the agricultural sector designed to reduce negative environmental impacts and safeguard important environmental benefits**

	Issues		
	Runoff of nutrients and erosion	Cultural landscape	Other
Legislative measures	• Regulations relating to manure	• Land Act • Cultural Heritage Act	• Act relating to Pesticides
Economic measures	• Environmental tax on commercial fertilizer (NOK 165.2 million)	• Acreage and cultural landscape support (NOK 3 130.1 million)	• Environmental tax on pesticides (NOK 22 million)
	• Grants for amended soil management (NOK 125 million)	• Extended support for landscape maintenance and development (NOK 86 million)	• Grants for ecological farming (NOK 50 million)
	• Investment grants for environmental measures (NOK 30 million)	• Grants for grazing livestock on outlying pastures (included in Acreage and cultural landscape support; see above)	
	• Conversion of cereal-growing areas on environmental grounds (NOK 5 million, included in Extended support for landscape maintenance and development)	• Grants for summer mountain farming (NOK 18 million)	
	• Grants for improvements of manure storage and silage effluent facilities and milking parlours		
Administrative	• Mandatory fertilization plans		• Collection of waste plastic, waste oil, tyres, pesticide residues, etc. Mandatory pesticide certificate.

Source: Ministry of Agriculture.

7.4. Environmental measures in the agricultural sector

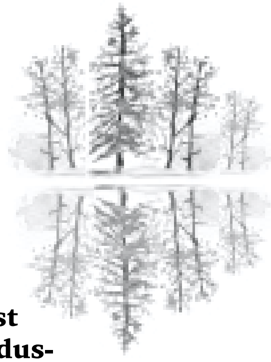
The overall objectives of the authorities are to ensure that agricultural production is in harmony with biogeochemical cycles and that nutrient losses are kept to a minimum, and to safeguard the important environmental benefits deriving from agriculture (e.g. the cultural landscape, biological diversity, and cultural monuments). The authorities have implemented a series of measures and instruments to achieve these objectives and limit the negative environmental effects of modern agriculture. Table 7.5 gives an overview of the most important of these.

Co-financed by: Ministry of Agriculture.

Documentation: Bye and Mork (1999).

Further information may be obtained from: Henning Høie and Kjetil Mork.

8. Forest



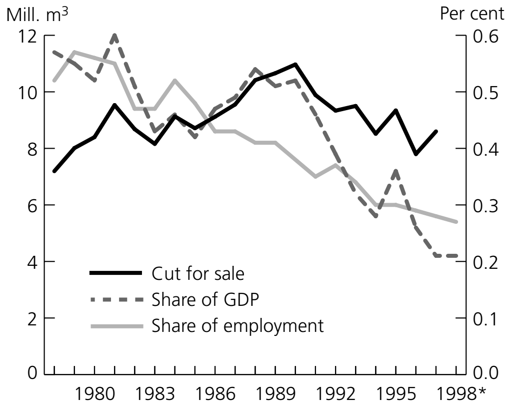
Forest covers about 37 per cent of mainland Norway excluding Svalbard. The main commercial uses of forest resources are in the sawmilling and pulp and paper industries. Ever since the first forest inventory was made in 1925, the annual increment has been larger than the harvest. As a result, the volume of the growing stock has more than doubled since 1925. The annual net increment is of the order of 12 million m³, which means that the growing stock increases by 1.6 per cent per year. If we consider forests as a sink for greenhouse gases, this means that the uptake of CO_2 from the atmosphere by forests corresponds to about 40 per cent of Norway's anthropogenic CO_2 emissions.

Norway has a statutory public right of access that allows people to pick mushrooms and berries on uncultivated land and ensures free access to forested areas. About 22 000 plant and animal species are associated with forests, and about 900 of these are classified as rare or endangered. For the first time for a number of years, measurements showed a slight improvement in the situation as regards forest damage in Norway from 1997 to 1998.

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 1998. In 1998, labour input in forestry was 5 200 full-time equivalent persons, or 0.3 per cent of total employment (figure 8.1). Forestry's share of Norway's GDP has shown the same trend, and dropped from 0.57 to 0.21 per cent in the period 1980-1998. The gross value of the roundwood cut for sale and industrial production in 1997 was calculated at NOK 2.9 billion. The average roundwood price was NOK 338 per m³ in 1997 (Statistics Norway 1999c).

Figure 8.1. **Forestry: share of employment and GDP 1978-1998*. Annual roundwood cut 1978-1997***



Source: National Accounts and Forestry Statistics from Statistics Norway.

8.2. Resources and harvesting

Biodiversity

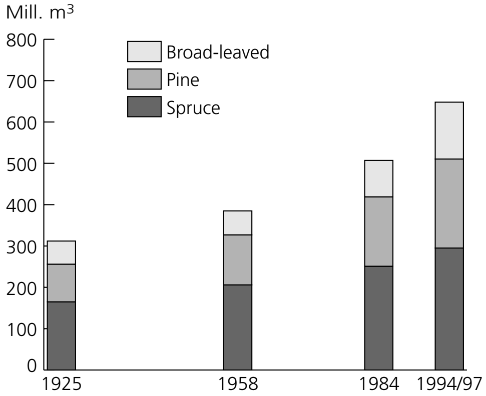
About 37 per cent of mainland Norway excluding Svalbard is forested today. The current status of forests and the biological diversity associated with them are the result of many generations of human influence combined with natural short- and long-term changes.

There have been dramatic changes in the utilization of forests since the end of the Second World War. The use of forested areas for grazing has been greatly reduced, and forestry has become industrialized and mechanized. This means that areas are clear-cut, and this is often followed by planting which may involve a change of tree species. The area covered by trees that are less than 20 years old is four times larger than it was before the war (Norwegian Institute for Land Inventory 1988), and one result has been the fragmentation of areas of old-growth forest.

It has been estimated that 22 000 plant and animal species are associated with forest in Norway, and that about 900 of these are rare or endangered (Directorate for Nature Management 1997). Norway has ratified the Convention on Biological Diversity, which was adopted by the UN Conference on Environment and Development in 1992, and is therefore required to take steps to identify and monitor its biological diversity.

On the initiative of the Ministry of the Environment, a national monitoring programme for biological diversity has been drawn up for important ecosystems in Norway, including forests (Directorate for Nature Management 1998). This has been done on the basis of the recommendations of Report No. 58 (1996-97) to the Storting on an environmental policy for sustainable development, which states that an integrated monitoring programme for biodiversity will be fully implemented by the year 2002.

Figure 8.2. **Volume of the growing stock without bark, 1925-1997**



Sources: Material from Statistics Norway and National Forest Inventory.

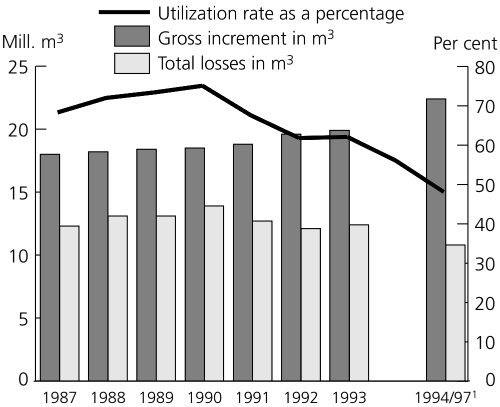
Areas and ownership structure

About 72 000 km² of the forested area of Norway is classified as productive. This corresponds to 60 per cent of the total area of forest. 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

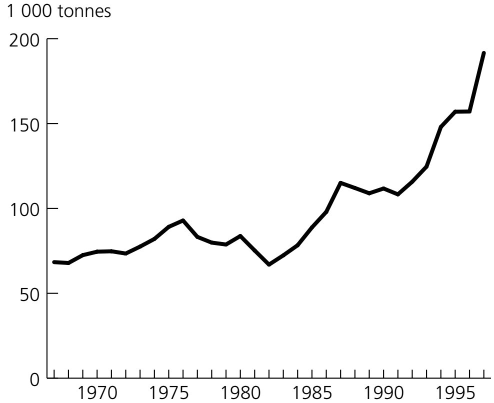
Forest inventories and calculations of volume show that the volume of the growing stock below the coniferous forest line has more than doubled since 1925 (figure 8.2). The increase was particularly rapid towards the end of the period. Annual figures for the volume of the

Figure 8.3. **Gross increment, total losses and utilization rate of the growing stock**



Source: Forestry Statistics from Statistics Norway.

Figure 8.4. **The pulp and paper industry's purchases of Norwegian waste paper and cardboard**



Source: Prosessindustriens landsforening (1999).

growing stock, the forest balance, show the calculated figures for the growing stock at the beginning and end of the year. Data from inventories carried out by the Norwegian Institute for Land Inventory show that the total volume of the growing stock, without bark, below the coniferous forest line was on average 649 million m^3 in the period 1994-1998. This total consisted of 45 per cent spruce, 33 per cent pine and 22 per cent broad-leaved trees. In 1996, the net increment (annual increment minus roundwood cut and calculated natural losses) in the growing stock was 10.8 million m^3, or 1.6 per cent of the total volume (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.

Roundwood cut

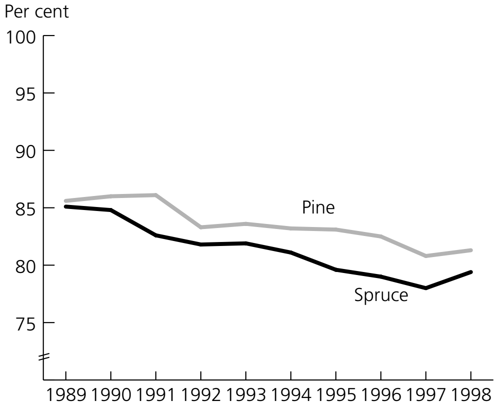
Preliminary figures show that in 1997, the total volume of the roundwood cut for sale and industrial production was 8.6 million m^3 (Statistics Norway 1999c). The harvest included 4.4 million m^3 special timber and sawlogs, 3.7 million m^3 pulpwood and 0.5 million m^3 fuelwood for sale and industrial use.

The annual utilization rate for timber can be calculated as the ratio between total annual losses in the volume of the growing stock and the gross increment in volume. The utilization rate has been decreasing since 1990, and was 48 per cent in 1996 (figure 8.3).

Material recovery of wood fibre from paper and cardboard

The pulp and paper industry has built up its capacity to use waste paper and waste fibre from production. According to the industry's own organization, annual purchases of Norwegian waste paper and cardboard have risen steadily from 68 400 tonnes in 1967 to 191 600 tonnes in 1997 (Prosessindustriens landsforening 1999), see figure 8.4. If the weight of waste paper and cardboard in tonnes is converted to cubic metres of timber, the quantity of waste paper and cardboard purchased in 1997 is found to correspond to about 695 000 m^3 timber, or 8.1 per cent of the roundwood cut for sales and production in the same year. The volume of imports and production waste from Norwegian firms are not included in these figures.

Figure 8.5. **Mean crown density of spruce and pine, 1989-1998**



Source: Norwegian Institute for Land Inventory.

Silviculture

From 1980 to 1991, an area of about 300 km^2 was planted with forest every year. More recently, the level of activity has dropped somewhat, and in 1996 the area planted was calculated to be about 218 km^2 (Ministry of Agriculture 1998). In 1996, a total area of about 481 km^2 was subjected to clearance and weed control. Chemical weed control was used on about 6 per cent of this area. A total of about NOK 243 million was invested in silviculture in 1997, and this is the lowest figure since 1993 (Report No. 17 (1998-99) to the Storting).

The reduction in afforestation may be partly explained by the lower roundwood cut and the fact that thinning accounts for a rising proportion of the roundwood cut. Another explanation may be 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 use of forest 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 areas of wilderness-like habitat in Norway (SSB/SFT/DN 1994). (Wilderness-like habitat is defined as being more than 5 km from major infrastructure development.) 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. By way of comparison, the total length of public roads in Norway is about 90 000 km. A further 4 800 km of forestry roads for year-round use were built from 1990 to 1996. However, since then the rate of construction of forestry roads has decreased. In 1997, investments in forestry roads totalled NOK 152 million, which is the lowest figure for the last ten years (Report No. 17 (1998-99) to the Storting). The proportion of the construction costs of road-building covered by state grants has been substantially reduced in recent years, from 25.6 per cent in 1990 to 8.6 per cent in 1996 (Statistics Norway 1998k).

8.3. Forest damage

Forest damage in Norway

The causes of forest damage are often complex. Unfavourable climate and 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, but rose by 1.4 percentage points to 79.4 per cent in 1998 (figure 8.5). The measurements also show that the mean crown density for pine, which was 81.3 per cent in 1998, has shown a positive trend in the past year, with a rise of 0.5 percentage points from 1997 to 1998. 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.

Birch has been included in the monitoring programme since 1992, and preliminary records of birch trees in coniferous forest were made from 1990 onwards. The proportion of birch trees showing no signs of damage (discoloration and/or a reduction in crown density) has dropped from 15 per cent in 1997 to 12 per cent in 1998. Broad-leaved 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.

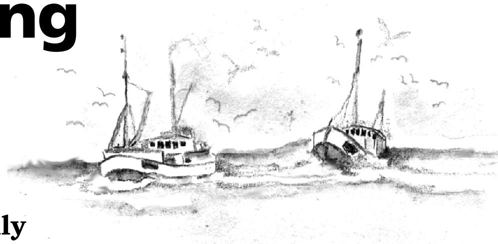
Forest damage in Europe

Since 1985, European countries have been cooperating to register and monitor the effects of air pollution on forests. In 1997, 30 countries took part in the programme, and a total of 124 041 trees were sampled.

The results from 1997 show that 25.6 per cent of all the trees surveyed showed clear signs of damage, with more than 25 per cent defoliation. The most sensitive species are common oak, beech, and Norway spruce (UN/ECE 1998). However, the results for individual countries show that there are large regional variations in the health of European forests. Biotic and climatic stress factors are the most commonly reported causes of forest damage, but it should be noted that one third of the countries that provided reports consider air pollution to be important as part of the cause or a local inciting factor in forest damage.

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

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. The fisheries are important in economic terms, and 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.

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 has been very low for a number of years, but has grown substantially during the past year. The spawning stock of Norwegian spring-spawning herring has now reached the same high level as in the 1950s, and catches of herring have therefore risen steeply in recent years. The situation for the North-East Arctic cod stock is more uncertain.

9.1. Principal economic figures for the fisheries

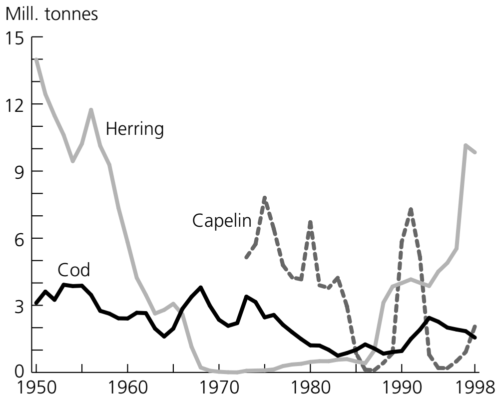
According to the national accounts, fishing, sealing and whaling contributed NOK 9.3 billion to Norway's gross domestic product (GDP) in 1998. This is 0.8 per cent of GDP (Statistics Norway 1999a). The share of total employment was also 0.8 per cent in 1998. At the end of 1998, 21 100 fishermen were registered in Norway, and fishing was the main occupation of 71 per cent of these.

9.2. Trends in stocks

Barents Sea and Norwegian Sea

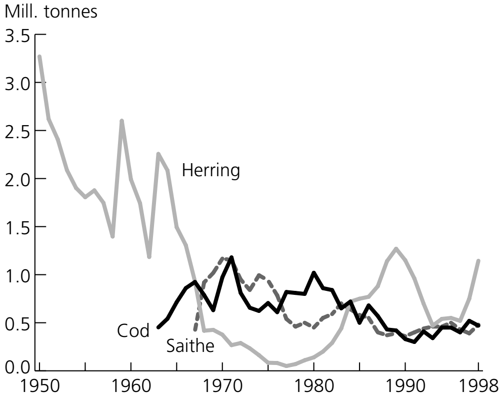
Norwegian spring-spawning herring, capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Since the end of the 1960s, all three of these stocks have at some time reached a historical low (figure 9.1). The herring stock was severely depleted by overfishing at 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 10 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. A substantial reduction of the spawning stock is expected in the next few years, since there have been several weak year-classes since 1992 (Toresen et al. 1998).

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 and 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.

The capelin stock in the Barents Sea collapsed in 1986-1987, partly as a result of overfishing, but also from natural causes, It recovered rapidly after this, but dropped sharply again in 1993. This was a result of a significant increase in the natural mortality of both larvae and older capelin. This is explained by predation; cod and marine mammals in particular feed on adult capelin, and juvenile herring feed on capelin larvae. The amount of capelin consumed by cod was calculated to be 3.3 million tonnes in 1993, but this was reduced to 0.5 million tonnes in 1996 as a result of the decrease in the capelin stock (Toresen et al. 1998). Better recruitment to the capelin stock has resulted in substantial growth from 1997 to 1998. A modest experimental catch of capelin (80 000 tonnes) is being permitted in the Barents Sea in 1999, for the first time since winter 1993.

The cod stock was low throughout the 1980s, but rose again in the early 1990s. Since 1993, there has been a steady decrease to the current level of about 1.6 million tonnes. This is a result of a large harvest, in addition to an increase in cannibalism and a reduction in individual growth (Toresen et al. 1998).

North Sea

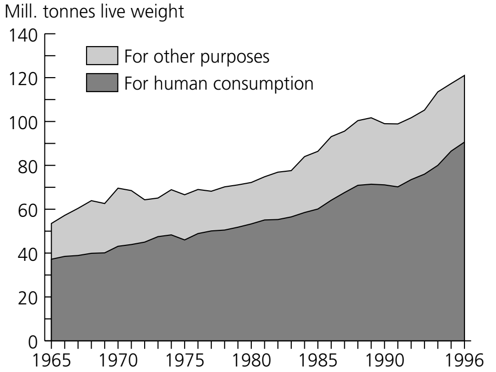
The stock of North Sea herring rose steadily from 1980 onwards. However, from 1990 to 1996, the spawning stock dropped to considerably less than the 800 000 tonnes that is regarded as the minimum biologically acceptable level[1] (figure 9.2 and Appendix, table H1). One reason for this is that recruitment to the stock was generally poor, partly because

[1] The minimum biologically acceptable level (MBAL) is the minimum size of the spawning stock which has proved to result in satisfactory recruitment.

of the large annual harvest of juvenile herring. The fishing pressure on adult herring was also high. Stocks of demersal fish, e.g. cod and saithe, are now showing signs of growth, but are still lower than they were in the early 1970s. Since these species feed on herring, 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 by means of quotas. This allowed for some growth of the stock in 1997, and the spawning stock in 1998 is calculated to be more than 1 million tonnes (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 has been about 2.5 million tonnes since 1994. 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 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). The strict regulation of the fisheries that was introduced in 1996 and 1997 appears to have had an effect, and resulted in a small rise in the spawning stock (Toresen et al. 1998).

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



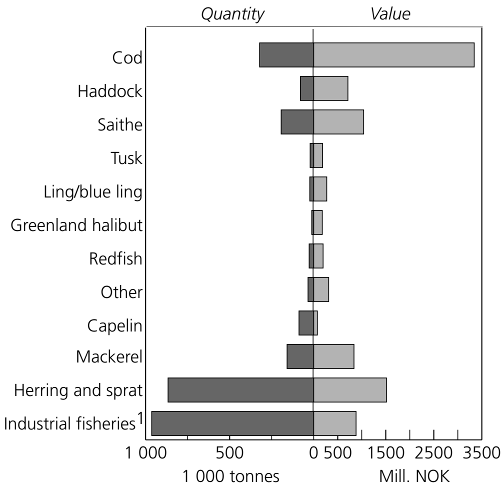
Source: FAO.

9.3. Fisheries

World catches

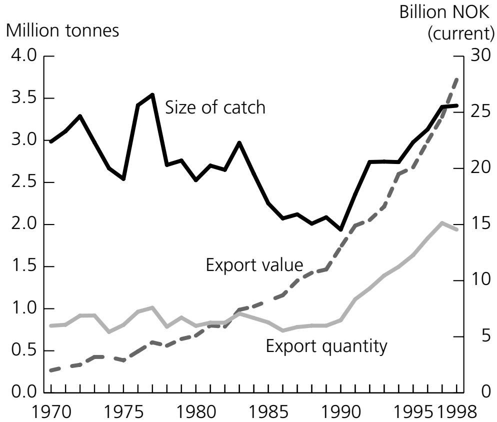
Production in the world's fisheries, including both fresh-water and marine catches and production in the fish farming industry, has increased substantially from slightly more than 50 million tonnes in 1965 to about 121 million tonnes in 1996 (figure 9.3). More than 70 per cent of total production is 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. World aquaculture production rose by more than 8 per cent from 1995 to 1996, while the rise for both fresh-water and marine fisheries was about 2 per cent. As a result, both fish meal production and fish supplies for human consumption have reached record levels (FAO 1997, 1998a, b and c). The rise in marine fisheries is largely due to higher catches in the north-western Pacific, where almost 30 per cent of all marine catches are taken. In the Mediterranean and Black Seas, catches dropped by about 11 per cent.

Figure 9.4. **Norwegian catches by groups of fish species, 1998**



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

Figure 9.5. **Catches, weight of products exported and export value[1]**



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

Norway's fisheries rank as number 10 in the world (excluding farmed production), with a total catch of 2.6 million tonnes in 1996. The countries at the head of the list are China (14.2 million tonnes), Peru (9.5 million tonnes), Chile (6.7 million tonnes), Japan (6.0 million tonnes) and the USA (5.0 million tonnes) (see Appendix, table H7).

The proportion of world fish production used for human consumption has remained relatively stable at about 70 per cent for the entire period after 1965. In 1996, the proportion was 75 per cent for the world as a whole and 67 per cent in Norway. However, in 1966 and 1975, when there were large catches of herring and capelin respectively, less than 30 per cent was used for human consumption in Norway. These species are important raw materials for the production of fish meal and oil.

Norwegian catches

The total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) in 1998 was 3 million tonnes, and the value of the catch was NOK 10.4 billion. The total catch was about the same as in 1997, but the value rose by more than NOK 1 billion. The catch of herring dropped by about 90 000 tonnes in 1998, and its value fell by about NOK 100 million to NOK 1.46 billion. The catch of cod was about 80 000 tonnes lower than in 1997, but its value rose by almost NOK 500 million to NOK 3.34 billion as a result of price rises. There has also been an increase in the catch and its value in industrial fisheries (fish as raw material for meal and oil). This is explained mainly by a large increase in the catch of blue whiting. First-hand values and catches in 1998 are shown in figure 9.4 (see also Appendix, table H2). Figure 9.5 shows trends in catches in Norwegian fisheries, export quantities and the export value of fish and fish products.

9.4. Fish farming

Production of farmed fish

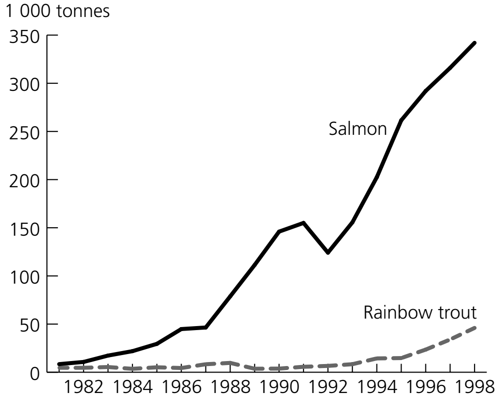
The production of farmed fish has risen steeply since the industry was established at the beginning of the 1970s. The slaughtered quantity of farmed salmon rose from about 316 000 tonnes in 1997 to 342 000 tonnes in 1998 (figure 9.6). More than 80 per cent of the farmed salmon is exported. The production of rainbow trout has also risen and was about 46 000 tonnes in 1998. Production in the Norwegian fish farming industry is now higher than total meat production in Norwegian agriculture, which was about 250 000 tonnes in 1997. The value of the production of farmed fish was higher than that of traditional catches for the first time in 1998 (Statistics Norway 1999). However, the quantity of salmon and trout produced in 1998 only corresponded to 14 per cent of total catches.

The health of farmed salmon

According to figures from the National Veterinary Institute and the Norwegian Animal Health Authority, the most important diseases affecting salmon farming are:

- Furunculosis, caused by the bacterium *Aeromonas salmonicida* (diagnosed at four fish farms in 1997);
- Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum* (diagnosed at 15 fish farms in 1997);
- Vibriosis and cold-water vibriosis, caused by the bacteria *Vibrio anguillarum* and *Vibrio salmonicida* (diagnosed at five and one fish farm respectively in 1997);

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



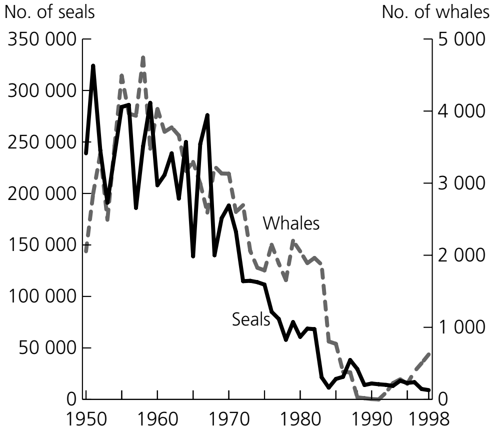
Sources: Fishery Statistics from Statistics Norway, Directorate of Fisheries and Kontali AS.

- Infectious salmon anaemia (ISA), a virus disease (diagnosed at six fish farms in 1997);
- Infectious pancreatic necrosis (IPN), a virus disease (diagnosed at 224 fish farms in 1997).

The health of farmed fish has been considerably improved, and the use of medicines by the fish farming industry has been greatly reduced in recent years. New vaccines and improvements in the operation of fish farms are probably the main reasons for this. The consumption of antibacterial agents was highest in 1987, when it reached 49 tonnes (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 1998, consumption had been reduced to 679 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 and Mortensen et al. 1998). It is controlled by chemical means using delousing preparations (e.g. hydrogen peroxide) 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. The parasite can also be a threat to wild salmon and sea trout stocks.

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



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

9.5. Sealing and whaling

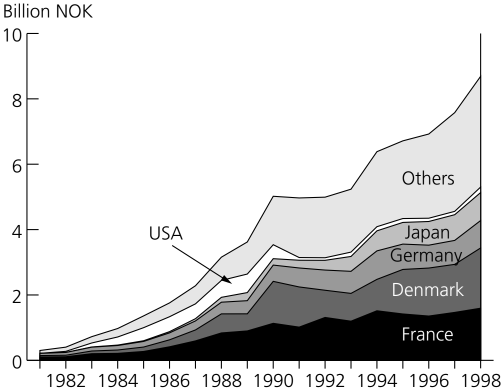
Since the early 1980s, catches of seals have been small, varying between 10 000 and 40 000 animals per season (figure 9.7). In 1998, the total catch was 9 021 animals (2 689 harp seals and 6 332 hooded seals). Since 1983, Norwegian sealing has taken place only in the West Ice (off Jan Mayen) and in the East Ice (drift ice areas at the entrance to the White Sea). The catch in the West Ice includes both hooded seals (6 332) and harp seals (1 857), whereas that in the East Ice consists entirely of harp seals (832).

Until the early 1980s, the annual value of the seal catch was between NOK 10 and 40 million (current prices). In 1998, the value was just over 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 1998 season, only four 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 1998, 624 minke whales of a total quota of 671 animals were caught. The quota for 1999 is 753 animals, including 140 transferred from earlier quotas that were not filled. For an explanation of why the traditional hunt was discontinued, the reduction in quotas and the prohibition on exports of whale products, see *Natural Resources and the Environment 1998*.

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

Figure 9.8. **Export value of farmed salmon by main purchasing countries**



Source: External Trade Statistics from Statistics Norway.

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 numbers 118 000 animals (Toresen et al. 1998).

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 1998, the value of the catch was about NOK 27 million.

Both harp seals and minke whales are important consumers of fish and other species 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 1.8 million tonnes, of which 1.2 million tonnes consists of fish (mainly herring, cod, capelin and haddock). Consumption by harp seals totals about 1.2 million tonnes, 0.8 million tonnes of which consists of fish (Toresen et al. 1998).

9.6. Exports

Preliminary figures show that in 1998, exports of fish and fish products were about 1.9 million tonnes, with a value of NOK 27.9 billion (figure 9.5 and Appendix, tables H4 and H5). Exports to EU countries accounted for 63 per cent of the total. Salmon exports totalled NOK 8.7 billion in 1998 (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, partly because of the high import duty imposed on whole fresh salmon, whereas exports to Japan have risen considerably.

In all, the export value of fish and fish products accounted for 15.8 per cent of exports of traditional goods from Norway in 1997 (i.e. exports excluding crude oil, natural gas, ships and oil platforms), and 9.1 per cent of total exports of goods.

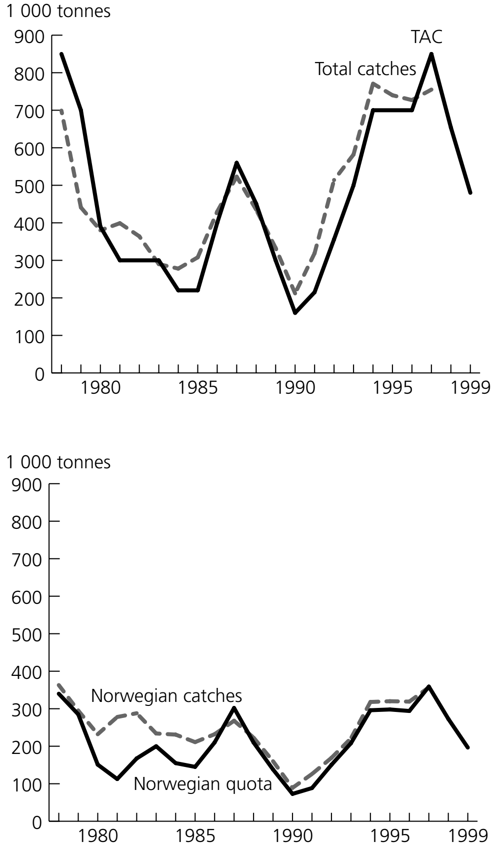
According to the FAO, in 1996 Norway ranked second in the list of the world's largest fish exporters, after Thailand and followed by the USA, China and Denmark (FAO 1998b). The value of Norway's fish exports corresponded to about 7 per cent of the value of total world fish exports (Appendix, table H7).

9.7. Fisheries management

Regulation of fisheries

With the exception of the trawl fisheries, there was very little regulation of the Norwegian fisheries until the 1960s. Today, both fishing effort (licences, number of vessels, types of gear, etc.) and harvesting (various forms of quotas) are regulated. Total allowable catches (TACs),

Figure 9.9. **Quotas and catches of North-East Arctic cod**



Sources: Ministry of Fisheries and Institute of Marine Research.

the way quotas are split between countries and the transfer of fishing rights are agreed each year in negotiations between Norway and other countries. The most important of these are with the EU and Russia. Recommendations from the International Council for the Exploration of the Sea (ICES) are an important basis for setting quotas. Figure 9.9 shows quotas and catches of North-East Arctic cod from 1978 onwards. Norwegian catches were substantially higher than the quotas for much of the 1980s. Since then, the differences have been smaller. Table 9.1 shows quotas for some important fish stocks in 1998 and 1999.

Table 9.1. **Quotas of some important fish stocks in 1998 and 1999. 1000 tonnes**

Stocks	1998 TAC	1998 Norwegian quota	1999 TAC	1999 Norwegian quota
North-East Arctic cod[1]	654.0	273.0	480.0	196.5
North-East Arctic haddock[2]	130.0	66.0	78.0	41.0
Norwegian spring-spawning herring	1 300.0	741.0	1 300.0	741.0
Barents Sea capelin[3]	-	-	80.0	48.0
Saithe north of 62° N	145.0	137.5	145.0	137.5
Saithe south of 62° N	97.0	45.4	110.0	52.2
Mackerel	482.8	151.8	484.6	151.8
North Sea herring[4]	254.0	73.7	265.0	76.9
North Sea cod[5]	140.0	14.8	132.4	12.5
North Sea haddock[5]	115.0	24.0	88.6	14.9

[1] Not including coastal cod. [2] Not including coastal haddock. [3] Caught after the Barents Sea capelin fishery was closed in winter 1993. [4] Caught for human consumption in the North Sea. [5] Norway's quota in the agreement with the EU: quotas may subsequently be exchanged with other countries.
Sources: Ministry of Fisheries and Institute of Marine Research.

There are three main ways of setting quotas: they may be based on fixed values for fish mortality for various stocks (in other words, the proportion of the stock to be harvested is decided, and quotas are then set on the basis of the calculated stock size), fixed quotas that apply indefinitely, or quotas intended to maintain spawning stocks of a fixed size. These three options and various management strategies are further discussed in the journal *Havets ressurser 1998* (Toresen et al. 1998).

9.8. Do model-based analyses improve fisheries management?

To what extent do model-based economic analyses improve economic policies? Models will always give a simplified picture of the world, and many important factors are normally omitted from any model. It is therefore unlikely to be a sensible strategy to rely entirely on the results of a model: instead, an intuitive grasp of the situation is needed to correct for factors that have not been taken into account. This essential element of evaluation means that the usefulness of models cannot be investigated on a purely theoretical basis. At the same time, it is difficult to determine how model-based analyses influence real-world policies.

We designed an experimental study to shed some light on this issue. It was restricted to the management of cod and capelin stocks in the Barents Sea. Sixty-four students were asked to manage "virtual" fish stocks for a period of 25 years. Stock trends and the economic results ("virtual reality") were described by a relatively complex stochastic multispecies model. The students were asked to set quotas for both cod and capelin each year. When the quotas had been set for a particular year, estimates of the size of each stock the following year were given, and the process was repeated. The students were asked to manage the stocks in such as way as to maximize their current value, including a valuation of the stock at the end of the period, and corrected for unemployment as a result of fluctuations in catches.

Two different models were provided to help the students make stock management decisions. One of these, a deterministic simulation model, provided what we called "help from a biological model", It gave forecasts of stocks for four years at a time, based on yearly catches of 15 or 30 per cent of the stock for cod and 40 or 80 per cent of the stock for capelin. These forecasts were drawn up using a simplified version of the model used to describe virtual reality, but with the linkage between the two stocks broken and random variations removed. The second model was called "recommendations from an economist", and provided an optimal quota calculated using a stochastic optimization model including a highly simplified description of the biological system. The students were informed about the weaknesses of the models. Some students had neither model for support, some were given access to one model, and some were able to use both. We also distinguished between different starting points. Some students were given large initial stocks, at about the level expected if the stock had not previously been fished, and others were given low initial stocks. Together with the different options as regards models, this gave us at total of eight groups of equal size.

Even the students who had no model to support their decisions produced better results than those who followed the recommendations of the optimization model without adjustments. In other words, even though the students had no experience of the problem, they were able to manage the virtual reality better without any support than by using the rule given by a simplified optimization model without any adjustments. Nevertheless, we found that both models were useful, and gave roughly the same rise in the expected current value of the stocks, but for different reasons. The optimization model was not very useful for the students who were given low initial stocks, but very useful for the groups who started with high stocks. The deterministic model was equally useful for all groups.

One explanation for this is that the students were trying to maintain constant levels of the stocks. This is a good strategy given low initial stocks, but if the stocks are initially at a high level, it is better to reduce them first and then try to maintain them at a constant, lower level. The optimization model, with its "recommendations from an economist" was therefore particularly useful in situations where an intuitive rule-of-thumb strategy did not produce a sound management regime. The fact that the deterministic model was useful for all the groups suggests that regardless of which management strategy is preferred, it is useful to have some estimates of stock trends.

Project financed by: Research Council of Norway.

Project documentation: Brekke and Moxnes (1998).

More information may be obtained from: Frode Brunvoll and Kjell Arne Brekke.

10. Population and land use in urban settlements

Today, 74 per cent of Norway's population live in towns and urban settlements, but these urban settlements only take up 0.7 per cent of Norway's total area. Various user interests are therefore heavily represented in urban settlements and adjacent areas and many of these areas are under considerable development pressure. It is important to the local environment and for economic and environmental reasons that urban settlement areas are put to good use. Sound land use planning and management requires factual knowledge and an appreciation of the overall picture. To improve the knowledge base, Statistics Norway is currently expanding and standardizing land use statistics for urban settlements.

10.1. Introduction

There is a tendency for an increasing percentage of the population to live in urban settlements. This has created pressures within small, restricted areas and it has become even more important to control and monitor the development of land use. The Ministry of the Environment's report on regional planning and land use policy (Report to the Storting No. 29 (1996-97)) emphasizes the importance of creating environmentally friendly development patterns by, for instance, strengthening town centre activity and settlement, planning environmentally friendly transport systems and ensuring there are green spaces. The development of land use statistics for urban settlements in Statistics Norway is based on this report.

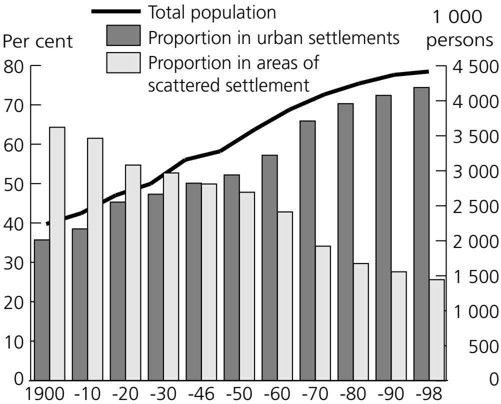
In 1998 Statistics Norway conducted a nationwide update of urban settlement boundaries and population count in these urban settlements. In addition, work has been done to develop methodology and analyse land use in urban settlements and to quantify indicators for the sustainable development of land use within them.

10.2. Population trends in urban settlements

In Norway, there has been a shift away from a large percentage of scattered settlements at the beginning of this century, when 35 per cent of the population lived in built-up areas, to the current situation where about 75 per cent of the population live in towns and urban settlements (figure 10.1). According to municipal statistics, there were a total of 889 urban settlements with at least 200 inhabitants in 1997. Of these, Oslo, Bergen, Trondheim and Stavanger had more than 100 000 inhabitants[1] and 27 per cent of the population were resident here. Figure

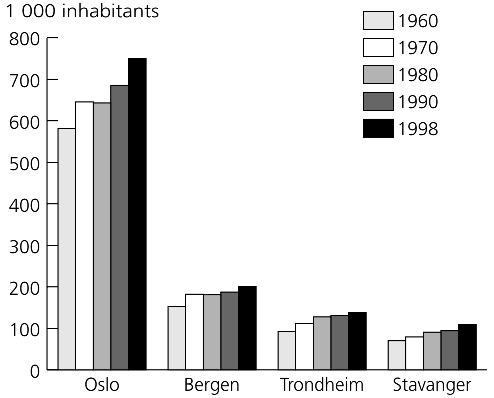
[1] The population figures refer to the urban settlements, but do not include municipalities, with the exception of Stavanger where the figures include the part of the urban settlement that is within the boundaries of Stavanger municipality.

Figure 10.1. **Total population, and percentage of population resident in urban settlements. 1900-1998**



Source: Population Statistics, Statistics Norway.

Figure 10.2. **Population[1] in Oslo, Bergen, Trondheim and Stavanger urban settlements**



[1] The population figures refer to the urban settlements, not the municipalities, with the exception of Stavanger where the figures include the part of the urban settlement that is within the boundaries of Stavanger municipality.
Source: Population Statistics, Statistics Norway.

10.2 shows official population statistics for the four largest urban settlements in the period from 1960 to 1998.

10.3. New method for delimitation of urban settlements

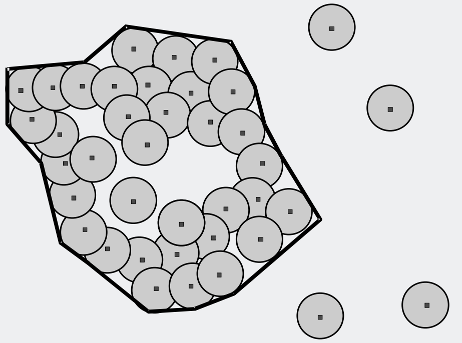
Even though the concept of urban settlements was first defined in 1960, Statistics Norway has calculated the proportion of the population living in built-up areas and areas of scattered settlement since the turn of the century. The term “urban settlement” was originally defined in connection with the 1960 Population and Housing Census, but has been expanded since then. To put it simply, an urban settlement is currently defined as an area where the distance between houses is usually not more than 50 metres and which has at least 200 residents. An urban settlement is therefore a dynamic unit whose boundaries are constantly changing in pace with building developments and changes in the number of residents.

Statistics Norway has now developed a method for register-based and automatic delimitation of urban settlements and aggregation of land use statistics, see Box 10.1. This has provided a uniform method for delimiting urban settlements, and has made it possible to monitor developments in the population and in land use on a regular and more frequent basis. The method for delimiting urban settlements is based on information from the National Population Register and the GAB register, the official Norwegian register for property, addresses and buildings, see Box 10.2. Geographically-referenced information from these registers is fed into a Geographical Information System (GIS), which carries out the final delimitation. This new method will gradually replace the previous resource-intensive method of drawing urban settlement boundaries onto maps by hand, and then digitalizing them, a process traditionally carried out about every ten years. There are also plans to conduct calculations for previous

Box 10.1. Method for automatic delimitation of urban settlements

The automatic delimitation of urban settlements is carried out in two main stages. First, all the residents are geographically referenced, either directly to coordinate-defined addresses or, if there are no address coordinates, by connecting persons resident at a specific address to a corresponding coordinate-defined building. The data of residents in combination with a georeferenced register of buildings is then used in a GIS (Geographical Information System) to delimit urban agglomerations. An operational version of the urban agglomeration definition constitutes the basis for this process. The process is described in detail in technical documentation (Dysterud and Engelien 1999).

Figure 10.3. **Urban settlement delimitation based on buffer zones around each building**



Box 10.2. Data sources

Area statistics are primarily based on data from the National Population Register (DSF) and the GAB register, the official Norwegian register for property, addresses and buildings. Vital data elements in the GAB register are the location of buildings, defined by coordinates, year of construction, type of building and base area. The quality of the information varies from county to county and from year to year. In most cases, there is more and better information on new buildings than on old in the GAB register.

Estimation techniques are used in cases where the data is incomplete or missing. These techniques will improve with time and all the results must be regarded as preliminary.

In addition to the GAB and DSF registers, mapping data is used, in particular information on the coastline, water contour, railways and roads, the latter using data from the Norwegian Mapping Authority's road database, VBASE.

Tests have been carried out using satellite images and digital property maps, and other data sources will be used in the future.

years to show developments in urban settlements over time.

10.4. Urban settlement areas and population in 1998

In 1998 a nationwide update of urban settlement boundaries was conducted based on the new method. The results showed that as of 1 January 1998, there were a total of 952 urban settlements in Norway with at least 200 residents. The total area taken up by urban settlements was 2 068.6 km^2, or 0.7 per cent of Norway's total land area.

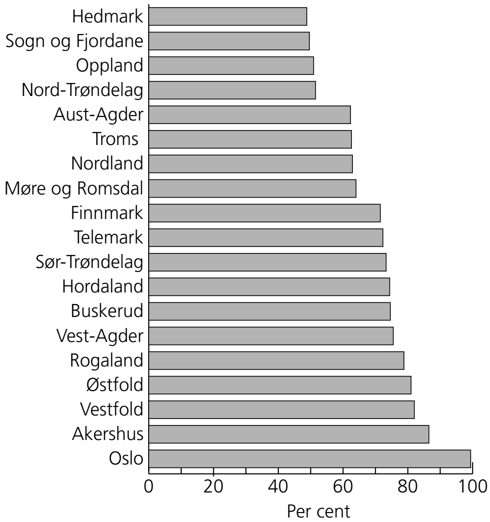
Because of the change in method, the results from this survey cannot be compared directly with previous statistics for urban settlements. The new method adheres strictly to the definition of an urban settlement, and the area of any particular urban settlement will tend to be somewhat smaller than the area drawn manually by municipal authorities on analogue maps in 1994/95[2]. At the same time, the new automatic method shows the existence of some small urban settlements previously not included.

[2] Urban settlements are usually delimited every ten years in connection with population and housing censuses. Urban settlement boundaries were last revised in 1994/95.

Calculations using the new method show that, as of 1 January 1998, a total of 3 279 195 persons were resident in urban settlements, or 74.2 per cent of Norway's population. According to official calculations, a total of 74.4 per cent of the population were resident in urban settlements that year[3].

The percentage of the population resident in urban settlements is greatest in the counties of Oslo and Akershus, where 99.4 and 86.5 per cent respectively of the total county population live in these areas. The lowest proportion of residents in urban settlements is found in the county of Hedmark, with 48.8 per cent, closely followed by Sogn og Fjordane with 49.6 per cent (figure 10.4).

Figure 10.4. **Percentage of population living in urban settlements, by county. 1998***



Source: Land use statistics, Statistics Norway.

Geographical distribution of urban settlement areas

The counties with the largest totals of urban settlement areas are Akershus and Hordaland with 230 km² and 201 km² respectively, see Appendix, table I1. The smallest totals are found in the counties of Finnmark, Sogn og Fjordane and Nord-Trøndelag, with 40 km², 49 km² and 53 km² respectively.

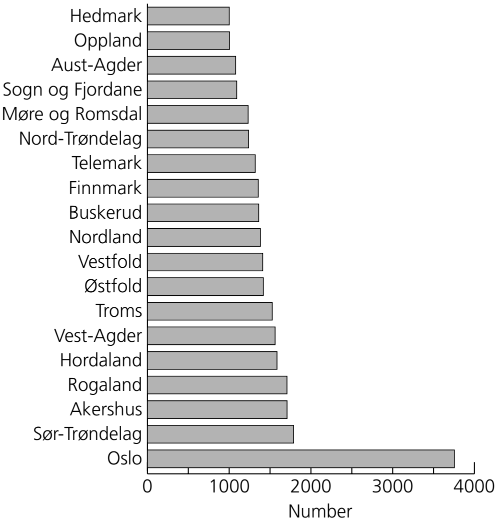
The largest proportion of urban settlement area by county is to be found, not surprisingly, in the counties around the Oslofjord. Oslo is at the top of the list, with 31 per cent of the total area of the county taken up by urban settlement, followed by the counties of Vestfold and Akershus, with urban settlement taking up 5.7 and 5.0 per cent respectively of their total areas.

Population density within urban settlements, calculated as an average per county, is easily largest in Oslo, which has 3 755 residents per km², followed by Sør-Trøndelag and Akershus, with 1 788 and 1 708 residents respectively per km² urban settlement area (figure 10.5). Population density in urban settlements is on average lowest in Hedmark, Oppland, Aust-Agder and Sogn og Fjordane. However, there are substantial variations within the individual county in the population density of the various urban settlements.

Most settlements in Norway are concentrated along the coast. The total length of the coastline[4] including islands (excluding Svalbard) from Halden in the southeast to Sør-Varanger in the northeast is 57 258

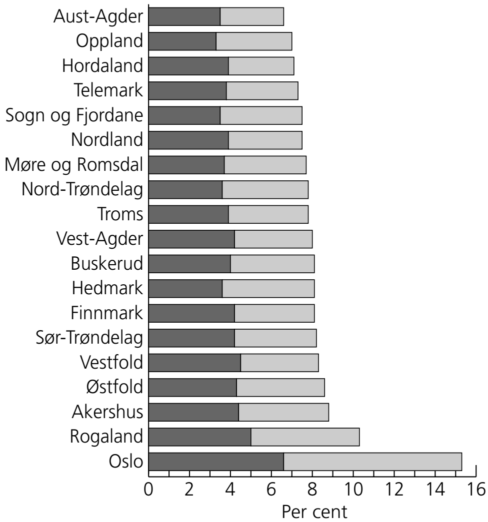
[3] Official figures are still based on the traditional method of calculation. Unless otherwise specified, figures in the text are based on the new method.
[4] Measured using the Norwegian Mapping Authority's map series 1:250 000.

Figure 10.5. **Residents per km² of urban settlement area, by county. 1998***



Source: Land use statistics, Statistics Norway.

Figure 10.6. **Base area of buildings as percentage of total area of urban settlement, by county. 1998***



Source: Land use statistics, Statistics Norway.

km. A total of 1.76 million people, or 39.8 per cent of the total population of Norway, lived at a distance of 1 km or less from the coastline as of 1 January 1998. Of these, 1.35 million people were living in urban settlements, which is the equivalent of 41.3 per cent of the urban settlement population.

Buildings in urban settlements

Despite the fact that buildings in urban settlements are less than 50 metres apart (as specified in the definition), only a modest proportion of the land area is taken up by buildings. Calculations show that buildings on average take up 8.6 per cent of the area in urban settlements and that only 4.2 per cent of the urban settlement area is taken up by dwellings. There are relatively modest variations in this pattern from county to county (figure 10.6 and Appendix, table I2). Oslo is an exception, with buildings taking up 15.3 per cent of the urban settlement area, followed by Rogaland with 10.3 per cent. Aust-Agder has the lowest percentage, with 6.5 per cent of its urban settlement area taken up by buildings. As far as dwellings are concerned, Oslo is again highest on the list with dwellings built on 6.6 per cent of its urban settlement area, while Rogaland has 5.0 per cent, and Oppland is lowest with 3.3 per cent its urban settlement area taken up by dwellings.

Approximately the same area is taken up by dwellings as by all the other buildings put together. However, in Oslo other buildings take up 30 per cent more land area than dwellings. At the other end of the scale is the county of Hordaland, where other buildings take up 19 per cent less land area than dwellings.

Table 10.1. **Average population density in urban settlements by size category. 1998***

Number of residents	No. of urban settlements	Total land area km^2	Population in urban settlements as of 1 January	Population density in urban settlements. Residents per km^2
Total	952	2 068.6	3 279 195	1 585
200 - 499	383	172.5	128 797	747
500 - 999	232	187.2	161 557	863
1 000 - 1 999	142	194.1	206 417	1 063
2 000 - 19 999	176	657.1	898 374	1 367
20 000 - 99 999	15	392.4	650 960	1 659
100 000 og over	4	465.3	1 233 090	2 650

Source: Land use statistics, Statistics Norway.

The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.

Population and building density in large and small urban settlements

Population density increases with the size of the urban settlement (table 10.1). In comparison with similar measurements from Swedish urban settlements in 1995, we find that population density in Norway is on average somewhat larger in small urban settlements and somewhat smaller in large urban settlements. Although differences in method, different interpretations of the concept of the urban settlement and the time gap between measurements may all have contributed towards the difference in result, it must be assumed that there is a difference in real terms between Norway and Sweden in this context.

It is important to be aware of the significance of the kind of areas used in density measurements. For example, calculations show that the population density in a number of small urban settlements is particularly high. This is because some small urban settlements only consist of concentrated housing with no recreational areas, areas for transport or areas covered by water etc. In the figures for 1998, there are examples of urban settlements with as few as 200 residents and a theoretically calculated average density of up to 4 000 residents per km^2. In a similar comparison, Oslo urban settlement, with a calculated average density of 2 883 residents per km^2, would rank as our eighth most densely populated urban settlement, while Trondheim, Stavanger and Bergen would be numbers 14, 17 and 19. However, all the large urban settlements have large areas reserved for purposes other than housing. In the future development of land use statistics, we will classify residential areas in urban settlements and specify density measurements for these areas.

On average, however, the large urban settlements have as a rule both the highest building density and the highest population density. In urban settlements with 200-499 inhabitants, 6.1 per cent of the area is taken up by buildings, of which 2.6 per cent are dwellings, while in cities of over 100 000 inhabitants, 11.3 per

Table 10.2. **Area and population in the ten largest urban settlements in Norway. 1998***

Urban settlement	Population as of 1 January	Total area, km²	Residents per km²
Oslo	754 552	261,8	2 883
Bergen	197 572	86,1	2 295
Stavanger/Sandnes	143 857	61,2	2 351
Trondheim	137 109	56,2	2 438
Fredrikstad/Sarpsborg	91 442	63,0	1 451
Porsgrunn/Skien[1]	81 759	52,8	1 547
Drammen[2]	73 077	37,4	1 954
Kristiansand	58 708	28,1	2 090
Tromsø	47 496	19,2	2 472
Tønsberg/Åsgårdstrand	45 754	32,3	1 418

[1] After redelimitation of the boundaries of the Skien/Porsgrunn urban settlement, Brevik, Åfoss, Stathelle and Langesund are now included.
[2] Drammen urban settlement consists of Drammen, Krokstadelva and Mjøndalen.
Source: Land use statistics, Statistics Norway.

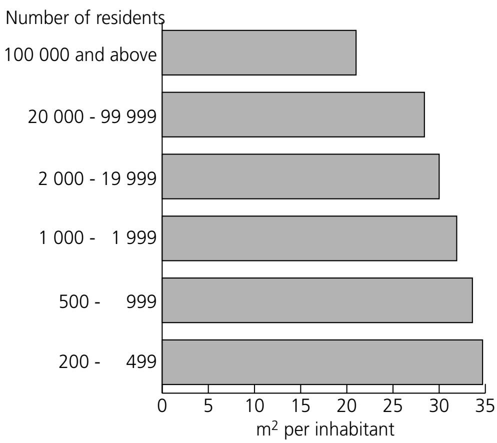
cent of the area is taken up by buildings, of which 5.6 per cent are dwellings (see figure 10.7 and Appendix, table I3). In the smallest urban settlements, the inhabitants each have 34.7 m² of housing base area at their disposal, while in the cities, they each have 21.0 m² (figure 10.7).

Few large urban settlements in Norway

In 1998, there were only four urban settlements with more than 100 000 inhabitants. A total of 1.23 million people, or 27.9 per cent of the overall population of Norway, lived in the urban settlements Oslo, Bergen, Stavanger/ Sandnes and Trondheim, see table 10.2.

Oslo urban settlement, with its population of 755 000 residents in an area of 261.8 km², is by far Norway's largest urban settlement both in terms of population and area (table 10.2). However, by both Scandinavian and European standards, Oslo, as a capital city, is regarded as a relatively small urban settlement in terms of its number of inhabitants. Stockholm

Figure 10.7. **Building base area per inhabitant in relation to number of residents in urban settlements. 1998***

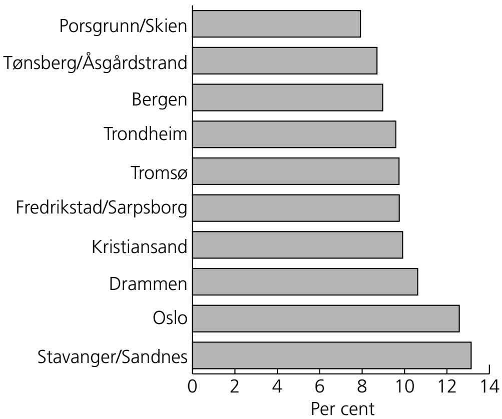


Source: Land use statistics, Statistics Norway.

urban settlement had a total of 1.48 million residents in 1995. In the same year, Helsinki had 949 000 residents.

In the major towns, the percentage of built-up area is highest in Stavanger/ Sandnes, 13.1 per cent, closely followed

Figur 10.8. **Percentage of built-up area in the ten largest urban settlements in Norway. 1998***



Source: Land use statistics, Statistics Norway.

by Oslo with 12.6 per cent (figure 10.8). Skien/Porsgrunn has the lowest percentage, 7.9 per cent. The percentage of area on which dwellings have been built is also higher in Stavanger/Sandnes than in Oslo.

10.5. Trends in urban development over time

With the introduction of a method for register-based and automatic delimitation of urban settlements, it should be possible to calculate area and land use in urban settlements in the past.

As a pilot project to examine whether it was possible to calculate past urban settlement delimitations in order to study trends in land use over time, Fredrikstad/ Sarpsborg[5] urban settlement was delimited on the basis of register data for the years 1995 and 1998.

In the course of these three years, expansion of the urban settlement Fredrikstad/ Sarpsborg has been modest, 0.5 km^2 or 0.8 per cent. In the same period, the population increased by 1 338 persons or 1.5 per cent. Population density therefore rose from 1 436 to 1 458 residents per km^2.

The new part of this urban settlement was not unoccupied in 1995, but there were few buildings. As of 1 January 1995, 69 people lived there. After development, 334 were resident in the same area. As mentioned above, 1 338 persons settled in the existing urban settlement in the course of the three-year period, or 83 per cent of the population increase of 1 603 persons.

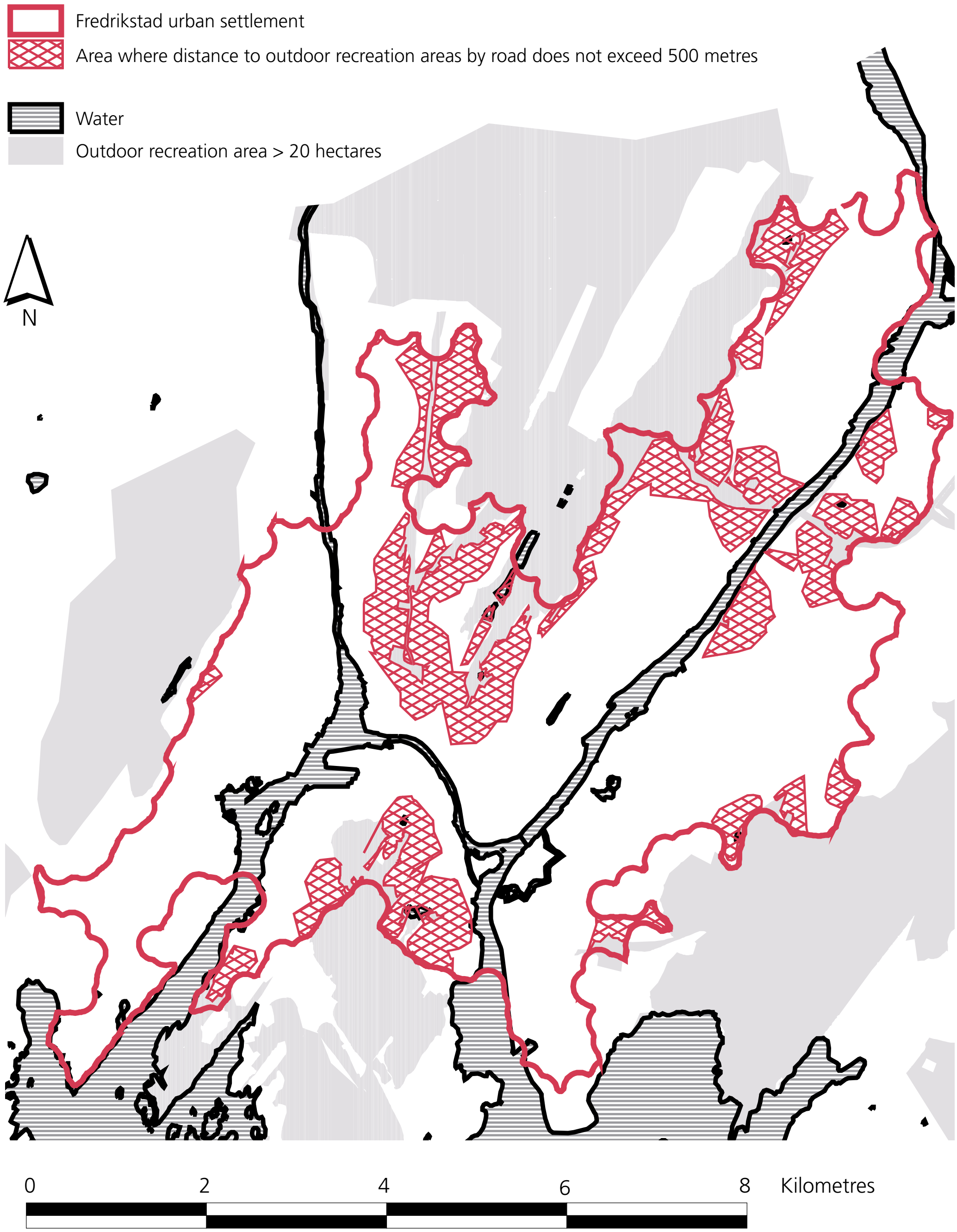
The buildings constructed in the period 1995-98 gave a total of 123 000 m^2 additional base area. A substantial proportion of this increase took place within the original urban settlement. Of the total increase in base area, 38 per cent was taken up by dwellings, and 92 per cent of this increase in dwelling base area took place within the original urban settlement.

Thus, whether in terms of population, total area taken up by buildings or area taken up by housing, growth in Fredrikstad/Sarpsborg is more the result of an increase in building density within the original urban settlement than of expansion.

The pilot project has shown that calculations of area- and population figures for previous years can produce statistics of interest in connection with area monitoring and management.

5 In this project the urban settlement area includes land area, parts of the Glomma watercourse and some salt water areas near the coast.

Figure 10.9. **Areas in Fredrikstad urban settlement with good access to outdoor recreation areas along the road network. 1996**



Digital map data: Norwegian Mapping Authority and Fredrikstad municipality.
Source: Land use statistics, Statistics Norway.

Table 10.3. **Percentage of population with access to various services. Fredrikstad urban settlement. 1997***

Indicator	By road	In a straight line
Play and recreation areas near dwelling[1]	..	89
Easily accessible outdoor recreation areas[2]	29	60
Age group 0-5 years, walking distance[3] from day-care centre	66	92
Age group 6-12 years, walking distance[3] from school	52	82
Walking distance[3] from post office	53	74
Walking distance[3] from shops	70	89
Up to 500 metres from public transport stop	80	97

[1] Defined as an area of at least 0.25 hectares at a distance of up to 200 metres from dwelling.
[2] Recreation areas larger than 20 hectares up to 500 metres from dwelling.
[3] Defined as up to 1 000 metres from dwelling.
Source: Land use statistics, Statistics Norway.

10.6. Quantifying indicators of sustainable urban settlement trends

In a national programme for the development of five environmental towns – Fredrikstad, Old Oslo, Kristiansand, Bergen and Tromsø – the Ministry of the Environment has established 10 goals for sustainable development in these towns (Ministry of the Environment 1995). In the course of 1996 and 1997, the Norwegian Pollution Control Authority, in cooperation with the environmental towns and others, proposed a number of indicators to accompany these goals.

In spring 1998, Statistics Norway carried out a minor project to advance and harmonize the practical work of quantifying a given set of indicators developed in connection with the environmental town programme (Dysterud and Schøning 1998), see table 10.3. Fredrikstad municipality was selected as a trial area, and the municipality provided digital background data from the section of the municipal master plan dealing with land use.

On the basis of digital urban settlement boundaries, data on buildings, population statistics at defined addresses and digital data on the road network, the indicators were quantified by using a Geographical Information System (GIS). Travel distances to various facilities were measured both in a straight line (the buffer method) and by road (network analysis).

These two methods of calculation produce different results. Measuring distances in a straight line does not take restrictions on access into account. In practice, access depends on the road network in an urban settlement. The areas of Fredrikstad that can be reached by road are shown in figure 10.9. The road network method should therefore give the best results. However, a great deal of uncertainty underlies the results produced by this method because means of access such as pathways and cycle paths are not available in digital form. Until the entire road network in the urban settlement, including cycle paths and pathways, has been digitalized, the conclusion is that both methods of calculation should be employed.

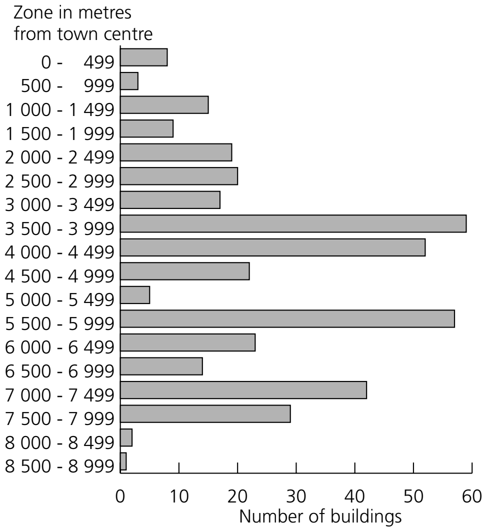
The project also charted the location of new buildings in the period 1993-96 in relation to the town centre (Fredrikstad market square) as an indicator of transport requirements. Fifty per cent of new dwellings were built 3.5-6 km from the town centre and along the road network. Figure 10.10 shows the distribution of new housing by distance from the town centre.

It was not possible to carry out quality control of the background data or verify the results with the resources available for the project. It must therefore be stressed that the project must be regarded primarily as a pilot and methodological project.

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

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

Figure 10.10. **Number of new dwellings built in Fredrikstad 1993-96 by distance from town centre**



Source: Land use statistics, Statistics Norway.

11. Other analyses

11.1. Significance of the unit of measure in cost-benefit analyses

The net social benefits of a project have traditionally been calculated by totalling the population's net willingness to pay for that project, i.e. the maximum amount people are willing to pay for the project minus what the project costs to complete. If the project involves an improvement to the environment, an attempt is made to measure this improvement in money terms so that it can be compared with the cost. However, in order to measure the pecuniary importance of a project in this way, we have to assume that one additional krone provides equal utility for everyone, irrespective of factors such as individual income or preferences. This is an assumption that simplifies the analysis considerably but that cannot be tested directly because there is no generally accepted method of measuring and comparing utility for different people. In addition, traditional cost-benefit analysis is based on a utilitarian approach, i.e. society's interests are defined as the sum of individual utility.

In theory, any unit of measure can be used to measure the utility and cost of a project. In the example above, the *environment* could have been used as a unit of measure instead of money in order to weigh the importance of the environmental impact of a project against the cost. The definition of an "environmental unit" may depend on the project. If the aim of a project is to ascertain the value of conserving virgin forest, an environmental unit might be defined as 1 m^2 virgin forest. We might then want to calculate the net social benefit of a project by measuring each individual's net utility in environmental units and then adding them up. Brekke (1997) has shown that the choice of measurement unit can be very important when calculating the net social benefit of a project. This is because with the use of environmental units there is the implicit assumption that an additional *environmental unit* gives everyone the same additional utility, while using money as the measurement unit assumes instead that an additional *krone* will provide equal utility for everyone. In practice, these two assumptions entail differing emphasis on the interests of different individuals and might therefore lead to conflicting conclusions as to the net social benefit of a project. However, on the basis of economic theory it is difficult to say that the one is more plausible than the other: Consumer demand theory focuses on *relative* marginal utility, i.e. the marginal utility of one good as compared to another, and has very little to say about the absolute level of marginal utility, which is what is needed here.

Since individual utility cannot be measured directly, it is not immediately obvious how the traditional assumption of equal utility for an additional krone can be tested empirically. However, we can test how sensitive analytical results are to alternative methods of measurement and comparison of individual utility. We have therefore calculated the net social benefit of several environmental projects using each of the alternative methods outlined above, i.e. by measuring in money and environmental units respectively. In order to do this, we have used individual willingness to pay data from seven different willingness to pay studies. Even by the most conservative estimates, where all those reporting a zero willingness to pay for the environmental good had been removed from the data sets, we found that the net social benefit of the environmental improvements in question was reduced by a factor of between 2 and 307 if the environment was used as the unit of measure instead of money. This means that the highest acceptable cost per person that leaves the project with a positive net benefit is reduced by a factor of between 2 and 307.

The general validity of our results depends of course on whether the individual willingness to pay responses reported in these studies are representative of valuation studies in general. Nonetheless, our results show that the method used to measure and compare the utility of different individuals may be very important for the calculation of the net social benefit of a project. The results indicate that the assumption traditionally used in cost-benefit analyses may produce entirely different results from an alternative assumption, although there is no clear basis in economic theory for asserting that the one is more “correct” than the other. There is therefore reason to exercise caution in interpreting calculations on social benefits.

It is important to note that the phenomenon described here does not only apply to the valuation of environmental goods. The problem can arise in any situation involving a conflict of interest in which the marginal willingness to pay varies between individuals, such as in the case of rationing or price discrimination. However, the calculations illustrate that it is difficult to resolve conflicts of interest in a “neutral” way by means of simple economic calculations, since the method used to weigh different interests against each other might have a decisive influence on the outcome of the analysis.

Project finance: Statistics Norway.

Project documentation: Medin, Nyborg and Bateman (1998) and Medin (1999).

11.2. Status and growth

Even though the importance of status goods has been recognized and remarked upon ever since the emergence of economics as a subject, most economic models generally ignore status. In this project an attempt has been made to examine some of the consequences of status-seeking behaviour for economic growth and the environment.

Brekke and Howarth (1998) discuss various mechanisms for changes in preferences. Their starting-point is Nobel prize winner Amartya Sen’s distinction between “commodities” and “functionings”. The same good might be used to provide different functionings: a pizza, for example, can be used to satisfy one’s own hunger or to gather a group of friends to a party. The functionings that will be covered by the consumption of specific goods will depend on the social setting (poor students will differ from wealthy stockbrokers in what constitutes a suitable meal at a party). We discuss several reasons why more goods are required in a wealthy society than in a poor society to cover the same function. Social recognition or status is only one of the functionings that requires greater consumption in a wealthy society than in a poor one. The study nevertheless uses the concept of "status" to refer to this relationship between income and what is required to achieve a function.

To illustrate the importance of status, we developed an adapted version of Nordhaus' (1994) Dynamic Integrated model of Climate and the Economy (DICE). The DICE model is a recognized and much-used model for studying optimal climate policy. The model was adapted by assuming that consumers are not solely concerned with absolute consumption, but also with relative consumption when the latter is presumed to represent status. Parameter estimates in recent studies show that socially optimal CO_2 reductions are twice as high as the reductions shown by the original DICE model. The reason for this is that when consumers attempt to achieve a high rate of consumption relative to everyone else, this is a beggar-thy-neighbour situation. Even though an individual might find it profitable to fight over relative positions, there is no social gain. A cleaner environment, on the other hand, benefits everyone.

The conceptual framework above has also made it possible to examine the arguments of Fred Hirsh more closely, presented in his famous book "The Social Limits to Growth" (Hirsh 1976). A natural interpretation of one of Hirsh's main arguments is that when a society becomes wealthier, the fight for positional goods requires an increasingly large proportion of its resources. However, Brekke, Howarth and Nyborg (1998) claim that there are empirical observations and theoretical arguments to contradict this hypothesis. Anthropological studies, for example, show that there is clear evidence of status-seeking even in impoverished societies, and this finding is also consistent with the result of the theoretical analysis in the study.

Different interpretations of what bestows status have also proved to have dramatic consequences in economic growth models. Howarth and Brekke (1998) compare three different ways of modelling status: either that consumption that is high in relation to others confers status, that a large accumulation of real capital compared to others gives status, or that status due to a more rapidly advancing career and a higher level of education is the most important source of status. We find that status stimulates growth more if it is associated with real capital or career advancement than if status is associated with consumption. Status-seeking is again a beggar-thy-neighbour situation, and if status is linked to capital or career advancement, growth will be stronger than the socially optimal level so that a lower rate of growth may be to everyone's advantage. In these cases, too much real and human capital is accumulated, at the expense of current consumption.

Project finance: The Research Council of Norway.

Project documentation: Brekke and Howarth (1998), Brekke, Howarth and Nyborg (1998) and Howarth and Brekke (1998).

11.3. NOREEA – the value of natural resources in the national accounts

NOREEA (NORwegian Economic and Environmental Accounts) is a project designed to develop integrated accounts for economic and environmental data in Norway. An integrated system has now been made for the national accounts and emissions to air, including a valuation of three selected natural resources: *oil and natural gas, forest and fish*. The first results for the national accounts and emissions to air were described in last year's publication (Statistics Norway 1998a), presenting statistics up to and including 1994. Figures are now also available for 1995. The focus this time is on describing how the value of the natural resources mentioned above is calculated.

The calculations are based on estimated resource rents for the three resources. Resource rents are the return on the resources in the year of calculation. By making assumptions about the development of resource rents in the future, we have estimated the value of the resources.

Resource rent

The natural resource of greatest economic value in Norway is the oil and natural gas reserves in the North Sea (see table 11.1). With regard to fish, only fish in the sea is considered a natural resource in this context, while fish in fish farms is regarded as produced. Our calculations showed that after wages for independent fishermen had been included in the costs, the operating surplus in the fisheries sector was not sufficient to cover the required "normal return" on capital in the fishing industry. We were therefore not able to calculate a positive wealth value for fish in the sea in the period studied. We were, on the other hand, able to calculate a value for forest wealth for every year except one.

Table 11.1. **Resource rent for oil, forestry and fish. 1995. In NOK billion**

	Oil and gas	Forestry	Fish
Production	132.2	4.2	8.3
- Intermediate consumption	28.5	0.7	2.9
- Wage costs incl. self-employed persons	9.8	1.2	3,2
- Consumption of fixed capital	35.5	0.5	1.6
- Normal return on capital	29.3	0.8	1.7
= Resource rent	**29.1**	**1.0**	**-1.0**

Sources: Todsen (1998) and Hass and Sørensen (1999).

The resource rent for one particular year is a measure of the economic return on the resource that year, calculated as the value of output less production costs, including a "normal return" on capital equipment.

The "normal rate of return" on capital has been set at 8 per cent. This rate is in keeping with the recommendations in NOU (Official Norwegian Report) 1997:27 with regard to high-risk activities. The statistical basis for income and costs is taken from the national accounts. For forestry and fishing, labour costs have been calculated for the work performed by self-employed persons. The costs include depreciation, which is the reduction in the value of the net capital stock as a result of normal wear and tear, damage and obsolescence. Depreciation is estimated in the national accounts on the basis of long time series for gross investment, economic life and depreciation profiles for various types of assets.

The subject of an important discussion still in progress is to what extent forests in Norway should be regarded as produced (cultivated) assets. For cultivated forests, any change in the stock of standing timber should be included in calculations of forestry output and resource rent. In the alternative presented here, it is assumed that 50 per cent of the forest is cultivated (the final percentage has not yet been established).

Estimate of wealth

Resource wealth is calculated as the present value of the resource rents that can be expected from the resources in the future. The estimate of wealth is therefore in principle based on a forecast. This means that there is a fundamental uncertainty in the estimates of resource wealth with regard to future income and costs. There is also uncertainty with regard to the size of the resources.

Since the wealth estimates are to be integrated into the national accounts, we have restricted the analysis to simple projections of observed conditions in the year of calculation, rather than basing our estimates on extensive analyses and forecasts of movements in oil prices, interest rates, wages, etc. This is in keeping with the methods used in national accounts in other countries. In our calculation of present values, we have used a discount rate of 8 per cent. A lower discount rate will result in a higher present value, especially for resources with a long economic life, such as gas.

Oil and gas wealth: The calculations are based on physical figures for the size of the oil and gas wealth. We have used a wide definition of the term resource to include the total remaining resources, as used by the Norwegian Petroleum Directorate in their annual calculations. A description of the calculations can be found in Todsen (1998) (see also Chapter 2).

Table 11.2. **Oil and gas wealth and forestry wealth as of 31 December 1992-1997. In NOK billion**

	1992	1993	1994	1995	1996	1997
Oil and gas wealth	344.1	336.4	313.2	315.7	758.7	748.4
Forestry wealth	6.0	0.7	(0)	12.3	..	..

Sources: Todsen (1998) and Hass and Sørensen (1999).

Calculations of oil wealth have been carried out on the basis of two alternative rates of future extraction. The figures in table 11.2 are based on the assumption that a constant extraction rate per year is maintained as long as the resources last. The alternative is based on the production profile assumed in the National Budget for 1998, which results in a somewhat higher rate of extraction. The stocks are valued by assuming the same resource rent per standard cubic metre oil and gas as in the year of calculation. Todsen (1998) shows the effect of some alternative assumptions. Wealth estimates (as of 31 December 1997) are approximately 8.5 per cent higher if calculations are based on the National Budget's production profile than if they are based on a constant rate of extraction. The increase refers to gas wealth. If we had also shifted to a discount rate of 3.5 per cent, wealth would have increased by another 63 per cent. Again, gas wealth would have increased most. The reasons for the changes in oil and gas wealth are explained in more detail below. The sharp upward revision in 1996 was mainly due to valuation changes following an increase in prices.

Forestry wealth: The forest is a renewable resource that can be maintained in the

Tabell 11.3. **Reasons for the change in oil and gas wealth 1994 - 1997. In NOK billion**

	1994	1995	1996	1997
Total change in wealth	-23,1	2,5	443,0	-10,3
Change in wealth due to extraction of resources	-3,2	-3,8	-8,1	-8,2
New discoveries	1,4	1,2	3,1	4,8
Other volume changes	1,1	2,0	46,5	0,5
Nominal holding gains	-22,5	3,2	401,4	-7,4

Source: Todsen (1998).

foreseeable future with the current rate of felling and sound management. To estimate wealth we have assumed that the resource rent in the year of calculation is maintained indefinitely. Since we have used a relatively high discount rate, revenues after the first 70-80 years will not have any practical consequence. Due to movements in timber prices, there are substantial variations in the estimates from year to year.

Reasons for changes in wealth estimates

The estimates of oil and gas wealth and forestry wealth vary considerably from year to year. The same applies to the resource rent for fish. To a great extent, these variations are due to the fact that there are normally substantial variations in the prices of these products from year to year (developments in costs are also of importance). This results in valuation changes in wealth. However, we want to separate the share of the change in wealth that is due to the extraction of resources in the course of the year from the overall figure, so that we are left with a more accurate picture of the consequences of production activities.

The value of the resources extracted in the course of a year is calculated as the change in the present value of the flow of future resource rents that is due to this extraction of resources. This calculation does not take into account other changes due to changes in resource estimates and changes in prices and costs. The value of the resources extracted can be divided into two components. First, the wealth value will be reduced by the resource rent in the year in question. Secondly, and with the opposite effect, is the fact that all future income will be discounted by one year less as we move ahead in time. In isolation, this results in an increase in wealth corresponding to the return on wealth at the end of the year. The figures in table 11.3 for changes in wealth due to the extraction of resources are the net effect of these two components.

With regard to oil wealth, we see that the major changes in 1996 are the result of nominal holding gains. The item nominal holding gains is the residual change in wealth that cannot be explained by the changes in the other specified items. It mainly shows the effect of changes in the resource rent per unit (changes in prices and costs), which were substantial in 1996. Changes in the rate of extraction have also influenced nominal holding gains.

The large size of “other volume changes” in 1996 is due to the upward revision in the Norwegian Petroleum Directorate’s estimate of how much oil could be extracted as a result of new extraction technology.

Project finance: Partial funding by EFTA/ Eurostat.

Project documentation: Hass and Sørensen (1999).

Appendix A

Energy

Table A1. **Reserve accounts for crude oil. Fields already developed or where development has been approved. Million Sm³ o.e.**

	1991	1992	1993	1994	1995	1996	1997	1998
Reserves as of 1.1	1 340	1 354	1 496	1 473	1 477	1 654	1 795	1 858
New fields	114	117	5	34	131	315	84	-
Re-evaluation	12	152	107	124	212	11	166	131
Extraction	-112	-127	-136	-154	-166	-186	-187	-179
Reserves as of 31.12	1 354	1 496	1 473	1 477	1 654	1 795	1 858	1 810
R/P ratio	12	12	11	10	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.**

	1991	1992	1993	1994	1995	1996	1997	1998
Reserves as of 1.1	1 230	1 274	1 381	1 356	1 346	1 352	1 479	1 173
New fields	54	138	1	2	32	195	12	-
Re-evaluation	17	-2	2	18	5	-27	-271	46
Extraction	-28	-29	-28	-30	-31	-41	-47	-48
Reserves as of 31.12	1 274	1 381	1 356	1 346	1 352	1 479	1 173	1 172
R/P ratio	46	48	49	45	43	36	25	25

Sources: Norwegian Petroleum Directorate and Statistics Norway.

Table A3. **Extraction, conversion and use[1] of energy commodities. 1997***

	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 1976-1997	Average annual change, per cent 1996-1997
	PJ									
Extraction of energy commodities	11	-	6 329	1 905	325[3]	399	-	8 969		
Energy use in extraction sectors	-	-	-	-153[4]	-14	-10	-	-177		
Imports and Norwegian purchases abroad	51	0	66	-	302	31	-	451		
Exports and foreign purchases in Norway	-8	0	-5 818	-1725	-698	-18	-	-8 267		
Stocks (+decrease, -increase)	-1	.	14	.	-12	.	.	1		
Primary supplies	52	0	590	27	-96	403	-	977		
Oil refineries	7	-	-597	-	568	-2	-	-24		
Other energy sectors or supplies	-1	41	-	-	14	2	6	63		
Registered losses, statistical errors	-1	-	6	-12	-7	-30	-2	-46		
Registered use outside energy sectors	58	42	0	15	478	373	5	969	0.8	0.4
Domestic use	58	42	-	15	322	373	5	813	1.4	1.5
- Agriculture and fisheries	0	-	-	-	28	4	0	32	0.4	-0.2
- Energy-intensive manufacturing	44	0	-	14	56	108	0	222	1.5	9.4
- Other manufacturing and mining	14	19	-	0	35	57	1	126	0.1	1.9
- Other industry	-	0	-	-	129	82	3	213	2.1	-0.2
- Private households	0	23	-	-	74	122	1	219	1.7	-3.9
International maritime transport	-	-	-	-	156	-	-	156	-1.5	-4.7

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

Table A4. **Use of energy commodities outside the energy sectors and international maritime transport**

Energy commodity	1976	1985	1990	1992	1993	1994	1995	1996	1997*	1998*	Average annual change, per cent 1976-1997	1997-1998
	PJ											
Total	606	731	733	718	744	765	780	802	813	846	1.4	4.0
Electricity	241	329	349	358	363	366	374	371	373	392	2.1	5.2
Firm power	232	312	324	330	335	347	348	357	:	:	.	.
Spot power	9	17	24	28	28	19	26	14	:	:	.	.
Oil, total	299	259	243	232	239	248	252	275	267	272	-0.5	2.1
Oil other than for transport	159	77	57	44	46	55	51	66	54	53	-5.0	-2.7
Petrol	9	0	0	0	0	0	0	0	0	0	-27.3	0.0
Kerosene	17	9	7	7	7	7	7	8	8	7	-3.8	-8.1
Middle distillates	66	43	36	28	28	31	30	39	31	30	-3.6	-2.9
Heavy fuel oil	66	25	14	10	11	17	14	18	16	16	-6.6	0.1
Oil for transport	141	183	187	188	193	193	202	209	213	220	2.0	3.3
Petrol, aviation fuel, jet fuel	74	92	100	96	97	98	102	101	100	100	1.5	0.6
Middle distillates	64	83	84	90	96	94	99	108	112	119	2.7	5.7
Heavy fuel oil	3	7	4	1	1	0	1	1	1	1	-6.4	16.0
Gas[1]	1	52	52	47	54	53	52	54	70	78	20.2	11.2
District heating	-	2	3	4	4	4	4	5	5	5	.	0.0
Solid fuel	64	89	86	78	85	93	97	97	99	99	2.1	0.0
Coal, coke	47	57	50	45	48	54	58	58	58	58	1.0	0.0
Wood, wood waste, black liquor, waste	17	31	36	33	37	39	39	39	42	42	4.3	0.0

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

Table A5. **Net use[1] of energy in the energy sectors. PJ**

	1976	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997*	1998*
Total	34	66	75	122	152	164	172	188	185	196	207	192
Of this:												
Electricity	4	6	8	7	8	8	8	11	10	7	12	9
Natural gas	12	30	45	79	113	118	125	137	140	150	153	148

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

Table A6. **Electricity balance**

	1975	1980	1988	1990	1995	1996	1997*	1998*	Average annual change, per cent 1975-1988	Average annual change, per cent 1988-1998
	TWh									
Production	77.5	84.1	110.0	121.8	123.0	104.7	111.6	116.7	2.7	0.1
+ Imports	0.1	2.0	1.7	0.3	2.3	13.2	8.7	8.0	26.3	17.5
- Exports	5.7	2.5	7.4	16.2	9.0	4.2	4.9	4.4	2.0	-4.0
= Gross domestic consumption	71.9	83.6	104.4	105.9	116.3	113.7	115.4	120.4	2.9	1.0
- Consumption in pumped storage power plants	0.1	0.5	1.0	0.3	1.4	0.4	1.7	0.8	17.4	5.4
- Consumption in power plants, losses and statistical differences	7.1	8.0	8.6	7.9	10.0	9.1	8.8	9.1	1.6	0.2
= Net domestic consumption	64.7	75.1	94.8	97.7	105.0	104.1	105.0	110.4	3.0	1.0
- Spot power	3.2	1.2	4.5	6.7	7.5	4.1	4.6	4.9	2.5	0.3
= Net firm power consumption	61.4	73.9	90.3	91.0	97.5	100.0	100.4	105.5	3.0	1.1
- Energy-intensive manufacturing	26.2	27.9	29.6	29.6	28.4	28.2	29.0	30.5	0.9	-0.2
= General consumption	35.2	46.0	60.7	61.5	69.1	71.8	71.4	75.0	4.3	1.6
General consumption, corrected for temperature	36.3	45.1	61.6	65.4	69.6	70.6	73.0	75.7	4.1	1.7

Sources: Statistics Norway and Norwegian Water Resources and Energy Administration.

Table A7. **Average prices[1] for electricity[2] and some selected oil products. Energy supplied**

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997*	1998*
Heating products[3]	Price in øre[4]/kWh										
Electricity	41.7	43.5	45.7	46.5	46.6	47.8	46.8	49.7	52.4	59.9	54.5
Heating kerosene	25.7	28.3	33.9	40.1	37.4	37.8	37.1	37.7	41.6	43.8	42.6
Fuel oil no.1/light fuel oils[5]	19.7	21.6	26.6	31.9	28.3	28.0	28.2	29.6	34.0	37.0	34.3
Fuel oil no.2	18.8	20.7	25.7	30.8	27.2	26.9	27.1	..[5]	..	..	..
Heavy fuel oil	12.3	15.2	19.4	23.2	23.0	22.4	22.5	22.8	..	..	..
Transport products	Price in øre[4]/liter										
Petrol, leaded, high oct.	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	904.0
Petrol, unl. 95 octane	503.0	540.5	594.4	677.0	717.0	757.4	761.0	807.0	849.0	888.0	873.0
Auto diesel	214.0	233.0	285.9	341.0	326.0	403.0	649.0	701.0	757.0	779.0	781.0

[1] Including all taxes.
[2] Households and agriculture. For 1987-1992, prices are for firm power only. After this, both firm power and spot power. For 1997 and 1998: prices for households as of 1 January and 23 February respectively.
[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 Competition Authority, Norwegian Water Resources and Energy Administration and Norwegian Petroleum Institute.

Table A8. **Total primary energy supply. World total and selected countries**

	1973	1980	1985	1990	1995	1996	Per unit GDP (1996)	Per unit GDP (1996)	Per capita (1996)
	Million toe						toe/1000 1990-USD	toe/1000 1990-USD PPP[1]	toe per capita
World total[2]	6185.1	7271.7	7817.2	8734.5	9236.3	9506.8	0.39	0.31	1.68
OECD	3749.3	4064.6	4121.1	4495	4865.2	5019.8	0.26	0.27	4.60
Norway	15.1	18.8	20.3	21.5	23.5	23.2	0.16	0.23	5.28
Denmark	19.8	19.7	19.9	18.3	20.3	22.9	0.16	0.22	4.35
Finland	21.4	25.4	26.5	28.8	28.9	31.5	0.23	0.38	6.14
Iceland	1.2	1.5	1.8	2.1	2.1	2.3	0.33	0.45	8.44
Sweden	39.3	41	47.6	47.8	50.9	52.6	0.22	0.33	5.91
Belgium	46.3	46.1	44.7	48.4	52.4	56.4	0.27	0.31	5.55
France	176.6	190.1	200.2	227.6	241.4	254.2	0.20	0.24	4.35
Greece	12.4	16	18.6	22.1	23.6	24.4	0.26	0.22	2.33
Italy	130.1	138.6	135.5	153.3	161.5	161.1	0.14	0.16	2.80
Netherlands	62.5	65	61.6	66.6	73.3	75.8	0.23	0.27	4.88
Poland	94.2	124.8	124.8	100.1	99.3	108.4	1.56	0.47	2.81
Portugal	7.2	10.3	11.4	16.4	19.3	19.2	0.26	0.17	1.93
Spain	52.4	68.6	71.8	90.6	103.3	101.4	0.19	0.19	2.58
United Kingdom	220.8	201.3	203.8	213.1	224.5	234.7	0.22	0.23	3.99
Switzerland	19.7	20.9	23	25	25.2	25.6	0.11	0.18	3.60
Czech Republic	45.5	46.9	49.8	44.7	38.9	40.4	1.51	0.43	3.92
Turkey	24.3	31.3	38.9	52.5	62.2	65.5	0.35	0.16	1.05
Germany	337.9	360.4	361.3	355.7	339	349.6	0.19	0.25	4.27
Hungary	22.4	28.9	30.4	28.6	24.9	25.5	0.79	0.39	2.50
Austria	21.8	23.5	23.2	25.7	26.3	27.2	0.15	0.19	3.37
Canada	161	193	193.4	210	232.4	236.2	0.38	0.42	7.88
Mexico	55.2	98.9	111.2	124.2	133.8	141.4	0.47	0.21	1.46
USA	1736.5	1811.7	1781.7	1925.7	2088.5	2135	0.34	0.34	8.04
Japan	323.6	346.5	367	438.8	497	510.4	0.15	0.20	4.05
South Korea	24.7	43.8	55.4	92.2	148	162.9	0.42	0.30	3.58
Australia	57.6	70.4	73.9	87.2	94.5	100.6	0.29	0.30	5.50
Non-OECD	2305.8	3096.8	3601.2	4121.2	4242.7	4356.4	0.89	0.34	0.95
Romania	47.4	64.7	64.6	61.1	45.6	45.8	1.26	0.60	2.03
Russia	..	..	..	..	621.5	615.9	1.80	0.90	4.17
Egypt	8.1	16	25.5	32.4	35.9	37.8	0.71	0.21	0.64
Ethiopia	9.4	11.2	12.7	15.2	16.6	16.6	1.96	0.66	0.28
Nigeria	39	52.9	61.9	70.9	83.2	82.7	2.45	0.69	0.72
South Africa	50	65.4	87.5	92.2	100.3	99.1	0.87	0.55	2.63
Argentina	35.6	41.9	41.4	43.3	56.1	58.9	0.31	0.24	1.67
Brazil	82.7	109	120.5	136	156.4	163.4	0.29	0.19	1.01
Guatemala	3	3.8	3.8	4.4	5.2	5.2	0.54	0.17	0.48
Venezuela	25	35	36.9	40.5	47.9	55	0.98	0.34	2.46
Bangladesh	11.8	14.9	17.1	20.8	23.4	23.9	0.84	0.18	0.20
India	193.7	242	292.3	359.9	436.7	450.3	1.10	0.37	0.48
Indonesia	40.2	59.6	73.3	98.9	124.9	132.4	0.74	0.18	0.67
China	425.4	593.1	705.5	856.2	1058.6	1096.8	1.57	0.31	0.90
Thailand	16.4	22.7	26.6	45	71.1	80	0.58	0.20	1.33

[1] PPP (purchasing power parity): GDP adjusted for local purchasing power. [2] Including international shipping.
Sources: OECD/IEA (1998a and b).

Appendix B

Transport and the environment

Table B1. **Domestic passenger transport. Million passenger-km**

	Total	Road transport total	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	53 823	48 092	42 696	79.3	3 890	801	705	2 665	2 430	636
1991	53 556	47 648	42 252	78.9	3 935	760	701	2 699	2 573	636
1992	53 867	47 821	42 390	78.7	3 945	782	704	2 946	2 511	589
1993	54 987	48 578	43 128	78.4	3 927	815	708	3 204	2 588	617
1994	56 140	49 433	43 840	78.1	3 956	928	709	3 397	2 703	607
1995	56 503	49 680	44 133	78.1	3 752	1 071	724	3 567	2 681	575
1996	59 341	52 029	45 957	77.4	4 093	1 211	768	3 938	2 776	598
1997	60 016	52 431	45 919	76.5	4 093	1 579	840	4 063	2 915	608

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	18 399	8 377	1 718	8 286	18	-	8 030
1992	18 992	8 880	1 746	8 348	18	-	10 226
1993	18 796	8 735	1 774	8 266	21	-	10 350
1994	18 047	7 715	1 599	8 714	20	-	12 662
1995	17 460	6 138	1 647	9 654	21	-	13 843
1996	19 940	7 434	1 835	10 651	20	-	18 515
1997	21 269	7 463	1 949	11 838	19	-	20 313

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

Table B3. **Road traffic: consumption of fuel and emissions from combustion and evaporation**

	Consumption of fuel	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Lead	PM_{10}[1]	$PM_{2,5}$[1]	PAHs[2]	Benzene
	Mill.tonnes		1000 tonnes							kg	Tonnes		kg	Tonnes
1973	1.5	4.6	2.0	0.1	4.5	44.8	0.0	53.6	521	661	1.9	1.8	449	2.3
1980	1.9	5.8	2.5	0.1	4.8	58.7	0.0	66.2	641	554	2.5	2.4	588	2.9
1986	2.4	7.6	2.9	0.2	4.6	78.4	0.1	79.2	642	256	3.7	3.6	805	3.2
1987	2.5	8.0	3.0	0.2	4.9	81.9	0.1	81.9	640	261	4.0	3.8	856	3.3
1989	2.5	7.9	3.1	0.2	3.7	79.0	0.1	82.5	626	254	3.9	3.7	835	3.3
1990	2.5	7.9	3.1	0.2	3.6	75.8	0.2	80.3	607	210	3.8	3.7	813	3.1
1991	2.5	7.8	3.0	0.3	3.2	72.5	0.3	76.5	571	170	3.8	3.7	796	2.9
1992	2.5	7.9	3.0	0.3	3.3	71.4	0.4	75.8	564	139	4.1	3.9	825	2.8
1993	2.7	8.4	2.9	0.4	3.3	73.5	0.5	73.7	545	97	4.5	4.3	880	2.7
1994	2.6	8.2	2.8	0.5	2.3	67.4	0.6	69.9	516	16	4.0	3.9	799	2.5
1995	2.7	8.4	2.8	0.7	1.9	66.4	0.8	65.9	482	10	4.0	3.8	801	2.3
1996	2.8	8.9	2.7	0.8	1.8	65.1	1.0	61.7	448	3	3.9	3.7	799	2.2
1997*	2.8	8.8	2.7	1.0	1.7	59.6	1.1	56.3	402	2	3.7	3.5	733	1.9

[1] Does not include wear of asphalt.
[2] Includes four selected PAH components: benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.
Source: Bang et al. (1999).

Table B4. **Road traffic: exhaust emissions and evaporation. Average of all vehicle categories, technologies and modes. 1997**

	Fuel consumption	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Lead	PM_{10}[1]	$PM_{2,5}$[1]	PAHs[2]	Benzene
	kg/km		g/km							mg/km	g/km		mg/km	g/km
Petrol														
Passenger cars	0.063	0.20	0.10	0.04	0.01	1.12	0.05	1.95	15.1	0.09	0.02	0.02	0.01	0.07
Vans	0.102	0.32	0.10	0.03	0.02	1.55	0.04	2.37	19.9	0.14	0.02	0.02	0.02	0.10
Lorries	0.157	0.49	0.36	0.01	0.03	8.54	0.00	7.74	43.8	0.22	0.02	0.02	0.03	0.18
Buses	0.159	0.50	0.46	0.01	0.03	9.56	0.00	9.24	43.3	0.22	0.02	0.02	0.03	0.17
Mopeds	0.019	0.06	0.11	0.00	0.00	0.05	0.00	6.93	13.2	0.03	0.00	0.00	..	..
Motor cycles	0.040	0.12	0.20	0.00	0.01	0.28	0.00	4.70	28.0	0.06	0.01	0.01	..	..
Diesel														
Passenger cars	0.049	0.16	0.00	0.01	0.06	0.39	0.00	0.14	0.56	0.01	0.17	0.16	0.02	0.00
Vans	0.079	0.25	0.01	0.01	0.09	0.66	0.00	0.27	1.00	0.01	0.24	0.23	0.02	0.01
Light goods	0.130	0.41	0.02	0.01	0.16	4.13	0.00	0.53	2.26	0.02	0.28	0.27	0.06	0.01
Medium goods	0.175	0.55	0.03	0.01	0.21	6.05	0.00	0.68	2.58	0.02	0.46	0.43	0.09	0.01
Heavy goods	0.268	0.85	0.04	0.01	0.32	8.84	0.00	1.00	3.83	0.03	0.66	0.62	0.13	0.02
Buses	0.251	0.80	0.03	0.01	0.30	10.00	0.00	0.73	2.64	0.03	0.65	0.62	0.10	0.01

[1] Does not include wear of asphalt.
[2] Includes four selected PAH components: benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.
Source: Bang et al. (1999).

Appendix C

Air

Table C1. **Emissions of greenhouse gases to air**

	CO_2	CH_4	N_2O	HFC 23	HFC 32	HFC 125	HFC 134	HFC 143	HFC 152	HFC 227	C_3F_8	CF_4	C_2F_6	SF_6	CO_2-equi-valents
	Mill. tonnes	1000 tonnes		Tonnes											Mill. tonnes
GWP[1]	1	21	310	11700	650	2800	1 300	3800	140	2900	7000	6500	9200	23900	
1950		131	7	-	-	-	-	-	-	-	..	..	..	..	..
1960		175	10	-	-	-	-	-	-	-	..	..	..	..	..
1973	30.1	216[2]	121	-	-	-	-	-	-	-	..	..	..	..	..
1974	27.2	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1975	30.1	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1976	32.8	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1977	33.0	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1978	32.2	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1979	34.4	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1980	32.6	267	14	-	-	-	-	-	-	-	..	..	..	..	..
1981	31.4	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1982	30.5	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1983	31.5	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1984	33.5	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1985	31.9	..	..	-	-	-	-	-	-	-	..	409	18	199	..
1986	34.6	..	..	-	-	-	-	-	-	-	..	401	18	240	..
1987	33.5	299	15	-	-	-	-	-	-	-	..	388	17	240	52.9
1988	35.3	298	16	-	-	-	-	-	-	-	..	371	16	223	54.4
1989	34.7	312	17	-	-	-	-	-	-	-	..	360	16	107	51.5
1990	35.2	317	17	-	-	-	-	-	0	-	..	369	16	92	52.0
1991	33.6	322	17	-	-	-	0	-	0	-	..	313	14	86	49.9
1992	34.3	328	15	-	-	-	0	-	1	-	..	242	11	29	48.1
1993	35.9	332	16	-	-	-	2	-	1	-	..	254	11	30	50.3
1994	37.9	340	16	0	0	0	5	0	1	-	..	231	11	35	52.6
1995	38.2	343	16	0	0	2	10	2	1	-	0	209	9	24	52.5
1996	41.1	345	16	0	0	5	17	4	1	0	0	187	6	22	55.4
1997*	41.4	350	16	0	0	10	26	7	2	0	0	211	8	21	55.9
1998*	41.6	346	17	..	..	..	..	..	..	..	..	..	..	..	..

[1]Impact on greenhouse effect of emission of 1 tonne of the gas compared with that of 1 tonne CO_2.
[2] 1970 figure.
Sources: Statistics Norway and Norwegian Pollution Control Authority.

Table C2. **Emissions to air**

	SO_2	NO_X	NH_3	Acid equi-valents[1]	NMVOCs	CO	Particu-lates[2]	Pb	Cd
	1000 tonnes							Tonnes	kg
1973	156	181	..	..	190	707	24	891	..
1974	150	178	..	..	181	664	23	834	..
1975	138	182	..	..	202	720	22	925	..
1976	147	180	..	..	204	765	21	762	..
1977	146	193	..	..	209	811	23	762	..
1978	143	185	..	..	169	836	21	784	..
1979	144	195	..	..	184	870	22	827	..
1980	137	188	23	9.7	180	866	19	624	..
1981	128	177	..	..	184	851	22	573	..
1982	111	181	..	..	191	861	20	648	..
1983	104	186	..	..	204	854	20	556	..
1984	96	200	..	..	216	882	21	400	..
1985	98	210	..	..	234	886	22	405	1 143
1986	91	226	..	..	253	918	23	341	..
1987	73	225	23	8.5	259	877	22	294	..
1988	68	221	21	8.2	248	903	22	291	..
1989	58	220	23	8.0	284	867	22	276	1 212
1990	53	218	23	7.7	310	856	23	228	1 193
1991	44	208	24	7.3	309	794	21	183	1 165
1992	36	207	25	7.1	331	782	21	149	1 064
1993	35	215	25	7.2	347	781	23	105	1 103
1994	34	212	25	7.1	358	766	24	20	606
1995	34	212	26	7.2	370	728	23	14	619
1996	33	220	27	7.4	368	695	24	7	614
1997*	30	222	26	7.3	359	656	24	6	601
1998*	30	225	27	7.4	342	631	23	..	..

[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. 1996**

	CO_2	CH_4	N_2O	HFK[1]	PFK[2]	SF_6	CO_2-equivalents
	Mill. tonnes	1000 tonnes		Tonnes			Mill. tonnes
Total	41.1	345.4	16.5	27.7	193.0	22.0	55.4
Energy sectors	12.3	30.7	0.1	-	-	2.4	13.1
Extraction of oil and gas[3]	10.0	27.2	0.1	-	-	-	10.6
Extraction of coal	0.0	3.2	0.0	-	-	-	0.1
Oil refining	2.0	0.1	0.0	-	-	-	2.0
Electricity supplies[4]	0.3	0.1	0.0	-	-	2.4	0.4
Manufacturing and mining	12.1	32.1	5.4	0.3	193.0	19.6	16.2
Oil drilling	0.4	0.2	0.0	-	-	-	0.4
Manufacture of pulp and paper	0.8	13.0	0.1	-	-	-	1.1
Manufacture of chemical raw materials	2.8	1.1	5.2	-	-	-	4.4
Manufacture of minerals[6]	2.0	0.0	0.1	-	-	-	2.0
Manufacture of iron, steel and ferro-alloys	3.0	0.0	0.0	-	-	-	3.0
Manufacture of other metals	2.0	0.0	0.0	-	193.0	19.5	3.7
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	17.8	0.0	0.3	-	-	0.6
Manufacture of consumer goods	0.7	0.0	0.0	-	-	-	0.7
Other	16.7	282.7	11.0	27.4	0.0	-	26.1
Construction	0.6	0.1	0.1	-	-	-	0.7
Agriculture and forestry	0.7	108.1	9.4	-	-	-	5.9
Fishing, whaling and sealing	1.5	0.1	0.0	-	-	-	1.5
Land transport, domestic	2.9	0.2	0.1	-	-	-	3.0
Sea transport, domestic	1.3	0.1	0.0	-	-	-	1.4
Air transport[5]	1.0	0.0	0.0	-	-	-	1.0
Other private services	2.1	0.6	0.2	27.4	0.0	-	2.3
Public sector, municipal	0.3	163.9	0.4	-	-	-	3.9
Public sector, state	0.5	0.0	0.0	-	-	-	0.5
Private households	5.6	9.6	0.7	-	-	-	6.0

[1] Distribution by source uncertain, figures will be improved.
[2] Includes C_3F_8, CF_4 and C_2F_6.
[3] Includes gas terminal, transport and supply ships.
[4] Includes emissions from waste incineration plants.
[5] Domestic air transport only, including emissions above 1000 m.
[6] Including mining.
Sources: Statistics Norway and Norwegian Pollution Control Authority.

Table C4. **Emissions to air by sector. 1996**

	SO_2	NO_x	NH_3	Acid equi-valents[1]	NMVOCs	CO	Particu-lates[2]	Pb	Cd
	1000 tonnes							Tonnes	kg
Total	33.2	220.1	26.5	7.4	368.1	694.9	23.8	7.0	614
Energy sectors	2.8	46.7	0.0	1.1	222.0	8.1	0.5	1.2	71
Extraction of oil and gas[3]	0.3	42.6	0.0	0.9	205.6	6.9	0.2	0.0	1
Extraction of coal	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0
Oil refining	1.7	2.7	0.0	0.1	16.0	0.0	0.1	0.0	0
Electricity supplies[4]	0.8	1.4	0.0	0.1	0.5	1.1	0.2	1.2	70
Manufacturing and mining	25.0	28.8	0.3	1.4	25.2	51.9	1.1	2.4	386
Oil drilling	0.1	6.0	0.0	0.1	0.5	0.3	0.0	0.0	1
Manufacture of pulp and paper	3.5	2.1	0.0	0.2	0.3	1.9	0.3	0.2	20
Manufacture of chemical raw materials	8.7	4.4	0.3	0.4	2.3	39.0	0.1	0.1	3
Manufacture of minerals[7]	2.3	6.3	0.0	0.2	2.0	0.9	0.3	1.5	62
Manufacture of iron, steel and ferro-alloys	6.8	5.0	0.0	0.3	1.5	0.1	0.0	0.1	12
Manufacture of other metals	2.2	1.4	0.0	0.1	0.0	1.7	0.1	0.5	253
Manufacture of metal goods, boats, ships and oil platforms	0.2	0.9	0.0	0.0	2.9	1.2	0.1	0.0	3
Manufacture of wood, plastic, rubber, and chemical goods, printing	0.3	0.8	0.0	0.0	14.2	5.3	0.1	0.0	31
Manufacture of consumer goods	0.8	1.9	0.0	0.1	1.4	1.6	0.1	0.1	2
Other	5.4	144.6	26.2	4.9	120.9	634.9	22.2	3.4	157
Construction	0.2	6.0	0.0	0.1	12.7	5.7	0.6	0.0	2
Agriculture and forestry	0.3	6.3	25.3	1.6	3.0	5.1	0.8	0.0	1
Fishing, whaling and sealing	0.7	33.1	0.0	0.7	0.8	6.8	0.2	0.1	3
Land transport, domestic	1.1	27.4	0.0	0.6	5.2	22.1	3.3	0.2	6
Sea transport, domestic	1.0	27.6	0.0	0.6	1.6	1.3	0.3	0.1	3
Air transport[6]	0.1	1.5	0.0	0.0	1.6	2.1	0.1	0.3	0
Other private services	0.6	11.8	0.2	0.3	18.8	80.6	0.7	0.5	3
Public sector, municipal[5]	0.1	0.4	0.0	0.0	1.5	0.4	0.0	0.0	1
Public sector, state	0.1	2.4	0.0	0.1	2.0	0.7	0.0	0.0	1
Private households	1.3	28.2	0.7	0.7	73.6	510.0	16.1	2.1	137

[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.
[4] Includes emissions from waste incineration.
[5] Includes water supplies.
[6] Emissions under 1000 m only, including international air transport.
[7] Including mining.
Source: Statistics Norway and Norwegian Pollution Control Authority.

Table C5. **Emissions to air by source[1]. 1996**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Mill.tonnes	1000 tonnes								Tonnes	kg
Total	41.1	345.4	16.5	33.2	220.1	26.5	368.1	694.9	23.8	7.0	614
Stationary combustion	17.6	11.3	0.3	8.5	46.9	-	13.3	153.1	15.2	1.8	329
Process emissions	8.6	330.7	14.9	20.5	8.7	25.6	276.2	40.3	2.0	1.9	266
Mobile combustion	15.0	3.4	1.3	4.2	164.5	1.0	78.6	501.5	6.7	3.3	19
Stationary combustion, total	17.6	11.3	0.3	8.5	46.9	-	13.3	153.1	15.2	1.8	328.6
Oil and gas extraction	9.0	3.2	0.1	0.2	31.6	-	1.5	6.7	0.1	0.0	-
- Natural gas	6.6	2.6	0.1	-	17.8	-	0.7	4.8	-	-	-
- Flaring	1.2	0.1	0.0	-	5.7	-	0.1	0.8	-	-	-
- Diesel combustion	0.4	0.0	0.0	0.2	7.2	-	0.5	0.5	0.1	0.0	-
- Gas terminal	0.7	0.5	0.0	0.0	0.9	-	0.2	0.6	-	-	-
Manufacturing and mining	5.9	0.5	0.1	6.4	11.3	-	1.8	7.6	0.9	0.5	129.1
- Refining	1.9	0.1	0.0	0.1	2.7	-	0.9	0.0	0.1	0.0	0.0
- Manufacture of pulp and paper	0.8	0.2	0.1	2.8	1.8	-	0.2	1.7	0.3	0.2	19.5
- Manufacture of mineral products	0.9	0.0	0.0	0.7	3.8	-	0.0	0.1	0.1	0.1	61.2
- Manufacture of chemicals	0.8	0.1	0.0	0.6	1.0	-	0.0	0.1	0.1	0.1	1.3
- Manufacture of metals	0.4	0.0	0.0	0.3	0.5	-	0.0	0.1	0.1	0.0	0.9
- Other manufacturing	1.2	0.1	0.0	1.9	1.6	-	0.6	5.7	0.3	0.1	46.1
Other industry	1.4	0.2	0.0	0.7	1.1	-	0.2	1.0	0.1	0.1	4.0
Dwellings, offices, etc.	1.2	7.3	0.1	0.9	1.9	-	9.5	137.7	14.0	0.0	136.3
Waste incineration	0.1	0.1	0.0	0.2	0.9	-	0.3	0.1	0.0	1.2	59.3
Process emissions, total	8.6	330.7	14.9	20.5	8.7	25.6	276.2	40.3	2.0	1.9	266.2
Oil and gas extraction	0.7	24.1	-	-	-	-	203.9	-	-	-	-
- Venting, leaks, etc	0.0	8.8	-	-	-	-	3.6	-	-	-	-
- Oil loading at sea	0.6	14.7	-	-	-	-	176.4	-	-	-	-
- Oil loading, onshore	0.1	0.1	-	-	-	-	22.1	-	-	-	-
- Gas terminal	0.0	0.6	-	-	-	-	1.8	-	-	-	-
Manufacturing and mining	7.5	4.2	5.2	20.5	8.7	0.3	18.6	40.3	-	1.8	266.2
- Refining	0.0	-	-	1.6	0.0	-	15.1	-	-	-	-
- 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	-	-	0.3
- Manufacture of mineral products	0.9	-	-	0.9	-	-	-	-	-	1.4	-
- Manufacture of metals	5.4	-	-	11.9	7.4	-	1.8	1.5	-	0.5	265.9
- - Iron, steel and ferro-alloys	3.7	-	-	9.5	6.7	-	1.8	-	-	0.1	13.8
- - Aluminium	1.5	-	-	1.7	0.6	-	-	-	-	0.4	102.0
- - Other metals	0.2	-	-	0.7	0.0	-	-	1.5	-	-	150.1
- Other manufacturing	0.0	3.2	-	0.1	-	-	0.9	-	-	-	-
Petrol distribution	0.0	-	-	-	-	-	6.2	-	-	-	-
Agriculture	0.2	108.1	9.3	-	-	25.3	-	-	-	-	-
Landfill gas	0.0	193.9	-	-	-	-	-	-	-	-	-
Solvents	0.1	-	-	-	-	-	47.6	-	-	-	-
Road dust	-	-	-	-	-	-	-	-	2.0	-	-
Other process emissions	0.0	0.4	0.4	-	-	-	-	-	-	0.0	-

Table C5 (cont.). **Emissions to air by source[1]. 1996**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Mill.tonnes	1000 tonnes								Tonnes	kg
Mobile combustion, total	15.0	3.4	1.3	4.2	164.5	1.0	78.6	501.5	6.7	3.3	19.2
Road traffic	8.9	2.7	0.8	1.8	65.5	1.0	61.2	442.3	4.1	2.7	8.3
- Petrol engines	5.0	2.4	0.7	0.4	31.8	0.9	53.0	412.0	0.5	2.5	-
- - Passenger cars	4.4	2.2	0.7	0.3	27.7	0.9	47.2	366.2	0.4	2.2	-
- - Other light vehicles	0.6	0.2	0.0	0.0	3.4	0.1	5.1	42.1	0.0	0.3	-
- - Heavy vehicles	0.0	0.0	0.0	0.0	0.7	0.0	0.7	3.8	0.0	0.0	-
- Diesel engines	3.8	0.2	0.1	1.4	33.7	0.0	4.4	17.4	3.6	0.1	8.3
- - Passenger cars	0.3	0.0	0.0	0.1	0.9	0.0	0.3	1.2	0.4	0.0	0.8
- - Other light vehicles	0.8	0.0	0.0	0.3	2.3	0.0	0.8	3.1	0.8	0.0	1.7
- - Heavy vehicles	2.7	0.1	0.0	1.0	30.5	0.0	3.2	13.1	2.4	0.1	5.9
- 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	-
Snow scooters	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.6	0.0	0.0	-
Small boats	0.2	0.2	0.0	0.0	1.0	-	8.8	19.7	0.3	0.1	0.1
Motorized equipment	0.8	0.1	0.3	0.3	11.9	0.0	3.9	25.6	1.4	0.1	1.6
Railways	0.1	0.0	0.0	0.0	1.0	-	0.1	0.2	0.1	0.0	0.2
Air traffic[2]	1.2	0.0	0.0	0.1	1.6	-	0.5	2.3	0.1	0.3	-
- Domestic < 1000m	0.4	0.0	0.0	0.1	1.2	-	0.5	2.0	0.0	0.3	-
- International < 1000m	:	:	:	0.0	0.4	-	0.0	0.3	0.0	0.0	-
- Domestic > 1000m	0.8	:	0.0	:	:	:	:	:	:	:	:
Shipping	3.8	0.3	0.1	2.0	83.3	-	2.8	8.8	0.7	0.2	8.9
- Coastal traffic etc.	2.1	0.2	0.1	1.3	44.6	-	1.6	1.9	0.4	0.1	5.0
- Fishing vessels	1.5	0.1	0.0	0.7	33.0	-	0.8	6.7	0.2	0.1	3.3
- Mobile oil rigs, etc.	0.3	0.1	0.0	0.1	5.7	-	0.4	0.3	0.0	0.0	0.6

[1] Does not include international sea traffic.
[2] Emissions from air traffic that is not included in national emissions inventories are marked with the symbol : (Not for publication).
Sources: Statistics Norway and Norwegian Pollution Control Authority.

Table C6. **Emissions to air by source[1]. 1997***

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Mill.tonnes	1000 tonnes								Tonnes	kg
Total	41.4	350.2	16.3	30.3	222.3	26.4	359.4	655.9	23.5	6.3	601
Stationary combustion	17.5	11.5	0.3	7.1	48.4	-	13.6	154.6	15.2	1.8	315
Process emissions	8.7	335.3	14.6	18.7	8.3	25.3	271.9	39.3	1.9	1.5	266
Mobile combustion	15.3	3.4	1.5	4.5	165.5	1.1	74.0	462.0	6.4	3.0	20
Stationary combustion, total	17.5	11.5	0.3	7.1	48.4	-	13.6	154.6	15.2	1.8	315.1
Oil and gas extraction	9.3	3.5	0.1	0.2	33.2	-	1.7	6.9	0.1	0.0	-
- Natural gas	7.1	2.8	0.1	-	19.0	-	0.7	5.2	-	-	-
- Flaring	1.1	0.1	0.0	-	5.2	-	0.1	0.7	-	-	-
- Diesel combustion	0.5	0.0	0.0	0.2	8.2	-	0.5	0.6	0.1	0.0	-
- Gas terminal	0.6	0.6	0.0	0.0	0.8	-	0.3	0.5	-	-	-
Manufacturing and mining	5.9	0.5	0.1	5.3	11.6	-	1.9	9.3	0.8	0.5	143.2
- Refining	2.0	0.1	0.0	0.1	2.6	-	0.9	0.0	0.1	0.0	0.0
- Manufacture of pulp and paper	0.7	0.2	0.1	2.3	1.7	-	0.3	2.6	0.3	0.2	23.8
- Manufacture of mineral products	0.9	0.0	0.0	0.6	3.8	-	0.0	0.1	0.1	0.1	66.9
- Manufacture of chemicals	1.1	0.1	0.0	0.5	1.6	-	0.0	0.1	0.1	0.1	1.3
- Manufacture of metals	0.3	0.0	0.0	0.3	0.4	-	0.0	0.1	0.0	0.0	0.8
- Other manufacturing	1.0	0.1	0.0	1.6	1.4	-	0.6	6.5	0.3	0.1	50.5
Other industry	1.1	0.1	0.0	0.5	0.9	-	0.1	0.8	0.1	0.0	3.3
Dwellings, offices etc.	1.0	7.3	0.1	0.9	1.7	-	9.5	137.4	14.1	0.0	136.1
Waste incineration	0.1	0.1	0.0	0.2	1.0	-	0.3	0.2	0.0	1.3	32.5
Process emissions	8.7	335.3	14.6	18.7	8.3	25.3	271.9	39.3	1.9	1.5	266.2
Oil and gas extraction	0.7	27.2	-	-	-	-	198.7	-	-	-	-
- Venting, leaks, etc.	0.0	8.8	-	-	-	-	3.6	-	-	-	-
- Oil loading at sea	0.6	17.7	-	-	-	-	171.6	-	-	-	-
- Oil loading, onshore	0.1	0.1	-	-	-	-	21.2	-	-	-	-
- Gas terminal	0.0	0.6	-	-	-	-	2.3	-	-	-	-
Manufacturing and mining	7.6	6.4	4.8	18.7	8.3	0.3	21.2	39.3	-	1.5	266.2
- Refining	0.1	-	-	1.9	0.0	-	17.8	-	-	-	-
- Manufacture of pulp and paper	-	-	-	0.6	-	-	-	-	-	-	-
- Manufacture of chemicals	1.1	1.0	4.8	3.6	1.1	0.3	0.8	37.3	-	-	0.3
- Manufacture of mineral products	0.9	-	-	1.0	-	-	-	-	-	1.0	-
Manufacture of metals	5.5	-	-	11.6	7.2	-	1.8	2.0	-	0.5	265.9
- - Iron, steel and ferro-alloys	3.7	-	-	9.0	6.5	-	1.8	-	-	0.1	13.8
- - Aluminium	1.6	-	-	1.8	0.7	-	-	-	-	0.4	102.0
- - Other metals	0.2	-	-	0.8	0.0	-	-	2.0	-	-	150.1
- Other manufacturing	0.0	5.4	-	-	-	-	0.9	-	-	-	-
Petrol distribution	0.0	-	-	-	-	-	6.1	-	-	-	-
Agriculture	0.2	108.1	9.4	-	-	24.7	-	-	-	-	-
Landfill gas	0.0	193.2	-	-	-	-	-	-	-	-	-
Solvents	0.1	-	-	-	-	-	45.8	-	-	-	-
Road dust	-	-	-	-	-	-	-	-	1.9	-	-
Other process emissions	0.0	0.4	0.4	-	-	-	-	-	-	0.0	-

Table C6 (cont.). **Emissions to air by source[1]. 1997***

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates	Pb	Cd
	Mill.tonnes	1000 tonnes								Tonnes	kg
Mobile combustion	15.3	3.4	1.5	4.5	165.5	1.1	74.0	462.0	6.4	3.0	20.2
Road traffic	8.8	2.7	1.0	1.7	59.6	1.1	56.3	402.1	3.7	2.4	8.5
- Petrol engines	4.9	2.4	0.9	0.3	28.2	1.1	47.9	371.6	0.4	2.2	-
- - Passenger cars	4.3	2.2	0.8	0.2	24.4	1.1	42.7	329.3	0.4	1.9	-
- - Other light vehicles	0.6	0.2	0.1	0.0	3.0	0.1	4.5	38.3	0.0	0.3	-
- - Heavy vehicles	0.0	0.0	0.0	0.0	0.8	0.0	0.7	4.0	0.0	0.0	-
- Diesel engines	3.8	0.2	0.1	1.5	31.3	0.0	4.2	16.2	3.3	0.1	8.5
- - Passenger cars	0.4	0.0	0.0	0.1	0.9	0.0	0.3	1.3	0.4	0.0	0.8
- - Other light vehicles	0.9	0.0	0.1	0.3	2.4	0.0	0.9	3.6	0.9	0.0	2.0
- - Heavy vehicles	2.6	0.1	0.0	1.0	28.0	0.0	2.9	11.3	2.0	0.1	5.7
- Motorcycles, mopeds	0.1	0.1	0.0	0.0	0.1	0.0	4.1	14.3	0.0	0.0	-
- - Motorcycles	0.0	0.1	0.0	0.0	0.1	0.0	1.6	9.5	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	2.7	0.0	0.0	-
Small boats	0.2	0.2	0.0	0.0	1.0	-	8.8	19.7	0.3	0.1	0.1
Motorized equipment	0.8	0.1	0.3	0.3	12.3	0.0	3.9	25.7	1.5	0.1	1.7
Railways	0.1	0.0	0.0	0.0	1.1	-	0.1	0.3	0.1	0.0	0.2
Air traffic[2]	1.2	0.0	0.0	0.1	1.7	-	0.5	2.3	0.1	0.3	-
- Domestic < 1000m	0.4	0.0	0.0	0.1	1.2	-	0.5	2.0	0.0	0.3	-
- International < 1000m	:	:	:	0.0	0.4	-	0.0	0.3	0.0	0.0	-
- Domestic > 1000m	0.8	:	0.0	:	:	:	:	:	:	:	:
Shipping	4.1	0.4	0.1	2.4	89.8	-	3.1	9.2	0.8	0.2	9.7
- Coastal traffic etc.	2.2	0.2	0.1	1.6	47.5	-	1.7	2.0	0.5	0.1	5.5
- Fishing vessels	1.6	0.1	0.0	0.7	34.6	-	0.9	6.8	0.2	0.1	3.5
- Mobile oil rigs, etc.	0.3	0.1	0.0	0.1	7.7	-	0.6	0.3	0.1	0.0	0.8

[1] Does not include international sea traffic.
[2] Emissions from air traffic that is not included in national emissions inventories are marked with the symbol : (Not for publication).
Sources: Statistics Norway and Norwegian Pollution Control Authority.

Table C7. **Emissions to air by county. 1996**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOCs	CO	Particu-lates[1]	Pb	Cd
	Mill. tonnes	1000 tonnes								Tonnes	kg
Total	41.2	345.4	16.5	33.9	222.3	26.5	368.2	695.0	23.9	7.0	614.5
Of this, national emission figures	41.1	345.4	16.5	33.2	220.1	26.5	368.1	694.9	23.8	7.0	614.0
Of this, international sea traffic[2]	0.1	0.0	0.0	0.7	2.2	0.0	0.1	0.1	0.0	0.0	0.5
Østfold	1.7	16.7	0.7	4.8	6.6	1.8	9.2	36.9	1.5	1.8	19.6
Akershus	1.6	17.7	0.8	0.6	9.8	1.7	15.9	72.4	1.7	0.4	17.1
Oslo	1.4	5.0	0.1	0.7	6.8	0.1	13.5	44.6	1.0	0.9	6.3
Hedmark	0.9	20.8	1.0	0.4	5.8	2.4	7.2	41.8	1.9	0.2	21.4
Oppland	0.8	23.2	1.0	0.3	5.2	2.5	6.6	34.9	1.4	0.2	14.6
Buskerud	1.1	19.8	0.5	1.0	6.4	1.1	8.3	39.6	1.3	0.5	14.0
Vestfold	1.2	11.7	0.4	1.3	5.7	1.0	9.0	31.7	0.9	0.2	15.3
Telemark	3.4	11.6	3.7	1.6	7.5	0.8	7.0	30.1	1.1	0.2	48.2
Aust-Agder	0.6	7.6	0.2	3.2	2.4	0.3	3.9	53.5	1.0	0.1	8.6
Vest-Agder	1.1	12.2	0.3	2.1	4.0	0.6	5.5	24.4	0.9	0.2	17.3
Rogaland	2.8	38.7	1.3	1.3	9.0	3.4	15.9	47.0	1.5	0.3	49.0
Hordaland	3.4	29.7	0.6	2.1	10.2	1.4	45.4	52.6	2.1	0.3	169.2
Sogn og Fjordane	1.2	12.6	0.5	1.6	4.1	1.3	3.5	17.1	0.8	0.1	16.0
Møre og Romsdal	1.0	17.5	0.7	0.6	5.6	1.8	7.7	32.7	1.4	0.3	52.7
Sør-Trøndelag	1.4	17.8	0.8	3.5	6.3	1.8	7.1	36.8	1.2	0.2	64.5
Nord-Trøndelag	0.6	16.1	0.9	0.7	3.8	2.2	4.6	23.8	1.2	0.1	9.4
Nordland	2.5	21.0	2.4	4.2	9.0	1.5	6.9	28.4	0.9	0.4	43.9
Troms	0.7	9.5	0.3	1.1	3.9	0.6	4.3	19.7	0.7	0.1	7.5
Finnmark	0.3	6.7	0.2	0.3	2.3	0.2	2.6	11.6	0.5	0.1	3.4
Svalbard	0.1	3.2	0.0	0.5	0.2	0.0	0.1	0.2	0.1	0.0	8.4
Continental shelf	12.0	26.4	0.1	1.8	98.6	-	183.6	13.5	0.7	0.1	7.3
Airspace[3]	1.0	0.0	0.0	0.0	0.9	-	0.2	1.0	0.0	0.3	-
Open sea[4]	0.4	0.0	0.0	0.2	8.4	-	0.2	0.9	0.1	0.0	0.8

[1] Process emissions calculated for road dust only.
[2] Emissions from international sea traffic in Norwegian ports.
[3] Emissions of CO_2 from Norwegian aircraft above 100 m and emissions of other components between 100 m and 1000 m from domestic and international air transport.
[4] 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. 1996**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes	Tonnes		
Total	41249	33890	222286	368163
Of this, national emissions	41140	33214	220059	368081
Of this, international sea traffic[1]	109	675	2227	82
Østfold	1675	4818	6587	9175
Halden	156	485	558	814
Moss	270	525	1056	816
Sarpsborg	587	2603	1493	1581
Fredrikstad	340	1112	1460	2943
Hvaler	14	3	93	374
Aremark	6	2	47	53
Marker	17	5	116	141
Rømskog	2	1	13	16
Trøgstad	18	5	118	147
Spydeberg	17	5	116	153
Askim	42	12	197	344
Eidsberg	43	11	278	443
Skiptvet	9	2	60	89
Rakkestad	31	9	186	236
Råde	38	10	278	315
Rygge	49	18	274	440
Våler	15	4	96	124
Hobøl	20	6	148	146
Akershus	1643	566	9830	15932
Vestby	57	14	417	599
Ski	71	18	427	775
Ås	94	26	538	718
Frogn	40	10	246	563
Nesodden	33	8	192	725
Oppegård	51	13	299	530
Bærum	318	89	1796	3543
Asker	162	40	946	1646
Aurskog-Høland	47	12	306	448
Sørum	60	14	414	459
Fet	32	8	202	264
Rælingen	49	44	274	212
Enebakk	18	5	108	161
Lørenskog	67	18	389	979
Skedsmo	167	131	858	1214
Nittedal	61	23	309	455
Gjerdrum	11	3	66	101
Ullensaker	120	33	811	1031
Nes	57	15	367	448
Eidsvoll	92	35	642	756
Nannestad	24	6	145	208
Hurdal	11	3	76	95

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes	Tonnes		
Oslo	1353	682	6791	13545
Hedmark	877	367	5845	7189
Kongsvinger	69	40	435	574
Hamar	83	28	426	646
Ringsaker	148	59	893	1198
Løten	31	10	222	258
Stange	99	30	675	746
Nord-Odal	16	5	113	170
Sør-Odal	45	16	293	309
Eidskog	26	9	185	242
Grue	25	9	183	236
Åsnes	34	11	231	411
Våler	22	7	134	170
Elverum	71	23	460	665
Trysil	36	24	285	364
Åmot	33	51	193	174
Stor-Elvdal	34	10	290	225
Rendalen	17	5	146	122
Engerdal	10	6	79	102
Tolga	11	3	71	74
Tynset	33	10	250	235
Alvdal	18	5	151	125
Folldal	9	3	62	71
Os	9	3	66	72
Oppland	782	254	5217	6558
Lillehammer	79	29	464	727
Gjøvik	117	43	686	1111
Dovre	25	7	191	168
Lesja	18	5	149	109
Skjåk	15	4	115	131
Lom	13	4	97	106
Vågå	19	6	144	153
Nord-Fron	30	9	202	210
Sel	37	11	248	290
Sør-Fron	16	5	119	120
Ringebu	29	12	215	244
Øyer	32	9	233	242
Gausdal	21	6	143	174
Østre Toten	49	16	297	417
Vestre Toten	47	12	268	350
Jevnaker	18	5	110	182
Lunner	30	13	227	257
Gran	47	13	317	422
Søndre Land	25	9	157	194
Nordre Land	24	7	172	232
Sør-Aurdal	17	5	127	133
Etnedal	8	2	62	64

Table C8 (cont.). **Emissions to air by municipality. 1996**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes	Tonnes		
Nord-Aurdal	33	9	234	277
Vestre Slidre	10	4	70	64
Øystre Slidre	14	4	100	110
Vang	9	3	69	71
Buskerud	1119	1018	6370	8263
Drammen	181	51	873	1462
Kongsberg	80	45	414	611
Ringerike	148	91	882	995
Hole	32	8	212	242
Flå	16	4	127	108
Nes	19	5	132	151
Gol	24	8	171	168
Hemsedal	12	4	88	80
Ål	21	11	141	160
Hol	26	7	176	181
Sigdal	17	5	116	143
Krødsherad	23	6	165	166
Modum	62	88	294	368
Øvre Eiker	98	120	512	492
Nedre Eiker	51	15	261	590
Lier	143	105	733	1224
Røyken	35	10	188	408
Hurum	98	424	620	390
Flesberg	13	4	101	114
Rollag	9	2	66	72
Nore og Uvdal	13	4	99	138
Vestfold	1223	1342	5706	9021
Borre	63	18	388	594
Holmestrand	89	13	274	311
Tønsberg	461	778	1558	2379
Sandefjord	128	64	720	1621
Larvik	181	205	1145	1391
Svelvik	47	5	103	151
Sande	78	211	422	404
Hof	13	3	86	101
Våle	32	10	230	303
Ramnes	11	3	76	98
Andebu	13	3	85	126
Stokke	40	11	259	317
Nøtterøy	41	11	197	833
Tjøme	13	3	73	295
Lardal	13	3	91	96
Telemark	3373	1557	7468	7003
Porsgrunn	2371	894	3944	1193
Skien	164	490	740	1283
Notodden	47	13	298	420
Siljan	6	2	39	62
Bamble	551	20	937	1768
Kragerø	46	44	270	655
Drangedal	13	4	95	123
Nome	36	51	163	212
Bø	15	4	93	140
Sauherad	18	5	125	146
Tinn	20	7	135	195
Hjartdal	8	2	62	83
Seljord	15	4	103	144
Kviteseid	14	4	96	120
Nissedal	7	2	55	63
Fyresdal	6	2	43	58
Tokke	13	3	100	121
Vinje	24	6	169	218
Aust-Agder	575	3171	2354	3897
Risør	29	18	166	297
Grimstad	57	18	354	647
Arendal	233	2029	657	1193
Gjerstad	12	4	88	115
Vegårshei	6	2	45	69
Tvedestrand	25	8	173	289
Froland	15	5	110	141
Lillesand	122	1067	270	452
Birkenes	25	5	134	177
Åmli	10	3	75	95
Iveland	3	1	21	28
Evje og Hornnes	15	5	96	129
Bygland	10	3	69	93
Valle	8	3	61	97
Bykle	6	2	36	77
Vest-Agder	1104	2091	3979	5460
Kristiansand	417	1209	1689	2155
Mandal	41	13	276	461
Farsund	161	308	321	384
Flekkefjord	31	9	206	358
Vennesla	135	463	389	323
Songdalen	17	5	117	160
Søgne	26	7	169	324
Marnardal	8	2	64	77
Åseral	5	2	45	41
Audnedal	5	2	45	65
Lindesnes	23	6	141	325
Lyngdal	31	21	188	314
Hægebostad	6	2	47	61
Kvinesdal	185	40	207	298
Sirdal	11	3	75	113

Table C8 (cont.). **Emissions to air by municipality. 1996**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes	Tonnes		
Rogaland	2849	1333	9047	15871
Eigersund	94	105	518	436
Sandnes	136	38	855	1466
Stavanger	256	236	1914	2539
Haugesund	58	18	315	720
Sokndal	32	48	194	142
Lund	18	5	140	149
Bjerkreim	19	4	125	128
Hå	50	13	302	438
Klepp	50	13	285	421
Time	41	10	211	364
Gjesdal	28	7	201	279
Sola	329	378	722	4182
Randaberg	17	5	119	180
Forsand	8	3	85	56
Strand	26	8	177	232
Hjelmeland	17	6	159	138
Suldal	19	6	172	165
Sauda	348	93	62	285
Finnøy	20	8	116	129
Rennesøy	23	7	181	152
Kvitsøy	1	0	10	25
Bokn	7	2	76	71
Tysvær	709	10	880	2071
Karmøy	516	301	1044	884
Utsira	1	0	6	21
Vindafjord	26	7	180	198
Hordaland	3398	2144	10166	45389
Bergen	526	225	2899	5225
Etne	18	6	150	142
Ølen	11	4	72	117
Sveio	17	5	140	177
Bømlo	21	8	168	301
Stord	31	14	244	402
Fitjar	10	3	83	127
Tysnes	9	4	83	157
Kvinnherad	222	297	381	477
Jondal	3	1	30	42
Odda	389	90	405	244
Ullensvang	15	5	133	158
Eidfjord	9	3	82	64
Ulvik	5	2	47	43
Granvin	8	3	80	61
Voss	50	16	333	439
Kvam	226	691	776	412
Fusa	11	4	93	141
Samnanger	10	3	75	98
Os	31	11	227	345
Austevoll	11	4	105	162
Sund	11	4	77	130
Fjell	38	11	246	454
Askøy	53	81	294	395
Vaksdal	22	7	142	167
Modalen	1	1	12	12
Osterøy	17	7	135	187
Meland	11	4	69	142
Øygarden	127	2	320	16656
Radøy	11	4	74	153
Lindås	1455	618	2034	17555
Austrheim	7	3	64	88
Fedje	1	1	12	29
Masfjorden	8	3	81	87
Sogn og Fjordane	1180	1638	4134	3492
Flora	42	34	342	317
Gulen	14	5	145	99
Solund	4	2	44	44
Hyllestad	6	2	46	70
Høyanger	120	176	168	136
Vik	9	3	86	84
Balestrand	12	4	96	69
Leikanger	8	3	77	64
Sogndal	28	8	183	237
Aurland	11	3	88	77
Lærdal	13	4	115	98
Årdal	389	394	290	121
Luster	14	4	102	136
Askvoll	8	3	76	90
Fjaler	8	3	67	81
Gaular	15	5	101	92
Jølster	16	4	120	119
Førde	33	10	190	306
Naustdal	8	2	59	75
Bremanger	279	880	793	232
Vågsøy	59	59	337	179
Selje	8	3	67	92
Eid	20	7	154	183
Hornindal	4	1	31	41
Gloppen	21	6	148	194
Stryn	31	9	210	255
Møre og Romsdal	1025	584	5574	7697
Molde	56	18	365	611
Kristiansund	33	11	195	840
Ålesund	125	68	797	1169
Vanylven	18	23	125	129
Sande	9	3	84	95
Herøy	37	76	209	187
Ulstein	14	4	96	204

Table C8 (cont.). **Emissions to air by municipality. 1996**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes	Tonnes		
Hareid	10	4	86	121
Volda	19	7	157	201
Ørsta	31	11	251	307
Ørskog	10	3	75	82
Norddal	9	3	86	67
Stranda	18	6	122	178
Stordal	4	1	27	55
Sykkylven	17	7	130	215
Skodje	17	5	121	152
Sula	19	7	156	173
Giske	13	4	87	147
Haram	23	8	184	241
Vestnes	25	8	178	236
Rauma	35	11	290	293
Nesset	13	4	101	107
Midsund	6	2	57	69
Sandøy	4	1	30	48
Aukra	7	3	68	78
Fræna	28	9	188	234
Eide	13	4	117	120
Averøy	18	7	125	162
Frei	11	3	73	105
Gjemnes	11	3	85	100
Tingvoll	12	4	101	112
Sunndal	304	236	341	232
Surnadal	19	7	150	214
Rindal	7	4	55	74
Aure	9	3	88	108
Halsa	8	3	72	80
Tustna	4	1	39	41
Smøla	7	2	60	110
Sør-Trøndelag	1386	3521	6264	7096
Trondheim	425	869	1813	3006
Hemne	249	893	685	237
Snillfjord	8	2	74	66
Hitra	12	4	100	144
Frøya	11	4	88	130
Ørland	16	5	95	126
Agdenes	7	2	60	58
Rissa	24	8	200	229
Bjugn	14	5	124	137
Åfjord	12	4	99	116
Roan	4	1	29	36
Osen	4	1	32	35
Oppdal	35	10	271	251
Rennebu	23	6	185	162
Meldal	13	4	87	120
Orkdal	341	1647	885	504
Røros	20	6	138	205
Holtålen	9	3	76	85
Midtre Gauldal	29	8	239	255
Melhus	52	15	395	437
Skaun	21	6	154	170
Klæbu	7	2	45	91
Malvik	35	10	265	324
Selbu	13	4	92	131
Tydal	4	1	31	40
Nord-Trøndelag	617	704	3766	4597
Steinkjer	76	25	536	671
Namsos	34	20	192	361
Meråker	98	459	219	133
Stjørdal	91	34	501	755
Frosta	7	3	46	72
Leksvik	10	3	77	120
Levanger	70	41	482	563
Verdal	50	16	325	513
Mosvik	3	1	21	42
Verran	8	3	57	75
Namdalseid	10	3	74	91
Inderøy	40	60	281	187
Snåsa	15	5	129	110
Lierne	7	2	62	65
Røyrvik	4	1	23	23
Namsskogan	11	3	102	65
Grong	20	6	163	128
Høylandet	8	2	60	69
Overhalla	15	4	100	121
Fosnes	3	1	31	27
Flatanger	4	1	31	40
Vikna	10	4	79	121
Nærøy	20	6	151	201
Leka	3	1	24	43
Nordland	2524	4153	9004	6942
Bodø	112	49	578	896
Narvik	51	22	334	431
Bindal	7	2	69	68
Sømna	8	2	58	57
Brønnøy	22	6	156	187
Vega	4	1	33	51
Vevelstad	3	2	44	25
Herøy	5	2	37	45
Alstahaug	19	6	125	153
Leirfjord	9	2	67	62
Vefsn	264	323	430	369
Grane	17	5	161	90
Hattfjelldal	6	5	50	71
Dønna	5	2	41	55

Table C8 (cont.). **Emissions to air by municipality. 1996**

	CO_2	SO_2	NO_x	NMVOCs
	1000 tonnes	Tonnes		
Nesna	5	2	58	37
Hemnes	19	6	152	180
Rana	704	1854	1587	1022
Lurøy	6	2	54	77
Træna	1	0	11	18
Rødøy	5	2	52	55
Meløy	15	10	428	126
Gildeskål	10	3	81	86
Beiarn	3	1	28	32
Saltdal	23	7	189	190
Fauske	33	9	232	294
Skjerstad	4	1	39	34
Sørfold	448	1439	1216	325
Steigen	10	3	72	94
Hamarøy	14	4	119	102
Tysfjord	484	318	1041	85
Lødingen	10	3	86	70
Tjeldsund	7	2	56	53
Evenes	13	3	80	92
Ballangen	14	5	112	90
Røst	2	1	15	23
Værøy	2	1	15	19
Flakstad	4	1	33	32
Vestvågøy	30	8	193	241
Vågan	25	8	179	207
Hadsel	24	8	179	193
Bø	10	3	71	74
Øksnes	13	4	81	83
Sortland	30	9	203	268
Andøy	21	6	135	159
Moskenes	3	1	22	22
Troms	739	1140	3872	4286
Harstad	54	20	333	518
Tromsø	144	60	879	1241
Kvæfjord	12	4	92	81
Skånland	13	5	98	106
Bjarkøy	2	1	26	14
Ibestad	5	2	47	45
Gratangen	7	2	53	48
Lavangen	5	2	37	38
Bardu	22	7	130	178
Salangen	7	3	52	68
Målselv	40	14	226	325
Sørreisa	13	11	85	140
Dyrøy	4	2	36	46
Tranøy	6	2	49	53
Torsken	2	1	19	17
Berg	6	2	39	29
Lenvik	291	964	927	434
Balsfjord	34	10	226	272
Karlsøy	8	3	66	73
Lyngen	10	4	70	90
Storfjord	12	3	82	93
Kåfjord	11	4	79	90
Skjervøy	6	3	47	54
Nordreisa	18	6	124	167
Kvænangen	7	2	50	68
Finnmark	336	338	2256	2623
Vardø	8	7	55	64
Vadsø	21	11	174	178
Hammerfest	24	25	139	205
Guovdageaidnu-Kautokeino	20	7	182	153
Alta	74	29	495	668
Loppa	3	2	31	34
Hasvik	3	2	23	30
Kvalsund	12	4	85	77
Måsøy	4	2	30	48
Nordkapp	13	8	112	95
Porsanger	25	9	159	214
Karasjohka-Karasjok	14	6	115	118
Lebesby	5	2	38	54
Gamvik	4	2	29	42
Berlevåg	4	2	27	34
Deatnu - Tana	19	7	135	154
Unjarga - Nesseby	8	3	65	60
Båtsfjord	8	9	78	52
Sør-Varanger	67	202	282	343
Other regions	87	2471	108059	184127
Spitsbergen	87	451	163	97
Bjørnøya	0	0	0	0
Hopen	0	0	0	0
Jan Mayen	0	0	0	0
Continental shelf south of 62°N	9738	896	61113	162093
Continental shelf north of 62°N	2243	914	37503	21551
Air space above 100 m[2]	1028	43	919	210
Fishing in distant waters[3]	373	168	8360	177

[1] Emissions from international sea traffic in Norwegian ports. [2] Emissions of CO_2 from Norwegian aircraft above 100 m and emissions of other components between 100 m and 1000 m from domestic and international air transport. [3] 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 1995[2]	Per capita 1995
	Mill. tonnes						kg/1000 USD	Tonnes per capita
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	11 352	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	1997*	Percentage change 1980-1997
Emissions from														
Norway	16.7	9.0	9.0	9.1	10.1	9.9	10.4	11.0	10.1	10.1	11.3	11.9	12.1	-28
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	1.2	-20
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	0.2	-33
Denmark	3.0	2.3	2.5	2.7	2.2	3.1	2.1	2.4	2.1	2.8	2.6	1.6	1.5	-50
Netherlands	1.7	2.2	1.2	2.3	1.8	2.3	1.9	1.4	1.0	1.3	0.9	0.9	0.4	-76
United Kingdom	3.4	3.1	2.6	3.3	4.5	4.4	3.3	3.4	2.0	2.4	2.7	1.6	1.7	-50
Germany	4.8	5.0	3.7	6.1	4.8	4.9	4.0	3.9	2.7	4.9	3.7	2.7	1.4	-71
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	0.5	-50
Belgium	0.4	0.6	0.3	0.7	0.6	0.9	0.5	0.5	0.4	0.4	0.4	0.3	0.2	-50
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	0.7	-22
Poland	2.1	2.0	1.7	2.8	1.7	1.5	2.4	1.0	1.2	1.9	1.6	1.2	0.9	-57
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	0.0	-100
Other countries	1.3	1.7	1.5	0.9	1.6	1.6	1.0	1.2	1.0	0.8	1.1	0.5	0.4	-69
Unspecified	11.5	10.5	9.3	9.3	12.9	13.6	10.6	12.4	8.1	8.5	12.1	11.5	12.5	9
TOTAL	48.9	42.8	36.9	43.1	44.4	47.3	40.7	40.8	33.4	38.2	41.6	36.4	33.9	-31

Source: Berge (1998).

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	1997*	Percentage change 1980-1997
Emissions from														
Norway	5.3	6.4	7.7	7.3	6.8	6.3	7.1	6.9	6.9	6.5	7.5	9.1	8.6	62
Sweden	4.3	4.9	5.7	5.0	3.3	3.6	3.6	3.2	4.3	4.0	3.4	3.9	3.6	-16
Finland	1.0	1.4	1.4	1.0	0.9	1.1	0.8	0.8	1.2	1.0	0.9	0.8	0.9	-10
Denmark	2.8	2.4	3.6	3.3	2.8	2.9	3.1	2.7	2.3	3.0	2.5	2.5	2.5	-11
Netherlands	3.1	2.6	2.4	4.5	3.2	4.5	3.5	3.3	2.2	2.3	2.1	1.9	1.4	-55
United Kingdom	15.3	13.5	13.9	18.2	24.2	24.4	19.6	19.2	11.5	12.8	12.9	8.6	9.8	-36
Germany	11.9	9.6	8.8	13.3	10.4	9.5	9.6	7.6	6.3	7.4	5.9	4.7	3.0	-75
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	1.5	-44
Belgium	1.6	1.2	0.8	1.8	1.6	1.8	1.4	1.3	0.9	0.9	0.9	0.8	0.7	-56
CIS	1.5	2.5	2.4	2.4	1.1	1.8	1.5	0.7	1.7	1.4	1.1	1.9	0.9	-40
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	1.4	-52
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	0.2	-89
Ocean	2.4	6.1	5.6	7.3	7.5	8.7	6.5	6.9	5.0	5.7	7.4	5.2	5.7	138
Other countries	1.4	1.2	2.1	1.2	2.1	2.6	1.4	1.7	1.0	1.1	1.9	1.1	0.6	-57
Unspecified	14.9	16.2	15.1	14.5	18.4	19.8	15.9	14.8	12.7	13.4	15.4	12.4	12.9	-13
TOTAL	72.7	74.3	75.6	88.2	88.8	94.8	81.5	74.9	61.1	65.7	68.7	57.9	53.7	-26

Source: Berge (1998).

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	1997*	Percentage change 1980-1997
Emissions from														
Norway	13.2	9.0	7.2	6.6	5.8	5.1	4.5	3.7	3.0	2.9	3.4	3.8	3.8	-71
Sweden	8.3	5.2	5.1	4.2	2.2	1.9	1.7	1.4	1.9	1.7	1.5	1.7	1.3	-84
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	0.3	-88
Denmark	5.9	3.3	3.9	3.5	2.6	2.6	3.1	2.3	1.7	2.4	2.0	1.9	1.8	-69
Netherlands	2.4	1.2	0.9	1.7	1.0	1.3	0.9	0.9	0.5	0.6	0.5	0.4	0.3	-88
United Kingdom	33.4	23.8	22.4	28.3	35.4	36.3	25.5	24.2	14.3	13.6	14.2	6.9	8.7	-74
Germany	27.0	25.1	21.7	28.6	19.6	16.7	15.7	9.9	9.6	12.5	6.8	5.2	2.6	-90
France	5.4	2.4	1.6	2.4	2.7	3.4	1.8	1.9	1.3	1.5	2.0	1.2	0.9	-83
Belgium	3.1	1.7	0.9	1.9	1.4	1.6	1.2	1.1	0.7	0.8	0.7	0.6	0.5	-84
CIS	16.5	20.6	18.8	14.5	10.3	10.7	11.3	7.5	8.6	6.2	7.3	6.7	6.8	-59
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	2.7	-68
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	0.7	-88
Ocean	2.6	5.5	5.0	6.0	6.1	6.7	5.2	5.9	4.2	4.9	6.5	4.8	4.9	88
Natural emissions[1]	3.2	3.2	2.8	2.7	3.8	3.7	3.1	3.2	2.2	2.5	3.1	1.7	2.0	-38
Other countries	4.4	3.5	3.5	1.8	3.4	4.1	2.3	2.4	1.9	2.7	3.2	1.2	0.9	-80
Unspecified	35.8	36.4	33.1	33.8	42.5	43.8	36.8	37.1	29.5	29.6	34.9	35.4	37.3	4
TOTAL	177.6	155.6	141.9	153.9	147.8	148.6	125.5	109.6	88.7	93.1	94.7	77.6	75.5	-57

[1] Emissions from natural sources in oceans. Source: Berge (1998).

Appendix D

Waste

Table D1. **Quantities of municipal waste by treatment and waste type. 1992, 1995, 1996 and 1997**

	Total		Household waste		Industrial waste	
	Total	Recycled	Total	Recycled	Total	Recycled
			1 000 tonnes			
1992[1]	2 223	186	1 088	93	1 134	93
1995	2 722	373	1 262	229	1 460	144
1996	2 761	549	1 285	280	1 476	269
1997	2 721	671	1 354	393	1 367	278
			kg per capita			
1992[1]	517	43	247	22	264	22
1995	623	85	289	52	334	33
1996	629	126	293	64	336	62
1997	619	153	308	90	311	63

[1] In all 94 000 tonnes of waste of unknown origin, or 22 kg per capita, has been split equally between household and industrial waste.
Source: Statistics Norway.

Table D2. **Municipal waste delivered for material recovery, by material. 1995, 1996 and 1997. Tonnes**

	1995			1996[1]			1997[1]		
Material	Total	House-hold waste	Industrial waste	Total	House-hold waste	Industrial waste	Total	House-hold waste	Industrial waste
Total	372 592	228 771	143 821	548 800	279 800	269 000	671 300	393 400	277 900
Paper and cardboard, total	169 700	131 458	38 242	222 000	139 400	82 600	279 600	177 600	102 000
Paper	70 838	60 925	9 913	124 500	97 200	27 300	104 700	85 900	18 800
Cardboard	24 712	5 548	19 164	52 100	14 000	38 100	58 600	17 800	40 700
Beverage cartons	960	960	-	2 300	2 300	-	3 300	3 300	-
Paper and cardboard, mixed	73 190	64 025	9 164	43 000	25 800	17 200	113 100	70 600	42 500
Glass	17 856	15 896	1 960	19 900	18 600	1 300	23 500	22 400	1 100
Plastic	1 871	1 054	817	1 800	900	900	8 800	3 300	5 500
Iron and other metals	47 762	19 924	27 838	63 800	23 600	40 200	101 400	33 300	68 100
Food and organic waste, total	34 399	17 671	16 728	46 900	29 200	17 700	79 900	54 300	25 600
Food, slaughterhouse waste and fish waste to animal feed	16 504	2 842	13 661	19 800	7 000	12 900	29 200	5 500	23 700
Food and organic waste to central composting facilities	17 896	14 829	3 067	27 100	22 300	4 800	50 700	48 800	1 900
Wood waste	44 890	9 736	35 154	40 100	12 100	28 000	77 300	27 600	49 700
Park and garden waste	33 080	26 661	6 419	54 700	41 700	13 000	73 000	57 300	15 700
Textiles	4 101	3 996	105	7 300	7 300	-	7 400	7 400	-
Other	18 934	2 374	16 560	92 400	7 000	85 400	20 300	10 200	10 100

[1] The figures are based on sample surveys.
Source: Statistics Norway.

Table D3. **Number of municipalities, households and inhabitants served by schemes for sorting and collection at source, by material. 1995 and 1997**

	No. of municipalities	No. of households	No. of inhabitants
Total 1995	234	1 033 514	2 242 700
Total 1997	300	1 421 630	3 397 696
Paper and cardboard	283	1 349 935	3 266 345
Beverage cartons	191	1 074 148	2 567 214
Batteries	38	66 284	158 419
Glass	43	106 577	254 719
Food and organic waste to central composting facilities	105	294 109	702 921
Food, slaughterhouse waste and fish waste to animal feed	29	75 632	180 760
Metal	20	44 578	106 541
Hazardous waste	61	189 068	451 873
Other	26	46 581	111 329

Source: Statistics Norway.

Table D4. **Number of municipalities served by intermunicipal waste management companies, by region. 1997**

	Total	Municipalities served by intermunicipal companies	Number of municipalities considering integration
Whole country	435	308	48
Oslo and Akershus	23	17	-
Hedmark and Oppland	48	44	3
South-Eastern Norway	72	32	10
Agder and Rogaland	56	36	15
Western Norway	98	67	13
Trøndelag counties	49	30	7
North Norway	89	82	-

Source: Statistics Norway.

Table D5. **Division of labour between municipalities and intermunicipal waste management companies. Number of municipalities**

Tasks	Munici-pality	Inter-municipal company	Both	Not relevant	Other
Collection of fees from households	273	28	2	1	4
Administration of waste collection from households	38	212	34	9	15
Information to users/subscribers	62	210	32	0	4
Operation and administration of waste treatment and disposal plants	33	155	116	0	4
Operation and administration of recycling centres	10	283	5	2	8
Preparation of waste management plans	40	126	137	0	5

Source: Statistics Norway.

Table D6. **Average standard municipal fee[1] for waste collection, by region and size of municipality. 1997. NOK**

	Whole country	Fewer than 5 000 inhabitants	5 000 to 20 000 inhabitants	More than 20 000 inhabitants
Whole country	1 081	1 093	1 075	1 025
Oslo and Akershus	935	759	966	920
Hedmark and Oppland	933	859	965	1 119
South-Eastern Norway	979	939	1 051	983
Agder and Rogaland	983	959	1 018	967
Western Norway	1 150	1 158	1 145	1 072
Trøndelag	1 148	1 178	1 091	1 085
North Norway	1 229	1 230	1 226	1 235

[1]The standard fee is the annual waste collection fee paid by the largest number of subscribers in the municipality.
Source: Statistics Norway.

Table D7. **Household waste delivered for material recovery, by sorting method and material. 1995 and 1997. 1000 tonnes**

	1995				1997			
Material	Total	Sorting and collection at source	Sorting on delivery	Sorting at waste treatment and disposal plants/ recycling centres	Total	Sorting and collection at source	Sorting on delivery	Sorting at waste treatment and disposal plants/ recycling centres
Total	228.7	120.5	67.1	41.1	393.4	192.0	136.9	64.5
Paper and cardboard, total	131.3	101.2	27.3	2.8	177.7	134.7	37.8	5.2
Paper	61.8	42.2	18.8	0.8	85.9	58.9	26.5	0.5
Cardboard	5.5	2.8	1.7	1.0	17.8	3.9	9.2	4.7
Drinking cartons	0.8	0.3	0.5	-	3.3	1.7	1.6	-
Paper and cardboard, mixed	63.2	56.0	6.3	0.9	70.6	70.1	0.5	-
Glass	16.0	0.7	15.0	0.3	22.3	1.3	20.9	0.1
Plastic	0.9	0.1	0.3	0.5	3.4	0.9	0.1	2.4
Iron and other metal (not scrapped cars)	19.5	2.1	6.3	11.1	33.4	1.6	20.6	11.2
Food and biol. waste, total	18.1	15.6	0.4	2.1	54.4	50.7	3.1	0.6
Food, slaughterhouse waste and fish waste to animal feed	3.3	3.3	-	-	5.5	5.5	-	
Food and biol.waste to central composting facilities	14.8	12.3	0.4	2.1	48.9	45.2	3.1	0.6
Wood waste	9.7	-	2.4	7.3	27.6	0.1	18.4	9.1
Park and garden waste	26.7	0.4	11.5	14.8	57.3	2.5	27.0	27.8
Textiles	4.0	0.3	3.3	0.4	7.4	0.2	6.9	0.3
Other	2.4	-	0.5	1,9	10.2	-	2.2	8.0

Source: Statistics Norway.

Table D8. **Hazardous waste delivered to the system for hazardous waste management, by category. 1990-1998[1]. Tonnes**

Category of hazardous waste	1990	1991	1992	1993	1994	1995	1996	1997	1998[1]
Total	59 643	65 629	87 542	98 369	92 211	101 756	118 810	128 366	139 363
Waste oil	31 203	29 921	32 896	34 261	39 115	41 637	41 162	42 645	42 404
Other oil-contaminated waste	17 512	8 259	9 625	10 967	12 808	16 676	16 235	18 232	13 271
Stable oil emulsions	4 003	2 095	1 747	2 051	2 813	2 002	2 480	6 359	6 254
Waste solvent	1 530	2 379	2 485	3 022	4 884	4 319	3 989	3 894	3 699
Paints, glue, varnish and printing ink	2 047	2 308	2 849	2 820	2 782	3 580	4 060	3 995	3 703
Distillation residues	141	259	287	389	668	207	69	15	3
Tars	1	31	0	17	220	253	673	362	526
Waste containing mercury (Hg) or cadmium (Cd)	881	1 099	950	1 244	1 371	346	93	206	229
High priority metals or metal compounds that constitute a health or environmental hazard	-	-	-	-	19	1 883	3 262	3 637	17670[2.]
Waste containing cyanide	6	19	8	33	22	13	14	19	20
Pesticides	16	16	12	45	52	72	87	45	40
Isocyanates and other very reactive substances	8	4	14	22	37	55	63	52	109
Corrosive substances and products	1 439	1 343	1 264	2 473	1 896	2 554	4 084	4 308	6 123
Waste brought ashore from oil-drilling/production	-	16 590	33 592	36 673	19 867	21 296	35 244	38 125	38 333
Other very toxic or environmentally hazardous substances	808	948	1 240	2 739	1 978	2 865	2 464	2 482	2 008
Waste containing PCBs	16	16	13	27	911	123	287	87	39
Photographic chemicals	8	312	527	1 554	2 682	3 838	4 488	3 510	4 002
Halons	-	-	-	-	-	3	2	130	5
CFCs	-	-	-	-	-	0	46	15	44
Asbestos	..	..	..	..	..	..	..	182	407
Other unspecified waste	24	30	33	32	86	34	7	66	474

[1] Some of the figures for December 1998 are calculated.
[2] The rise is in the category slag, dust, ash, catalysts, blasting agents, etc.
In addition, there are lead accumulators (13 554 tonnes in 1998, 12 350 tonnes in 1997 and 12 653 tonnes in 1996).
Source: Norsas.

Table D9. **Hazardous waste delivered to the system for hazardous waste management, by county. 1991-1998[2]. Tonnes**

	1991[1.]	1992[1]	1993[1]	1994[1]	1995	1996	1997	1998[2]
Total	49 091	53 890	61 707	72 091	101 766	118 740	128 366	139 363
Østfold	1 990	2 226	3 100	5 993	5 998	6 133	5 956	11 037
Akershus	3 361	4 080	4 623	4 957	4 845	4 810	5 039	6 130
Oslo	3 261	2 987	3 744	5 597	5 532	6 938	8 807	10 439
Hedmark	1 010	1 155	1 230	1 534	1 401	2 101	1 836	2 168
Oppland	1 478	1 149	1 740	2 145	2 221	2 673	2 758	2 779
Buskerud	2 906	2 534	2 787	3 581	3 890	3 681	4 276	3 818
Vestfold	2 318	3 238	3 754	4 419	4 890	4 820	4 611	10 019
Telemark	2 563	2 393	2 200	2 191	3 428	3 743	3 462	4 042
Aust-Agder	647	700	655	859	960	1 001	1 317	808
Vest-Agder	2 019	1 799	2 689	2 544	1 959	2 445	3 278	2 920
Rogaland	5 816	8 290	9 060	10 258	14 095	17 201	18 245	15 439
Hordaland	10 518	10 251	10 681	12 693	26 571	27 824	20 814	14 891
Sogn og Fjordane	1 383	1 822	2 901	1 989	11 639	13 086	14 560	19 594
Møre og Romsdal	2 785	3 430	4 131	4 206	4 534	11 628	22 299	22 035
Sør-Trøndelag	1 761	2 125	1 985	2 248	2 616	2 738	2 818	4 013
Nord-Trøndelag	976	1 015	1 157	1 443	1 370	1 333	1 331	2 014
Nordland	2 395	2 539	2 994	3 133	3 366	3 362	3 507	3 836
Troms	1 086	1 398	1 560	1 517	1 756	2 250	2 114	2 251
Finnmark	789	718	674	747	656	874	1 288	1 105
Svalbard and Jan Mayen	29	41	42	37	40	48	50	25

[1] Waste brought ashore from oil drilling/production not included.
[2] Some of the figures for December 1998 are calculated.
Source: Norsas.

Table D10. **Supply of goods for paper split by product category. 1976-1997. 1 000 tonnes**

	1976	1980	1985	1990	1994	1995	1996	1997
Total supply of paper	682	687	829	907	929	926	921	990
Total supply of printed matter	276	319	436	441	474	489	519	544
Primary goods	237	264	364	382	415	425	457	474
Imports	39	67	117	129	201	199	224	248
Exports	605	797	1046	1132	1367	1499	1390	1499
Production	802	995	1292	1385	1582	1725	1622	1725
Processed goods	39	55	73	59	59	64	62	70
Imports	53	65	91	70	74	78	79	84
Exports	13	10	19	11	15	14	18	14
Total supply of packaging	210	212	256	281	259	230	209	242
Primary goods	159	161	199	219	193	154	130	161
Imports	38	52	76	92	145	164	148	170
Exports	218	198	182	297	390	392	379	400
Production	339	308	306	423	438	382	361	391
Processed goods	1	1	7	13	17	26	29	32
Imports	12	19	24	27	41	48	51	54
Exports	11	18	17	15	24	22	22	23
Packaged goods	50	50	50	50	50	50	50	50
Imports	131	131	131	131	131	131	131	131
Exports	81	81	81	81	81	81	81	81
Supply of building paper	1	0	1	2	2	2	2	2
Primary goods	1	0	1	2	2	2	2	2
Imports	2	1	2	2	2	2	2	2
Exports	1	1	0	0	0	0	0	0
Supply of sanitary and household goods	34	50	70	95	79	75	75	77
Primary goods	29	43	58	76	60	56	56	59
Imports	6	14	25	45	42	42	46	47
Exports	4	5	5	19	15	17	19	19
Production	27	34	38	50	33	30	30	31
Processed goods	5	7	12	18	20	19	18	18
Imports	7	10	15	20	21	20	19	19
Exports	2	3	3	1	1	1	1	1
Supply of other products	161	106	64	89	114	130	116	125
Primary goods	160	105	63	85	110	127	113	121
Imports	18	24	38	55	69	66	74	81
Exports	54	53	58	40	77	78	69	77
Production	196	134	84	70	119	138	108	118
Processed goods	1	1	1	3	4	3	4	3
Imports	1	1	1	4	4	4	4	4
Exports	0	0	0	0	0	1	1	1

Sources: Statistics Norway and Norwegian Food Research Institute (1994).

Table D11. **Quantities of waste paper by method of treatment or disposal. 1976-1997. 1 000 tonnes**

	1976	1980	1985	1990	1994	1995	1996	1997
Calculated quantity of paper, total	682	687	829	907	929	926	921	990
Landfill	495	504	575	566	467	443	418	410
Material recovery	121	116	131	182	320	346	367	432
Incineration	49	47	94	128	106	101	98	111
To sewer system	17	20	30	32	36	36	38	37

Source: Statistics Norway.

Table D12. **Waste paper by origin. 1985-1997. 1 000 tonnes**

	1985	1990	1991	1992	1993	1994	1995	1996	1997
Total	829	907	928	941	931	929	926	921	990
From households	410	446	455	471	457	465	462	467	522
From manufacturing industries	180	201	206	205	209	191	175	163	175
From service industries	211	231	237	235	238	246	262	262	260
From other industries	28	30	30	30	27	27	27	28	32

Source: Statistics Norway.

Table D13. **Quantities of metal waste by product type. Calculated according to the supply of goods method. 1990-1996. Tonnes**

	1990	1991	1992	1993	1994	1995	1996
Total	1 320 749	1 602 357	1 767 257	1 939 176	1 947 168	1 970 391	2 130 892
Consumer waste	1 212 057	1 537 461	1 700 416	1 796 649	1 851 502	1 874 725	2 035 226
Buildings	49 515	51 526	53 422	55 212	56 917	58 524	63 803
Electrical/electronic	112 983	121 386	130 480	138 163	144 810	151 340	156 473
Packaging	47 721	41 887	43 844	43 385	42 903	41 991	40 244
Machinery and tools	147 141	149 686	164 447	175 397	181 175	182 928	195 317
Furniture	41 430	43 439	44 651	44 675	43 463	41 044	48 871
Ships and other large structures	100 374	106 726	113 408	120 364	127 684	133 356	148 068
Means of transport excl. ships	266 345	280 912	306 740	304 752	299 126	299 165	308 887
Roads and outdoor installations	34 309	36 480	38 764	41 141	43 643	46 250	52 969
Sanitary/household	9 180	9 471	9 759	10 115	10 628	11 316	12 728
Pipes and other products	403 060	695 949	794 899	863 445	901 153	908 811	1 007 864
Production waste[1]	108 693	64 896	66 841	142 527	95 666	95 666	95 666

[1] Quantity of production waste for 1994-1996 has been stipulated as the average of earlier years.
Source: Statistics Norway.

Table D14. **Metal waste by origin and treatment. Calculated from the available waste statistics. 1992-1996. Tonnes**

	Private households	Manufac-turing	Construc-tion	Service industries	Other	Total
Total 1992	111 097	201 525	41 547	156 171	13 995	524 335
Re-use (car parts)	2 688	..	..	520	..	3 208
Material recovery[1,2]	50 805	173 885	27 790	44 374	8 528	406 983
Landfill or dumped	57 603	27 640	13 757	27 018	5 467	131 486
Exports[1]	..	..	..	84 259	..	84 259
Statistical errors[2]	.	.	.	.	.	101 601
Total 1993	115 324	181 633	38 573	107 071	16 247	458 849
Re-use (car parts)	2 753	..	..	518	..	3 271
Material recovery[1,2]	60 406	159 716	25 801	45 552	9 423	382 784
Landfill or dumped	52 166	21 917	12 772	28 369	6 824	122 04
Exports[1]	..	..	..	32 632	..	32 632
Statistical errors[2]	.	.	.	.	.	81 886
Total 1994	116 909	214 972	40 300	266 141	19 790	658 112
Re-use (car parts)	2 670	..	..	512	..	3 182
Material recovery[1,2]	61 292	192 610	26 956	49 111	11 904	400 018
Landfill or dumped	52 947	22 362	13 344	30 193	7 886	126 731
Exports[1]	..	..	..	186 325	..	186 325
Statistical errors[2]	.	.	.	.	.	58 145
Total 1995	126 196	221 380	43 192	97 921	18 070	506 75
Re-use (car parts)	3 009	..	..	544	..	3 552
Material recovery[1,2]	66 251	202 010	28 890	59 664	10 396	514 113
Landfill or dumped	56 936	19 369	14 302	34 279	7 674	132 561
Exports[1]	..	..	..	3 434	..	3 434
Statistical errors[2]	.	.	.	.	.	146 902
Total 1996	263 145	256 863	44 873	131 917	20 217	717 016
Re-use (car parts)	9 779	..	..	1 096	..	10 875
Material recovery[1,2]	127 220	238 458	30 015	71 375	11 820	547 644
Landfill or dumped	126 146	18 406	14 859	42 528	8 398	210 336
Exports[1]	..	..	..	16 918	..	16 918
Statistical errors[2]	.	.	.	.	.	68 758

[1] Scrap metal exported for material recovery is classified as material recovery.
[2] The figures for total material recovery are from the industry's own statistics and Statistics Norway's export statistics. They do not agree with the total figures for material recovery reported in the waste statistics. The differences are given as statistical errors.
Source: Statistics Norway.

Table D15. **Quantities of wet organic waste calculated by the supply of goods and waste statistics methods. Tonnes**

	1990	1991	1992	1993	1994	1995	1996
Supply of goods	1 669 792	1 266 704	1 640 852	2 074 069	1 678 117	2 111 912	2 032 194
Waste statistics	1 061 840	1 149 178	1 272 919	1 371 814	1 443 663	1 526 198	1 509 574
Park and garden waste[1]	34 998	37 080	39 162	41 244	43 327	45 409	46 237

[1]Park and garden waste is not included in the figures for supply of goods. To allow comparison, this fraction has also been omitted from the figures for waste statistics, but is included in the figures in table D16.
Source: Statistics Norway.

Table D16. **Wet organic waste by origin and method of disposal. Tonnes**

	Total[1]	Private households	Manufacturing	Construction	Service industries	Fisheries	Fish farming	Other
Total 1993	1 413 058	358 325	463 750	2 666	68 968	462 000	37 000	20 350
Fodder	407 234	7 666	173 783	-	13 285	178 000	34 500	-
Compost	12 147	9 088	1 354	165	1 149	-	-	391
Incineration	91 725	66 080	10 131	500	11 201	-	-	3 814
Landfill	603 223	278 134	277 287	2 021	43 780	-	2 000	-
Dumped	268 000	-	-	-	-	268 000	-	-
Other/unspecified	34 398	-	1 600	-	-	16 000	500	16 298
Total 1994	1 486 990	375 709	440 239	2 899	74 015	530 000	42 000	22 128
Fodder	461 577	7 947	182 560	-	14 570	216 000	40 500	-
Compost	23 042	17 875	2 329	189	1 976	-	-	673
Incineration	98 052	69 951	11 101	547	12 274	-	-	4 179
Landfill	574 697	282 735	243 093	2 184	45 686	-	1 000	-
Dumped	297 000	-	-	-	-	297 000	-	-
Other/unspecified	36 543	-	1 600	-	-	17 000	500	17 443
Total 1995	1 571 607	393 608	416 728	3 132	79 234	602 000	53 000	23 905
Fodder	556 987	8 742	192 488	-	16 027	293 730	46 000	-
Compost	52 079	41 428	4 883	215	4 143	-	-	1 411
Incineration	104 464	73 873	12 085	596	13 361	-	-	4 549
Landfill	529 257	272 519	206 156	2 345	46 237	-	2 000	-
Dumped	287 270	-	-	-	-	287 270	-	-
Other/unspecified	45 728	-	1 600	-	-	21 000	5 000	18 128
Total 1996	1 555 811	396 632	393 217	3 166	79 632	596 000	63 000	24 164
Fodder	567 033	8 333	195 794	-	15 277	292 950	54 679	-
Compost	83 796	64 000	9 162	213	7 775	-	-	2 647
Incineration	156 183	110 684	17 974	886	19 873	-	-	6 766
Landfill	429 431	218 043	169 406	2 102	37 503	-	2 377	-
Dumped	282 050	-	-	-	-	282 050	-	-
Other/unspecified	43 565	-	1 600	-	-	21 000	5 943	15 022

[1] Including park and garden waste.
Source: Statistics Norway.

Table D17. **Calculated quantities of glass waste by sector and product type. 1996. Tonnes**

	Total	Private house-holds	Agricul-ture, fore-stry and fisheries	Mining and quarrying	Manu-facturing	Electricity, gas and water supplies	Con-struction	Service industries and other
Total	121 420	44 000	990	210	14 890	210	44 180	16 940
Packaging	55 010	33 800	470	100	13 370	100	560	6 610
Windows	43 000	-	-	-	-	-	43 000	0
Vehicles and other means of transport	3 000	-	-	-	-	-	0	3 000
Furniture and fittings	2 390	1 200	60	10	180	10	70	860
Electrical and electronic products	5 010	2 500	130	30	370	30	150	1 800
Other products	13 010	6 500	330	70	970	70	400	4 670

Source: Statistics Norway.

Table D18. **Percentages of glass waste used for material recovery by sector and product types. 1996**

	Total	Private house-holds	Agricul-ture, fore-stry and fisheries	Mining and quarrying	Manu-facturing	Electricity, gas and water supplies	Con-struction	Service industries and other
Total	28	50	13	13	58	13	2	11
Packaging	60	65	28	28	65	28	28	28
Windows	2	-	-	-	-	-	2	-
Other products	-	-	-	-	-	-	-	-

Source: Statistics Norway.

Appendix E

Waste water treatment

Table E1. **Inputs of phosphorus and nitrogen to the North Sea from Norway. 1985, 1990-1997. Tonnes**

	1985	1990	1991	1992	1993	1994	1995	1996	1997	Change 1985-1997
Phosphorus (P)										Per cent
Total inputs	1 519	1 280	1 228	1 100	1 088	1 019	962	962	948	-38
- of which anthropogenic[1]	1 154	915	863	735	723	654	597	597	583	-69
Agriculture	290	266	259	246	223	214	211	214	214	-26
Municipal waste water	731	541	501	396	390	364	307	301	289	-60
Industry	133	108	103	93	110	76	79	82	80	-40
Background runoff	365	365	365	365	365	365	365	365	365	0
Nitrogen (N)										
Total inputs	44 756	40 756	40 253	39 389	38 456	38 360	38 242	38 314	37 545	-16
- of which anthropogenic[1]	28 201	24 201	23 698	22 834	21 901	21 805	21 687	21 759	20 990	-26
Agriculture	12 640	12 029	11 769	11 406	10 720	10 267	10 245	10 289	10 289	-19
Municipal waste water	9 902	9 780	9 715	9 635	9 478	9 769	9 531	9 402	8 835	-11
Industry	5 659	2 392	2 214	1 793	1 703	1 769	1 911	2 068	1 866	-67
Background runoff	16 555	16 555	16 555	16 555	16 555	16 555	16 555	16 555	16 555	0

[1] Anthropogenic sources are agriculture, municipal waste water and industry.
Source: Norwegian Institute for Water Research.

Table E2. **Municipal waste water treatment. Hydraulic capacity (IE) and number of plants by size categories and treatment methods. 1997**

		Size by hydraulic capacity (IE)					
Treatment method	Total	50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total IE	5 801 220	34 910	283 950	500 820	1 073 960	1 456 580	2 451 000
Untreated	576 350	5 020	57 340	135 416	230 297	148 280	-
Mechanical	1 357 700	14 210	131 991	156 558	358 244	472 700	224 000
Chemical	2 568 060	1 175	7 172	62 524	316 590	728 600	1 452 000
Biological	95 450	1 285	14 460	31 205	6 500	42 000	-
Chemical/biological	1 114 840	1 421	33 655	105 930	133 830	65 000	775 000
Other/unknown	88 810	11 800	39 328	9 185	28 500	-	-
Number of plants, total	2 811	531	1360	550	274	79	17
Untreated	551	76	265	143	60	7	-
Mechanical	1 169	221	647	176	94	29	2
Chemical	234	16	30	64	74	36	13
Biological	125	19	67	34	3	2	-
Chemical/biological	319	23	132	121	37	5	2
Other/unknown	413	176	219	12	6	-	-

Source: Statistics Norway.

Table E3. **Hydraulic capacity by type of plant and per capita hydraulic capacity. By county. 1997**

Region/county	Hydraulic capacity							Proportion		
	Total	Chemical	Biological	Chemical/biological	Mechanical	Untreated discharges	Other	High-grade[1]	Other type	Per capita capacity
	1 000 I.E.							Per cent		I.E.
Whole country (01-20)	5801.2	2568.1	95.5	1114.8	1357.7	576.4	88.8	63	37	1.32
North Sea counties (01-10)	3377.7	2072.6	38.3	1021.1	187.7	5.6	52.5	92	8	1.41
- of which Inner Oslofjord	1182.7	477.7	0.1	703.1	0.8	-	1.0	99.8	0.2	1.50
Rest of country (11-20)	2423.5	495.4	57.2	93.8	1170.1	570.7	36.4	24	76	1.22
01 Østfold	354.6	328.5	0.6	22.9	2.4	0.1	0.2	99	1	1.47
02/03 Oslo and Akershus	1388.2	677.7	0.3	708.8	-	-	1.3	99.9	0.1	1.48
04 Hedmark	218.3	81.7	2.6	109.2	2.1	-	22.7	87	13	1.17
05 Oppland	276.3	155.1	0.6	101.8	1.4	-	17.5	93	7	1.51
06 Buskerud	309.0	264.5	1.8	33.3	1.9	-	7.6	96	4	1.34
07 Vestfold	224.0	166.3	-	14.9	42.6	-	0.2	81	19	1.09
08 Telemark	242.3	212.5	13.5	13.2	1.5	0.9	0.9	93	7	1.48
09 Aust-Agder	147.3	33.4	17.4	9.2	86.0	0.7	0.8	29	71	1.46
10 Vest-Agder	217.7	153.1	1.6	7.9	49.9	4.0	1.3	74	26	1.44
11 Rogaland	508.3	251.7	26.4	1.3	167.6	56.2	5.2	50	50	1.41
12 Hordaland	353.9	66.4	3.2	25.8	243.3	13.5	1.8	26	74	0.83
14 Sogn og Fjordane	109.2	0.1	4.1	2.9	68.9	29.5	3.7	3	97	1.01
15 Møre og Romsdal	374.8	20.0	0.8	2.8	141.1	204.0	6.2	6	94	1.55
16 Sør-Trøndelag	373.2	138.3	4.3	19.7	205.8	2.0	3.0	42	58	1.44
17 Nord-Trøndelag	180.9	10.2	11.0	10.1	144.0	2.1	3.5	11	89	1.42
18 Nordland	222.9	2.1	6.4	1.9	97.7	112.8	2.0	2	98	0.93
19 Troms	206.1	4.6	0.9	17.9	70.7	102.4	9.8	11	89	1.36
20 Finnmark	94.3	2.1	0.1	11.5	31.0	48.4	1.3	14	86	1.25

[1] High-grade plants are those providing chemical or chemical/biological treatment.
Source: Statistics Norway.

Table E4. **Number of separate waste water treatment plants (scattered settlements). County. 1997**

County/region	Total	Type of plant							
		Un-treated dis-charges	Sludge separa-tor	Mini wwtp without precipi-tation	Mini wwtp with precipi-tation	Infiltra-tion	Sand-trap	Separate toilet systems	Sealed tank
Whole country (01-20)	331 820	23 000	146 740	1 390	2 690	105 480	33 020	13 890	5 610
North Sea counties (01-10)	154 880	6 000	48 940	910	1 920	69 230	11 810	11 550	4 530
- of which inner Oslofjord	8 630	930	2 970	130	360	1 990	1 160	530	560
Rest of country (11-20)	176 940	17 000	97 800	480	770	36 250	21 210	2 340	1 080
01 Østfold	13 690	487	8 396	55	430	468	1 012	2 768	74
02/03 Oslo and Akershus	19 093	1 943	8 227	625	564	3 650	2 460	806	818
04 Hedmark	30 906	363	6 026	-	209	18 605	2 147	3 393	163
05 Oppland	29 173	175	3 541	3	21	21 986	372	2 253	822
06 Buskerud	17 670	351	5 053	37	163	9 460	901	891	814
07 Vestfold	13 352	1 914	8 334	120	180	717	919	208	960
08 Telemark	12 960	122	4 654	42	55	5 272	2 338	38	439
09 Aust-Agder	10 008	478	2 939	10	204	4 873	1 114	178	212
10 Vest-Agder	8 024	164	1 771	19	87	4 198	547	1 011	227
11 Rogaland	16 139	1 815	9 413	58	179	2 747	1 333	289	305
12 Hordaland	39 719	1 764	20 531	104	478	8 621	7 456	607	158
14 Sogn og Fjordane	13 939	1 317	5 504	22	5	4 331	2 718	6	36
15 Møre og Romsdal	25 042	2 966	16 389	7	10	2 889	2 303	329	149
16 Sør-Trøndelag	19 819	1 132	8 555	59	63	6 115	2 922	847	126
17 Nord-Trøndelag	12 356	846	5 571	210	27	1 659	3 618	173	252
18 Nordland	23 274	3 981	14 458	19	10	3 849	823	80	54
19 Troms	21 138	2 485	15 170	-	1	3 452	14	14	2
20 Finnmark	5 517	699	2 204	-	-	2 589	25	-	-

Source: Statistics Norway.

Table E5. **Total sludge production and quantities used for different purposes. Whole country, 1993-1997. Tonnes dry weight**

	1993	1994	1995	1996	1997
Total	70 250	71 850	75 810	78 570	94 040
Agriculture	39 900	40 070	44 630	46 510	48 110
Parks etc.	8 880	3 370	6 270	8 640	8 730
Landfills	17 660	15 460	11 070	11 680	20 010
Other	3 810	12 950	13 840	11 740	17 190

Source: Statistics Norway.

Table E6. **Nutrients and organic matter in sewage sludge as percentage of dry weight. 1996**

Substance	Mean value per plant	Min. value	Max value	Standard deviation
Organic material	62.1	19.9	97.0	15.7
Nitrogen (Kjeldahl-N)	2.8	0.2	5.0	0.9
Nitrogen (NH_3-N)	0.3	0.0	1.3	0.3
Total phosphorus	1.6	0.0	10.2	1.2
Potassium	0.2	0.0	1.3	0.2
Calcium	3.4	0.0	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. 1993-1997**

	Annual costs per subscriber[1]					Income-to-cost ratio[2]				
County/region	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
	NOK					Per cent				
Whole country	2 405	2 109	2 240	2 081	2 075	77	91	92	95	102
North Sea counties	2 790	2 507	2 648	2 632	2 393	76	89	92	93	99
- of which Oslofjord Oslofjord municipalities	2 523	2 045	2 106	2 120	1 721	73	106	107	105	111
Rest of country	1 848	1 585	1 721	1 470	1 662	80	96	94	99	107
Østfold	2 881	2 661	2 842	2 841	2 826	91	90	96	97	103
Akershus	2 481	2 324	2 488	2 378	2 255	71	79	84	86	101
Oslo	2 675	1 955	1 974	2 075	1 567	74	121	120	114	114
Hedmark	3 157	2 787	2 830	2 725	2 803	72	79	83	86	90
Oppland	5 017	3 422	3 605	3 755	3 467	65	70	71	69	74
Buskerud	3 339	2 989	3 443	3 240	3 058	70	76	82	85	92
Vestfold	1 712	2 155	2 294	2 332	2 217	92	112	98	106	114
Telemark	2 898	2 570	2 956	2 893	2 874	78	63	86	99	95
Aust-Agder	2 950	3 529	3 651	3 538	3 377	78	80	81	87	93
Vest-Agder	2 687	3 135	3 149	3 035	3 020	79	75	80	81	88
Rogaland	2 076	1 992	2 043	1 959	1 958	54	83	84	89	96
Hordaland	1 865	1 824	2 070	1 566	1 646	102	114	110	114	121
Sogn og Fjordane	1 850	1 722	1 821	1 916	1 772	81	87	82	90	101
Møre og Romsdal	1 865	1 685	1 610	1 564	1 545	77	85	88	95	101
Sør-Trøndelag	2 206	1 224	1 346	1 337	1 366	92	95	95	99	113
Nord-Trøndelag	2 516	2 062	2 270	2 154	2 092	83	102	91	95	98
Nordland	1 371	1 149	1 279	783	1 608	85	93	91	93	103
Troms	1 593	1 179	1 465	1 335	1 648	83	111	103	121	113
Finnmark	794	1 071	1 251	1 137	1 124	33	90	93	91	101

[1] Reported figures for subscribers in 1997 adjusted using estimated figures for muncipalities that did not provide reports.
[2] Municipalities that did not report investments or that reported no investments in 1997 omitted.
Source: Statistics Norway.

Table E8. **Average fees quoted by municipality, 1994 - 1998. NOK**

	Connection fee					Annual fee per 140 m^2 dwelling				
County/region	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998
Whole country	8 836	10 661	11 151	11 324	11 690	1 152	1 463	1 517	1 668	1 770
North Sea counties	10 000	13 550	14 158	14 260	14 647	1 609	2 021	2 072	2 247	2 343
-of which inner Oslofjord municipalities	13 992	14 605	14 050	13 475	15 875	1 696	2 126	2 291	1 860	2 070
Rest of country	8 069	8 730	9 143	9 378	9 860	889	1 116	1 176	1 314	1 390
Østfold	7 112	7 450	8 015	7 916	8 248	1 958	1 979	2 242	2 456	2 576
Akershus	12 788	17 192	15 358	15 395	25 809	1 646	2 195	2 317	2 403	2 410
Oslo	..	3 570	18 300	18 300	5 981	770	1 080	1 128	1 128	1 877
Hedmark	10 450	13 315	17 522	17 931	19 147	1 599	2 485	2 077	2 333	2 449
Oppland	8 557	18 151	22 274	22 891	22 853	1 629	2 085	2 288	2 413	2 447
Buskerud	8 737	11 780	10 731	11 544	9 642	1 745	2 462	2 353	2 434	2 316
Vestfold	16 216	16 618	19 379	17 942	20 286	1 538	1 496	1 686	1 909	2 023
Telemark	5 374	8 058	7 539	6 286	6 146	..	2 002	2 073	2 359	2 567
Aust-Agder	9 789	12 372	11 148	11 889	12 204	1 287	1 692	1 738	1 864	2 041
Vest-Agder	9 882	15 512	11 017	11 658	12 371	1 435	1 596	1 606	1 861	2 094
Rogaland	9 557	10 951	10 401	11 257	11 024	868	944	1 111	1 162	1 269
Hordaland	8 930	8 495	10 140	10 742	11 132	803	990	1 098	1 217	1 284
Sogn og Fjordane	8 124	11 556	11 735	11 841	11 954	1 007	1 179	1 207	1 417	1 469
Møre og Romsdal	8 642	8 926	9 427	9 227	9 247	899	1 025	1 108	1 242	1 288
Sør-Trøndelag	9 980	11 810	12 313	12 116	13 074	1 183	1 390	1 475	1 579	1 664
Nord-Trøndelag	7 340	7 588	8 230	9 000	10 734	1 194	1 690	1 759	1 899	1 953
Nordland	5 280	5 898	7 124	7 698	8 060	726	951	1 088	1 248	1 324
Troms	3 339	4 198	4 349	4 431	4 573	662	848	928	1 044	1 101
Finnmark	10 349	12 588	9 524	8 574	9 419	793	1 309	910	1 131	1 264

Source: Statistics Norway.

Table E9. **Gross investments in the municipal waste water sector. Planned investments and investments per subscriber. By county. 1997**[1]

County/region	Actual investments	Planned investments in 1997	Proportion carried out	Number of subscribers	Investment per subscriber
	1 000 NOK		Per cent		NOK
Whole country	1 459 960	1 940 215	75	1 567 482	931
North Sea counties	739 623	1 035 448	71	889 636	831
- of which inner Oslofjord municipalities	157 454	278 845	56	376 209	419
Rest of country	720 337	904 767	80	677 846	1 063
Østfold	110 804	140 198	79	84 928	1 305
Akershus	144 292	205 430	70	170 856	845
Oslo	75 075	180 900	42	256 273	293
Hedmark	69 897	87 918	80	58 159	1 202
Oppland	58 717	70 649	83	55 772	1 053
Buskerud	47 408	52 000	91	67 931	698
Vestfold	64 179	100 969	64	70 205	914
Telemark	57 746	60 744	95	50 828	1 136
Aust-Agder	46 112	85 970	54	29 937	1 540
Vest-Agder	65 394	50 670	129	44 748	1 461
Rogaland	104 981	177 808	59	131 163	800
Hordaland	269 073	273 785	98	149 640	1 798
Sogn og Fjordane	27 366	47 822	57	25 732	1 063
Møre og Romsdal	63 531	85 799	74	73 724	862
Sør-Trøndelag	57 140	84 206	68	104 618	546
Nord-Trøndelag	48 899	80 264	61	42 899	1 140
Nordland	84 481	81 249	104	69 215	1 221
Troms	52 264	58 923	89	51 404	1 017
Finnmark	12 601	14 911	85	29 451	428

[1] Some counties did not report these figures, and in these cases estimates have been used.
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
1998*	10 465	3 421	716	4 894	1 434

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	72.8	17.0	91.7	76.0	13.8	12.0	18.6	7.3
1997	112.9	73.6	17.2	93.6	75.8	13.5	12.1	18.9	6.7

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
1997/98	112 327	13 408	10.7	1.3

Sources: Statistics Norway and Norwegian Agricultural Inspection Service.

Table F4. **Cereal and oil seed acreage by type of tillage. Autumn-sown cereals**

	Total[1]	Autumn-sown	Autumn-ploughed	Autumn-harrowed, no autumn ploughing	All tillage in spring	No tillage	Unspecified tillage[2]
	Decares	Per cent					
Whole country							
1989/90	3 649 601	3.0	81.6	..	..	0.3	18.2
1996/97	3 363 586	6.8	56.5	3.2	39.2	1.2	..
1997/98*	3 271 955	11.1	57.3	4.6	36.4	1.7	..
Sensitive area for phosphorus (P)							
1989/90	3 019 682	3.5	83.6	..	..	0.3	16.1
1996/97	2 841 914	7.9	56.8	3.7	38.2	1.3	..
1997/98*	2 764 138	12.9	58.3	5.2	34.6	1.9	..
01 Østfold							
1989/90	660 337	5.3	91.6	..	..	0.5	7.9
1996/97	646 500	13.4	62.0	2.7	34.0	1.3	..
1997/98*	637 944	21.9	61.9	5.8	30.3	1.9	..
02/03 Akershus/Oslo							
1989/90	699 503	3.6	89.5	..	..	0.2	10.3
1996/97	650 036	9.0	64.1	2.8	31.3	1.7	..
1997/98*	622 656	15.7	63.2	6.3	27.1	3.5	..
04 Hedmark							
1989/90	657 356	1.1	75.5	..	..	0.1	24.4
1996/97	619 397	2.0	52.6	5.5	41.0	0.9	..
1997/98*	593 427	4.3	54.2	5.9	38.7	1.2	..
05 Oppland							
1989/90	287 309	2.6	74.6	..	..	0.4	25.0
1996/97	253 259	1.3	56.5	4.9	37.4	1.3	..
1997/98*	247 286	4.4	63.2	4.8	30.5	1.5	..
06 Buskerud							
1989/90	306 307	3.6	81.7	..	..	0.1	18.1
1996/97	289 284	7.7	47.7	5.2	45.8	1.3	..
1997/98*	286 981	10.7	48.8	4.9	44.9	1.4	..
07 Vestfold							
1989/90	327 163	5.2	84.1	..	..	0.7	15.2
1996/97	315 115	11.7	52.8	1.5	43.9	1.8	..
1997/98*	306 149	15.7	58.2	2.1	38.9	0.9	..
08 Telemark							
1989/90	107 438	4.1	74.0	..	..	0.0	26.0
1996/97	95 237	4.1	42.1	2.4	55.5	0.0	..
1997/98*	92 807	5.3	44.0	2.3	53.3	0.4	..
11 Rogaland							
1989/90	50 788	0.1	9.6	..	..	0.7	89.7
1996/97	34 563	0.2	2.8	0.3	95.8	1.1	..
1997/98*	36 696	0.4	4.7	1.9	89.6	3.7	..
16 Sør-Trøndelag							
1989/90	165 710	0.1	74.5	..	..	0.1	25.5
1996/97	139 830	1.3	57.8	0.2	41.8	0.3	..
1997/98*	140 492	0.3	54.0	0.2	44.9	0.8	..
17 Nord-Trøndelag							
1989/90	327 353	0.4	82.0	..	..	0.0	17.9
1996/97	281 808	0.4	61.5	0.5	37.9	0.0	..
1997/98*	270 613	1.3	58.5	0.7	40.4	0.4	..

[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 (1999).

Table F5. **Sales of pesticides. Environmental taxes on pesticides**

	Sales of pesticides/Tonnes active substances					Taxes as per cent of purchase price		Taxes, million NOK		
	Total	Fungicides	Insecticides	Herbicides	Other substances, including additives	Environmental tax	Control fee	Total	Environmental tax	Control fee
	Tonnes					Per cent		Million NOK		
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. **Areas farmed ecologically and in the process of conversion. 1998**

	Ecologically farmed and in the process of conversion	Total agricultural area	Proportion
	Decares		Per cent
Whole country	105 200	10 160 920	1.0
Østfold	3 819	759 979	0.5
Akershus	9 372	801 825	1.2
Hedmark	14 170	1 064 076	1.3
Oppland	10 973	1 012 627	1.1
Buskerud	5 949	509 866	1.2
Vestfold	5 640	428 026	1.3
Telemark	3 226	251 093	1.3
Aust-Agder	1 449	116 813	1.2
Vest-Agder	3 601	197 197	1.8
Rogaland	3 685	916 624	0.4
Hordaland	4 975	461 252	1.1
Sogn og Fjordane	5 719	469 804	1.2
Møre og Romsdal	5 564	609 814	0.9
Sør-Trøndelag	8 871	751 984	1.2
Nord-Trøndelag	6 472	878 242	0.7
Nordland	6 957	564 625	1.2
Troms	4 483	265 021	1.7
Finnmark	274	102 052	0.3

Sources: DEBIO and Norwegian National Grain Administration.

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	Total	Spruce	Pine	Broad-leaved
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	70	4 800	280	50	820
1978	1 800	260	480	60	4 250	350	70	810
1979	1 490	320	480	70	4 160	390	110	800
1980	1 210	250	550	60	6 720	470	140	1 020
1981	1 200	190	530	70	3 900	500	200	860
1982	1 010	110	480	70	3 780	500	290	840
1983	750	70	480	80	4 230	570	440	650
1984	870	50	400	70	2 960	590	720	720
1985	1 010	150	370	70	860	490	750	500
1986	1 250	290	350	70	120	410	770	680
1987	1 060	250	370	60	100	980	880	570
1988	840	170	360	60	430	3 120	1 140	430
1989	910	140	330	60	860	3 840	1 270	420
1990	960	130	400	50	5 830	3 990	1 150	330
1991	1 500	170	510	40	7 290	4 160	960	300
1992	1 910	280	650	30	5 150	4 000	700	410
1993	2 440	550	690	30	800	3 860	470	340
1994	2 270	610	660	30	200	4 510	540	450
1995	2 010	610	700	30	190	4 900	550	450
1996	1 920	550	660	40	500	5 540	520	400
1997	1 850	430	620	40	910	10 150	750	520
1998	1 560	330	640	40	2 050	9 840	1 150	470

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	4 060	..
1982	840	590	490	570	60	2 970	..
1983	760	700	510	560	70	2 040	..
1984	1 490	640	480	570	70	1 790	2 750
1985	860	580	440	560	60	2 080	2 710
1986	720	550	660	660	50	2 490	2 740
1987	1 070	400	540	650	60	2 080	2 730
1988	430	370	420	640	70	1 760	2 830
1989	400	390	560	600	100	1 670	2 880
1990	340	360	480	570	110	1 570	2 770
1991	740	400	460	480	100	1 900	3 140
1992	610	440	410	450	110	2 440	3 160
1993	880	460	380	400	100	2 320	2 850
1994	520	460	370	340	90	2 200	2 560
1995	960	500	390	330	80	1 990	2 600
1996	620	430	320	340	60	1 850	2 460
1997	710	390	260	340	50	2 020	2 530
1998	560	480	360	470	70	2 720	2 650

[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*	1998*
Total	1804	1686	1725	1519	1949	2372	2353	2292	2468	2598	2811	2785
Cod	305	252	186	125	164	219	275	374	365	358	402	322
Haddock	75	63	39	23	25	40	44	74	80	97	106	79
Saithe	152	148	145	112	140	168	188	189	219	222	184	193
Tusk	30	23	32	28	27	26	27	20	19	19	14	21
Ling/blue ling	25	24	29	24	23	22	20	19	19	19	16	23
Greenland halibut	7	9	11	24	33	11	15	13	14	17	12	11
Redfish	18	25	27	41	56	38	33	29	22	31	22	27
Others and unspecified	34	29	29	30	44	43	57	31	27	25	33	34
Capelin	142	73	108	92	576	811	530	113	28	208	158	87
Mackerel	159	162	143	150	179	207	224	260	202	137	137	158
Herring	347	339	275	208	201	227	352	539	687	763	923	831
Sprat	10	12	5	6	34	33	47	44	41	59	7	35
Other industrial fisheries[1]	500	526	696	655	447	527	541	587	745	642	798	963

[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-fenicol
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
1998	679	55	-	436	-	-	53	135

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	427.2	801.5	241.4	82.3	75.7	18.0	64.0	55.1
1998*	486.1	639.7	239.0	69.4	83.6	19.2	154.4	40.9

Source: Statistics Norway.

Table H5. **Export of fish and fish products by important recipient country. Million NOK**

	Total	EU countries total	Of this: France	Den-mark	United Kingdom	Ger-many	Other countries total	Of this: 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	19 536.9	11 709.4	2 250.3	1 767.8	1 484.5	1 698.3	7 827.5	1 999.2	723.1
1995	20 095.0	13 176.4	2 138.0	2 192.2	1 591.4	1 605.4	6 918.6	1 987.5	800.1
1996	22 444.5	13 839.2	2 167.5	2 431.0	1 765.1	1 529.5	8 605.2	2 503.8	762.7
1997	24 632.3	14 531.5	2 274.3	2 640.9	2 022.2	1 532.0	10 100.8	2 752.2	962.9
1998*	27 892.5	17 605.6	2 542.2	3 156.9	2 819.4	1 951.1	10 286.9	2 801.2	1 000.0

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	1359.7	21.4	1160.6	2.6	147.8	0.5	51.4
1986	39.8	1756.9	34.4	1458.6	4.5	205.1	0.9	93.2
1987	44.2	2281.4	39.2	1967.3	4.0	207.1	1.0	107.0
1988	66.7	3155.9	56.0	2594.9	10.0	484.8	0.7	76.2
1989	96.8	3621.4	81.1	2954.6	14.4	531.5	1.3	135.3
1990	132.6	5019.0	92.8	3423.8	37.9	1411.1	1.9	184.1
1991	134.3	4968.0	91.3	3149.3	35.4	1300.3	7.7	518.4
1992	130.9	4991.9	107.1	3881.8	15.0	518.1	8.8	592.0
1993	141.0	5236.1	117.9	4087.4	13.1	466.0	10.0	682.9
1994	168.8	6383.5	140.7	4942.2	13.1	483.1	15.0	958.2
1995	206.3	6714.6	169.4	5007.1	19.7	653.7	17.2	1053.8
1996	237.2	6923.7	191.1	5041.2	23.0	651.7	23.0	1230.9
1997	260.3	7577.2	205.2	5388.0	27.8	803.0	27.3	1386.1
1998*	281.0	8688.4	223.1	6251.3	29.3	886.3	28.6	1550.7

Source: Statistics Norway.

Table H7. **Catch quantities[1] and export value[2] of fish and fish products. Selected countries**

	1993		1994		1995		1996	
Country[3]	Catch quantity 1000 tonnes	Export-value Million USD	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	9 351	1 542	10 867	2 320	12 563	2 835	14 222	2 857
Peru	9 004	685	11 999	978	8 937	870	9 515	1 120
Chile	5 948	1 125	7 721	1 304	7 434	1 704	6 693	1 697
Japan	7 248	767	6 617	743	5 967	713	5 964	709
USA	5 523	3 179	5 535	3 230	5 225	3 384	5 001	3 148
Russia	4 370	1 471	3 705	1 720	4 312	1 635	4 676	1 686
Indonesia	3 085	1 419	3 320	1 583	3 509	1 667	3 730	1 678
India	3 119	836	3 210	1 125	3 220	1 105	3 492	978
Thailand	2 928	3 404	3 013	4 190	3 202	4 449	3 138	4 118
Norway	2 415	2 302	2 333	2 735	2 525	3 123	2 638	3 416
South Korea	2 257	1 335	2 358	1 411	2 320	1 565	2 414	1 513
Iceland	1 716	1 138	1 557	1 265	1 613	1 343	2 060	1 426
Philippines	1 835	478	1 852	533	1 862	502	1 790	437
North Korea	1 701	..	1 720	..	1 765	..	1 725	..
Denmark	1 614	2 151	1 873	2 359	1 999	2 460	1 682	2 699

[1] Catch quantities include sea-water and fresh-water fisheries, but not aquaculture production. Whales, seals and other marine mammals and marine plants are not included. [2] Aquaculture production included in the export figures. [3] Countries are ranked according to catch quantities in 1996.
Source: FAO (1998a and b).

Appendix I

Urban settlements

Table I1. **Area[1] and population in urban settlements. Whole country and counties. 1998***

	Area		Population in urban settlements as of 1 January 1998		
	km²	Percentage of total area	Residents	Percentage of total population	Residents per km²
Whole country	2 068.6	0.7	3 279 195	74.2	1 585
01 Østfold	139.1	3.6	197 292	81.0	1 418
02 Akershus	229.8	5.0	392 413	86.5	1 708
03 Oslo	132.2	30.9	496 454	99.4	3 755
04 Hedmark	90.7	0.3	90 754	48.8	1 001
05 Oppland	92.4	0.4	92 768	50.9	1 004
06 Buskerud	127.7	0.9	173 779	74.6	1 361
07 Vestfold	121.3	5.7	171 051	82.0	1 410
08 Telemark	89.8	0.6	118 448	72.3	1 319
09 Aust-Agder	58.4	0.7	62 983	62.3	1 079
10 Vest-Agder	73.8	1.1	115 239	75.5	1 562
11 Rogaland	168.1	2.0	286 981	78.8	1 707
12 Hordaland	201.4	1.3	319 181	74.4	1 585
14 Sogn og Fjordane	49.0	0.3	53 488	49.6	1 092
15 Møre og Romsdal	125.8	0.9	154 944	64.0	1 232
16 Sør-Trøndelag	106.3	0.6	190 077	73.3	1 788
17 Nord-Trøndelag	52.8	0.3	65 289	51.5	1 237
18 Nordland	108.8	0.3	150 388	62.9	1 382
19 Troms	61.6	0.2	94 086	62.6	1 527
20 Finnmark	39.5	0.1	53 572	71.5	1 356

[1] The area of an urban settlement has not been reduced for any areas of sea which come within its boundary.
Source: Land use statistics, Statistics Norway.

Table I2. **Building base area in urban settlements. Whole country and counties. 1998***

	Total building base area[1]	Dwelling base area[1]	Area of urban settlement	Building base area as percentage of total area	Dwelling base area as percentage of total area
	m^2		km^2	Per cent	
Whole country	177 319 000	87 827 000	2 068.6	8.6	4.2
01 Østfold	12 028 000	6 023 000	139.1	8.6	4.3
02 Akershus	20 369 000	10 223 000	229.8	8.9	4.4
03 Oslo	20 211 000	8 773 000	132.2	15.3	6.6
04 Hedmark	7 328 000	3 271 000	90.7	8.1	3.6
05 Oppland	6 464 000	3 017 000	92.4	7.0	3.3
06 Buskerud	10 283 000	5 077 000	127.7	8.1	4.0
07 Vestfold	10 096 000	5 452 000	121.3	8.3	4.5
08 Telemark	6 591 000	3 418 000	89.8	7.3	3.8
09 Aust-Agder	3 818 000	2 028 000	58.4	6.5	3.5
10 Vest-Agder	5 919 000	3 122 000	73.8	8.0	4.2
11 Rogaland	17 304 000	8 371 000	168.1	10.3	5.0
12 Hordaland	14 427 000	7 953 000	201.4	7.2	3.9
14 Sogn og Fjordane	3 656 000	1 705 000	49.0	7.5	3.5
15 Møre og Romsdal	9 739 000	4 688 000	125.8	7.7	3.7
16 Sør-Trøndelag	8 775 000	4 500 000	106.3	8.3	4.2
17 Nord-Trøndelag	4 099 000	1 904 000	52.8	7.8	3.6
18 Nordland	8 201 000	4 260 000	108.8	7.5	3.9
19 Troms	4 792 000	2 379 000	61.6	7.8	3.9
20 Finnmark	3 219 000	1 663 000	39.5	8.1	4.2

[1] The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.
Source: Land use statistics, Statistics Norway.

Table I3. **Building base area in urban settlements by size category. 1998*. m²**

	Total building base area[1]	Dwelling base area[1]
Total	177 319 000	87 827 000
200 - 499	10 449 000	4 466 000
500 - 999	12 154 000	5 436 000
1 000 - 1 999	13 478 000	6 586 000
2 000 - 19 999	53 596 000	26 923 000
20 000 - 99 999	35 200 000	18 501 000
100 000 -	52 442 000	25 915 000

[1] The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.
Source: Land use statistics, Statistics Norway.

Table I4. **Building base area in the ten largest urban settlements in Norway. 1998*. m²**

	Total building base area[1]	Dwelling base area[1]
Oslo	32 400 000	15 039 000
Bergen	7 015 000	4 323 000
Stavanger/Sandnes	7 768 000	3 700 000
Trondheim	5 258 000	2 853 000
Fredrikstad/Sarpsborg	5 859 000	2 801 000
Porsgrunn/Skien	3 950 000	2 207 000
Drammen	3 854 000	1 935 000
Kristiansand	2 696 000	1 478 000
Tromsø	1 831 000	1 006 000
Tønsberg/Åsgårdstrand	2 706 000	1 540 000

[1] The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.
Source: Land use statistics, Statistics Norway.